POWER EFFICIENT PROCESSOR FOR PREDICTING VENTRICULAR ARRHYTHMIA BASED ON ECG

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ABSTRACT

The power efficient processor for predicting ventricular arrhythmia based on ECG is a fully integrated signal processor for predicting arrhythmia. The term "arrhythmia" refers to any change from the normal sequence of electrical impulses. This paper presents the design of signal processor (ESP) for the prediction of ventricular arrhythmia using a unique set of ECG features. Real-time and adaptive techniques for the detection and the delineation of the P-QRS-T waves were investigated to extract the fiducial points. The proposed architecture of this paper analysis the logic size, area and power consumption using Xilinx. The P-QRS-T detection is done using MATLAB. In MATLAB, Pat and Tompkins algorithm is used for removing powerline noise, muscular noise and base line noise. After removal of these noises using MATLAB the signal is forced manually in Model Sim. The filtering is done using Model Sim. After filtration, the signal is again sent into MATLAB for arrhythmia classification. The objective of this project is find and increases the number of interval as compared to the previous work, and increase the possibility of the Predicting Ventricular Arrhythmia and also to reduce the power consumption and area. The results obtained are in such a manner that the area is reduced and throughput is increased.

Keyword*: Ventricular fibrilation, Ventricular tachycardia, QRS detection, Pan and Tompkins algorithm; Ventricular Arrhythmia. ,*

1. INTRODUCTION

In recent years there is an increased scenario of cardiac arrest. Ventricular arrhythmia is one such type of cardiac arrest that can be deadly. It occurs when the heart beats with rapid, erratic electrical impulses. This causes pumping chambers in your heart to quiver uselessly instead of pumping blood. Without an effective heartbeat, the blood even a few seconds in advance can potentially save lives.

The objective of this project is to detect and increase the number of intervals when compared to the existing system thereby increasing the possibility of predicting Ventricular Arrhythmia with reduced power consumption.

The goal of this system is to investigate the possibility of predicting ventricular arrhythmias from an electrocardiogram. The first deflection of the heartbeat is a small upward wave called the P wave. It indicates atrial depolarization. The initial portion of the P wave is largely a reflection of right atrial depolarization and the terminal portion is largely a reflection of left atrial depolarization. The Q wave that is seen following a heart attack may be wide and deep. The R wave is the first upward deflection after the P wave (even when Q waves are absent). The R wave is normally the easiest waveform to identify on the ECG and represents early ventricular depolarization. The S wave is the first negative deflection after the R wave. It represents the late ventricular depolarization. The T wave represents repolarization of the ventricles. During the test, the patient will lie on an examination table. A technician will clean the areas on your body where the electrodes will be placed, usually your chest, back, wrists, and ankles. The electrodes have wires called leads, which hook up to the electrocardiogram machine. Once the electrodes are in place, you will be asked to lie down. The technician will enter some information into the electrocardiogram machine and then tell you to lie still for about a minute while the machine takes its readings. The test is completely safe and painless. This is the conventional method which requires a lot of time. Here heart rate sensor is used to extract the ECG signal from the body.

The wide range of applications includes ECG Preprocessing Stage, ECG filtering, QRS detection, T and P wave delineation arrhythmia classification.

2. PROPOSED SYSTEM

Sudden cardiac death accounts for approximately 300000 deaths in the United States per year, and in most cases is the final result of ventricular arrhythmias, including ventricular tachycardia (VT) or ventricular fibrillation (VF), cardiac death. Ventricular arrhythmia is an abnormal ECG rhythm and is responsible for 75%-85% of sudden deaths in persons with heart problems unless treated within seconds. Most ventricular arrhythmias are caused by coronary heart disease, hypertension, or cardiomyopathy, and if not accurately diagnosed nor treated, immediate death occurs. So to treat them before suffering, this technique is used.

2.1 Block diagram

Initially, the ECG signal from the patient is extracted using heart rate sensor and it is sent to the hardware (PIC microcontroller) where it converts the analog signal into digital. The digital signal is then simulated using the MATLAB Software where the digital values are processed using Pan Tompkins algorithm. After processing by PAT Algorithm, it leads to the detection of P-QRS-T waveform. Now the ECG waveform is manually forced into the Model Sim for filering. The output from Model Sim is sent into the MATLAB for arrhythmia detection. Finally the total area and power used is found out using Xilinx.

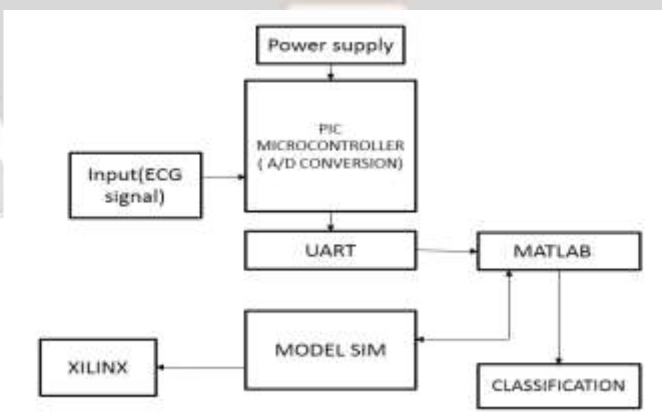

Fig -1: Block diagram for power efficient processor

Fig 1 shows the block diagram representation of the power efficient processor for predicting ventricular arrhythmia. Model Sim is used for further filtering to get pure ECG waveform. This leads to the detection of variation in the waveforms. Thus, VA can be predicted before the patient could suffer the heart attack. Initially, the signal is sent into the MATLAB for ECG extraction. Pan-Tompkins algorithm is generally used in MATLAB for ECG extraction.

2.2 PAN AND TOMPKINS ALGORITHM (PROCESS IN MATLAB)

a) QRS Detection

PAT is based on amplitude threshold technique. It exploits the fact that R peaks have higher amplitudes compared with other ECG wave peaks. There are five steps involved in the extraction of QRS complex.

The fig 2 shows the block diagram explaining the detection of QRS detection using PAN-Tompkins algorithm. The steps involved in the algorithm include filtering. With proper filtering of the signal, the method is highly capable of detecting the R peaks in every heartbeat. The unnecessary noises are removed in this method and then it is sent into the differentiation block. On performing differentiation of the filtered signal, it is possible to distinguish the QRS complex from other ECG waves by finding high slopes. Then, a nonlinear transformation is performed through point-to-point squaring of the filtered ECG signal in which it is important to emphasize the higher frequencies in the signal obtained from the previous step, which is normally characteristic of QRS complex. After that, integration is carried out by a moving time window to extract additional features, such as the QRS width. Finally, adaptive amplitude thresholds are applied to the averaged signal to detect R peaks.

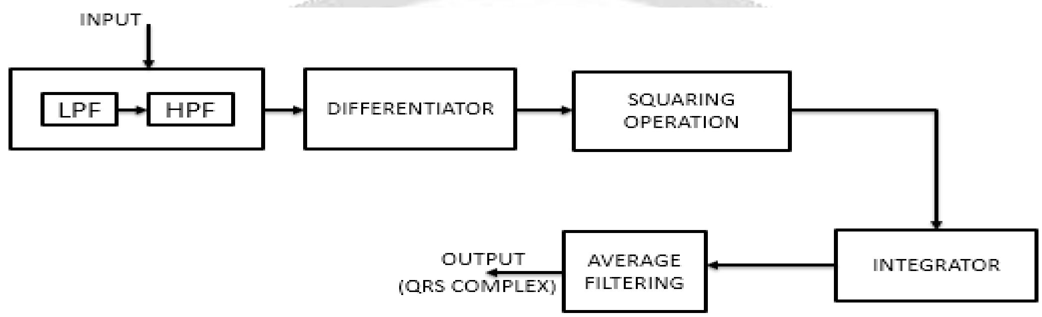

Fig -2: Block diagram for QRS detection

b) Detection of T and P wave

The delineation of T and P waves is based on a novel technique. The method is based on adaptive search windows along with adaptive thresholds to accurately distinguish T and P peaks from noise peak. In each heartbeat, the QRS complex is used as a reference for the detection of T and P waves in which two regions are demarcated with respect to R peaks. These regions are then used to form the forward and backward search windows of the T and P waves. A forward search window is assumed to contain the T wave, and the boundaries are extended from the QRS offset to two third of the previously detected RR interval. Similarly, a backward search window for the P-wave is identified and extended from the QRS onset backwardly to one-third of the previous RR interval. The position of T and P peaks is demarcated in their respective search windows by finding the local maximum or/and a local minimum that are above the associated thresholds. The thresholds are modified in each heartbeat based on the most recent detected values.

c) Process in ModeSim

After the detection of QRS waveform from the noisy ECG signal using MATLAB, it is then manually forced into the MODEL SIM software. Here the addition of salt and pepper noise is done in order to filter the minute noise and interference. After filtering, the signal is sent again into the MATLAB for arrhythmia classification. Xilinx is used to calculate the power and area calculation.

3. RESULTS

The input ECG signal detected from the patient contains various levels of noise. Some common noise includes baseline noise, powerline noise and muscular noise which is nothing but EMG signals.

3.1 MATLAB results

Fig-3 shows the elimination of baseline noise from ECG signal. Fig 4 represents the QRS signal after feature extraction using MATLAB. Muscle noise is not associated with narrow band filtering, but is more difficult since the spectral content of the noise considerably overlaps with that of the PQRST complex. Naturally precautions should be taken to keep power lines as far as possible or shield and ground them, but this is not always possible.

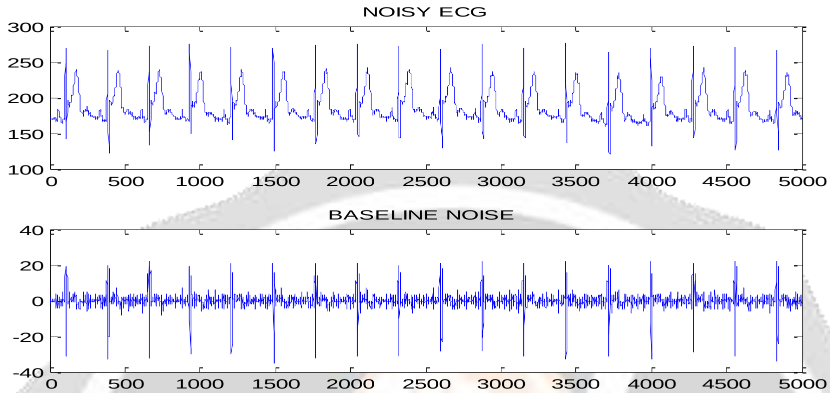

Fig-3: Baseline noise in ECG signal

The ECG signal alone is extracted using Pan and Tompkins algorithm. The extraction of the QRS complex helps in arrhythmia detection. Fig-4 represents the QRS signal extracted from ECG signal with all noises.

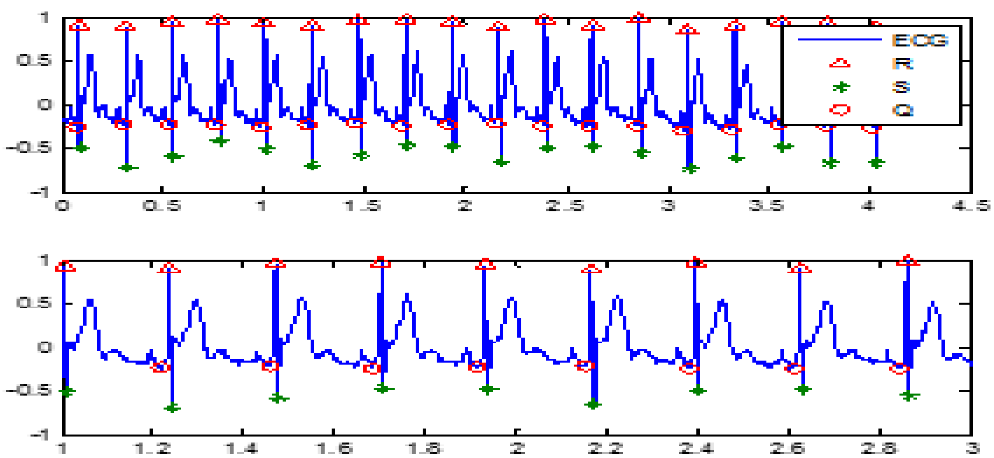

Fig-4: QRS complex extraction

3.2 Model Sim results and Arrhythmia detection

The output from MATLAB is forced into the Model Sim for further filtering. For arrhythmia detection, the R peak has to be detected keenly. Hence salt and pepper noises are added to the signal to eliminate the minute variations and filter it further. Fig-5 shows the Model Sim results (binary output).

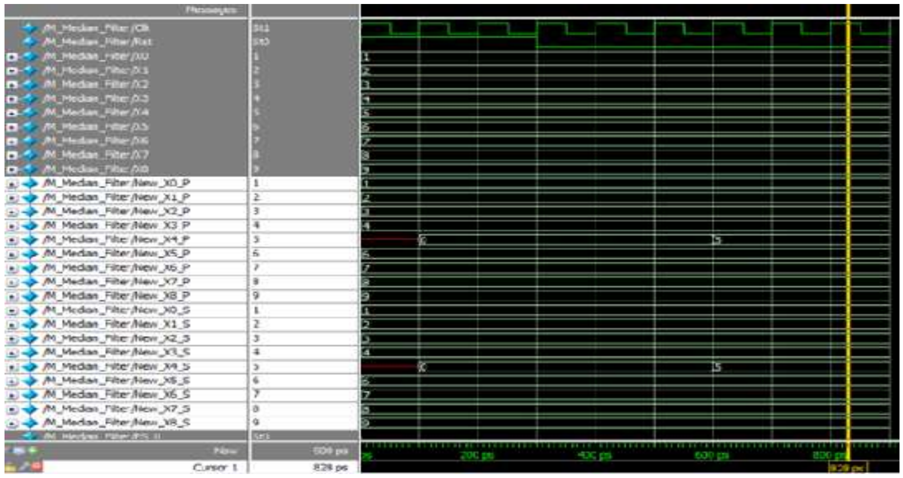

Fig-5: Model Sim result

Now the Model Sim results are forced again to the MATLAB for ventricular arrhythmia prediction. Finally, after forcing into MATLAB the signal is classified for arrhythmia. Fig-6 represents the normal waveform obtained as output without the traces of arrhythmia.

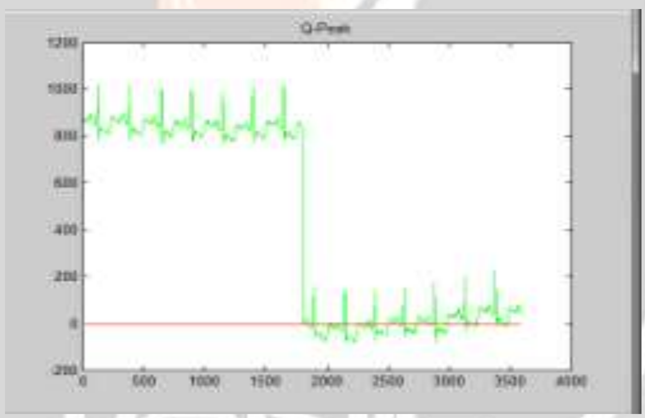

Fig-6: Normal waveform

Fig-7 shows the arrhythmia affected waveform. The type of arrhythmia can also be detected if the extraction of R peak is clear.

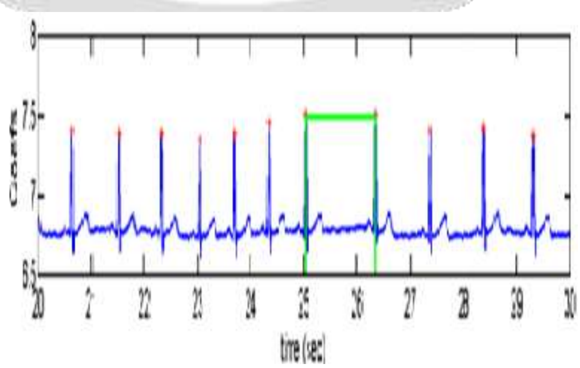

Fig-7: Arrhythmia affected waveform

The fig 7 shows the arrhythmia affected waveform. The arrhythmia classifier works only for the patient suffering from heart disease. For normal person with no arrhythmia detection, there will not be any variations in the ECG waveform. The waveform may vary from patient to patient.

Device Utilization Summary				
Logic Utilization	**Used**	**Available**	**Utilization**	**Note(s)**
Number of Slice Flip Flops	208	26,624	1%	
Number of 4 input LUTs	184	26,624	1%	
Logic Distribution				
Number of occupied Slices	208	13,312	1%	
Number of Slices containing only related logic	208	208	100%	
Number of Slices containing unrelated logic	0	208	0%	
Total Number of 4 input LUTs	184	26,624	1%	
Number of bonded IOBs	210	487	43%	
IOB Flip Flops	64			
Number of GCLKs	1	8	12%	
Total equivalent gate count for design	3,331			
Additional JTAG gate count for IOBs	10,080			

Fig-8: Device utilization summary

The fig 8 represents the device utilization summary using Xilinx. This utilization summary gives the total power and area used in this processor and is comparatively lower than the existing system.

4. CONCLUSION

A fully integrated digital ESP is designed for the prediction of ventricular arrhythmia. This combines a unique set of ECG feature was proposed. Detection and delineation of the P-QRS-T waves were investigated by real time techniques and employed to extract the fiducial points. The combination of feature extraction has never been used in any previous detection or a prediction system. The proposed ESP achieved an outstanding capability of predicting the arrhythmia up to 3 hours before the onset. The small area, low power, and high performance of the proposed system make it suitable for inclusion in system on chips targeting wearable mobile medical devices.

5. REFERENCES

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