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# Optimization And Reduction in Noise in Digital Filters Using Biomedical Application

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***Abstract*— The main emphasis is laid on bit-level optimization of digital filters architecture such that all the coefficients are representable using few bits with given constraints. The desired finite-precision (quantized) coefficients can be conveniently optimized within acceptable filter parameters specification such that the resulting filter meets the given criteria with the simplest coefficient representation forms. The optimized filter is used for filtering biomedical signals such as Electrocardiograms (ECG), Electroencephalogram (EEG). MATLAB package is used which is a powerful tool for the interactive design in most of the scientific applications and complex engineering calculations.**

***Keywords*— Optimization, Integer linear programming, Electrocardiogram, Simulation, Equiripple Filter.**

## I. INTRODUCTION

Optimization is the procedure or procedures used to make a system or design as effective or functional as possible, especially the mathematical techniques involved. Optimization is done by taking ECG signal as a biomedical application for which Integer linear programming technique is used. It is a mathematical method for determining a way to achieve the best outcome (such as maximum profit or lowest cost) in a given mathematical model for some list of requirements represented as linear relationships. Its feasible region is a convex polyhedron, which is a set defined as the intersection of finitely many half spaces, each of which is defined by a linear inequality. The focus is on the efficient pipelined reduction of the partial products, which is done using a bit-level optimization algorithm for the tree design. sThe method is not limited only to filter design, but may also be used in other applications where high-speed reduction of partial product is required. [1].An electrocardiogram (EKG or ECG) is a test that checks for problems with the electrical activity of your heart. An electrocardiogram (ECG) is a recording of the electrical activity on the body surface generated by the heart. ECG measurement information is collected by skin electrodes placed at designated locations on the body. The ECG signal is characterized by six peaks and valleys labeled with successive letters of the alphabet P, Q, R, S, T, and U (Figure 1).[2]

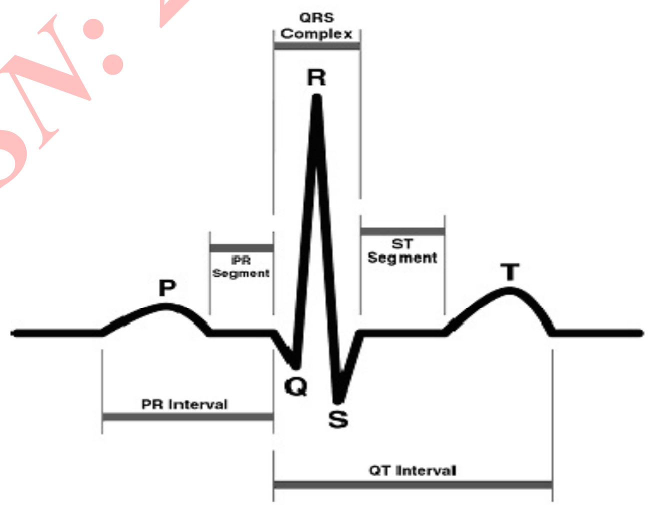


Fig 1:Ecg Signal

P wave: the sequential activation (depolarization) of the right and left atria.

QRS complex: right and left ventricular depolarization.

T wave: ventricular re-polarization.

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U wave: origin not clear, probably after "de-polarizations" in the ventricles

A. TYPES OF NOISES IN ECG SIGNAL

The major sources of noise are

1. Power line interference

2. Muscle contractions

3. Electrode contact noise

4. Motion Artifacts

5. Baseline wandering

6. Noise generated by electronic devices used in signal processing circuits

7. Electrical interference external to the subject and recording system

8. High-frequency noises in the ECG

9. Breath, lung, or bowel sounds contaminating the heart sounds (PCG).

There are various types of methods to extract the ECG parameters from the noisy ECG signal. First we need to analyze ECG signal to get which type of noise mesh up with the signal.[3]

B.DESIGN OF LOW PASS FIR FILTER FOR ECG

The higher the frequencies contained in the filtered signal, the more accurate will be the measurement of rapid upstroke velocity, peak amplitude, and waves of small duration. Inadequate high-frequency response reduces the amplitude of QRS measurements and the ability to detect small deflections. Because digital ECGs have a temporal resolution in milliseconds and an amplitude resolution in micro-volts, recommendations for the high-frequency response of ECGs have evolved over the years. To measure routine durations and amplitudes accurately in adults, adolescents, and children, an upper-frequency cut off of at least 150 Hz is required; an upper-frequency cut off of 250 Hz is more appropriate for infants. An obvious consequence of these high-frequency recommendations is that reduction of noise by setting the high frequency cut off of a standard or monitoring ECG to 40 Hz will invalidate any amplitude measurements used for diagnostic classification.

C INTEGER LINEAR PROGRAMMING

It is a mathematical method for determining a way to achieve the best outcome (such as maximum profit or lowest cost) in a given mathematical model for some list of requirements represented as linear relationships .Its feasible region is a convex polyhedron, which is a set defined as the intersection of finitely many half spaces, each of which is defined by a linear inequality.

## II. ECG FILTERING

The filtering techniques are primarily used for pre processing of the signal and have been implemented in a wide variety of systems for ECG analysis. Filtering of the ECG is contextual and should be performed only when the desired information remains ambiguous. Many researchers have worked towards reduction of noise in ECG signal.

Most types of interference that affect ECG signals may be removed by band pass filters; but the limitation with band pass filter is discouraging, as they do not give best result. At the same time, the filtering method depends on the type of noises in ECG signal. In some signals the noise level is very high and it is not possible to recognize it by single recording, it is important to gain a good understanding of the noise processes involved before one attempt to filter or pre process a signal. The ECG signal is very sensitive in nature, and even if small noise mixed with original signal the characteristics of the signal changes.[3]

## III. EQUIRIPPLE DESIGN METHOD:

FIR filter coefficients can be calculated using the window method. But the window method does not correspond to any known form of optimisation. In fact it can be shown that the window method is not optimal - by which we mean it does not produce the lowest possible number of filter coefficients that just meets the requirement. The art of FIR filter design by the window method lies in choosing the window function which meets your requirement with the minimum number of filter coefficients. Any filter FIR/IIR shows best result for large number representation and available large number representation is. Remez Exchange algorithm is something

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clever. It uses a mathematical optimisation method. The following explanation is not mathematically correct, but since we are trying to get an idea of what is going on, and not trying to duplicate the thinking of geniuses, it is worth going through anyway.

## IV.RESULTS

Following figure shows Bio-Medical signal "Noisy ECG" which is input to given filter and output is the filtered ECG signal without quantization and optimization and Filtered ECG signal with optimization

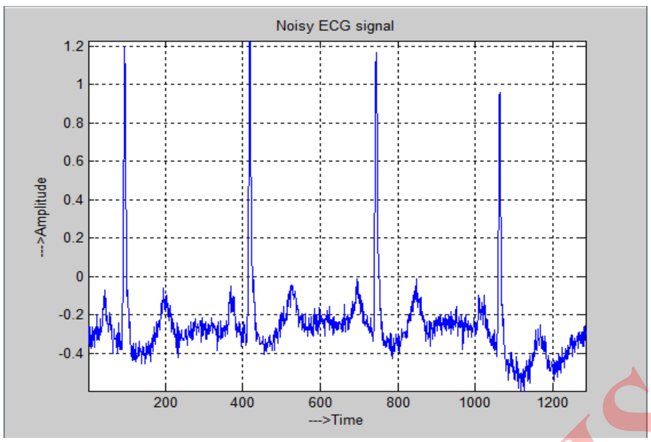


Fig. 2 Noisy ECG signal

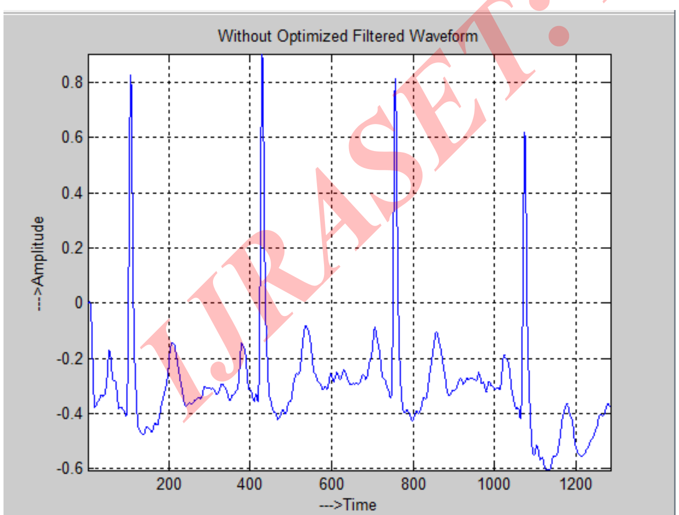


Fig. 3 Filtered ECG signal without quantization and optimization

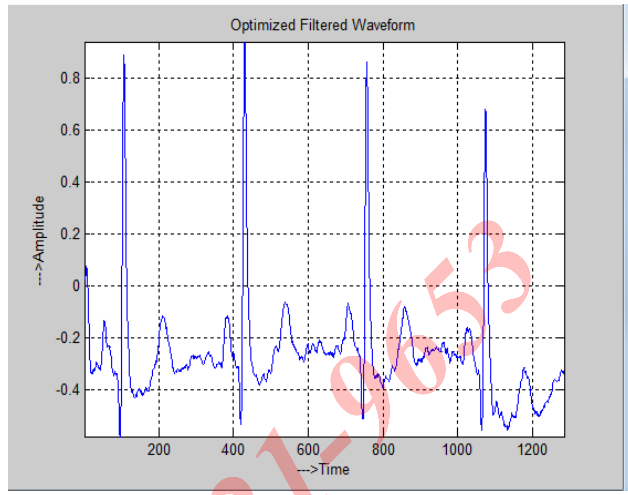


Fig. 4 Filtered ECG signal with optimization

## V.CONCLUSION

The FIR filters are widely used in most of digital signal processing applications. But in the realization of filters the speed, cost, and flexibility is affected because of complex computations. This is due to the fact that the hardware implementation of a lot of multipliers. Filters give best result for double precision floating arithmetic which cost more hardware resources if we plan for hardware implementation. The remedy to this problem is quantization, but the problem with this is filter response gets disturbed as well as filter specification gets violated. The solution for both problems that filter response should not get disturbed as well the filter specification and hardware requirements also get reduced is optimization only. With optimization one can get better result without violating filter specification as well minimum word length for filter coefficients representation. Initially for filter coefficients representation double precision floating arithmetic i.e. 64 bits are required. With respected to result analysis and system design minimum word length required to represent the filter coefficients is 6 bits maximum. From this one can conclude that with this hardware resources get reduced significantly for implementation.

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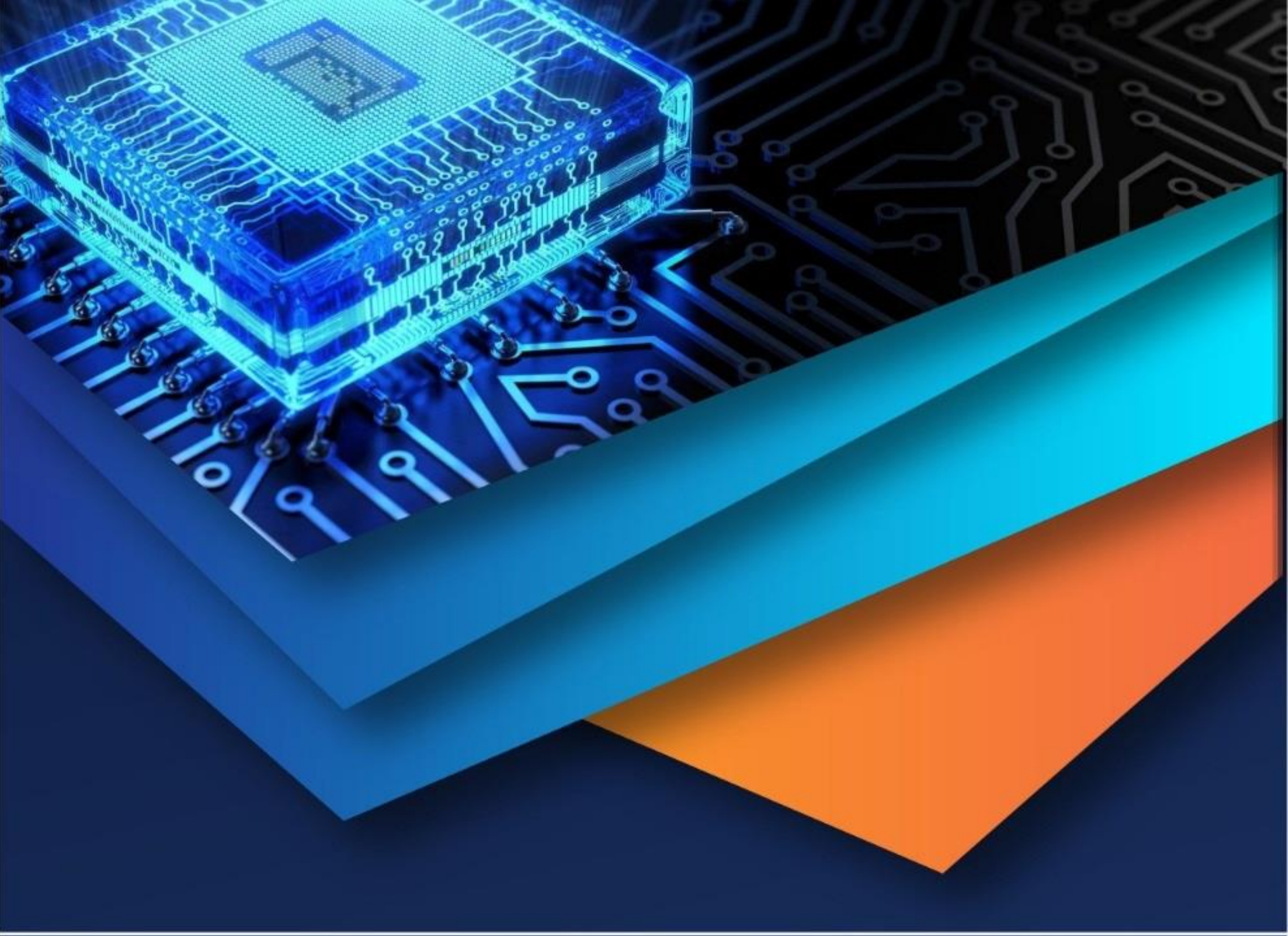


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