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ANALYSIS OF ECG WITH DB10 WAVELET USING VERILOG HDL

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Abstract-The abnormal condition of electrical activity of the heart given by ECG (Electrocardiogram) shows the cardiac diseases affecting the human being. The P, QRS, T wave shape, amplitude and time intervals between its various peaks contains useful information about the nature of disease.
This paper presents wavelet technique to analyze ECG signal.

Discrete Wavelet Transform (DWT) is employed as noise removal and feature extraction tool to achieve efficient design. Daubechies wavelet of order 10 has been designed using Verilog Hardware Description Language (HDL) and ModelSim Altera 6.4a is used as simulator. MIT-BIH database has been used for the analysis.

Keywords- Discrete Wavelet Transform, ECG (Electrocardiography), FIR Digital filter, STFT (Short time Fourier transform), Wavelet

I. INTRODUCTION

The Dutch Physician Willem Einthoven, in 1903 marked the beginning of new era in medical diagnostic techniques for establishment of clinical ECG. [2]
It is the objective measurement for the activation, transportation and recovery of heart activities.

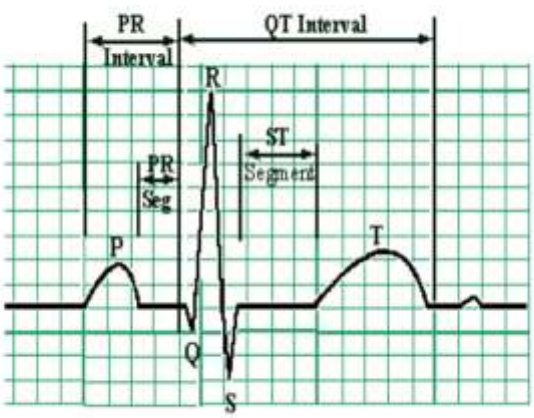


Figure 1: Electrocardiogram Signal

ECG gives two kinds of information:

1. The duration of electrical wave crossing the heart decides the electrical activity is normal, slow or irregular.
2. The amount of electrical activity passing enables to find whether parts of heart are too large or overworked. [3]

ECG signal is characterized by P wave, QRS complex, T wave. Each wave conveys useful information.
The information conveyed by different waves of ECG is shown in the form of table:

Table No.1: Information conveyed by P-QRS-T wave of ECG signal

ECG wave	INFORMATION
P wave	Atrial activation(contraction)
PQ interval	Signal travels from SA node to AV node
Q wave	Activation of Interventricular septum
R wave	Activation of major mass of ventricles
S wave	Last phase of activation of ventricles
ST interval	Represents activity of pumping of blood by ventricles
T wave	Ventricular relaxation

ECG signal is easily interfered by the different noises because it is very faint. Method to suppress noises effectively is always an important problem in the analysis of ECG signal. ECG varies in time, thus there is a need for an accurate description of the ECG frequency contents according to their location in time. This justifies the use of time frequency representation in quantitative electro cardiology. [4]

II. WAVELET TRANSFORM

The meaning of wavelet transform is that a series of translated and compressed wavelet function is used to describe sampling signal. A series of shifted and compressed wavelet basis functions are used for mapping sampling signal.

A set of analyzing wavelets allows the decomposition of ECG signal into a set of coefficients. Each analyzing wavelet has its own time duration, time location and frequency band. The wavelet coefficient resulting from the wavelet transformation corresponds to a measurement of the ECG components in this time segment and frequency band. [4],[7]

The required information characteristic of time is obtained through shifting the signal, and the frequency characteristic of the signal is available through scaled transform of Wavelet.

Wavelet Transform can be divided into two categories, as shown below:

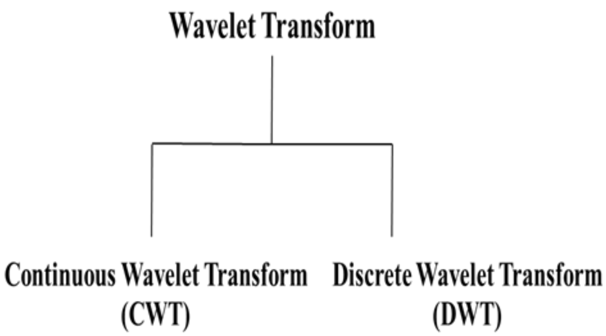
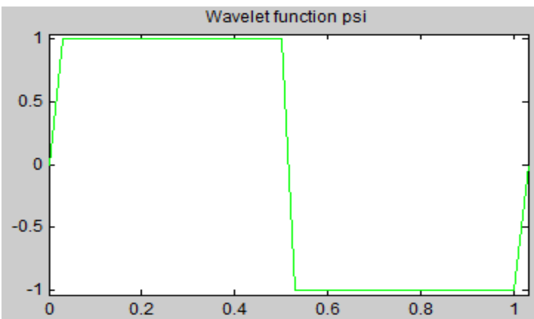
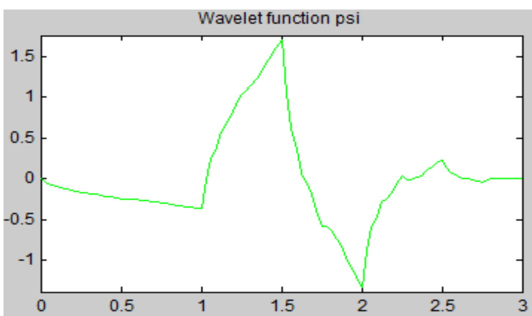
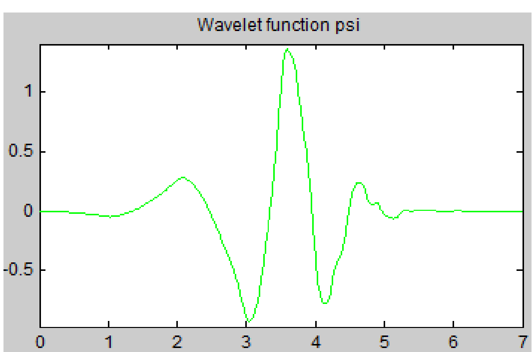


Figure 2: Wavelet Transform categories

Wavelet basis functions have many families which include Haar, Daubechies, meyer, symlets, coiflets, B-spline etc, shown in the figures below:







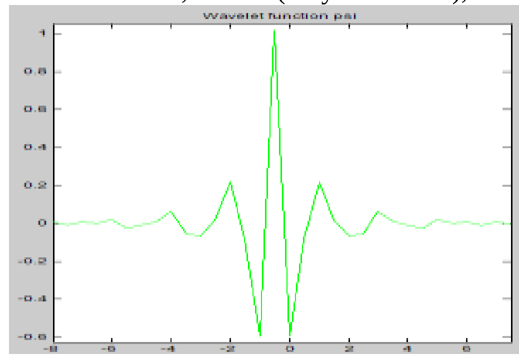
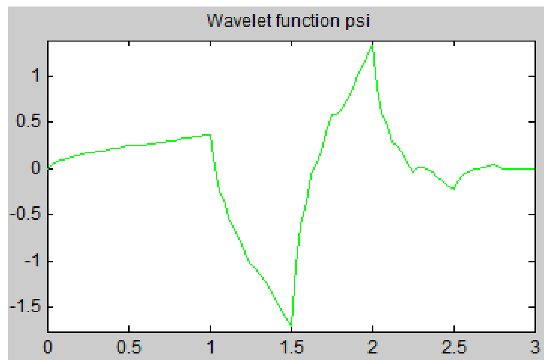
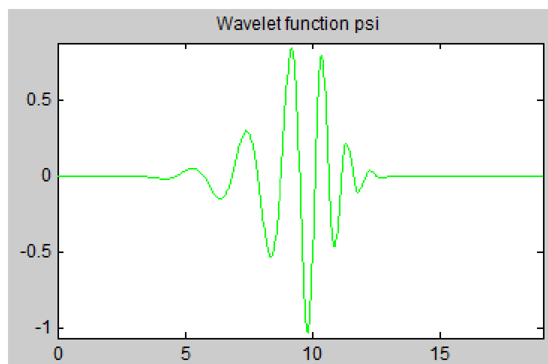
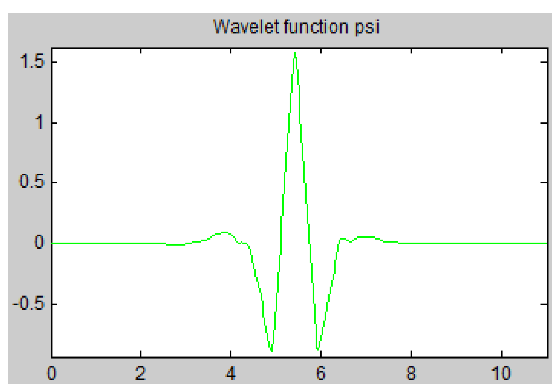


Figure 3: Representing wavelet basis function (haar, db2, db4, meyr wavelet)







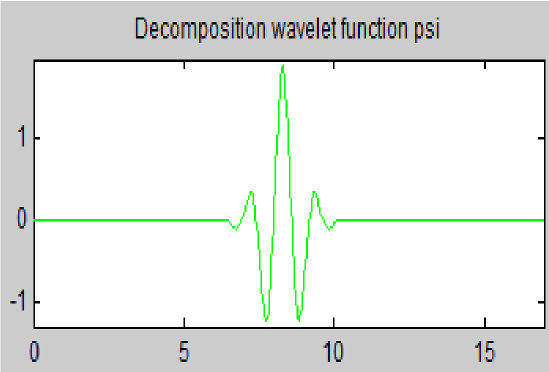


Figure 4: Representing wavelet basis function (sym2, coif1, coif2, bior2.8 wavelet)

If the wavelet basis function has a certain similarity with sampling signal, the energy of filtered signal becomes more concentrated and complexity of calculation is reduced after transformation.

III. OPTIMAL WAVELET SELECTION

The selection of suitable mother wavelet basis function is necessary for efficient analysis of ECG. Optimal wavelet will lead to maximization of coefficient values; this will produce highest local maxima of the ECG. The best characterization of frequency content of ECG signal is possible with optimally selected wavelet filter.

Daubechies wavelet picks up the minute detail that is missed by the other wavelet algorithm. Even if a signal is not represented well by one member of daubechies family, it may be efficiently represented by another.

In this paper, Db10 is used in order to study its effect on the noisy ECG signal.

IV. DESIGN ALGORITHM

Step 1: Choose a wavelet

Step 2: Choose a decomposition level, up to N. In this paper the decomposition level chosen is 4.

Step 3: Design of FIR lowpass filter

Step 4: Design of FIR highpass filter

Step 5: Downsample the output from step 3 and 4 by factor of 2.

Step 6: The output of step 5 is again passed through the lowpass filter and highpass filter, followed by downsampling.

Step 6 is repeated up to the desired level of decomposition.

V. SIMULATION RESULTS

LOWPASS FILTER: The lowpass filter module in instantiated in the top module. Depending upon the wavelet decomposition tree, the module is instantiated.

The waveform in sky blue color is the input ECG signal and red color waveform is the lowpass filter output

Figure 5: Waveform output from the Lowpass filter

HIGHPASS FILTER: The highpass filter is responsible for removing of the noise from the ECG signal. The module is instantiated in the top module, depending upon the desired decomposition levels.

The yellow wave, in the figure 6 shows the ECG signal and the sea green waveform shows the noise filtered out from the ECG signal.

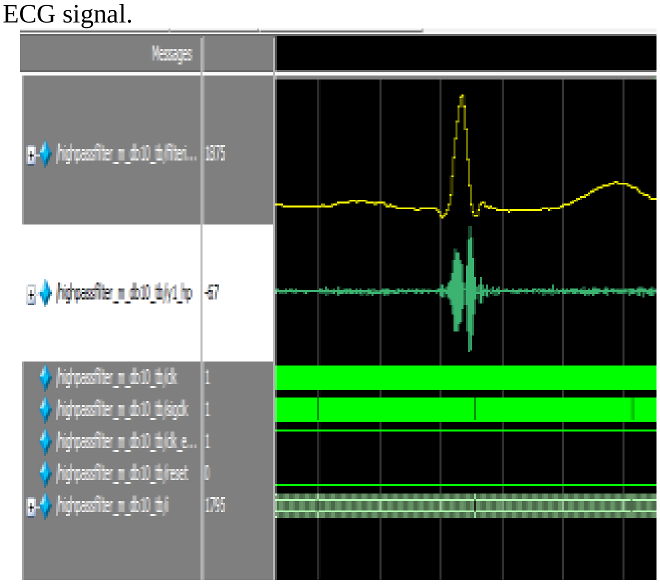


Figure 6: Noise removed output from the Highpass filter

WAVELET DECOMPOSITION TREE OUTPUT: In the design, decomposition tree up to level 4 has been designed. The input ECG signal is given through the test bench in the form of '.txt' file.

In figure 7 below, the signal in white is the input ECG signal while the signal in pink is the wavelet output.

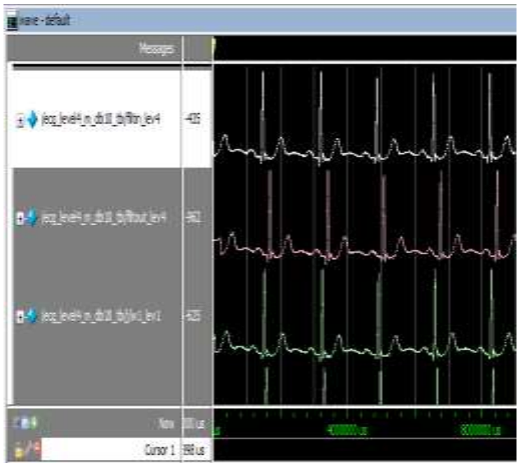


Figure 7: Noisy free ECG signal

The input ECG signal does not contain considerable amount of noise. So some amount of the noise is added in order to verify the design.

The pink waveform in the figure 8, shows the noise added ECG signal, while the original ECG signal is shown with help of white waveform. The yellow waveform, which is the output of the wavelet decomposition tree shows that the design is able to remove considerable amount of noise.

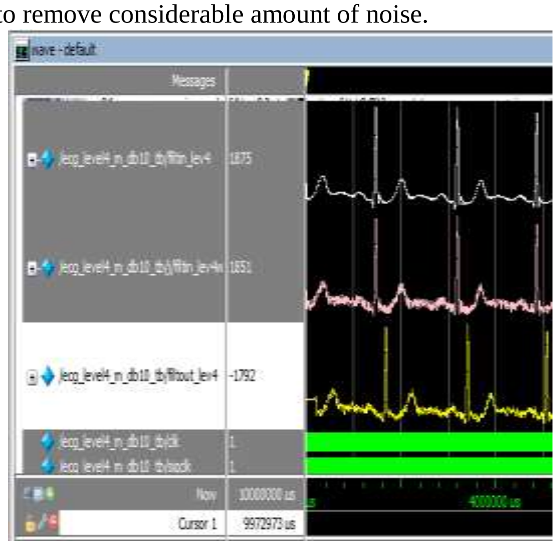


Figure 8: Noise free ECG waveform at output, after noise being added to it.

VI. RESULTS AND DISCUSSIONS

The design removes considerable amount of noise.

Wavelet transform (WT) is used to solve the problem of non-stationary signal such as EGG.

Wavelet transform allows processing of ECG by using multi resolution decomposing into sub signals. The benefit of wavelet transformation lies in its capacity to highlight the details of ECG signal with optimal frequency resolutions.

VII. FUTURE WORK

The proposed design can be implemented on FPGA. The wavelet decomposition level can be increased in order to remove noise significantly.

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