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A Digital Filter Chip for ECG Signal Processing

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SUB:-DIGITAL SIGNAL PROCESSING

CONTENTS

Highlighted Points

1. Study of ECG signal ,Electrocardiogram technique Visualisation

2. This work describes the implementation of wavelet-based denoising algorithm on. electrocardiogram (ECG) signal and detection of important parameter such as heart rate, amplitude, timings of the ECG, etc.

3. Analysis of removal of power line frequency and high frequency component removal.

4.Analysis of ECG component QRS peak detection, heart rate calculation, etc is performed using linear filter technique called first order derivative and moving average filter.

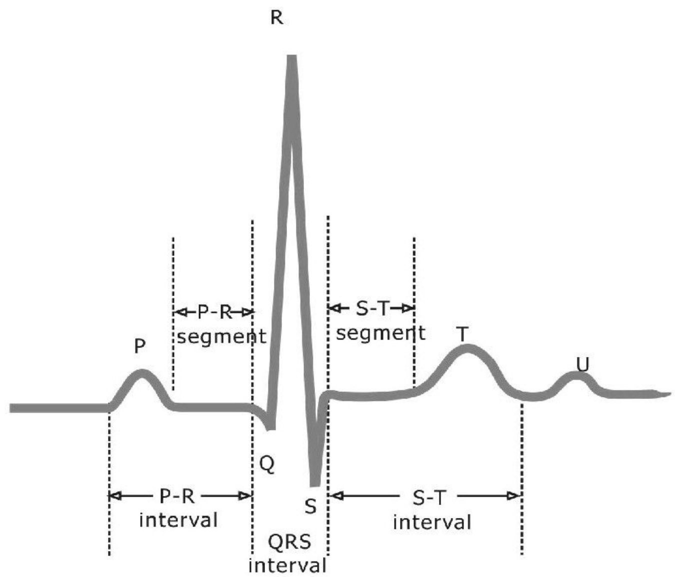
5.Filter architecture based on recursive summing block And use very low computational complexity.

INTRODUCTION

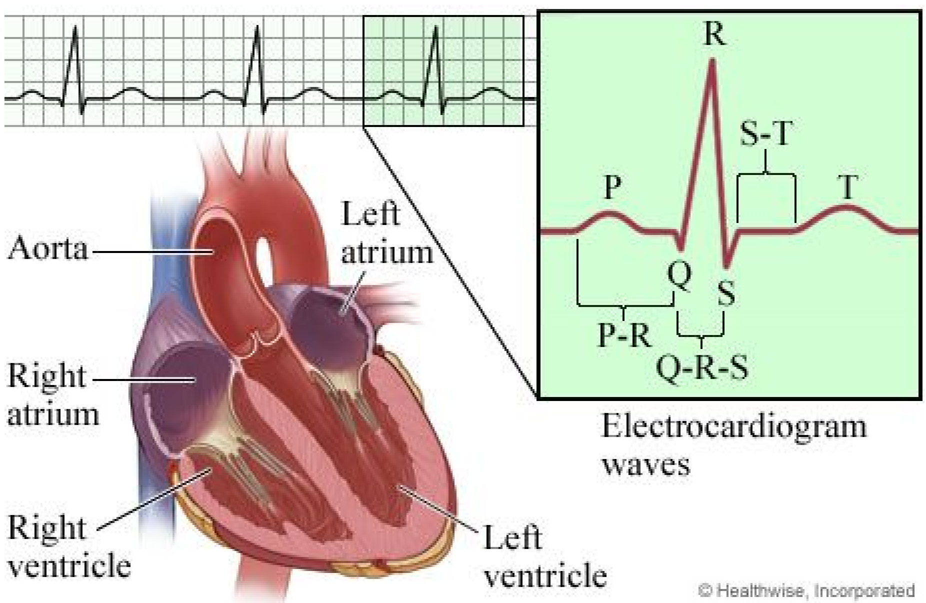
THE electrocardiogram (ECG) is an electrical signal caused by the functioning of the heart. The amplitude is typically a few millivolts. The ECG signal can be used to count the heart rate as well as for various diagnostic purposes in medicine. The time-domain characteristics and artificial generation of ECG signals are described, for instance Recent results of applying modem signal-processing methods to ECG signal analysis.

In signal processing of ECG primary signal contain relatively strong disturbances .The varying ECG contact potentials and breathing artefacts (below 0.5 Hz) cause unwanted baseline drift Especially in stress ECG recordings, this drift may sometimes make the recording impossible. Another problem is the mains frequency (50 Hz) noise which occurs within the clinically important frequency range. Up to now, the harmful baseline drift is usually removed from the measurements using analog high-pass filters. Because of their highly nonlinear phase response linear-phase finite impulse-response (FIR) filters, it is possible to increase the cutoff frequency up to the fundamental heart rate without causing any distortion to the ECG signal. The linear-phase performance of FIR filters enables us to make the stopband deeper and wider compared with nonlinear-phase filters

ECG Signalling



Electrocardiography is the process of producing an **electrocardiogram** (**ECG** or **EKG**), a recording - a graph of voltage versus time - of the electrical activity of the heart using electrodes placed on the skin.



The **P wave** is a record of the electrical activity through the upper heart chambers (atria)

- ➔ The **QRS complex** is a record of the movement of electrical impulses through the lower heart chambers (ventricles).
- ➔ The **ST segment** shows when the ventricle is contracting but no electricity is flowing through it. The ST segment usually appears as a straight, level line between the QRS complex and the T wave.
- ➔ The **T wave** shows when the lower heart chambers are resetting electrically and preparing for their next muscle contraction.

Detection of Diseases using ECG

PR Interval :-

In electrocardiography, the **PR interval** is the period, measured in milliseconds it is normally between 120 and 200 ms in duration.

Variations in the PR interval can be associated with certain medical conditions:

Duration:-

- ➔ A long PR interval (of over 200 ms) may indicate a first heart degree block.It can be associated Hypokalemia(Low level of potassium in the blood)
- ➔ A short PR interval (of less than 120ms) may be associated with an atrioventricular reentrant tachycardia(is a type of abnormal fast heart rhythm and is classified as a type of supraventricular tachycardia)
- ➔ A variable PR interval may indicate other types of heart block
- ➔ PR segment depression may indicate atrial injury

QT Interval:-

The **QT interval** is a measurement made on an electrocardiogram used to assess some of the electrical properties of the heart It is calculated as the time from the start of the **Q wave** to the end of the **T wave**, and approximates to the time taken from when the cardiac ventricles start to contract to when they finish relaxing.

the QT interval is dependent on the heart rate.

the faster the heart rate, the shorter the R–R interval and QT interval

Bazett's formula:-

$$QTcb = \frac{QT}{\sqrt{\frac{RR}{1s}}}$$

calculating the heart rate-corrected QT interval

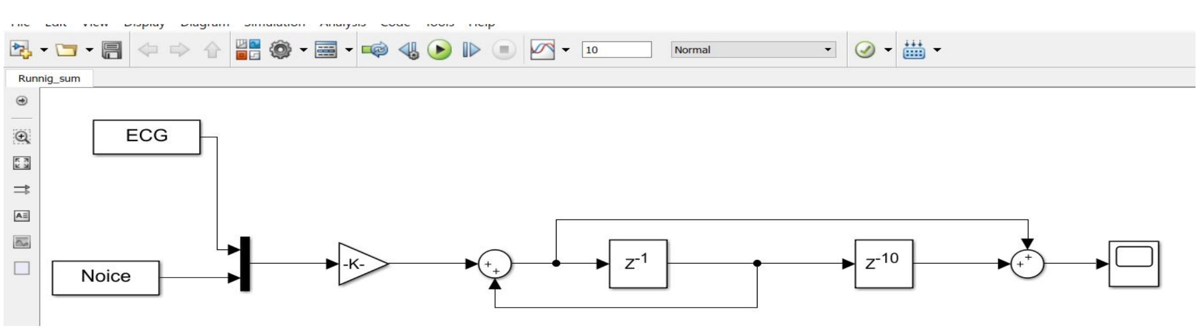
Causes :-

- This increases the risk of developing ventricular arrhythmias,
  including fatal ventricular fibrillation
- An abnormally prolonged QT interval could be due to long QT syndrome (**Long QT syndrome** (**LQTS**) is a condition which affects repolarisation of the heart after a heartbeat
- This results in an increased risk of an irregular heartbeat which can result in palpitation, fainting, drowing, or sudden death)

Filter Specification

Specification are as follows :-

- sampling rate of the ECG signal was specified in the application under consideration to be fs = 100 Hz
- Filter passband range is 0.5Hz to 0.45Hz
- the peak-to-peak passband ripple is 0.5dB,
- The minimum length of a conventional minimax FIR filter to meet these criteria is 281
- exploiting the coefficient symmetry, this design requires 71 general multipliers. This figure is high for practical
- VLSI implementations, where the implementation of a general multiplier is very space consuming
- Technique which is used as recursive summing block.



From the VLSI implementation point of view, the simplest FIR filter is the recursive running-sum (RRS) filter. The desired implementation form is obtained by expressing an averaging FIR filter transfer function of length K in the following recursive form:

$$G_K(z) = \frac{1}{K}\sum_{n=0}^{K-1} z^{-n} = \frac{1}{K}\frac{1-z^{-k}}{z-z^{-1}}$$

The frequency response of this filter is given by

$$G_K(\omega) = \frac{1}{K}\frac{sin(K\omega/2)}{sin(\omega/2)}$$

Step I: Cascade two RRS filters of length K yielding the following transfer function:

$$E_K(z) = |G_K(z)|^2 = [\frac{1}{K}\frac{1-z^{-k}}{1-z^{-1}}]^2$$

Step 2: Subtract EK(z) from $Z^{-(K-1)}$ yielding

$$F_K(e^{j\omega}) = e^{-j(K-1)}F_K(\omega)$$

Where $F_K(\omega) = 1 - E_K(\omega) = 1 - [\frac{1}{K}\frac{sin(K\omega/2)}{sin(\omega/2)}]$

Step 3: Replace z-l by z-2 in FK(z) giving

$$H_K(\omega) = F_K(z^2) = z^{-2(K-1)} - [\frac{1}{K}\frac{1-z^{-2k}}{1-z^{-2}}]^2$$

Overflows can be avoided in the overall filter by further rewriting BK(z) as

$$B_K(z) = [\frac{1}{64}\frac{1-z^{-k}}{1-z^{-2}}][\frac{1}{32}\frac{1-z^{-k}}{1-z^{-2}}][\frac{64*32}{(K/2)^2}]^2$$

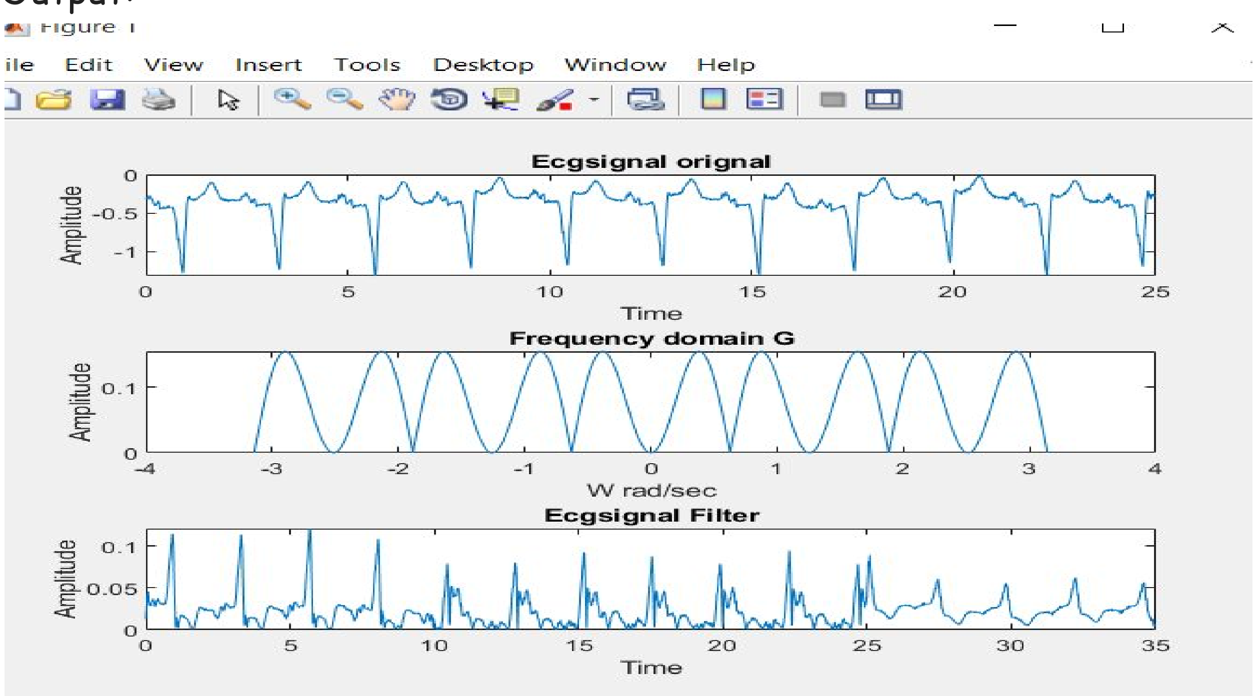
Code:-

```
clc;
close all;
w=-pi:2*pi/1000:pi;
K=5;
load('chf03m.mat')
Ecgsignal=(val-0)/200;
Fs=100;
tt=(0:length(Ecgsignal)-1)/Fs;
subplot(3,1,1);
plot(tt,Ecgsignal);

title('Ecgsignal orignal');
xlabel('Time');
ylabel('Amplitude');
G=exp(-1i*(K-1)*w/2).*(sin(K*w/2)./K.*sin(K*w));
subplot(3,1,2)
plot(w,abs(G));
title('Frequency domain G');
xlabel('W rad/sec');
ylabel('Amplitude');
b=ifft(G);
c=conv(b,Ecgsignal);
t=(0:length(Ecgsignal)-1+1000)/Fs;
subplot(3,1,3);
plot(t,abs(c));

title('Ecgsignal Filter');
xlabel('Time');
ylabel('Amplitude');
```

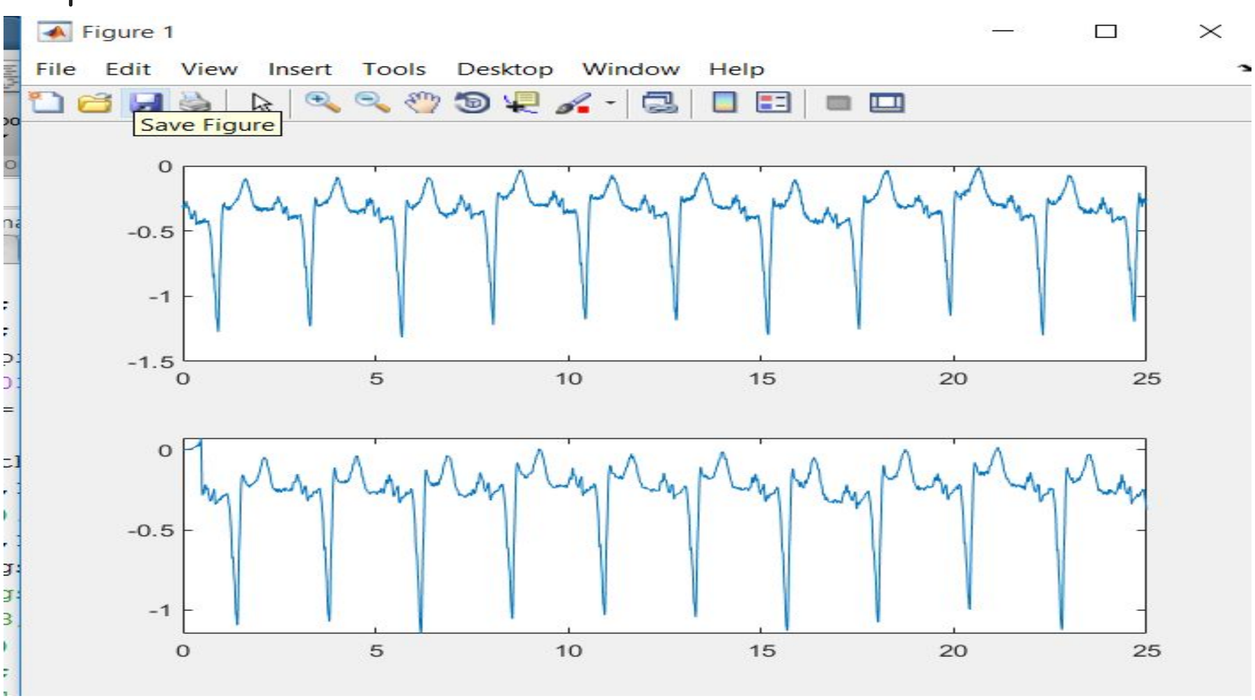
Output:-



Code2:-

```
clc;
clear all;
close all;
wc=-pi:2*pi/1000:pi;
load('chf03m.mat')
Ecgsignal=(val-0)/200;
Fs=100;
t=(0:length(Ecgsignal)-1)/Fs;
subplot(2,1,1);
%figure(1);
subplot(2,1,1);
plot(t,Ecgsignal);
%v=fft(Ecgsignal);
%subplot(3,1,2);
%plot(t,v)
%Boxcar=1;
%n=-5:0.01:5;
%hideal=sin(wc.*n)./(pi.*n);
%hnew=hideal.*Boxcar;
%k=cconv(Ecgsignal,hnew);
%m=(0:length(k)-1)/Fs;
%subplot(2,1,2)
%plot(m,k)
%figure(2);
b=fir1(99,[0.005 0.495]);
%freqz(b,1,'whole');
y=filter(b,1,Ecgsignal);
subplot(2,1,2)
plot(t,y)
```

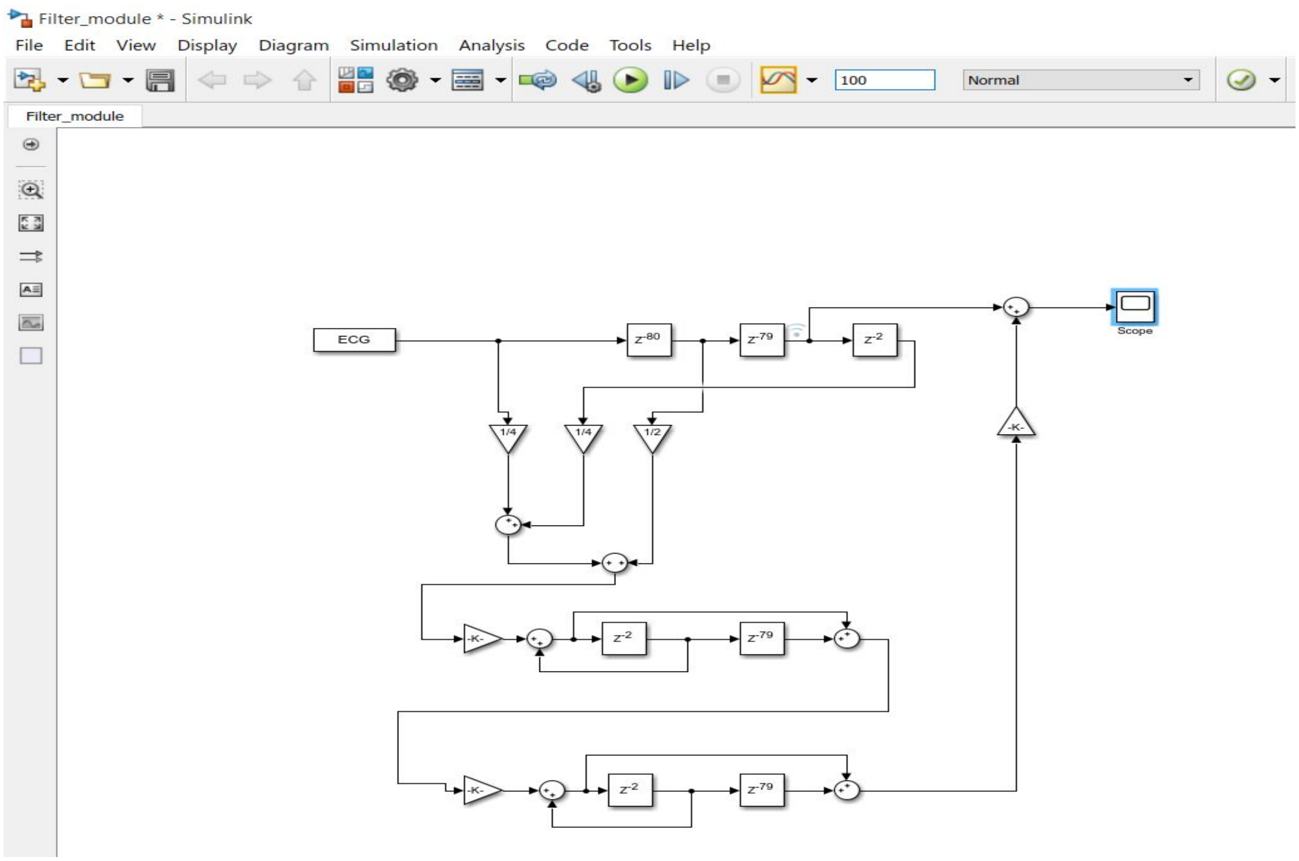
Output2:



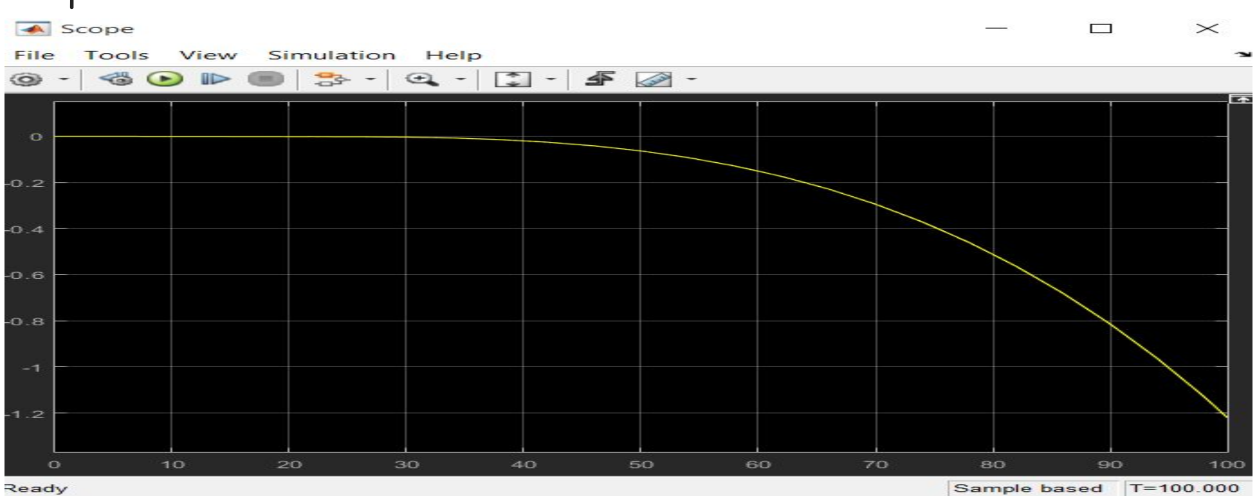
DESIGN AND VERIFICATION

Optimization of ECG Filtering in Matlab Simulink

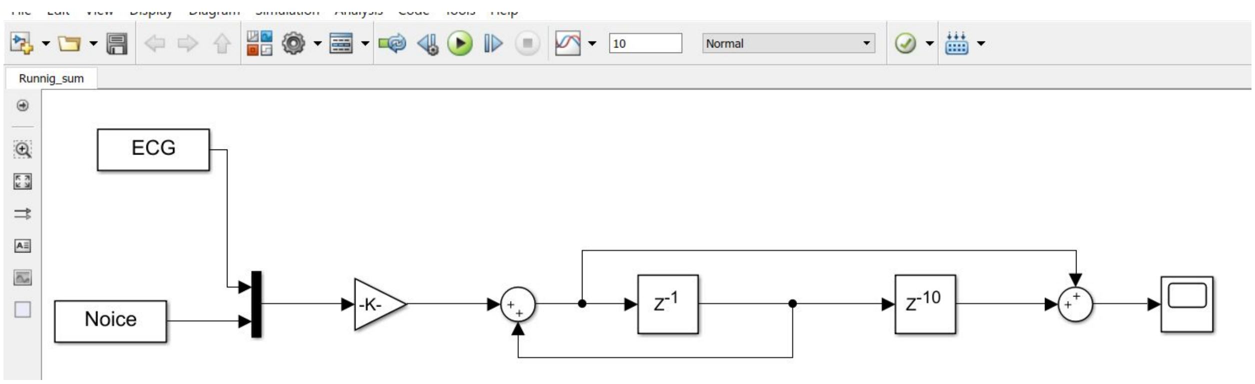
$$B_K(z) = [\frac{1}{64}\frac{1-z^{-k}}{1-z^{-2}}][\frac{1}{32}\frac{1-z^{-k}}{1-z^{-2}}][\frac{64*32}{(K/2)^2}]^2$$



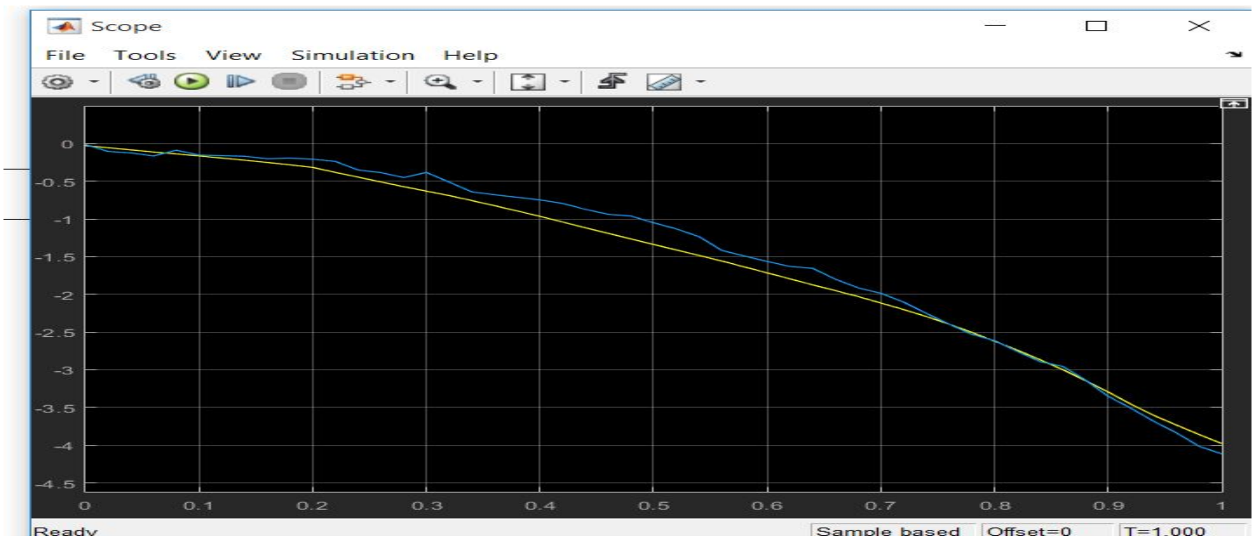
Output:-



Efficient implementation of the Recursive-Sum Filter



Output:-



CHIP DESIGN AND IMPLEMENTATION

1)The proposed filter is very attractive for VLSI implementation because it consists mainly of delays, adders, subtracters, and shift operations.

2) It needs no general multipliers. Two's complement arithmetic is used; the word length of data input and output is 12 bits. Eighteen-bit accuracy is used internally in the recursive running-sum sections in order to keep the noise level generated in these sections below the dynamic range of chip size, because more than half of the chip area is occupied by data storage registers, and their size is not affected by the arithmetic blocks.

3)The bit-parallel implementation of the filter needs no control logic besides the two-phase clock and is therefore faster to design than a bit-serial structure.

4)The hardware blocks of the ECG filter circuit are dynamic 55454D-latches, adders, subtracters, buffers and a clock generator. The implementation technology is 2.0-pm CMOS with two metal layers

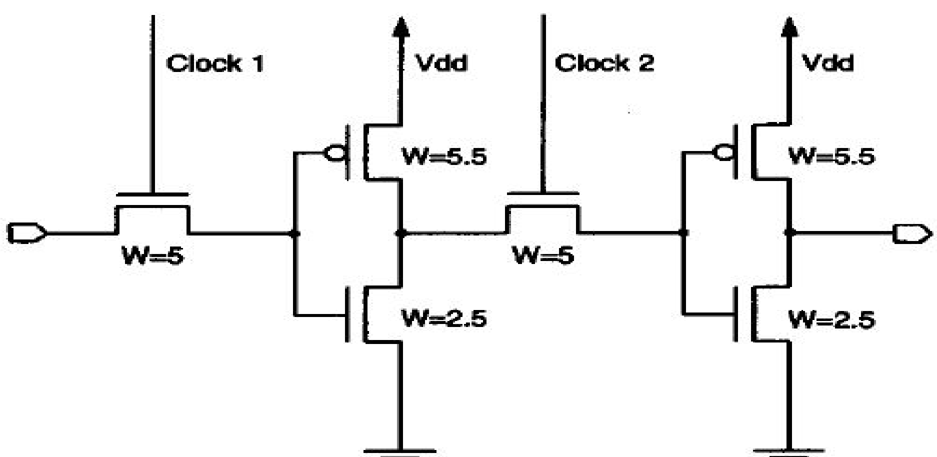


Fig. 6. Implementation of the dynamic two-phase clocked latch. All transistors have a length of 2.0 μm, and the widths are shown.

CONCLUSION AND DISCUSSION

A digital filter chip for ECG signal processing has been Design a small chip area is a result of using a computationally efficient architecture based on recursive running-sum structures. The proposed design concept is suitable to a module-generator-based VLSI design.

The filter was designed for the sampling rate of 100 Hz. If the sampling rate of 200 Hz is desired to be used, then the same design can be used by replacing each unit delay by two unit delays. This modification would increase the overall silicon area from 15.43 mm2 to approximately 21 mm2. Another alternative is to apply switching and two chips in such a way that every second sample is fed into one chip and the remaining samples into another chip. The desired overall output is then obtained by interlacing the outputs of the two chips

Besides ECG signal processing, the proposed digital filter design and construction approach could be applied also to other kinds of biomedical signal processing where bandpass filtering is needed, for instance, electromyogram (EMG) measurements.

REFERENCES

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2).Kohler, B.-U.; Hennig, C.; Orglmeister, R. The principles of software QRS detection. Engineering in Medicine and Biology Magazine IEEE, vol. 21, pp. 42 – 57, January -February 2002