

Design FIR Band Pass Filter With Centered At 50 Hz For Medical Application

Nabil Jalil Aklo

Thiqr University , Electrical Engineering Dept., Thiqr, Iraq
nabilj.aklo@gmail.com

Abstract:

Digital signal processing techniques used widely to cancel undesired parts of the signals, like that interference with other frequency range. Electromagnetic signals can be interference with human body signals such as Electrocardio signal Electroencephalogram and Electromyography. These interferences can be affect on the diagnosis signal during the examination and when these happen with different frequencies, such as (EMG) noise, devices that have high vibration which give fault data or effect the final result. Filtering of signals interference is very useful in the diagnosis of biomedical cases, as instant as the ECG signal that represent weak signal. This work treat problems of all kinds of interference with ECG signal and reduce it based on the development of digital Finite Impulse Response (FIR) filter for ECG signal which has the frequency between (5Hz to 100Hz) using fdtool by **MATLAB** instead of classical filters that often unaccurate. It is hard to get pure signal from human body without any interferences specially with that range of frequencies. In this paper the ECG signal has been presented from human body with its frequency spectrums before filtering then filtered from unwanted frequencies and show the elimination of the disturbance interference from this signal.

Keywords-component; formatting; digital filter ,frequency bandwidth, reduction

الخلاصة:

ان تقنيات معالجة الإشارات الرقمية المتنوعة تستخدم على نطاق واسع لإزالة الأجزاء غير المرغوب فيها عن الإشارة المطلوبة و التي تتأثر بالانواع المختلفة من الضوضاء الواقعة ضمن نطاق ترددي معين. ان الإشارات الكهرومغناطيسية يمكن أن تتداخل مع إشارات الجسم البشري مثل إشارة نبضات القلب و إشارة الرسم الكهربائي للدماغ و اشارات عضلة القلب وغيرها، هذه التداخلات يمكن أن تؤثر على إشارة التشخيص أثناء فحص المريض و كذلك عندما تكون المعدات والادوات المستخدمة للفحص ذات اهتزاز عالي التردد و بالتالي تتسبب بنتائج و قراءات غير دقيقة. و لهذا السبب تستخدم تقنية الترشيح اثناء الفحص في الحالات الطبية من اجل التخلص من التداخل الحاصل بين الإشارة المطلوبة و الإشارات الزائدة و الضارة المتولدة نتيجة الاسباب المذكورة و بالتالي الحصول على إشارة نقية يمكن التعامل معها بسهولة.في هذا البحث يتم التعامل مع المشاكل التي تحصل نتيجة التداخل بين إشارة تخطيط القلب (ECG) و الإشارات الأخرى حيث انه من الصعب الحصول على إشارة نقية من جسم الإنسان من دون أي تداخل و خصوصا مع إشارة القلب التي تعتبر إشارة قليلة التردد و ضعيفة و من السهولة ان يحصل تداخل بينها وبين الإشارات الأخرى ذات التردد العالي و التي تؤدي الى تشويهِ شكل الإشارة بنسبة معينة و التي تؤثر على نتيجة التشخيص لذلك تم اعتماد تطوير مرشح (FIR) رقمي ضمن نطاق ترددي (5Hz – 100Hz) باستخدام برنامج الماتلاب بدلا من استخدام المرشحات الاعتيادية التي عادة ما تكون غير دقيقة، و قد تم بهذا البحث استخدام إشارة قلبية من جسم انسان و عرضها قبل الترشيح و بعد الترشيح و مشاهدة الإشارة النقية التي ستظهر بعد الترشيح.

1. Introduction

The ECG instruments used to measure the effectiveness of the heart and provide the guide of circulation system flow to the muscle of heart [1]. The ECG signal represents the electrical activity signal generated by harmonious contractions of the heart, where the signal can be picked by An electrode lead or patch that placed across the chest wall [1]. The ECG signal effected by any external signal like any nearest vibrate equipments and others . For better and accurate reading of ECG signal , steps have been followed to filtrate or remove the noisy signals[4]. Reduce and remove the noise from ECG signal is one of the major problems that many studies work on to filtering it using various ways and techniques. One of these techniques is enahancement the signal through using the signal processing and then using digital signal processing which has many application in biomedical engineering such ultrasonic, MRI, seismology, communication, laboratory events and many others[5]. In EEG and ECG analysis, sometime these applications used to get information and parameters only to remove interference, like unwanted signal which companion with our original signal or to modify the signal. Nowadays biomedical signals processing have been towarded to analysis all the related objects through the feedback signal analysis. One of the most advantage of using the signal processing in biomedical applications is the noncontact diagnosis which is more effective technique for online monitoring, rehabilitation, and emergency aid for the target. Using different kinds of techniques are gaining acceptance by benefit and some of these roles design by engineering in diagnosis and treatment consider as the major strength in the applications of computer. In this step a band pass FIR filter which regard as one of the most reliable technique in DSP systems where make a specific frequencies to pass through and attenuates the remaining others. Using digital FIR filter with very small range of signal voltage about 0.5 and 5mV [5]. Frequency signal of human heart (ECG) over a range from 0.05 to 100Hz and the noise comes from different electrical activity of humanan body and other instruments which work in the same place . Figure (1) illustrates typical ECG signal.

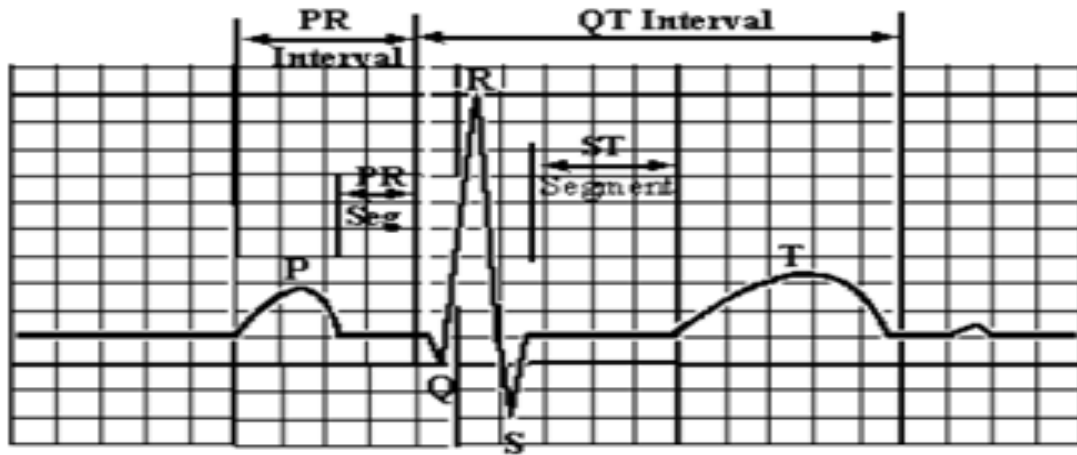


Figure (1) Typical ECG signal [2]

2. Interfering And Modifying Desired Signal

The measured signals represent the target signal that the device is designed to remove the interfering inputs, we should isolation signal, otherwise the interfering input can even be the occur with same value input required . changing the values of inputs can affect processing of either required or unwanted signals[2]. In Figure (2) where the all input is the electrocardiographic show among more than the signals [4].. There are two options when the plane of cable and the magnetic field parallel, interference is zero. If not the magnetically the interference is maximal [2].

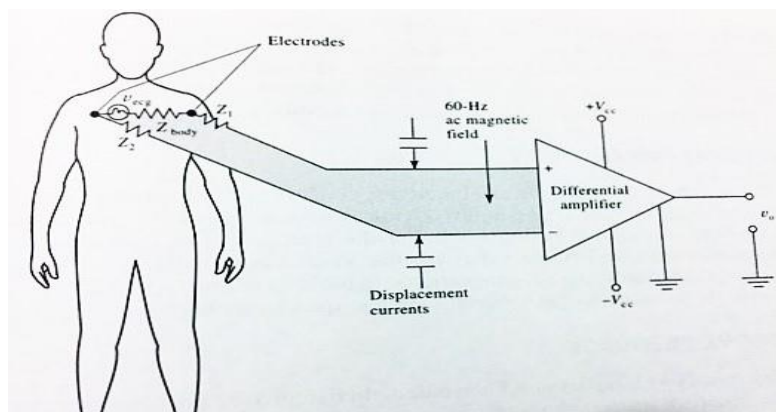


Figure (2) Simplified electrocardiographic recording[2].

2.1 Substitute Techniques

The interfering inputs that generated by noise can be vanished by change or modify the structure of the device, it is possible also enhance the instrument by adding new components designed to substitute the undesired inputs[5]. After this procedure compensation technique had been discussed to remove the effects of interfering and modifying inputs[2].

2.2 Sensitivity

Instrument parts are sensitive to external effects such as sounds, electromagnetic waves, noisy signals, etc, where these undesired signals interfere with actual signal and deform it[3]. The electrode wires can effect to reduce the number of magnetic flux lines that cut the shaded loop and this lead to increase the efficiency of reached signal [1].

2.3. Signal Filtering

Filter can be used to allow signals pass depend on their frequencies, all filters work to attenuating the part of the signal that is not required[2]. Definition of a filter is a circuit or programming code that split up data represent values of waveforms or signals in accordance with specified criteria. The Engineer designer prefer mechanical input instead of the electronic input circuit or electromagnets principles to prevent all the other interfering as envermental inputs[2]. Shock-mounted to reduce the instrument components vibration that affect on the sensitivity. There are a lot of filtering process to assist the filtering process in frequency such as mixer and modulators [4]. Computers are used range of input frequencies to filterate more signals depending on the matching rule to achieve high level of recognize between wanted and unwanted signal [7].

3. Design And Implementation Of Finite Impulse Response Filter (FIR)

When input signal in any system is impulse $\delta(t)$ (1,0,0,0,.....) the system response called impulse response $h(n)$ [4]. If the tap is denoted b_n then $h(n)$ is shown by eq.1:

$$h(n) \triangleq \begin{cases} 0 & n < 0 \\ b_n & 0 \leq n \leq M \\ 0 & n > M \end{cases} \dots\dots\dots(1)$$

Generally, impulse response construct by taps coefficients.digrammed are show the differences between the FIE equation and second couple [7]. Table 1 listed some applications that FIR regard an essential part in its components.

Table (1) List some applications of FIR filter

1. Noise Suppression.	(a) Imaging Devices (medical, etc) (b) Biological signals (heart, brain,etc) (c) taps
2. improvement of wanted frequency ranges.	a) system of audio (b) Edge improvement In medical images.
3. Disappear of required frequency	a) choose only The DC Signal required (b) eliminate Interferences

4.Design of a digital band pass FIR filter

Design digital band pass filter (FIR) require specific detail depending on the function of filter and source of signal so that make the designer to a various terminology and practical condions associated with it [8]. Figure(3) illustrate a direct-form implementation FIR filter can be called a transversal filter[5]. Filters are used for selecting desired frequencies and there are two kinds of filters: finite impulse response (FIR) and infinite impulse response (IIR).

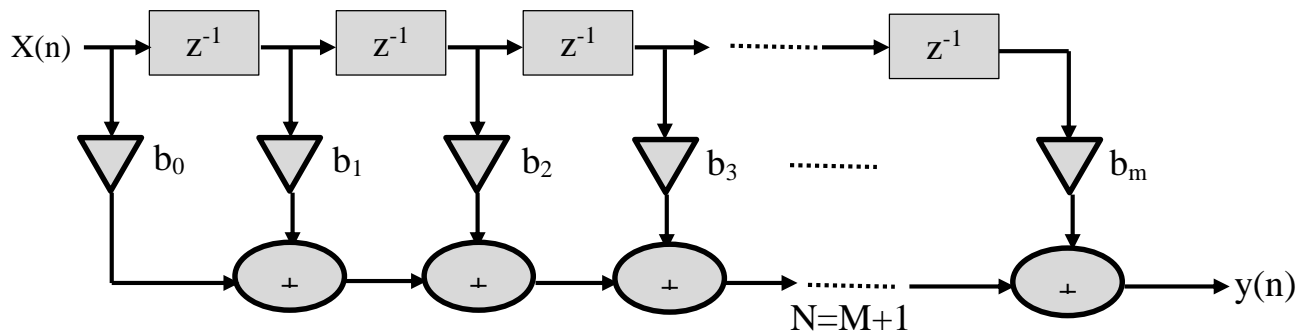


Figure (3) FIR digital filter.

IIR filter contain feedback loop from the output to help for comparing and effect on the system make it not stable. Also non-linear response compare to FIR filters[11]. The differential equation that represent the output of IIR filter in terms of its input is:

$$y[n] = 1/a_0*(b_0*x[n] + b_1*x[n-1] + \dots + b_N* x[n-N]-a_1*y[n-1]-a_2*y[n-2]- \dots *y[n-Q]) \dots(2)$$

where:

x[n] is the source signal (input), **y[n]** is the desired signal (output), **b_i** is the feed forward coefficients of filter.

a_i is the feedback coefficients of filter, Q is the feedback order of filter, N is the feed forward order of filter.

This equation can also be expressed as :

$$y[n] = 1/a_0 \sum_{i=0}^N b_i * x[n - i] - \sum_{j=0}^Q a_j * y[n - j] \dots\dots\dots (3)$$

5. Design Band Pass Filter (FIR) by fdtool using MATLAB.

A band pass FIR filter allows frequencies in a specified range to pass through and attenuates the remaining frequencies. In this step the frequency centered in the range 2500Hz to pass through and attenuates the rest. Thus, a peak is expected as the FFT magnitude response of the output at the frequency 2500Hz.

Code with Explanation :The code had been desiged using fdtool using MATLAB. It only requires to include the “bp2500.cof” to the program instead.Explanation for the code: The code above designs an FIR band pass filter with a center frequency of 2500 Hz. The buffer is used at the input and at the output to observe filters’ behavior using CCStudio. The coefficient header file includes the required filter coefficients that were calculated by the FDTool of MATLAB. The coefficient included “bp3000.cof “specifies the filter’s characteristics. The coefficient file contains 201 coefficients (order of filter=200) which designed and generated using the GUI in MATLAB[14]. The input sine wave is supplied in real time using a sine wave generator. FIR filter has a center frequency of 2500Hz. Figure (4) illustrates band-pass filter specifications with a cut off frequencies fc1=2050Hz and fc2=2950Hz.

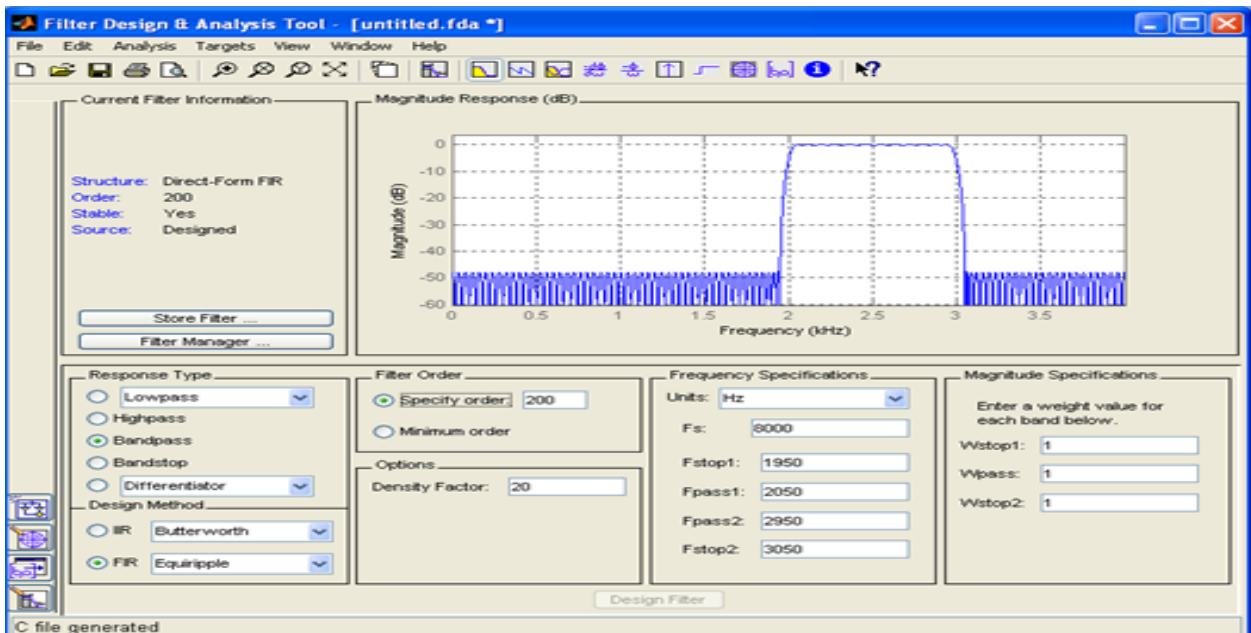


Figure (4) Band-pass filter specifications with a cut off frequencies fc1=2050Hz and fc2=2950Hz

6. Observations and Interpretations

Observe the signals lying in the range 2050-2950 Hz are passed and the peak is observed somewhere around 2125Hz. The frequencies beyond the band stop range are all curtailed as it can be observed from the signal. Figure (5) and Figure (6) shows some signals with different frequencies filtered by Band pass FIR filter.

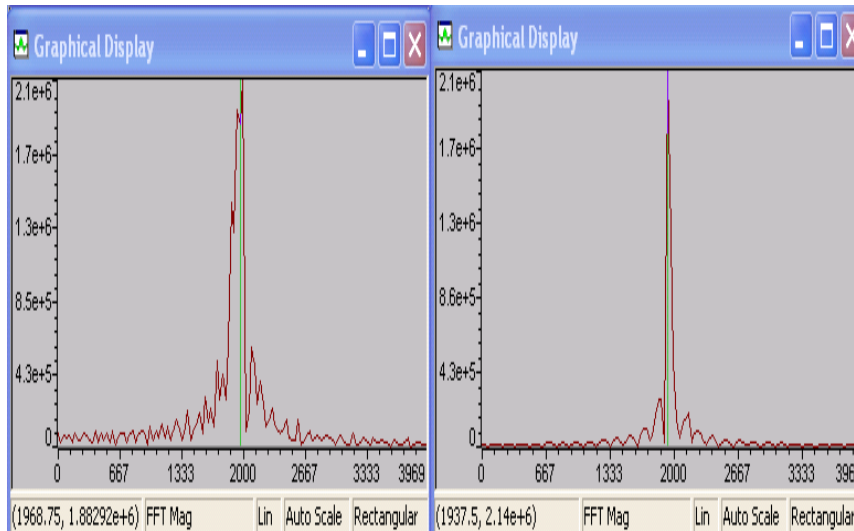


Figure (5) Frequency response of Band pass FIR filter centred at 2 kHz

- a. Input =2 kHz in Freq. domain,
- b. Filtered output in freq. domain

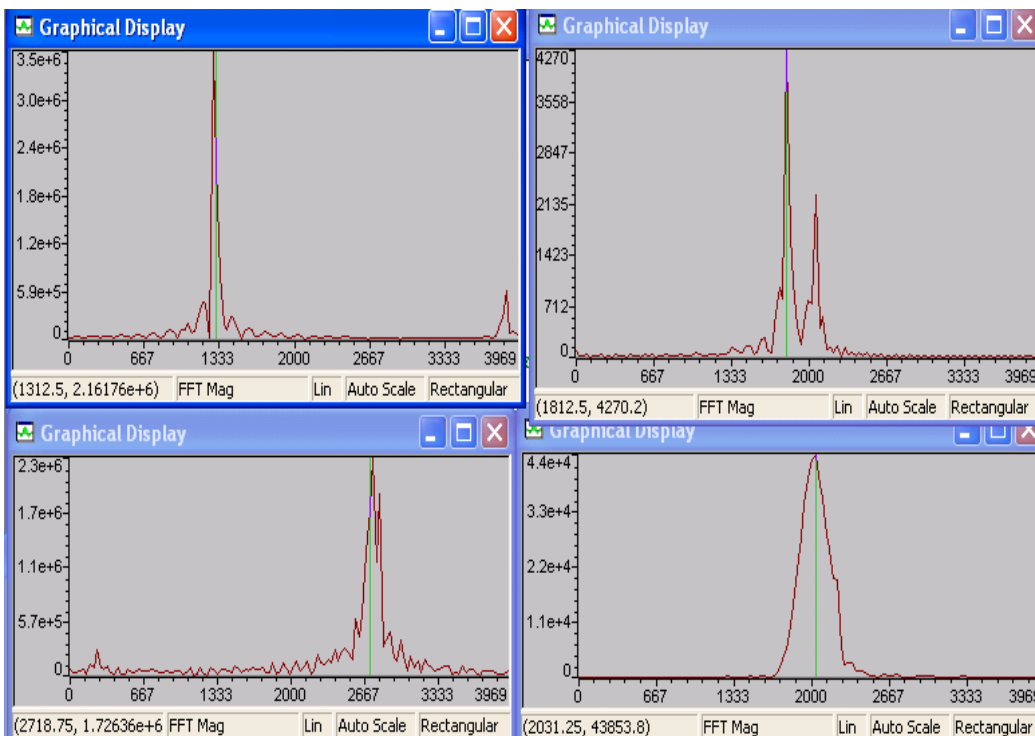


Figure (6) Frequency response of Band pass FIR filter centred at 2 kHz

- a. Input <2 kHz in Freq. domain, b. Filtered output in freq. domain
- c. Input >2 kHz in Freq. domain, d. Filtered output in freq. domain

7. Results

The figures clarify ECG motion after utilization of equiripple step channel. Comparing recurrence range of the before use of channel and after use of the channel are appeared in Figure (7) and Figure (8) respectively. From the recurrence range for the before filtration ECG it is seen that power comparing to the 50 Hz is - 26.29dB. At the point when the step channel is connected the power compares to the 50 Hz flag is diminished to - 35.75dB. It clears that channel diminishes the electrical cable impedance in the ECG flag. The impediment of this channel it is requires higher request so that computational intricacy is increasingly and extremely hard to understand the channel. Figure (9) demonstrates the ECG follow, after filtration clears that because of computational overhead the first ECG follow is moved towards to right. Figure (10) represent immaculate ECG motion after filtration.

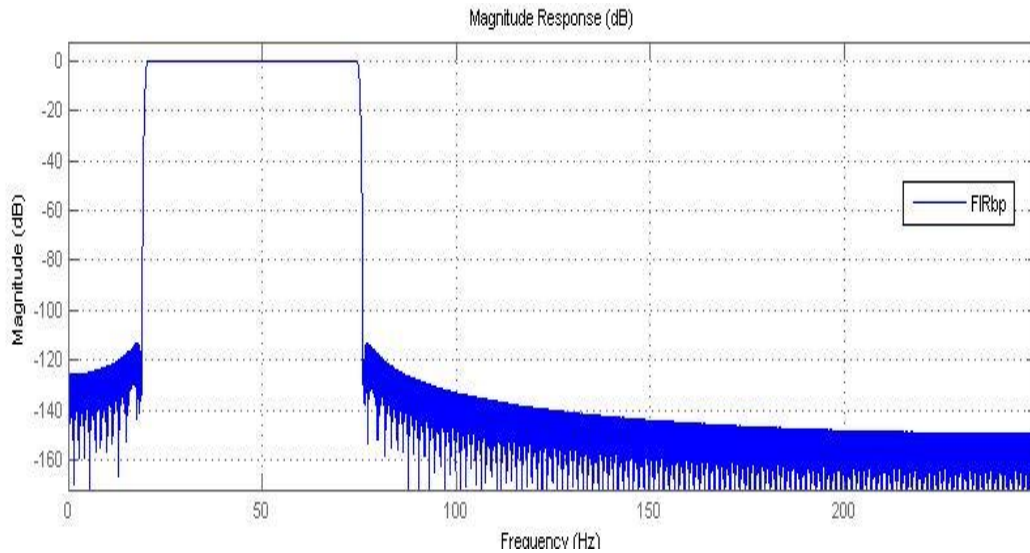


Figure (7) Relationship between magnitude response (db) and frequency

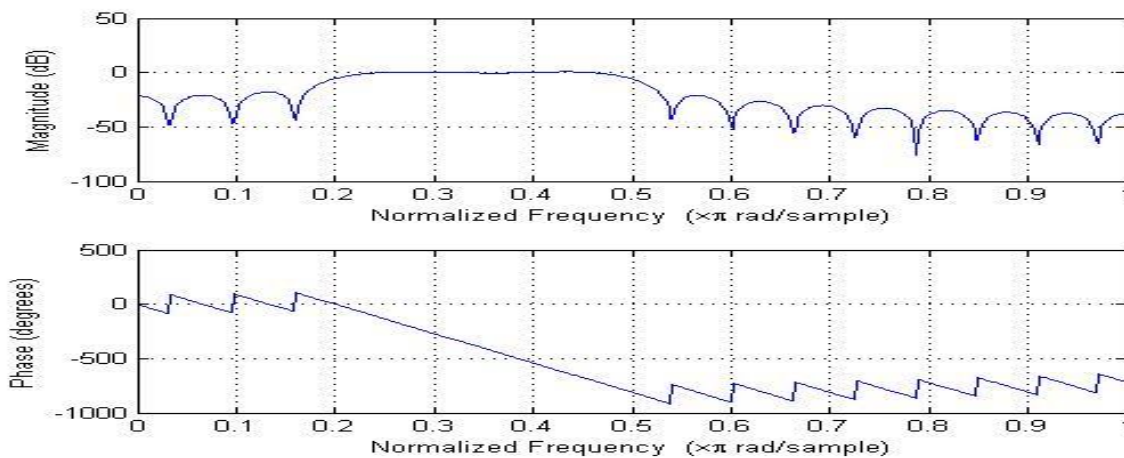


Figure (8) Normalization Frequency

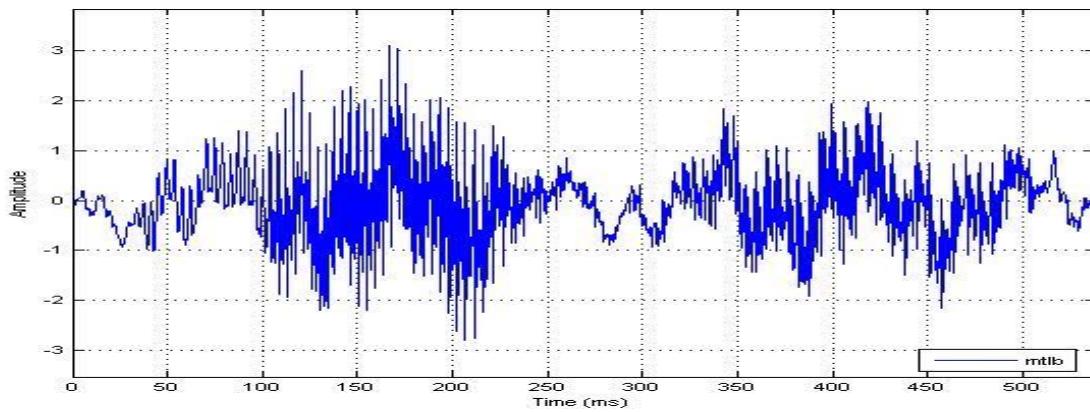


Figure (9) Noisy ECG signal

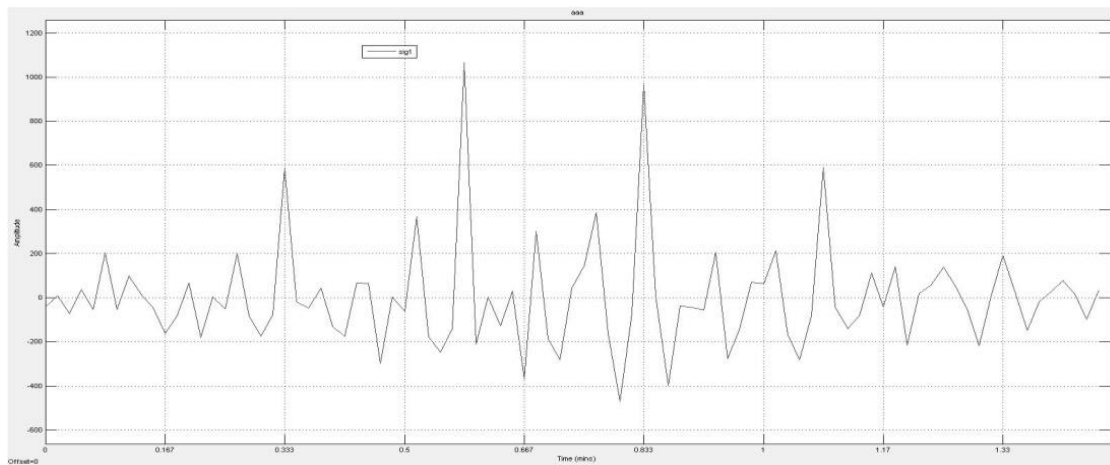


Figure (10) Pure ECG signal

Conclusions

Applying diverse method to eliminate the clamor (disturbance) at ECG Signal through utilizing FIR channel with programming application framework, fdtool by utilizing Matlab give a best outcomes help us to deal with the signals. Innovative advances in correspondence like band pass circuit configuration have permit the improvement of more safty ECG gadgets with an ability to great analytic instrument even though there is affectability issue of ECG signs. In this paper we have the unhandled signal from ECG by FIR channel, the normal power and flag to clamor proportion was completed to concentrate the impact of commotion on ECG flag. Outline of the channels utilizing fdtool is straightforward in correlation with different sorts of the techniques. It is found that in the plans of the channel there is swell present in the pass band of all channels they give stable reactions. By the envisioning recurrence range it is seen that there is elimination noise in the 50 Hz commotion exhibit in the ECG flag. Among the diverse window method, on the off chance that we contrasted with plan and actualize low pass, high pass and Notch channel the channels were outlined utilizing distinctive systems by utilizing channel arrange 100 and testing recurrence 1000Hz. The signal power was measured before utilization of the channel and after filtration of the flag. It is seen that on a normal flag control diminishes by 3 to 5dB after utilization of the channel. Finally the clamor decrease was more, where the noisy signal in the Figure (9) had been improved to become pure approximately as shown in the Figure (10).

References

- [1] Scokolow M., McIlroy M. B. and Cheithen, M.D, 1990, "Clinical Cardiology"; 5th edition, VALANGEMedical Book.
- [2] John G. Webster, 2009, "Medical Instrumentation Application and Design", fourth edition, Wiley.
- [3] Cramer E, McManus CD, Neubert D., 1987 Feb; 20(1):12-28, "Estimation and removal of power line interference in the electrocardiogram: A comparison of digital approaches", Comput Biomed Res.
- [4] Mitov IP., 2004 Dec, "A method for reduction of power line interference in the ECG", Med Eng Phys.; 26(10):879-87.
- [5] Dotsinsky I, Stoyanov T., 2005 Mar-Apr, "Power-line interference cancellation in ECG signals", Biomed Instrum Technol. 39(2):155-62.
- [6] Levkov C, Mihov G, Ivanov R, Daskalov I, Christov I, Dotsinsky I. 2005 Aug 23; 4:50, "Removal of power-line interference from the ECG: a review of the subtraction procedure", Biomed Eng Online..

- [7]Sornmo, L., Laguna, P., 2005, “Bioelectrical Signal Processing in Cardiac and Neurological Application”, Elsevier, Amsterdam.
- [8] Ferdjallah M, Barr RE., 1990, “Frequency domain digital filtering techniques for the removal of power line noise with application to the electrocardiogram”, *comput Biomed Res.*
- [9] Ying-Wen Bai, 2004, “The Combination of Kaiser Window and Moving Average for the Low-Pass Filtering of the Remote ECG Signal”, *IEEE.*
- [10] Choy TT, Leung PM., 1988 May;10(3):285-8, “Real time microprocessor-based 50 Hz notch filter for ECG”, *JBiomed Eng.*
- [11] Youcef Ferdi, 2010, “Improved Lowpass Differentiator for Physiological Signal Processing”, *CSNDSP.*
- [12]Kaiser W, Findeis M., 1999 , “Artifact processing during exercise testing”, *J Electrocardiol.*, 32 Suppl: 212-9.
- [13]Christov II, Daskalov IK., 1999 Dec , “Filtering of electromyogram artifacts from the electrocardiogram”, *Med Eng Phys.*, 21(10):731-6.
- [14] Von Wagner G, Kunzmann U, Schochlin J, Bolz A., “Simulation methods for the online extraction of ECG parameters under Matlab/Simulink”, *Biomed Tech (Berl).* 2002; 47 Suppl 1 Pt 2:534-7.
- [15] Mahesh S. Chavan, RA. Agrawal, M.D. Uplane, 2008, “Suppresion of Baseline Wander and power line interfecing in ECG using Digital IIR Filter”, *ISPRA.*
- [16] ChristovII, Daskalov IK., 1999 Dec, “Filtering of electromyogramartifacts from the electrocardiogram”, *Med Eng Phys.*, 21(10):731-6.
- [17] SheffieldLT., 1987 Aug , “Computer-aided electrocardiography”, *J Am Coll Cardiol.*, 10(2):448-55