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Reduction of Noise & QRS Detection by Using FIR Band Pass Filter

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Abstract— ***Electrocardiogram (ECG) provides useful information of the condition of heart. Accurate measurement of ECG parameters is an important requirement of quantitative ECG analysis, particularly if the results of the ECG signal are to be used for clinical purposes. Filtering of ECG signal is very important because noisy ECG signal can mask some important features of the Electrocardiogram (ECG). Hence it is desirable to reduce this noise for proper analysis of the ECG signal. This paper presents the study of FIR filter using window techniques for ECG signal Processing. Almost all the analysis methods use the standard Massachusetts Institute of Technology-Beth Israel Hospital (MIT-BIH) database which is available in the digital form . The main objective of this work is to use normal ECG of Indian patients. ECG signals from Modified Lead II (MLII) are chosen for processing. QRS complexes are detected and then can be used for further processing.***

***Keywords**— Electrocardiogram, Window techniques, FIR Digital Filter, MLII ECG Data Signal*

I. INTRODUCTION

Human body is a volume conductor i.e. body fluids are good conductor of electricity. So electrical changes occurring in the heart with each heart beat are conducted all over the body and can be picked up from the body surface. The record of these electrical fluctuations during cardiac cycle is called Electrocardiogram (ECG). It is a non-invasive test that records the electrical activity of the heart over time and it is very useful in the investigation of heart disease, for example a cardiac arrhythmia. The ECG signal is a trace of an electrical activity signal generated by rhythmic contractions of the heart and it can be measured by electrodes placed on the body's surface. An electrode lead, or patch, is placed on each arm and leg and six are placed across the chest wall. The signals received from each electrode are recorded. Fig.1 shows an example of a normal ECG signal, which consists of a P wave, a QRS complex and a T wave. The small U wave may also be sometimes visible, but is neglected in this work for its inconsistency. The P wave is the electrical signature of the current that causes atrial contraction, the QRS complex corresponds to the current that causes contraction of the left and right ventricles, the T wave represents the repolarization of the ventricles, and the U wave, although not always visible, is considered to be a representation of the papillary muscles or Purkinje fibers.

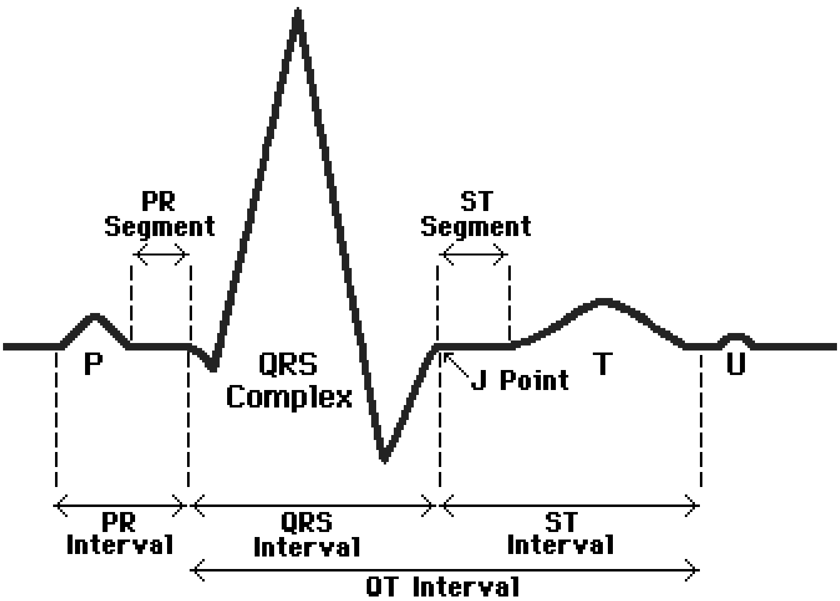

Fig. 1 Normal ECG Signal

ECG measurements may be corrupted by many sorts of noise. The ones of primary interest are: Power line interference, Electrode contact noise, Motion artifacts, EMG noise, Instrumentation noise .These artifacts strongly affects the ST segment, degrades the signal quality, frequency resolution, produces large amplitude signals in ECG that can resemble

PQRST waveforms and masks tiny features that are important for clinical monitoring and diagnosis. Cancelation of these artifacts in ECG signals is an important task for better diagnosis. Removal of noises from ECG signal is a classical problem and many researchers work on signal noise removing by different filtering method and algorithms. Baseline wanders and power line interference reduction is the first step in all electrocardiography signal processing. Therefore, to reduce and remove the noises, digital filters are widely used in biomedical signal processing. Analog filters can also be used to remove these noises, but nonlinear phase shift is introduced by them. Digital filters are more accurate and precise than analog filters. Digital filters are of two kinds:-

1. Finite Impulse Response (FIR)
2. Infinite Impulse Response (IIR).

II. LITERATURE REVIEW

Mbachu C.B. and Offor K..J. designed a digital FIR filter for reducing 50Hz powerline noise in ECG signal and implemented with Hamming window[1]. Rinky Lakhwani has done the comparison of different digital filters for QRS complex extraction from ECGs [2]. Nalini Singh has designed a digital IIR filter for noise reduction in ECG signals [3]. Seema Rani did comparative study of FIR and IIR filter for the removal of baseline noises from ECG signal[6].

III. DIGITAL FILTER

There are two categories of digital filter, namely the recursive filter or infinite impulse response (IIR) filter & the non recursive filter or finite impulse response (FIR) filter. The desired frequency response specification is given by $\boldsymbol{H_d(\omega)}$ & the corresponding unit sample response is given by $\boldsymbol{h_d(n)}$ & that is determined by using the following relation

$$h_d(n) = \frac{1}{2\pi}\int_{-\pi}^{\pi} H_d(\omega)e^{j\omega n}d\omega \ldots\ldots\ldots\ldots(1)$$

$$H_d(\omega) = \sum_{n=-\infty}^{\infty} h_d(n)\, e^{-j\omega n} \ldots\ldots\ldots\ldots(2)$$

The unit sample response $h_d(n)$ in the above relation is infinite in duration, so it must truncate to some point n=M-1 to yield an FIR of length M (0 to M-1).The algorithm is given by

$$b(n) = \omega(n)h(n)\ ,\ 1 \leqq n < N \ldots\ldots\ldots\ldots(3)$$

where h(n) gives the impulse response of the ideal filter & ω(n) denotes the window.

1. Kaiser Window

In this window the side lobe level can be controlled with respect to the main lobe peak by varying a parameter α. Kaiser window parameter β is affected by the side lobe attenuation α dB. The width of main lobe can be varied by adjusting the length of the filter.

$$\beta = \begin{cases} 0.1102(\alpha-8.7), & \alpha > 50 \\ 0.582(\alpha-21)^{0.4}+0.07886(\alpha-21), & 21 \leqq \alpha \leqq 50 \\ 0, & \alpha < 21 \end{cases} \ldots\ldots\ldots\ldots(4)$$

The filter order for the FIR filter is given by:

$$N = [(\alpha-8)/2.285\Delta\omega] + 1 \ldots\ldots\ldots\ldots(5)$$

Here N is the filter order and Δω is the width of the smallest transition region.

IV. METHODOLOGY

Almost all the analysis methods use the standard Massachusetts Institute of Technology-Beth Israel Hospital (MIT-BIH) database which is available in the digital form. We have taken ecgs of Indian patients using BPL 108T machine and convert it into digital form. The ecg signals are digitized with sampling frequency of 295 Hz. This ecg contains P-QRS-T waves but the most important part of this ecg is QRS complex. The frequency of QRS complex is within the range of 15-17 Hz. To detect QRS complex we have designed a FIR band pass filter which gives QRS complex at the output and eliminates P and T waves. This output of filter contains only QRS complex and parameters like RR interval can be calculated. By using the FDA tool of MATLAB software we set the lower cut off frequency of the FIR Band Pass Filter at 15.9 Hz and the upper cut off frequency at 16.5 Hz. The order of the filter is 20. Fig 2 gives the magnitude response of the filter. The phase response is shown in fig. 3.

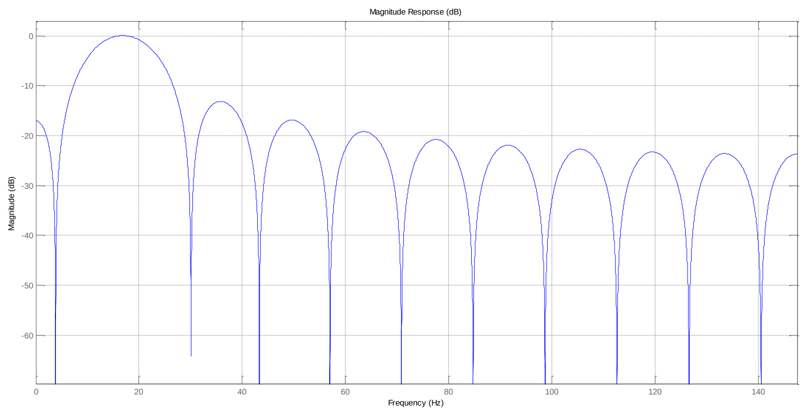

Fig. 2 Magnitude Response Of Digital Kaiser window BPF

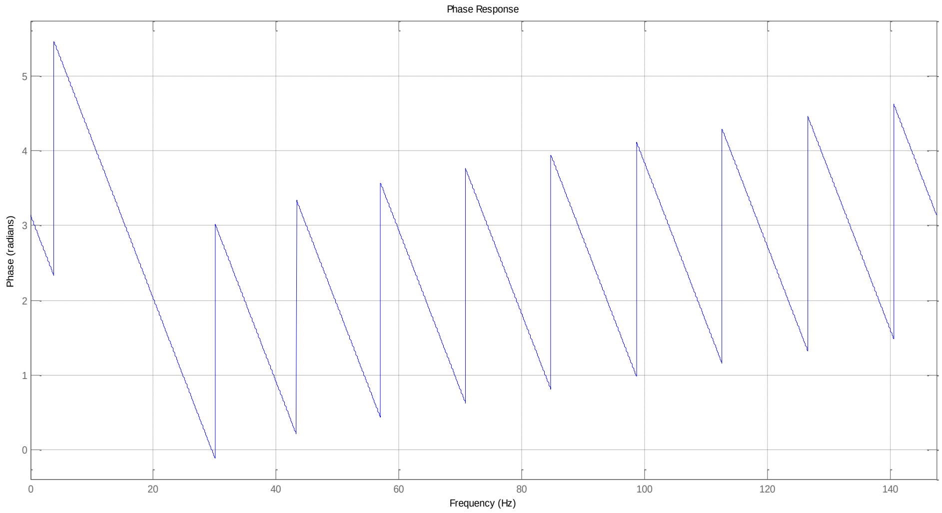

Fig. 3 Phase Response Of Digital Kaiser window BPF

The simulink model used for the detection of QRS complex is as below:

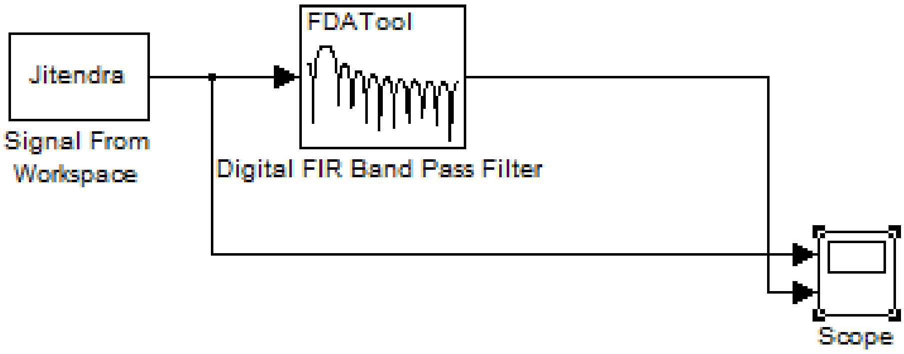

Fig. 4: Simulink model for QRS complex detection

V. RESULTS

The input ecg signal is shown in fig.5. The noisy data signal is filtered by the filter whose impulse response is h_d. The noisy input ECG data signal is filtered with Kaiser window technique. Filtered signal of the window shown below.

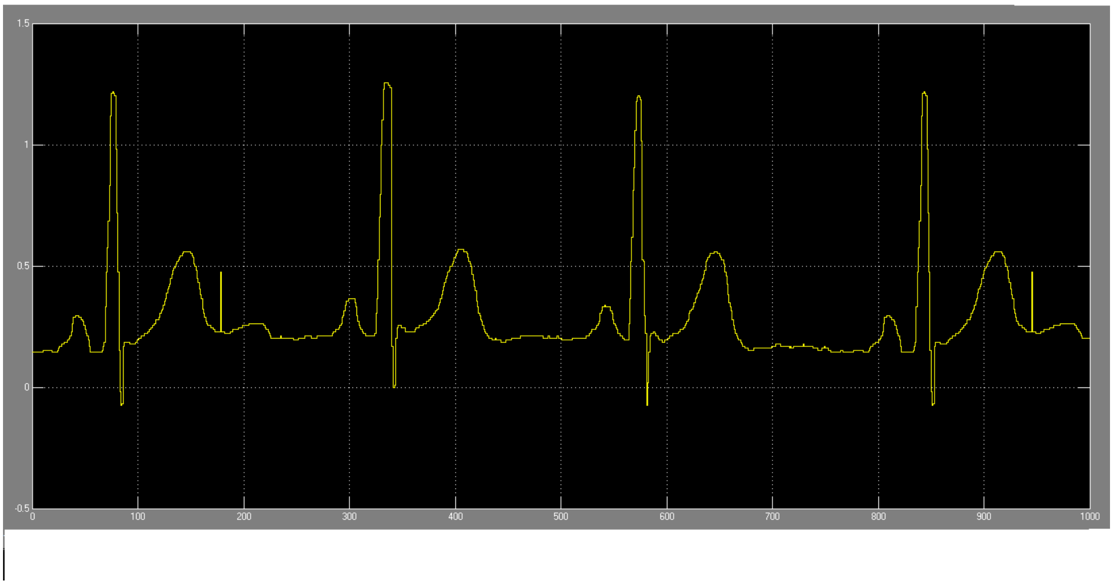

Fig .5 Original ECG Signal

The following figure will give the ECG signal when it is passed through a digital band pass filter employing Kaiser Window technique.

Fig. 6: ECG signal after passing through Kaiser Window

The figure below gives the power spectral density of the ECG wave.

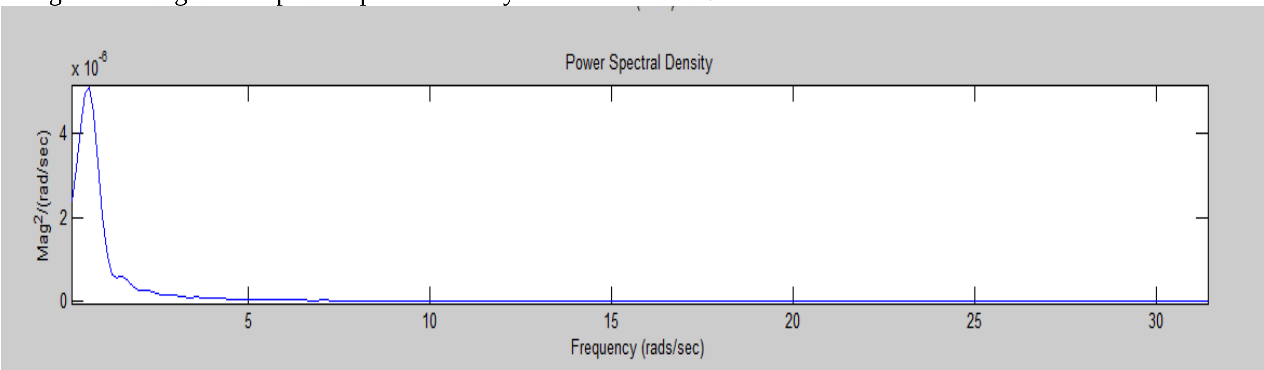

Fig. 7: Power Spectral Density of ECG Wave Before Filtering

The figure below gives the power spectral density of ECG wave after filtering with Kaiser Window.

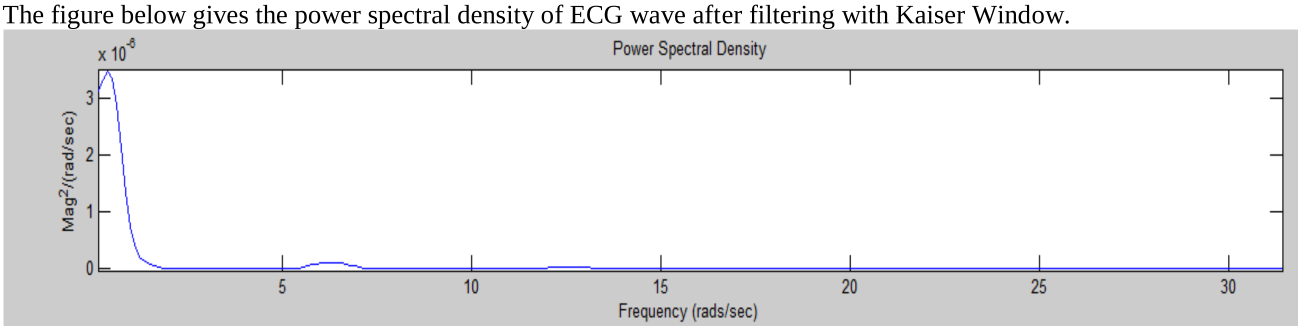

Fig. 8: Power Spectral Density of ECG Wave After Filtering With Kaiser Window

VI. CONCLUSIONS

In this paper a method of extraction of QRS complex from ECG signal is discussed. The original Indian ECGs are taken as input. A digital FIR band pass filter is used to remove the noise and suppress the P & T waves from the ECG wave so that the QRS complex is detected which is the main important aspect of ECG signal. The duration, amplitude, and morphology of the QRS complex are useful in diagnosing cardiac arrhythmias, conduction abnormalities, ventricular hypertrophy, myocardial infarction, electrolyte derangements and other diseases.

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