Digital filter design for powerline noise cancellation of wireless ECG monitoring system

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***Abstract*—Coronavirus disease (COVID-19) is an infectious disease which has affected over 516 million people in around world. Older adults are also at significantly greater risk of complications from COVID-19 and case fatality rates increase significantly with age due to reduced immunity and the increased likelihood of pre-existing chronic diseases. The objective of this paper is to design digital filter for wireless ECG health monitoring system and this paper mainly focus to remove the power line interference noise. Present paper deals with design and implementation of digital FIR equiripple band stop filter. The basic ECG signal has the frequency range from 5Hz to 100Hz. Artifacts plays the vital role in the processing of the ECG signal. It becomes difficult for the Specialist to diagnose the diseases if the artifacts are present in the ECG signal. The need for an ECG monitors digital filter in this situation to cater to the health issues is necessary.**

***Index Terms*—Electrocardiogram, Band stop filter, Covid-19, MATLAB**

I. Introduction

THE electrocardiogram (ECG) is one of the important tools to monitor cardiac activity in COVID-19 patients. A typical ECG tracing of a normal heartbeat (or cardiac cycle) consists of a P wave, a QRS complex and a T wave. A small U

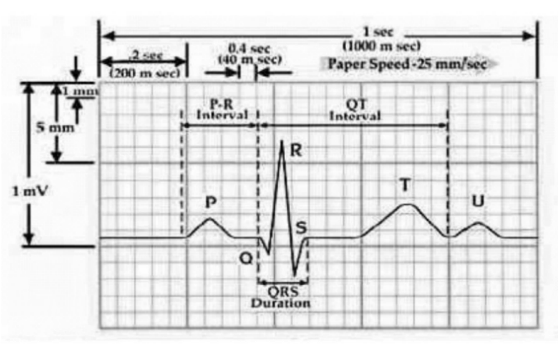

Fig. 1: Typical ECG trace

wave is normally visible in 50 to 75% of ECGs. The baseline voltage of the electrocardiogram is known as the isoelectric line. Typically, the isoelectric line is measured as the portion of the tracing following the T wave and preceding the next P wave. From the heart the SA node spontaneously depolarizes to initiate an action impulse that is rapidly propagated through the atria (causing atrial contract), then slowly through the AV node and rapidly via the bundle branches and Purkinje system to the ventricles, causing ventricular contraction. The electrical activity of the heart can be recorded at the surface of the body using an electrocardiogram. Therefore, the electrocardiogram (ECG) is simply a voltmeter that uses up to 12 different leads (electrodes) placed on designated areas of the body. Fig.1 shows the typical ECG trace [1].

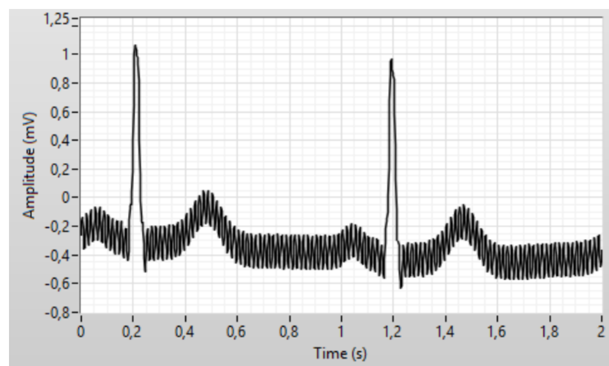

Fig. 2: ECG signal with 50Hz power noise

ECG signal is normally corrupted by noises. There are many noise sources on ECG signal measurement such as powerline interference, electrode contact noise, motion artifacts muscle contraction, base line drift, instrumentation noise generated by electronic devices, and electrosurgical noise [2]. Noise is classified based on their frequency content. The most significant noise of ECG signal is at 50 Hz / 60 Hz power line interference. This noise can make an ECG signal difficult to be analyzed by the specialist, and this is caused by a change in ECG signal shape as shown in Fig. 2. As shown in the Fig.

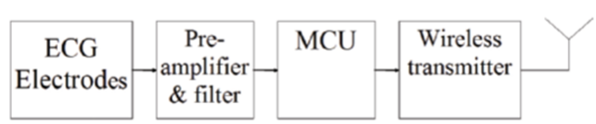

Fig. 3: Simple diagram of Wireless ECG monitoring system

3, The power line interference in the ECG signal should be attenuated before processing and transmitting. For that reason, a filter which is able to attenuate a single frequency component of inference is needed. This purpose can be fulfilled by Band stop Filter which can be applied using digital filter design. Digital Filter can be designed with precise value of cut - off frequency and higher order. This filter is not sensitive to temperature or other environmental conditions.

II. Filter design using MATLAB.

Power line interference is one of the reasons of corruption of the ECG signal. Mostly it causes the 50Hz interference and their higher order harmonics gets added to the ECG. This section deals with the design and implementation of the equiripple digital band filter to the ECG signal. The filter

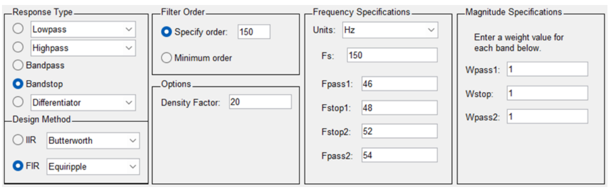

Fig. 4: Value set for FDA tool in MATLAB

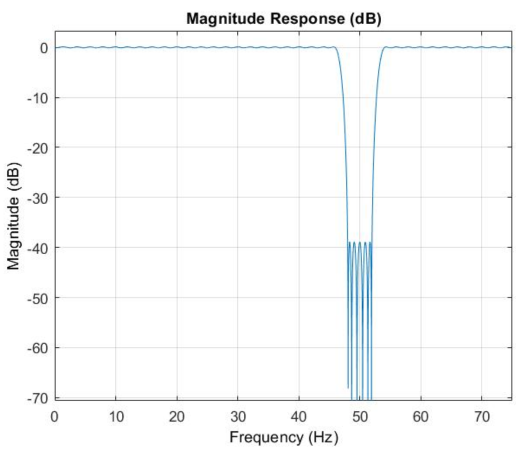

Fig. 5: Magnitude response of the filter

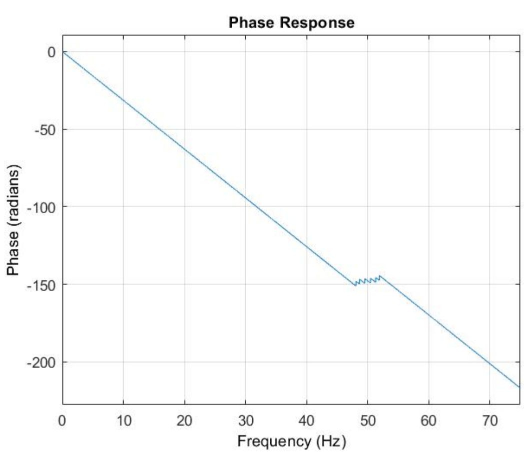

Fig. 6: Phase response of the filter

is designed using FDA tool in MATLAB. In this design the order of the filter selected is 150 and the sampling frequency of 150Hz and other filter requirements are set according to the values shown in Fig. 4. The magnitude response and the phase response of the band stop filter is also shown in Fig.5 and Fig.6. Following observations are shown from the design and responses:

- higher order filter is required to get the desired magnitude response
- linear phase response
- stable filter

III. Methodology

ECG signals from the MIT-BIH data base were used as test data for the filtering process which was sampled at 150 Hz. The power noise of 50Hz is added to conduct the experiment and the corrupted ECG signal is created.

IV. Results of implementation of Equiripple band stop filter

After Corrupted ECG signal is filtered, clean ECG signal is obtained. Corrupted ECG is shown in Fig. 7. After signal is filtered using equiripple band stop filter is shown in Fig. 8. There is a noisy wave occurred in the first filtered signal due Corresponding frequency spectrum of the corrupted ECG signal and the filtered ECG signal are shown in Fig. 9 and Fig. 10 respectively. Considering the frequency spectrum for corrupted ECG signal, the power corresponding to the 50 Hz power noise is -13.01dB. After Corrupted ECG signal is filtered, the power corresponds to the 50 Hz power noise is reduced to -50.22dB.

It clearly seen that filter attenuated the power line interference in the ECG signal by significantly large value. The limitation of this filter is it requires higher order so that computational complexity is more and very difficult to realize the filter [1].

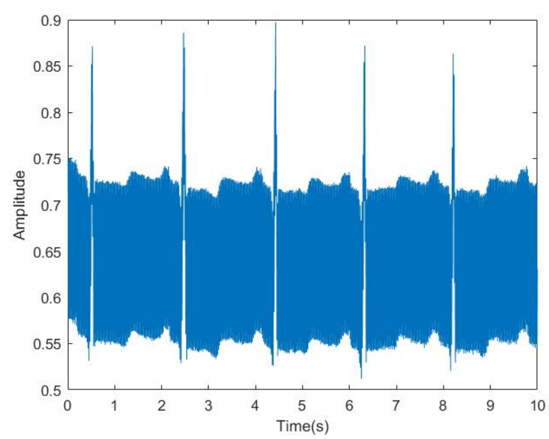

Fig. 7: Corrupted ECG signal

V. Conclusion

Results of this investigation have shown that band stop filter method can successfully remove power noise from the ECG signal. Increasing the order of the filter creates a longer delay and a greater calculation load which is not acceptable for real time signal processing applications.

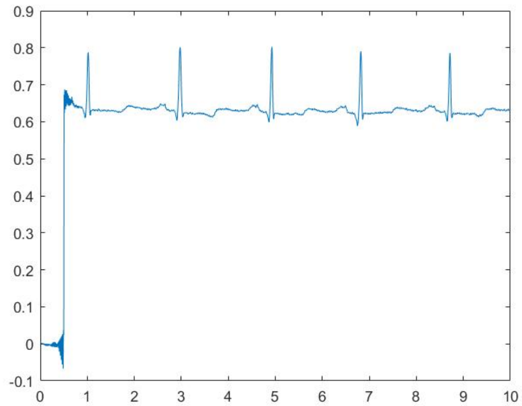

Fig. 8: Filtered ECG signal

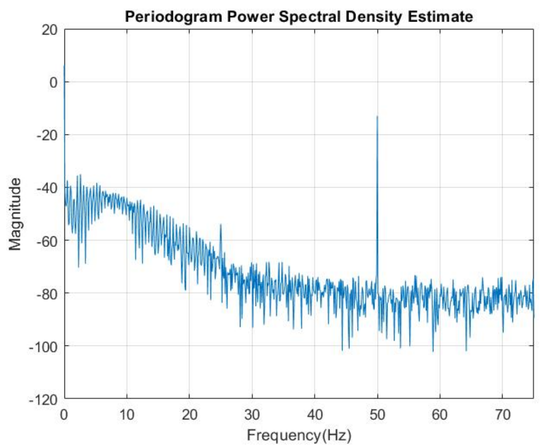

Fig. 9: Frequency spectrum of corrupted ECG signal

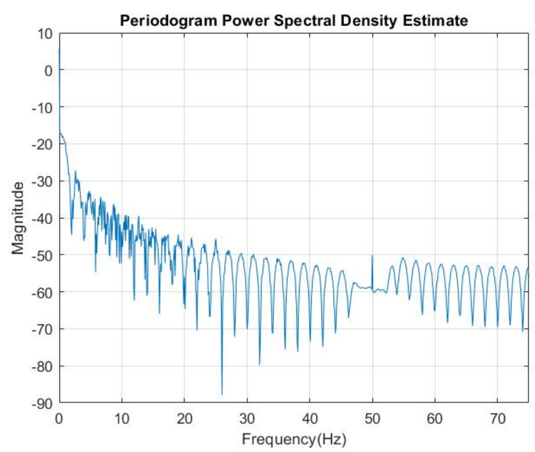

Fig. 10: Frequency spectrum of filtered ECG signal

References

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