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VLSI Design Approach of Heart Beat Measurement Using ECG Pattern Recognition

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Abstract-A low cost and portable method for measuring heart rate is described. A heart rate measurement simply takes a raw ECG signal and processes it to obtain sample of heart beats and computes the beats per minute so that the information can easily be used to track heart condition. First a raw ECG signal is taken and then filtered to remove unwanted signals which are then passed through moving window, finally QRS complex is discriminated and samples are obtained using MATLAB software and then tested using Verilog code in Xilinx ISE Version 9.2i software. The simulation shows the ideal and practical values of heart beat for various age samples are 99% accurate.

Keywords- ECG,Xilinx ,MATLAB,MVI,LPF,HPF,Modelsim

I. INTRODUCTION

Continuous Measuring and Monitoring is a valuable tool that helps to provide additional information to medical and nursing staff about physiologic condition of a patient. A heart beat measurement system measures pulse rate of patient under examination. This system uses sensors connected to a central processing unit with firm ware for continuously measuring physiological signals. The system consists of single lead ECG to capture electrical signal for pulse/Heart beat measurement. Suitable sensors are incorporated in the design whichare accurate enough to properly find heart beat and interface it to FPGA.

II. PROPOSED METHOD

The concepts of heart beat measurement is taken from[1].This system is useful for measurement and monitoring the pulse rate of the patient periodically which can be verified by doctors for correct treatment. It can be upgraded to include the features of transmitting the health data through communication media of a remote patient to be monitored by the doctor at the centralized location. It can also be miniaturized in size and operated with a battery which can be carried by soldiers coasted in remote sites whose health condition can be monitored by the respective people at the headquarters by upgrading the system to use communication links[2]. The paper is organizedin four parts. First part describes the introduction, second part deals with basic concepts of ECG signal, analysis of integer filter in designing LPF,HPF and BPF in detail, third part deals with block diagram of heart beat measurement system consisting of moving window integration, peak detection with QRS discrimination, QRS interval calculation, adaptive threshold.The Fourth part deals with design implementation using Verilog code and results obtained from MATLAB and Xilinx ISE Version 9.2i software.

Electrocardiography (ECG) signal is the recording of the electrical activity of the heart. An ECG is used to measure the heart's electrical conduction system.The ECG device detects and amplifies the tiny electrical changes on the skin that are caused when the heart muscle depolarizes during each heartbeat. The QRS complex is a name for the combination of three of the graphical deflections seen on a typical electrocardiogram (ECG).Typically an ECG has five deflections, arbitrarily named "P" to "T" waves. The Q, R, and S waves occur in rapid succession and do not appear in all leads.They reflect a single event, and thus are usually considered together. A Q wave is any downward deflection after the P wave. An R wave follows as an upward deflection, and the S wave is any downward deflection after the R wave[3]. The T wave follows the S wave, and in some cases an additional U wave follows the T wave.

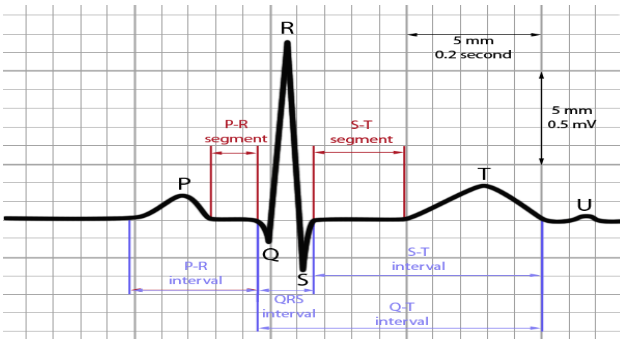

Figure 1.1: Pattern of ECG Signal

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The block diagram of ECG system is as shown in figure 1.2

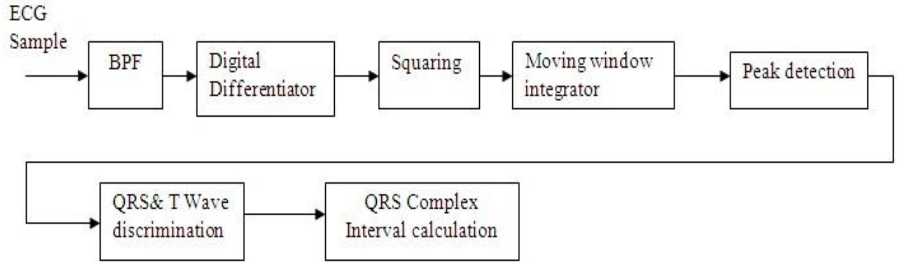

Figure 1.2: block diagram of ECG system

The ECG samples are takenfrom physiconetwebsite and then passed to low pass filter. A band pass filter can be generated from high pass filter followed by low pass filter.The order for low pass filter chosen is 2[3].
The transfer function of LPF filter is:

$$H_l(Z) = \frac{[1-z^{-6}]^2}{[1-z^{-1}]^2} \text{-------------(1)}$$

The difference equation for second order LPF is given as :

y(n) = 2y(n-1) - y(n-2) + x(n) - 2x(n-6) + x(n-12)------------(2)

Desired cutoff frequency for high pass filter of an ECG Signal is 5Hz.Designing such a high pass filter directly is very difficult in integer filters. So HPF is designed by subtracting LPF response with cutoff frequency of5Hz from an all pass filter.

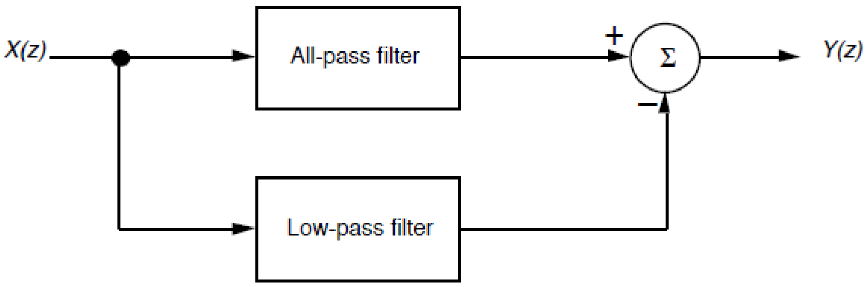

Figure 1.3: High Pass Filter

The transfer function of LPF with 5Hz cutoff frequency :

$$H_{lp}(z) = \frac{1-z^{-32}}{1-z^{-1}} \text{------------------(3)}$$

This filter has gain of 32 and processing delay of 15.5 sampling periods. So scaling LPF transfer function by gain 32 and subtracting it from all pass filter gives us desired HPF.All pass filter produces simply delay, and this delay should compensate delay produced by LPF[4,5].

$$H_{hp}(z) = \left[z^{-16} - \left(\frac{H_{lp}(z)}{32}\right)\right] \text{--------------------------------------(4)}$$

and $$H_{hp}(z) = \left\{\frac{(-1/32+z^{-16}-z^{-17}+z^{-32}/32)}{1-z^{-1}}\right\} \text{--------------------------(5)}$$

The difference equation of High Pass Filter is given as:

y(n) = y(n-1) –[(x(n) – x(n-32))(1/32)]+x(n-16) – x(n-17)----(6)

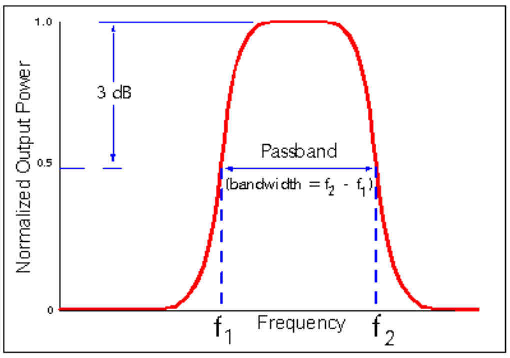

Figure: 1.5 Response of Band Pass Filter

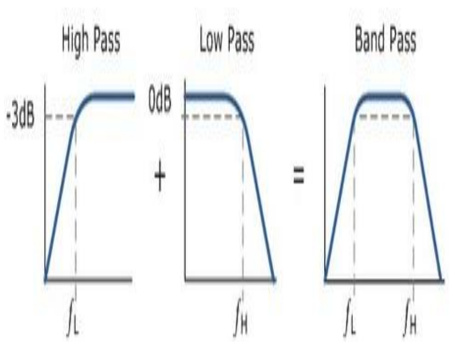

Figure: 1.4 Design of Band Pass Filter

Thus a band pass filter is designed as shown in figure 1.4.The response is as shown in figure 1.5. Next block is digital differentiator which uses Least squares polynomial derivative such that it amplifies signal components of only high frequency[7]. Thus QRS peak can be magnified and identified easily.The response from digital differentiator is as shown in figure 1.7.

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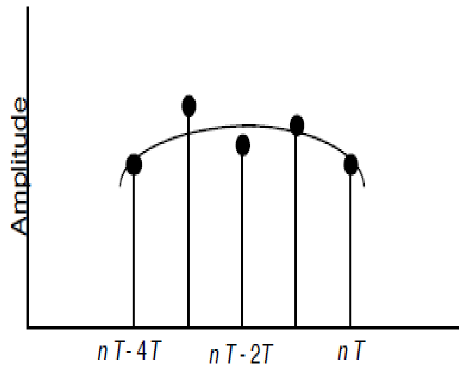


Figure 1.6Digital Differentiator

The difference equation is given by:

$$y(nT) = \frac{\{2x(nT)+x(nT-T)-x(nT-3T)-2x(nT-4T)\}}{10T} \text{----------------------(7)}$$

OR

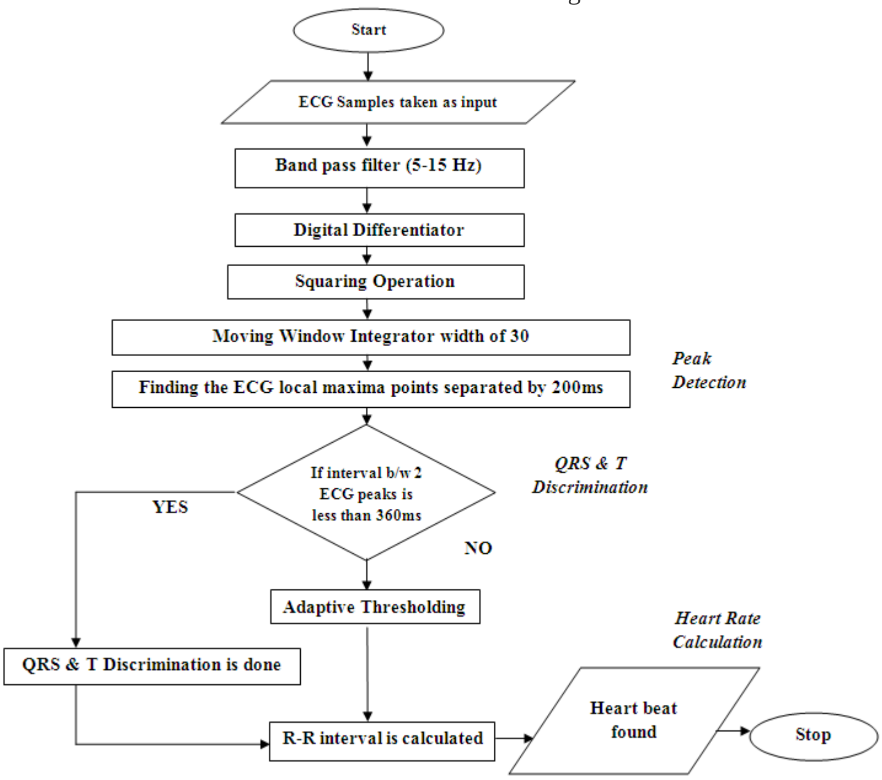
$$y(nT) = \frac{[2x(nT)+x(nT-T)-x(nT-3T)-2x(nT-4T)]}{8} \text{---------------------(8)}$$

The next block is squaring operationcircuit which convert bipolar signal to unipolar signal. It is used to increase signal strength[8]. The next block is moving window integrator which is used to smooth these peaks and produces peak at QRS complex location.The next block is peak detection which determines locations at which QRS locations are present. The next stage is to separate QRS and T signal. First QRS complex interval is calculated. It gives heart rate as follows:
Heart beat rate=12,000 samples/R-R interval.
The next block is moving window integration. The slope of the R wave alone is not a guaranteed way to detect QRS event. Many abnormal QRS complexes that have large amplitudes and long durations (not very steep slopes) might not be detected using information about slope of the R wave only. Thus, we need to extract more information from the signal to detect a QRS event.Moving window integration extracts features in addition to the slope of the R wave. It is implemented with the following difference equation:

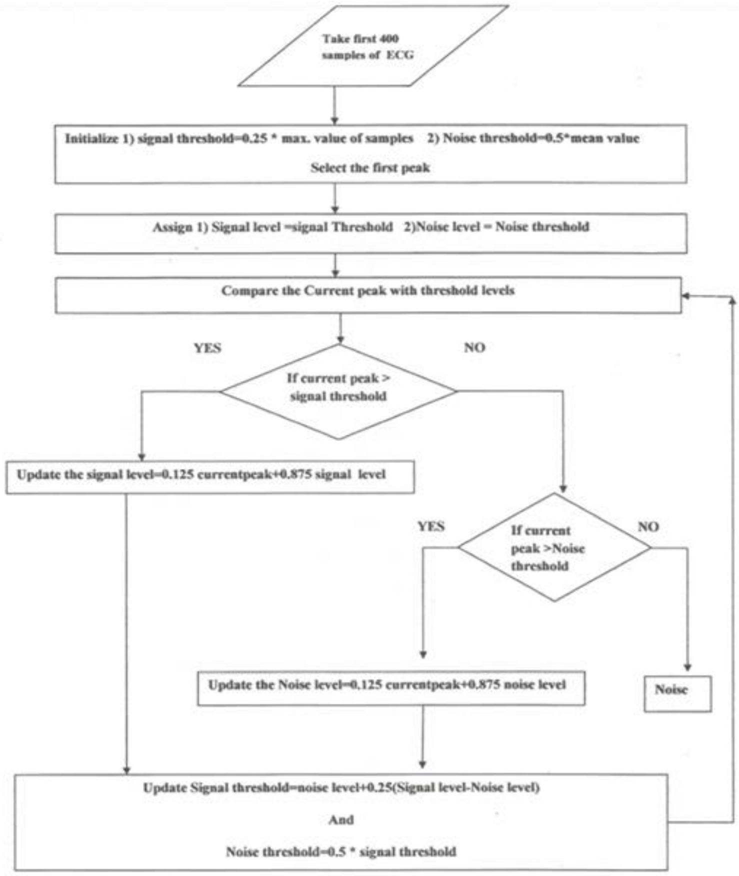
$$y(nT) = 1/_N [x(nT-(N-1)T) + x(nT-(N-2)T) + \ldots + x(nT)] \text{-------(9)}$$

where N is the number of samples in the width of the moving window. The value of this parameter should be chosen carefully.The no of samples N taken for this design is N=30,which corresponds to 150ms.The next block is Peak detection. It is the process of finding the locations and amplitudes of local maxima and minima in a signal[4]. An adaptive threshold algorithm has been developed in order to achieve a real time waveform extraction and reconstruction[8]. The overall operations during design are shown in the flowchart 1 and adaptive threshold algorithm is shown in flowchart 2.

Flowchart for overall design



Flowchart of Adaptive Threshold Algorithm



III. RESULTS

The verilog code was written using Modelsim simulator.The results were verified on FPGA 5vfx100tff1738-2. They are a shown in figure 1.7.

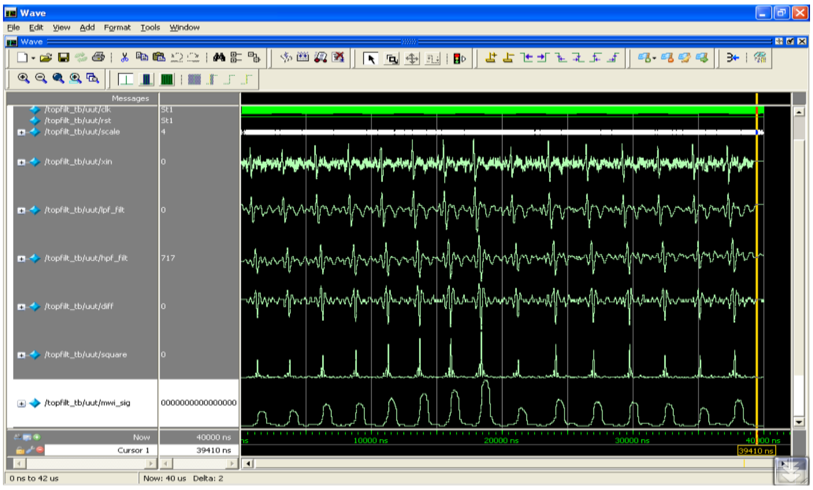


Figure 1.7: Synthesis Result

The synthesis report is as shown in table 1.1. The comparison of various samples obtained from different age group and measured beat rate is shown in table 1.2.

Table 1.1: Synthesis Report

Name of signal sample	Ideal Value	Practical value
Baby ECG sample	110	110.09
18 years and above	70	70.17
6-15 years	85	85
Athelitics ECG signal	44	43.9
Normal Person	59	59.11
Bradycardia ECG Sample	51	51.06
Tachycardia ECG sample	104	103.8

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Slice Logic Utilization:		
Number of Slice Registers	989 out of 64000	1%
Number of Slice Registers	1153 out of 64000	1%
Number used as Logic	1090 out of 64000	1%
Number used as Memory	63 out of 19840	0%
Number used as SRL	63	
Number of LUT Flip flop pairs used	1726	
Unused Flip flop	737 out of 1726	42%
Number of unused Flipflop	573 out of 1726	
Number of unique control sets	9	
Number of IO	32	
Number of bonded IOBs	32 out of 680	4%

IV. CONCLUSION

A simple method for heart beat measurement using adaptive threshold algorithm is presented .The system can be enhanced for the entire medical data acquisition system which could be made wireless and wearable. Such a package would contain the circuiting for inputs from ECG sensors, EEG sensors, pressure measurement and pulse rate transducers.

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REFERENCES

[1] Krej, M., Dziuda, L. and Skibniewski, F.W. ,"A method of detecting heartbeat locations in the ballistocardiographic signal from the fiber-optic vital signs sensor " in IEEE Journal of Biomedical and Health Informatics, Volume:10, Issue: 99

[2] Paalasmaa, J. , Toivonen, H. ; Partinen, M ,".Adaptive Heartbeat Modelling for Beat-to-beat Heart Rate Measurement in BallistocardiogramsIEEE Journal of Biomedical and Health Informatics, Issue: 99

[3] MIT/BIH ECG database. Available from: MIT-BIH Database Distribution, Massachusetts Institute of Technology, 77 Massachusetts Avenue, Room 20A-113, Cambridge, MA 02139

[4] Hamilton, P. S. and Tompkins, W. J. 1986. Quantitative investigation of QRS detection rules using the MIT/BIH arrhythmia database. *IEEE Trans. Biomed. Eng.*BME-33: 1157–65.

[5] R Duda P hart D Stroke Pattern classification 2nd edition John Willey and Sons 2001

[6] YogendraNarin Singh and Sanjay Kumar," Identification using Heart beat interval features and ECG Morphology ", Proceeding of 7th International Conference on Bio inspired computing Theories and applications Vol 1,2013 Pg 87-98

[7] Derek BredlyGeredRoth "Adaptive thresholding using integral image".

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