

# **An Efficient Noise Reduction Technique for ECG Signal Using Model SIM**

R.Suja<sup>1</sup>, J.Ashok kumar<sup>2</sup>, V.Rajeshkumar<sup>3</sup>

PG Scholar, Dept of ECE, Sri Venkateswara college of Engineering and Technology, Thiruvallur, India<sup>1</sup>

Asst. Professor, Dept of ECE, Sri Venkateswara college of Engineering and Technology, Thiruvallur, India<sup>2&3</sup>

**ABSTRACT:** Electrocardiogram (ECG) signal can be used to count the heart rate beat for various diagnostic purposes in medicine. There are many research are related to the ECG signal such as fatigue driver detection using ECG signal. However, most of the captured ECG signal will be distorted by the noise that cause by the measurement instrument. Sometimes, the noise will totally mask the ECG signal. The signal is hardly to be processed for further analysis. Therefore, it is essential that the ECG signal must be filtered to avoid the failure detection of the signal. In QRS complex detection, R peak detection and to reduce the noise for ECG signals have been designed using windowed filter. By using FIR filter the noise removed in ECG Signals compared to windowed filter. The ECG signal will be generate without noise, detect the QRS complex and R peak. There are some advantages that the FIR filter is chosen. Due to all zero structures of filters, it is guaranteed to be stable. Moreover, FIR filter is simple to design and it has linear phase characteristics. The output of ECG signal is compared with the ECG signal before filtering by plotting the signal in time domain and frequency domain using MODEL SIM. The power is reduced.

**KEYWORDS:** ECG, Electro Myo Graph, And Fast Fourier Transform, FPGA, HRV, IFFT, and LEPS.

## **I. INTRODUCTION**

Electrocardiogram (ECG) is a diagnosis tool that reported the electrical activity of heart recorded by skin electrode. The morphology and heart rate reflects the cardiac health of human heart beat. It is a non-invasive technique that means this signal is measured on the surface of human body, which is used in identification of the heart diseases. Any disorder of heart rate or rhythm, or change in the morphological pattern, is an indication of cardiac arrhythmia, which could be detected by analysis of the recorded ECG waveform. The amplitude and duration of the P-QRS-T wave contains useful information about the nature of disease affecting the heart. The electrical wave is due to depolarization and repolarization of Na<sup>+</sup> and k<sup>+</sup> ions in the blood. The ECG signal provides the following information of a human heart.

- Heart position and its relative chamber size
- Impulse origin and propagation
- Heart rhythm and conduction disturbances
- Extent and location of myocardial ischemia
- Changes in electrolyte concentrations
- Drug effects on the heart.

ECG does not afford data on cardiac contraction or pumping function. Medical diagnosis is a complex procedure of determining if the patient's body and its functions work in terms of normality. The diagnosis consists of gathering signs and symptoms from the results of various diagnostic procedures and making conclusion. Commonly numerous diagnostic procedures are performed measuring blood pressure, checking the pulse rate, listening to the heart with a stethoscope, urine tests, fecal tests, saliva tests, blood tests, medical imaging, electrocardiogram, hydrogen breath test and others, from these measurements is determine departure from homeostasis and the degree of departure. This process is called diagnosis. In some cases diagnosis can be time and resources demanding, especially in such cases which require to make diagnosis at basis of multiple measurements examined for longer time, therefore appeared tendencies to move routine work from physician to automation and make the physician to make the final diagnosis. This is also the case of Polysomnography used in the diagnostic procedure for sleep studies which require observation of numerous signals during sleep time.

Evaluating these signals in 30 seconds interval is time consuming even for experience physician. Because that these signals are recorded in digital form and the diagnosis is made directly from these records, so they are suitable for

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automatic processing. The aim of the project is to reduce the noise by using windowed filter. Automatically classify the heart beat in electrocardiogram (ECG) records and to find if conditions of heart attack (or other cardiac disorder) are fulfilled for each analysed interval. In this work, two problems are treated using non-invasive records such as Nasal Airway Flow (NAF), Electrocardiogram (ECG) and Pulse Transit Time (PTT). All these methods are based on analysis of tachogram (record of RR intervals), but each introduces different approaches e.g. Detrended Fluctuation Analysis, Heart Rate Variability analysis.

The standard ECG has 12 leads: which includes 3 - bipolar leads, 3 - augmented unipolar leads and 3 - chest (precordial) leads. A lead is a pair of electrodes (+ve & -ve) placed on the body in designated anatomical locations & connected to an ECG record.

Bipolar leads: Record the potential difference between two points (+ve & -ve poles). Unipolar leads: Record the electrical potential at a particular point by means of a single exploring electrode.

Leads I, II and III are commonly referred to bipolar leads as they use only two electrodes to derive a view. One electrode acts as the positive electrode while the other as the negative electrode (hence bipolar).

**Table 1.1 Types of leads used in ECG monitoring**

Standard Leads	Limb Leads	Chest Leads
Bipolar Leads	Unipolar Leads	Unipolar Leads
Unavailable Leads	Unavailable Leads	V1
Lead I	AVR	V2
Lead II	AVL	V3
Lead III	AVF	V4
Unavailable Leads	Unavailable Leads	V5

### Einthoven leads:

Lead I: records potentials between the left and right arm

Lead II: between the right arm and left leg

Lead III: those between the left arm and left leg.

Goldberger leads are unipolar augmented limb leads in the frontal plane.

Unipolar Limb leads: (when the +ve terminal is on the right arm: AVR, left arm AVL, or left leg, AVF)

One lead connected to +ve terminal acts as the different electrode, while the other two limbs are connected to the -ve terminal serve as the indifferent (reference) electrode. Leads (V1-V6R) are unipolar chest leads positioned on the left side of the thorax in a nearly horizontal plane. The indifferent electrode is obtained by connecting the 3 standard limb leads. When used in combination with the unipolar limb leads in the frontal plane, they provide a three dimensional view of the integral vector.

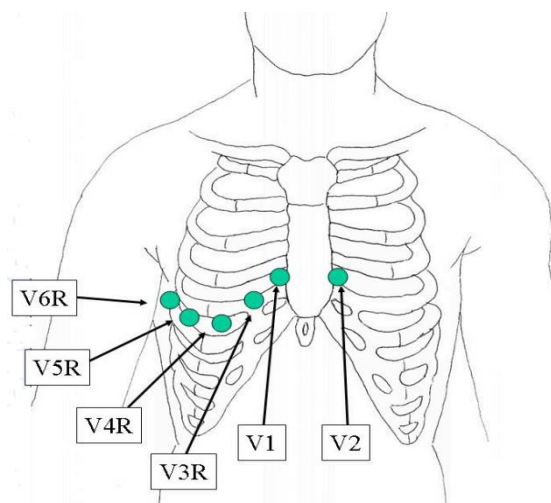


Fig .1.1 Precordial chest electrodes are normally placed on the left side of the chest

Chest (pericardial) leads

V1 : 4th intercostal space, right sternal edge

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- V2 : 4th intercostal space, left sternal edge
- V3R: between the 2nd and 4th electrodes
- V4R: 5th intercostal space in the midclavicular line
- V5R: on 5th rib, anterior axillary line
- V6R: in the mid axillary line.

To make recordings with the chest leads (different electrode), the three limb leads are connected to form an indifferent electrode with high resistances. The chest leads mainly detect potential vectors directed towards the back. These vectors are hardly detectable in the frontal plane. Since the mean QRS vector is usually directed downwards and towards the left back region, the QRS vectors recorded by leads V1–V3R are usually negative, while those detected by V5R and V6R are positive. In leads V1 and V2, QRS = -ve because, the chest electrode in these leads is nearer to the base of the heart, which is the direction of electro negativity during most of the ventricular depolarization process. In leads V4R, V5R, V6R, QRS = +ve because the chest electrode in these leads is nearer the heart apex, which is the direction of electro positivity during most of depolarization.

A need among scientists and clinicians for low-noise low-power bio signal amplifiers capable of amplifying signals in the milli hertz-to-kilohertz range while rejecting large dc offsets generated at the electrode–tissue interface. The advent of fully implantable multi electrode arrays has created the need for fully integrated micro power amplifiers. To designed and tested a novel bio amplifier that uses a MOS-bipolar pseudo resistor element to amplify low-frequency signals down to the milli hertz range while rejecting large dc offsets.

The theoretical noise power trade off limit the noise efficiency factor for this amplifier and demonstrate that our VLSI implementation approaches this limit by selectively operating MOS transistors in either weak or strong inversion. The resulting amplifier, built in a standard 1.5m CMOS process, passes signals from 0.025 Hz to 7.2 kHz with an input-referred noise of 2.2 Vrms and a power dissipation of 80 W while consuming 0.16 mm of chip area. In design technique was also used to develop an electro encephalogram amplifier having a bandwidth of 30 Hz and a power dissipation of 0.9 W while maintaining a similar noise power trade off.

## II. NOISE IN ECG SIGNAL

Generally the recorded ECG signal is often contaminated by different types of noises and artifacts that can be within the frequency band of ECG signal, which may change the characteristics of ECG signal. Hence it is difficult to extract useful information of the signal. The corruption of ECG signal is due to following major noises. Electrocardiogram traces used for identification are obtained using surface electromyography (EMG), where electrodes are placed on the skin in the vicinity of the heart. Potential differences of 1 to 3 mV generated at the body surface by the current sources in the heart are picked up by the electrodes and are amplified in order to improve the signal to noise ratio (SNR). The ECG waveform is observed on an oscilloscope digitized for further processing by a computer (as will be the case for recognition purposes). The digitization process should use a sampling rate of at least 1 kHz to ensure that the ECG trace is of a high enough resolution as required for biometric purposes.

ECG measurements may be corrupted by many sorts of noise. The ones of primary interest are:

1. Power line interference
2. Electrode contact noise
3. Motion artifacts
4. EMG noise

An idealized block diagram of each of these noise sources is shown in Fig. 3.1. The various noise signals presented in the figure will be characterized in greater detail in this section.

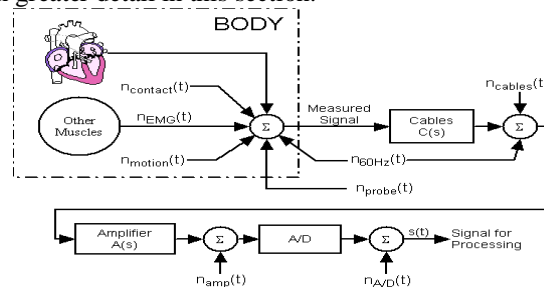


Fig. 3.1 Block diagram showing the principal noise sources in electro cardiology

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Power line interferences contains 60 Hz pickup (in U.S.) or 50 Hz pickup (in India) because of improper grounding. It is indicated as an impulse or spike at 60 Hz or 50 Hz harmonics, and will appear as additional spikes at integral multiples of the fundamental frequency. Its frequency content is 60 Hz or 50 Hz and its harmonics, amplitude is up to 50 percent of peak-to-peak ECG signal amplitude. A 60 Hz notch filter can be used remove the powerline interferences.

Power line interference occurs through two mechanisms: capacitive and inductive coupling. Capacitive coupling refers to the transfer of energy between two circuits by means of a coupling capacitance present between the two circuits. The value of the coupling capacitance decreases with increasing separation of the circuits. Inductive coupling on the other hand is caused by mutual inductance between two conductors. When current flows through wires it produces a magnetic flux, which can induce a current in adjacent circuits. The geometry of the conductors as well as the separation between them determines the value of the mutual inductance, and hence the degree of the inductive coupling. Typically, capacitive coupling is responsible for high frequency noise while inductive coupling introduces low frequency noise. For this reason inductive coupling is the dominant mechanism of power line interference in electro cardiology. Ensuring the electrodes are applied properly, that there are no loose wires, and that all components have adequate shielding should help limit the amount of power line interference.

The average peak value,  $A$ , of the noise depends on the amount of coupling between the ECG equipment and the power lines, and will vary between measurements. During measurement the peak-to-peak value is also liable to fluctuate due to changing environmental conditions, which influence the amount of inductive or capacitive coupling of power lines to the ECG equipment. The phase of the sinusoidal is a random variable with a uniform distribution in the range  $[-\pi, \pi]$ . This simplistic model assumes that the noise will occur only at 60 Hz, but in reality the power line noise will have a finite bandwidth around its nominal centre frequency, suggesting that the total noise is composed of many sinusoids of similar frequency.

Electrode contact noise is caused by variations in the position of the heart with respect to the electrodes and changes in the propagation medium between the heart and the electrodes. This causes sudden changes in the amplitude of the ECG signal, as well as low frequency baseline shifts. In addition, poor conductivity between the electrodes and the skin both reduces the amplitude of the ECG signal and increases the probability of disturbances (by reducing SNR). The underlying mechanism resulting in these baseline disturbances is electrode-skin impedance variation. The larger the electrode-skin impedance, the smaller the relative impedance change needed to cause a major shift in the baseline of the ECG signal. If the skin impedance is extraordinarily high, it may be impossible to detect the signal features reliably in the presence of body movement. Sudden changes in the skin-electrode impedance induce sharp baseline transients which decay exponentially to the baseline value. This transition may occur only once or rapidly several times in succession. Characteristics of this noise signal include the amplitude of the initial transition and the time constant of the decay. The contact noise is represented by  $n$  contact in Fig .3.1.

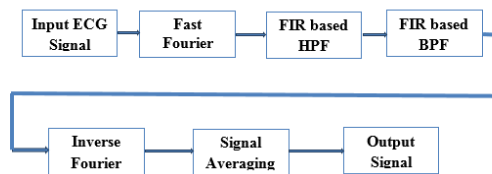
Motion artifacts are transient (but not step) baseline changes caused by electrode motion. The usual causes of motion artifacts are vibrations, movement, or respiration of the subject. The peak amplitude and duration of the artifact are random variables which depend on the variety of unknowns such as the electrode properties, electrolyte properties (if one is used between the electrode and skin), skin impedance, and the movement of the patient. At 70 second segment of a high resolution ECG trace, where the baseline drift varies from approximately 400mV to 400mV. In this ECG signal, the baseline drift occurs at an unusually low frequency (approximately 0.014Hz), and most likely results from very slow changes in the skin-electrode impedance. This noise can also be observed on the Fourier power spectrum the large peak nearest to DC is the result of very low frequency base line shifts.

### III. QRS COMPLEX DETECTION

The detection of QRS complex is the first step towards automated computer based ECG signal analysis. To detect the QRS complex more accurately it is necessary to identify the exact R-peak location from the recorded data. Morphological differences in the ECG waveform increase the complexity of QRS detection, due to the high degree of heterogeneity in the QRS waveform and the difficulty in differentiating the QRS complex from tall peaked P or T waves. Several techniques are reported to improve the accuracy of QRS complex detection from ECG signal because the exact detection of QRS complex is difficult, as the ECG signal is added with different types of noise like electrode motion, power line interferences, baseline wander, muscles noise etc. As reported technique where, the detection of QRS complex was achieved by windowed filtering. In another method the QRS complex of ECG signal was found out using multi rate signal processing and filter banks. As reported in the QRS complex can be found after finding the R-

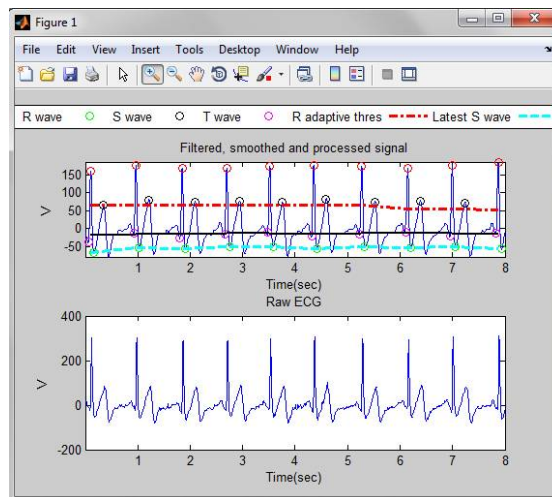
peak by differential operation in ECG signal. The first differentiation of ECG signal then find the location of R-peak in the ECG signal.

The main function of the stage is to increase the signal to noise ratio of ECG signal by emphasizing the QRS complex. A band pass FIR Butterworth filter of pass band frequencies of 5-15 Hz is used to remove the power-line interference and high frequency noises from the original signal. The approximate popular pass band to maximize the QRS energy is 5-15 Hz.



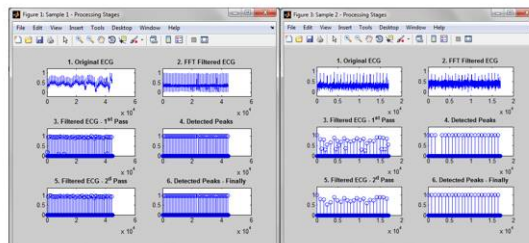
**Fig. 4.4 Noise removing ECG signal by using FIR filter**

#### IV. RESULTS



**Fig. 5.4 Output for QRS detection**

In the above Fig. 5.4 the raw ECG signal generated using QRS detection algorithm is filtered and smoothed for elimination of noise and then the processed signal is obtained.



**Fig. 5.5 ECG signal filtering for normal and abnormal**

The filtering of both normal and abnormal ECG signal is done by taking the FFT of the filtered ECG signal and the signal is filtered using two pass filters then R peaks are detected and shown in Fig. 5.5.



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## V. CONCLUSION

To remove the noise in ECG signals QRS complex detection, R peak detection using windowed filter. It is helpful to detect the heart beat rate in medical purpose. Some noises are occurred using windowed filtering. Here the power is 3.702. The aim is to reduce the noise in ECG signal and R peak detection, QRS complex detection by using FIR filtering. When comparing with the windowed filter QRS complex detection, R peak detection will be accurately and ECG signal noise will be reduced by using FIR filter technique. The simulation carried out in MODEL SIM. The power will be reduced less than 3.702.

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