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**ERROR FREE ECG OUTPUT BY MATLAB SOFTWARE USING OPTIMAL  
FILTERING CONCEPT- DIGITAL BIO-SIGNAL PROCESSING.**

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**ABSTRACT-** The recording of heart signal is called Electrocardiogram (ECG). ECG is used to measure, analyze, observe the heart function and heart abnormalities like cardiac murmur, myocardial infarction etc. The ECG electrodes are sensitive in nature, even the small noise mixed with original signal changes the ECG wave pattern. The ECG signal voltage ranges from 0.5 to 6mV and artifacts can be easily mixed with such small voltage range even frequency artifacts can also affect the signal by frequency distortion while taking ECG. Filtering plays major role for getting clear and noise free ECG. Various filters are used like band pass, low pass filters, etc. Optimal Filtering is one of filtering method used to extract the desired signal from noise and interfering signals. By using optimal filtering we can able to clear the base line wandering, movement artifacts, etc.

**KEYWORDS** – ECG, Artifacts, Optimal filtering.

### **I. INRODUCTION**

Biosignal are the small voltage created by action potential of cells. All the Biosignals are weak in nature but those signals are amplified and filtered, with the help of filters and we can able to analyze

the functioning of biosystems like heart, brain, muscles etc. Recording of heart signal is called ECG, with the help of the recorded signals, the heart functions and abnormalities are analyzed..

### **II. OMNIPRESENT IN ECG SIGNALS**

ECG signals are affected by interference or noise. Generally, noises are Omnipresent nature which alters the response obtained. External noise like power line interference, AC mains, frequency noise etc have possibilities of affecting the ECG signal. The great challenge facing now a days is getting noise free ECG waveforms without affecting the input characteristics of physiological signals. Such noises can be filtered by using filters like low pass, high pass, notch filters etc. The designing of logical filters with accurate input values is a challenging phenomenon in biomedical field.

### **III. EXISTING FILTERING TECHNIQUES**

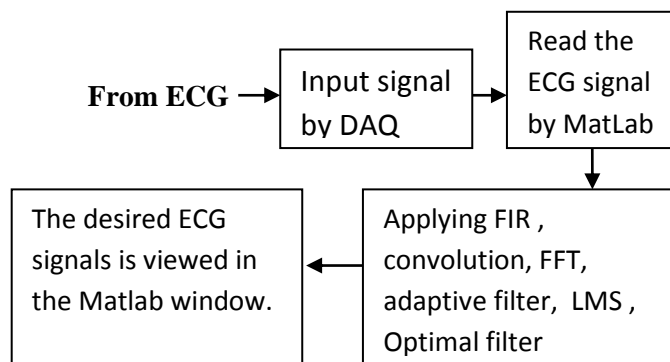
- Low pass filtering – A low pass filter that passes signals with a frequency lower than a certain cutoff frequency and attenuates signals with frequencies higher than the cutoff frequency.
- High pass filtering – A filter which passes signals with a frequency higher than a certain cutoff frequency and attenuates signals with frequencies lower than the cutoff frequency.

- Notch filtering – A filter which remove the frequency noise created by AC mains.

#### IV. DESIGNED SYSTEM

- The normal ECG (real time signal with noise) is taken from the subject.
- The obtained signal values (Amplitude and time duration) are transformed to Microsoft excel in the extension of .xlsx by Digital Acquisition ( DAQ).
- .xlsx file is transformed to directive files of MatLab software.
- Read the file from the directives and load it into MatLab.
- Apply FIR ( Finite Impulse Response) to convert the unstable signal to stable signal.
- Take FFT ( Fast Fourier Transform ) to convert stable ECG signal to get continous, periodic and symmetry signal with respect to frequency and time.
- Add random signal over periodic signal and take Convolution in order to remove desired signal from correlated errors ( noise).
- Use Least Mean Square algorithm from Adaptive filtering in order to differentiate desired and actual signal from convolution.
- Optimal filtering method is applied in order to convert the desired ECG signals to Error free ECG signal.

Then the desired waveform is viewed under Matlab window.



**Figure 1.0** ECG waveform taken from DAQ

#### V. WHAT IS OPTIMAL FILTERING?

Optimal filtering is the technique in order to optimize the real time physiological ECG signals from interference. Optimal filtering needs single input and gives single desired output. Optimal filtering is applied when,

- The input is non –stationary signal.
- Overlapping with original signals
- Availability of zero spectral characteristics of original signals.
- Correlation between reference signal and noise, not with original signals.

Therefore, the frequency response of optimal filtering is given by,

$$H[f] = \frac{S[f]^2}{S[f]^2 + N[f]^2}$$

Where,  $H[f]$  = frequency response,  
 $N[f]$  = frequency spectra of noise,  
 $S[f]$  = signal frequency.

## **VI. NEED FOR OPTIMAL FILTER**

Optimal filter is a fixed filter, hence it has desired frequency response and magnitude response. Let see the need for optimal filtering when compared to other filtering techniques.

- Frequency response is not upto when high-pass filter applied.
- Base line drift may occurs when low-pass filter applied.
- Powerline interference is possible when Notch filter is applied.

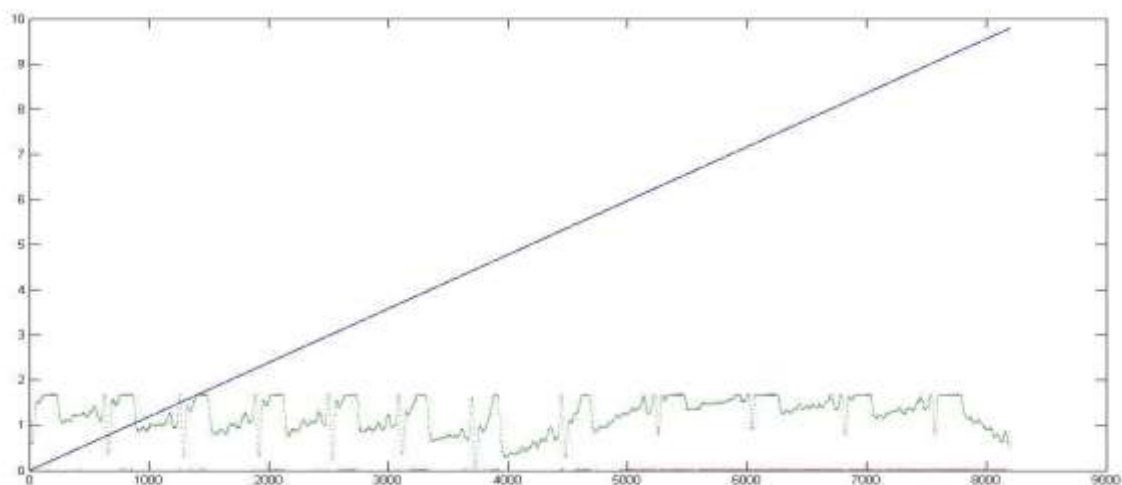
- Overlapping of signals may occur when Band-pass filter applied.

Inorder to get-rid of above problems we need to go for optimal filtering method.

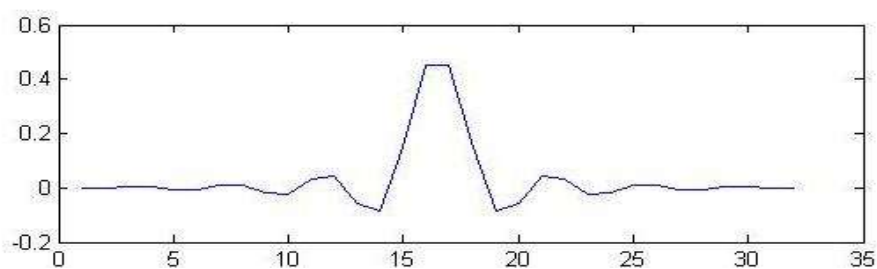
## **VII. OUTCOMES**

- Compared to other filtering, optimal filtering technique gives more gain.
- Filtered ECG signal is converted to continuous patterns of ECG signals.
- The filtered signal is free from powerline interference, overlapping, baseline drift and other interference.

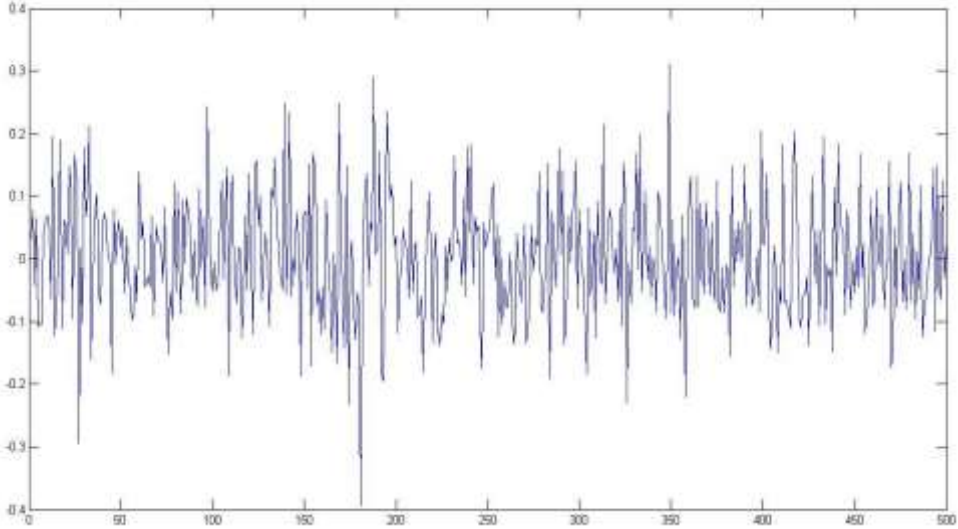
## **VIII. OUTPUT**



**Fig 1.1** Reading of ECG signal to MatLab



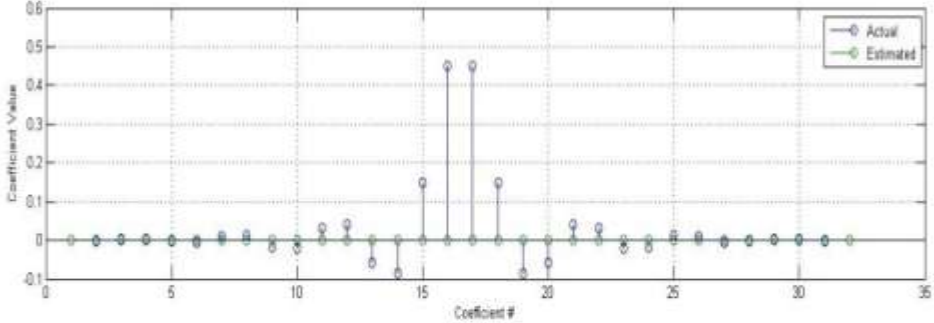
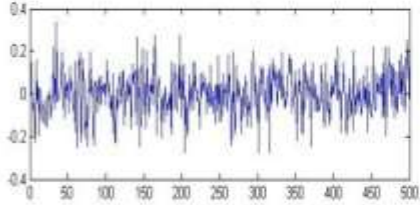
**Fig 1.2** particular portion of ECG signal by FIR filter.



**Fig 1.3** output image by FFT algorithm.

**Scale- X axis= time period(ms)**

**Y axis = amplitude( mv)**



**Fig 1.4** optimal filtering of ECG signals.

## **IX. ADVANTAGES**

- Greatly helpful for ambulatory ECG monitoring and avoids paper consumptions
- Though the software connection is very easy to connect with ECG amplifier digitally. This filtering can able to reduce the various filtering over ECG signals. As an output, optimal filtering entirely reduce the non stationary signals can convert it to stationary signals.
- The spectral characteristics of original signals can be recovered.
- Capturing particular frequency and amplitude range of PQRST complex in order to find exact heart problems like blockage, heart functioning, etc..

## **X. FUTURE WORKS**

- With this idea we gonna filter all the physiological signals like EEG, EMG, EGG, ERG/EOG etc.
- Can also implement for image processing like ultrasound Doppler imaging, Thermal imaging.
- Thus we gonna to implement this concept for speech processing.

## **XI. ACKNOWLEDGEMENT**

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