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S/N - ECG SIGNAL WITH HYBRID WINDOW TECHNIQUE

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Abstract

The Electro-Cardiogram (ECG) waves suffer from power line interference. This work deals with problems of power line interference reduction. We proposed a new window which is hybrid combination of hamming and Bartlett window? This method gives better results than hamming and Bartlett individually

Key_ Words: Electrocardiography, biomedical, power line interference, FIR filter, MIT-BIH database, SNR (Signal to noise ratio).

I. INTRODUCTION

The ECG is a biological (Biomedical) signal; it is the electrical manifestation of the contractile activity of the heart. ECG is a quasi- periodical, rhythmically repeating signal, synchronized by the function of the heart, which acts as the generator of bioelectrical events [1]. A typical ECG cycle is defined by the various features (P, Q, R, S, and T) of the electrical wave shown in fig.1. The P wave marks the activation of the atria, which are the chambers of the heart that receive blood from the body. The activation of the left atrium, which collects oxygen-rich blood from the lungs, and the right atrium, which gathers oxygen-deficient blood from the body, takes about 90 msec. Next in the ECG cycle comes the QRS complex.

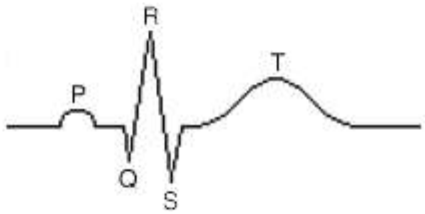

Figure.1 Typical ECG signal

The heart beat cycle is measured as the time between the second of the three parts of the QRS complex, the large R peak. The QRS complex represents the activation of the left ventricle, which sends oxygen-rich blood to the body, and the right ventricle, which sends oxygen-deficient blood to the lungs. During the QRS complex, which lasts about 80 msec, the atria prepare for the next beat, and the ventricles relax in the long T wave. It is these features of the ECG signal by which a cardiologist uses to analyze the health of the heart and note various disorders, such as atrial flutter, fibrillation, and bundle branch blocks. Electrocardiographic signals (ECG) may be corrupted by various kinds of noise [2]. Typical examples are:

• Power line interference.
• Electrode contact noise.
• Motion artifacts.
• Muscle contraction.
• Base line drift.

Muscle noise can cause severe problems as low-amplitude waveforms can be obstructed. Muscle noise is not associated with narrow band filtering, but is more difficult since the spectral content of the noise considerably overlaps with that of the PQRST complex. However, ECG is a repetitive signal and thus techniques like ensemble averaging can be used. Successful reduction is restricted to one QRS morphology at a time and requires several beats to become available. Electromagnetic fields from power lines can cause 50 Hz sinusoidal interference, possibly accompanied by some of its harmonics. Such noise can cause problems interpreting low-amplitude waveforms and spurious waveforms can be introduced.

The ECG signal is a very weak time varying signal (about 10 microvolt) and has a frequency between 0.5Hz to 100Hz [1]. The waveforms thus recorded have been standardized in terms of amplitude and phase relationships and any deviation from this would reflect the presence of an abnormality. Abnormal patterns of ECG may be due to undesirable artifacts. Normally ECG is contaminated by power line interference of 60Hz.So it is desired how best the signal can be improved.

In this paper we describe the design of low pass filter for the removal of high frequency noise by hybrid combination of boxcar and Blackman window, and design of notch filter by hybrid combination of Hamming and Bartlett windows for removal of power line interference. SNR values of all combinations are tabulated in table1.This hybrid window based analysis of ECG signals [6] gives better results than Hamming and Bartlett windows individually.

II. Proposed method:

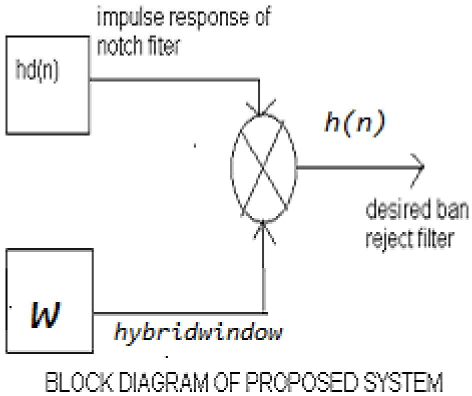

Figure-2

As in figure-2 above NOTCH filter is designed by combining hamming and Bartlett window techniques. In our work we mainly use the NOTCH filter which yields the better performance in enhancing the ECG signal through the removal of power line interference [3].

III. Notch filter design:

Notch filter design specifications:

f_L is lower cutoff frequency=59.5hz;
f_H is higher cutoff frequency=60.5hz;

Desired impulse response of notch filter is calculated as:

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

The designed hybrid window of the above notch filter is considered as:

$w=m*w_{hamm}(N) + (1-m)*w_{bartlett}(N)$
where

$W_{bartlett\,(n)} = 1-\{2\,|n|\}/(N-1);$

$$w_{hamm}(n) = 0.54\frac{\sin wN/2}{\sin w/2} + 0.23\frac{\left[\frac{wN}{2} - \frac{\pi N}{N-1}\right]}{\sin\left[\frac{w}{2} - \frac{\pi}{N-1}\right]} + 0.23\frac{\left[wN/2 + \frac{\pi N}{N-1}\right]}{\sin\left[\frac{w}{2} + \frac{\pi}{N-1}\right]}$$

$W_{hamming}$ and $w_{bartlett}$ are from[4,6]
Finally the frequency response of notch filter is:

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

STEPS FOR PROPOSED NOTCH FILER:

1. Calculate impulse response $h_d(n)$ of desired notch filter forgiven specifications

2. Prepared hybrid window for the desired notch filter:
   w=m*Hamming+ (1-m)*Bartlett;
   Where:
   'm' is a real number
   Now obtain response of hybrid window for different values of 'm'.
3. Calculate transfer function h(n) of desired notch filter by convolving $h_d(n)$ with hybrid window
4. Now obtain response of desired notch filter for different values of 'm'

The below figure shows the frequency response characteristics of NOTCH filter with a single null at frequency w_o. Null points are the frequency points where amplitudes are zero.

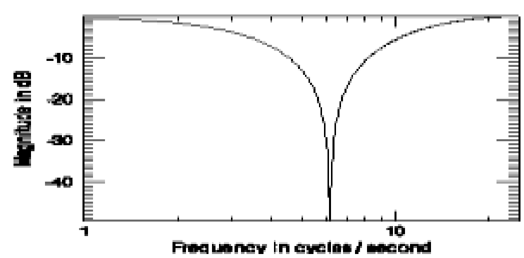

Fig.3: Response of notch filter

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IV. Responses of low pass filter With 120 Hz cutoff:

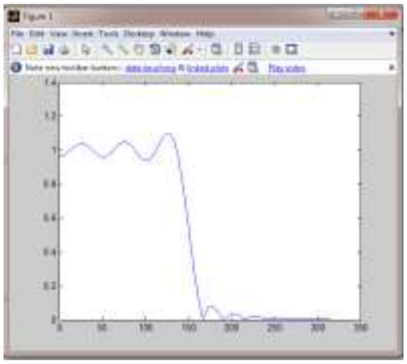

Figure 4 boxcar window

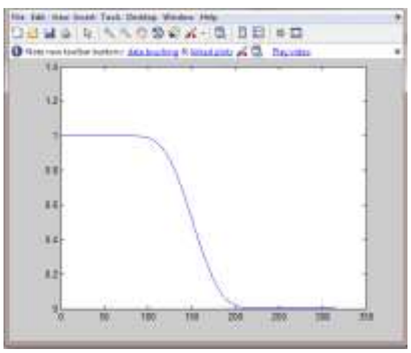

Figure 5 Blackman window

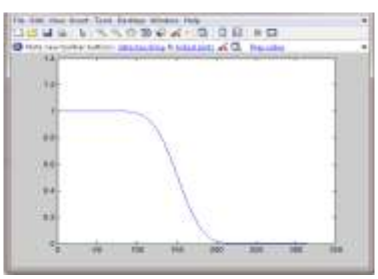

Figure 6 boxcar and Blackman window

V. RESPONSES OF NOTCH FILTER WITH 60 HZ CUTOFF:

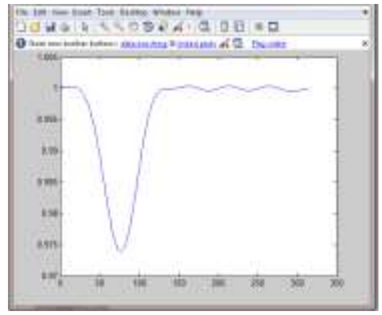

Figure 7 hamming window

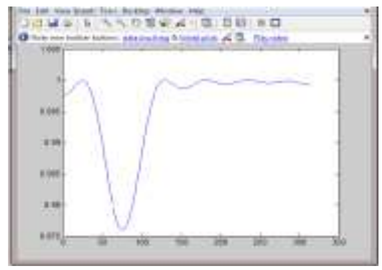

Figure 8 Bartlett window

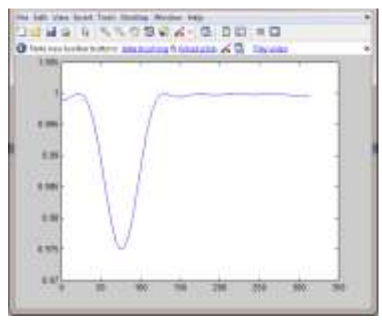

Figure 9 hamming and Bartlett windows

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VI. Results and Discussions

We have considered the following ECG signal as our inputs. An ECG contaminated with Power line interference of 60 Hz and an otherwise normal trace is considered as an input. The figure below Figure shows an unfiltered ECG signal (figure10).

Unfiltered ECG

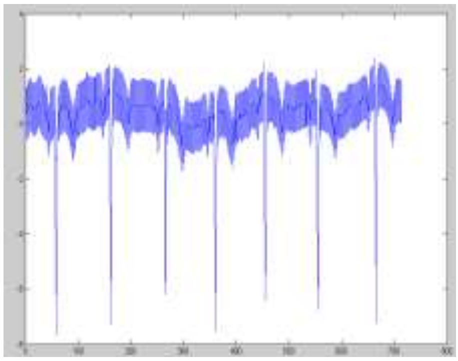

Figure 10

This noise was filtered by combining The following filters;

- Hamming Band Stop
- Bartlett Band Stop

The following figure show the ECG signal after filtering with the low pass and notch filter.

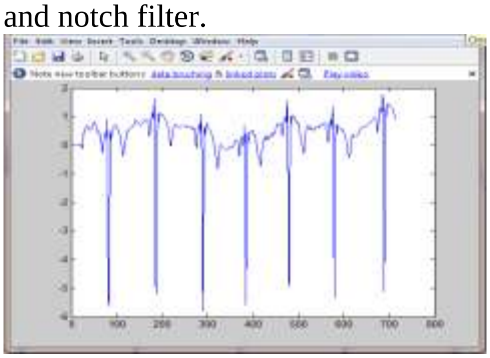

Figure 11

VII. Comparison of SNR values for different values of 'm'

Value of 'm'	SNR value
0.02	-9.16
0.5	-9.75
0.6	-9.74
2	-9.56

Table-1

VIII. Conclusion

In this design of the notch filters using frft based windows, it is seen that there is reduction in the 60 Hz noise present in the ECG signal. The power line interference removal is mainly a question of filtering out a narrow band of lower-than-ECG frequency interference. The main problems are the resulting artifacts and how to optimally remove the noise. Muscle noise on the other hand, is more difficult as it overlaps with actual ECG data. 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 values of 'm' taken in the present work.

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