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Noise Reduction in ECG Signals Using Notch Filter

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Abstract— Heart problems are increasing frequently day by day and ECG reflects the activities and the attributes of the human heart. The information extracted from the signal is used for analysis and identifying various pathological conditions, but these ECG signal can be distorted with noise as Electrocardiogram (ECG) signals are the electrical recording of heart activity. These signals are very low frequency signals of about 0.5Hz -100Hz. Noise can be any interference due to motion artifacts or due to power equipment that are present where ECG had been taken. A typical computer based ECG analysis system includes a signal pre-processing, beats detection and feature extraction stages, followed by classification. Automatic identification of arrhythmias from the ECG is one important biomedical application of pattern recognition. Moreover ECG signal processing has become a prevalent and effective tool for research and clinical practices. This paper focuses on ECG signal processing using Notch Filter for biomedical application.

Keywords- ECG, Signal Pre-processing, Pattern recognition, Noise

I. INTRODUCTION

It is difficult to get accurate result for biomedical signal's recording while patient is diagnosis by medical monitoring. The signal can be corrupted by electromagnetic field (EMF) by the machinery which is placed nearby [1] or by the fluctuation in electric supply to which measuring equipment is attached.

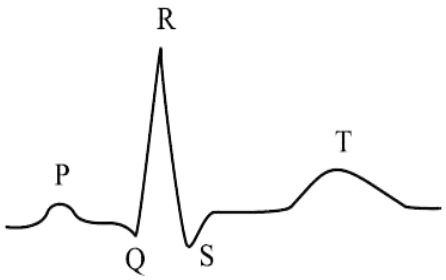

Fig 1.1: ECG Signal

The noise from electric power system is a main source of noise during the recording or monitoring of ECG. Different noises have different frequencies; the noise with low frequency creates problem with ECG signal and some time high frequency noises also interfere ECG i.e. mobile phone. The frequency is measured in cycle/second or in "Hertz". For example the electric power used in daily life is 50 Hz in India [3].

Filters

A filter is a device when a signal is given; it changes to some desired form by changing its shape, amplitude, frequency or phase frequency. They are usually employed to remove the noise, extract information signals and separate two or more combined signals. There are two main classes of filter, analog and digital filters. These filters are used for different applications; the selection for the filter depends upon the required output of the application.

Notch Filter-Notch filter is used in many applications where specific frequency component is eliminated. For example instrumentation and recording system signals are interfered by power line frequency 50Hz and these interferences are eliminated by notch filter [8].

The Notch filter removes the noise by attenuating the entire signal content at 50 Hz. This result in a loss of the frequency components of the desired signal range around 50 Hz.

Notch Filter contains one or more null in its frequency response characteristics. Fig.1.2 illustrate the pole zeros plot for notch filter. For complete rejection at frequency $Z_{1,2}=e^{\pm jw0}$ for the perfect shape of notch filter or reduced the width of notch filter, the pole are placed at $p_{1,2}= re^{\pm jw0}$. The system function of the resulting filter is

$$H(z) = b_0 \frac{(1-e^{-j\omega})(1-e^{+j\omega})}{(1-re^{-j\omega})(1-re^{+j\omega})}$$

$$H(z) = b_0 \frac{(1-2\cos\omega_0 z^{-1}+z^{-2})}{(1-2r\cos\omega_0 z^{-1}+r^2 z^{-2})}$$

$$H(\pi) = b_0 \frac{(2+2\cos\omega_0)}{(1+r^2+2r\cos\omega_0)} = 1$$

$$b_0 = \frac{(1+r^2+2r\cos\omega_0)}{2(1+\cos\omega_0)}$$

The value of b_0 is calculated in such a way that $|H(\omega)| = 1$ for $\omega = \pi$. The frequency response of filter is shown in Fig 1.3 for $\omega_0 = \pi/4$, r = 0.8, and r = 0.95.

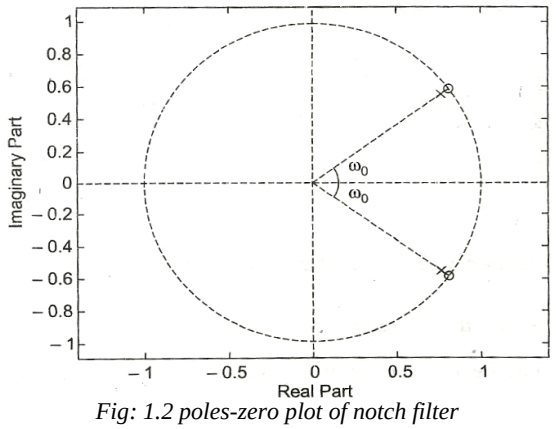

Fig: 1.2 poles-zero plot of notch filter

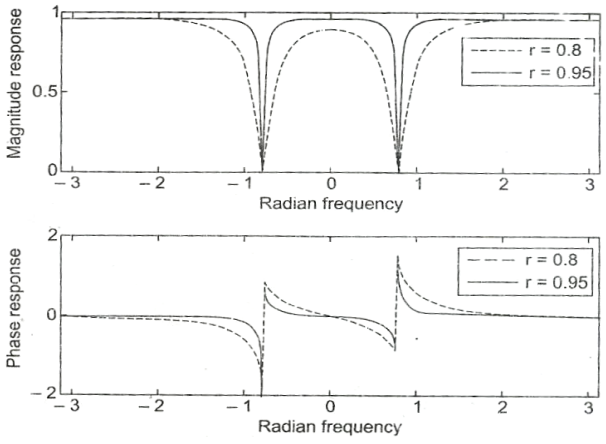

Fig: 1.3 Frequency response notch filter for $w_0=\pi/4$

Above mentioned proposed work is implemented using MATLAB as it is commercial software product, of Math works. This programming language is very powerful allows matrix manipulation, plotting of functions and data, implementation of algorithms, creation of user interfaces, and interfacing with other programming languages.

MATLAB has some advantages compared with conventional computer languages for technical problem solving. Among them are following [2].

(1) Ease of use.
(2) Platform independence.
(3) Predefined functions.
(4) Device-independent plotting.
(5) Graphical user interface.

Rest of the paper is organized as follows, Section I contains the introduction of ECG signals and about the software, Section II contain the related work on ECG signals, adaptive filters of digital signal processing and noise removal filters. Section III contains the methodology that consists of MATLAB and Notch Filter. Section IV contains the results and analysis of Notch Filter on ECG signals using MATLAB software. Section V explains the conclusion of the work and its future scope.

II. RELATED WORK

Electrocardiogram (ECG) is one of the important tools in the diagnosis of heart abnormalities. Electrocardiography has an important role in cardiology since it consists of effective, simple, on-invasive, low cost way for the diagnosis of cardiac disorders which have a high rate of occurrence and are very relevant to their impact on patient life and social costs (Linh & Osowski, 2003).

Yaghoub Mollaei has presented that the adaptive filter is one of the most important areas in digital signal processing. This paper seeks to use this area to remove noise from noise corrupted audio signals. An adaptive FIR filter with normalized LMS algorithm is designed to cancel the noise [9].

Different filter structures have been proposed by Thakor et al (1991) to eliminate the base line wander, 60 Hz power line interference, muscle noise and motion artifact[10].

Ban-Hoe Kwan et al (2005) have proposed a method using Legendre moments to reconstruct ECG signal immersed in noise [11].
Hae-Jeong Park et al (2002) have used two-step process i.e. ECG artifact detection using the energy interval histogram method and ECG artifact elimination using a modification of ensemble average subtraction. This method has already been proposed to estimate the rate of
false positives and false negatives that are necessary to determine the optimal threshold for the detection of the ECG artifact [12].

Barbosa et al (2003) have proposed a technique to improve the quality of high-resolution ECG by weighting the coherent average of beats by a function of the energy of the corrupting myoelectric noise. The results obtained with 20 patients indicated that the method requires fewer beats than conventional non-weighted average method to achieve the same noise level [13].

III. METHODOLOGY

In this paper, a narrow band, Notch filter was designed using simulation in MATLAB software, to cancelled 50 Hz noise cancellation using notch filter from the ECG signal. The filter was designed to meet the following specifications in table 1.1 given.

S. No	Description	Parameter
1	Notch frequency	50Hz.
2	3 dB Width	10 Hz.
3	Attenuation at notch frequency	3 dB.
4	Sampling frequency	600Hz.
5	R	0.947
6	b_0	0.9463

Table 1.1 Summary Notch Filter

IV. RESULTS AND DISCUSSION

This paper presents the results of simulation using MATLAB to investigate the performance of Notch Filter.

Results of Notch Filter

We can remove the noise in the ECG signal using notch filter at 50Hz.

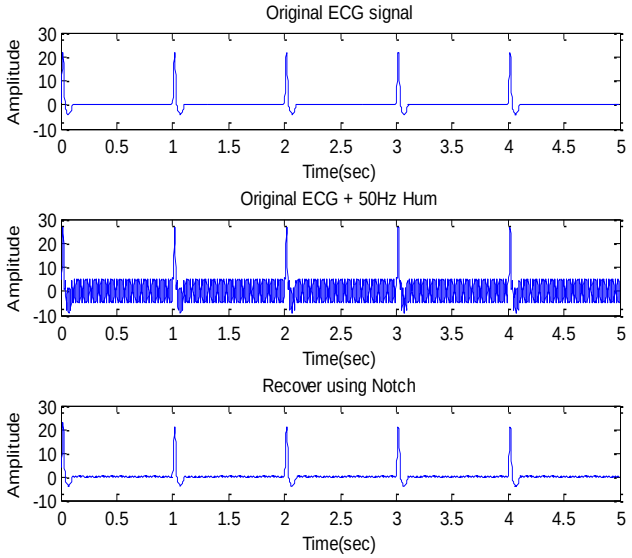

Fig.1.4 Remove the noise is to filter the signal with a notch filter at 50 Hz.

V. CONCLUSION AND FUTURE SCOPE

The objective was to analyze that Notch filter removes the noise by attenuating the entire signal content at 50 Hz. This result in a loss of the frequency components of the desired signal range around 50 Hz.

Making the bandwidth narrower can reduce this violation of the frequency components of the desired signal. But narrowing the bandwidth of the notch filter requires a higher order of the filter that will result in many coefficients and more processing time. Another problem encountered when using a narrow band notch filter is that the filter loses its effectiveness in removing the AC noise when the interference frequency shifts or deviates from 50 Hz.

In this work, only the Notch Filter is studied other noise filters can be studied and their suitability for application can be compared. Other algorithms that can be used include Recursive Least Squares and Least Mean Square. Moreover, this project does not consider the real time processing of finite-length filters and the causal approximation and also improvement of the thesis can be further implemented with different algorithms such as RLS algorithm and wiener filter to achieve the desired results.

REFERENCES

[1] R.S Khandpur, "*Biomedical instrumentation hand book*", 11th reprint 2008 Tata McGraw –Hill publication company Limited New Delhi. ISBN-13: 978-0-07-0473355-3.

[2] Stephen J. chapman "*MATLAB programming for engineers*" 3rd Reprint Edition 2003 by Thomson asia Pte Ltd., Singapore ISBN: 981-240-606-9.

[3] Malindi, P., "Cancelling power line interference in electrophysiological signals". ECT Research Journal, Vol.2, 2002

[4] Widrow B. and Hoff M.E. (1960), "*Adaptive switching circuits*", In IREWESCON Convention Record, pp. 96-104, New York.

[5] Zhang Jiashu, Tai Heng-Ming, "*Adaptive Noise Cancellation Algorithm for Speech Processing*", IEEE Transactions, pp 2489-2492, 2007.

[6] Jigram H. Shah, Jay M. Joshi, "*Digital signal processing*", University science press laxmi publication company Limited New Delhi.

[7] Suzanna M. M. Martens, Massimo Mischi, S. Guid Oei, "*An Improved Adaptive Power Line Interference Canceller for Electrocardiography*" IEEE transactions on biomedical engineering, vol. 53, no. 11, November 2006.

[8] Syed Zahurul Islam, Syed Zahidul Islam, Razali Jidin, Mohd. Alauddin Mohd. Ali, "*Performance Study of Adaptive Filtering Algorithms for Noise Cancellation of ECG Signal*", IEEE 2009.

[9] Y. Mollaei, "*Hardware implementation of adaptive filters*," 2009 IEEE Student Conference on Research and Development (SCOReD), 2009.

[10] Thakor N.V. and Zhu Y.S. (1991), "*Applications of adaptive filtering to ECG analysis: noise cancellation and arrhythmia detection*" , *IEEE Transaction on Biomedical Engineering*, Vol. 38, Issue No. 8, pp. 785-794.

[11] Ban-Hoe Kwan, Kok-Meng Ong and Paramesran R., "*Noise removal of ECG signals using legendre moments*", 27th Annual International Conference on Engineering in Medicine and Biology Society, pp. 5627-5630, 2005.

[12] Hae-Jeong Park, Do-Un Jeong and Kwang- Suk Park, "*Automated detection and elimination of periodic ECG artifacts in EEG using the energy interval histogram method*", IEEE Transactions on Biomedical Engineering, Vol. 49, Issue No. 12, pp. 1526- 1533, 2002.

[13] Barbosa P.R.B., Barbosa-Filho J., De Sa C.A.M., Barbosa E.C. and Nadal J., "*Reduction of electromyographic noise in the signal-averaged electrocardiogram by spectral decomposition*", *IEEE Transactions on Biomedical Engineering*, Vol. 50, Issue No. 1, pp. 114-117, 2003.

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