ELECTROCARDIOGRAM- QRS WAVE DETECTOR

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Abstract: Evaluation of electrocardiogram is an important method on diagnose of the heart disease. However, ECG signal affected by many noise of physiological and measurement origin must be passed through a processing unit of analog and digital origin. Detection of QRS wave on ECG is very important. For this purpose, various algorithms have been developed. First stage of our study contains measuring and recording of ECG signal. Signal received from the body has been amplified by a designed amplifier. Output signal of amplifier has been recorded by a ADC card (PLC 711) on the computer environment. This signal and MIT-BIH data base's signal have been used to test algorithm..As a result, one impulse per QRS wave has been obtained. Algorithm has been tested at different noise levels separately. Finally, it has been found that algorithm is sufficient.

Keywords- Electrocardiography,QRS wave, digital signal processing.

I- INTRODUCTION

Today the most important reason of death is the fact that, the heart has been working abnormally. Recently, most newest devices have been developed by using engineering methods so that significant reducing has been obtained on heart diseases. Electrocardiograph signal has been generated from electrical activity of the heart. The system where ECG recordings are generated is called as electrocardiography. Processing and interpretation of the ECG signal are very important aspects.

Automatic classification of QRS wave is useful diagnosing of the cardiac disease. Classification and early detection of QRS's variations have great importance on real- time monitoring, data compression, data transferring and data storage.Laguna et al [1] have developed an adaptive Hermit Model estimation system which has described QRS wave complex by Hermit model. Suziki developed a QRS recognition system by using Artificial Neural Network [2]. This system consists of a preprocessor Adaptive resonance theory(ART) network and a recognizer. Sahambi et al have used method of wavelet transformation for detection of ECG characteristics[3]. Wavelet analysis is a mathematical tool which gives a good prediction on time frequency localization. Analysis of signal in various resolutions has been obtained by on elementary functions which have located in time-frequency.

In our study, ECG signal which is received from body surface by three electrodes has been amplified; then converted and recorded by PCL 711 ADC board. In the second stage of study, recorded ECG and MIT-BIH data-base's ECG signals have been used for testing of algorithm.

II. ELECTROCARDIOGRAM

Electrocardiogram is changing of electrical potentials which come from heart muscles during pumping cycle of the heart. Electrical activity and mechanical activity of the heart are related to each-other Therefore, ECG has great significance for evaluating of function of the heart. The electrical cycle of the heart begins from sino-atria node (SA) at right atrium . Impulses on SA cause contracting of ventricle. In this time P wave has been generated. Impulses reach to atrio ventricular node (AV)through some fibers. Contracting of the ventricles produces a pumping effect for the heart. In this period, QRS wave has been generated on ECG wave-from. [4].A typical electrocardiogram is illustrated in Figure 1.

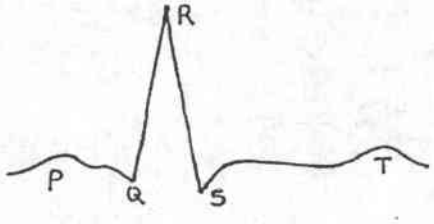

Fig. 1. A typical electrocardiogram waveform.

Most of the analysis of ECG is taken from body surface. ECG signal consists of PQRST wave parts. Recognizing of R wave is first step on ECG processing.

III. SIGNAL AMPLIFIER

The aim of biomedical measurements is receiving, processing and monitoring of electrophysiological

signals. A typical electrophysiological amplifier has to have following features. It must be in galvanic isolation for reduction of noise.[5] An isolating unit has been used so that the patient could be protected from reverse leakage current.

In our designed amplifier, there are an instrumentation amplifier as the preamplifier, optical isolated unit and output amplifier, too . The block diagram of complete system that we have used is illustrated in Figure2.

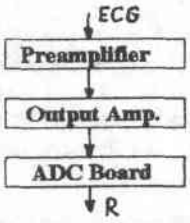

Fig 2. The signal acquisition system.

A- Instrumentation amplifier

In instrumentation amplifier four op-amps circuits have been used . Input difference amplifier is constructed by OP1 and OP2.These op-amps have low noise levels and electrodes were applied to this stage. Input impedance very high level and gain tuning has been implemented by R1 , R2 and R3 resistors. OP4 is an integrator circuits and its time constant is 100 sec. Instrumentation is shown in Figure 3.

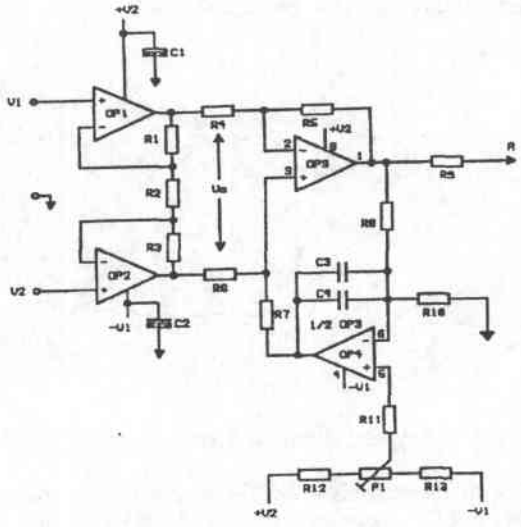

Fig.3 Instrumentation amplifier.

B- Optical isolating unit

The patient have been connected to instrumentation devices directly while electro physiological measurements. Therefore the patient must be isolated from power line and reverse currents also. Isolating circuits have been designed as a magnetic coupled or optical coupled manner. In these system we used an optical coupled circuits (4N25). This stage is shown in Figure 4.

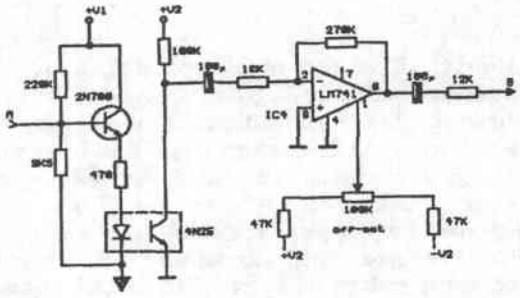

Fig.4 Optical isolating unit.

C- Output amplifier

Output of isolating unit is applied to output amplifier .This circuits has been designed as an inverting amplifier and its voltage gain is Rb/Ra. The resistor of 56 ohms value is omitted during deriving of this equation. The output amplifier is shown in Figure 5.

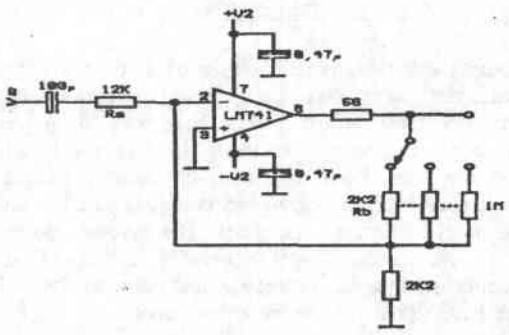

Fig.5 Output amplifier.

IV. MATERIAL AND METHOD

Generally, the QRS detection has been implemented in different ways. Those are; Linear filtering, Nonlinear transformation and Decision-rule algorithm. The linear filtering consists of band-pass filtering and moving-window integral. Adaptive thresholding and T wave separating are components of the decision rule algorithm. In our algorithmic system; filtering blocks, differentiator, squaring and smoothing process respectively have been used.

ECG signal was taken from triple metal electrodes system. In this configuration; each one of the right wrist, chest and right ankle is connected to one

electrode. Received ECG signal has been amplified by designed amplifier and then recorded by PLC 7ll ADC board within the computer.

A-ECG Database

MIT-BIH ECG data base was used for testing of our algorithm. MIT-BIH (Massachusetts Institute of Technology-Beth Israel Hospital) ECG recordings were taken between 1975 and 1979 years and consist of more than 4000 long-term Holter recordings. There are 48 recordings in this data base. Signals are sampled at 360 Hz and have a range of ±5 mV with 11 bits resolution.

We used three periods of MIT-BIH data base ECG signals. We also added artificial noise with various levels and variance to ECG signal for the testing of our algorithm. Flow chart is show in Figure 6.

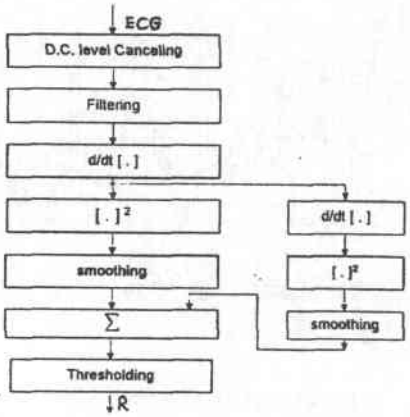

Fig. 6 QRS detection algorithm.

B-Algorithm

In order to reduce the line-interference (50 Hz), we have used following digital filter structure.

$$y(k)=x(k)-2x(k-1)\cos(2\pi f/f_s)+x(k-2)\cos(2\pi f/f_s) -d^2y(k-2)$$

(1)

In this equation, d; band-witdh of notch filter (0<d<1), f; line-frequency and fs; sampling-rate, respectively. This filter is a typical IIR filter(f/fs=0,25 and d=0,95).Below filter has been used for canceling of muscles noises. Equation of this band-pass filter is given as follows.

$$y(n)=1,849(n-1)-0,933y(n-2)+0,0337x(n) -0,0337x(n-2)$$

(2)

After filtering process, the slope of QRS wave is determined by a differentiator in equation 3.

$$y(n)=(1/8)[-x(n-2)-2x(n-1)+2x(n+1)+x(n+2)]$$

(3)

It is necessary that we use a smoothing filter for cancellation of some noises. Hanning filter has been used for this purpose. Filter difference-equation is given as follows.

$$y(n)=1/4[x(n)+2x(n-1)+x(n-2)]$$

(4)

The filter response is like that of a low pass filter. In the second path, a differentiator was used again , so that the prediction could be placed in reasonable range[6]. Than the signal that comes from second Hanning filter is applied to a thresholding unit. If the signal level is more than thirty per cent a of maximum value of the signal, a pulse will be generated that corresponds to a QRS wave.

IV- RESULTS

In these applications, we used three periods of ECG signals which come from MIT-BIH data base. This signal is shown in Figure7.

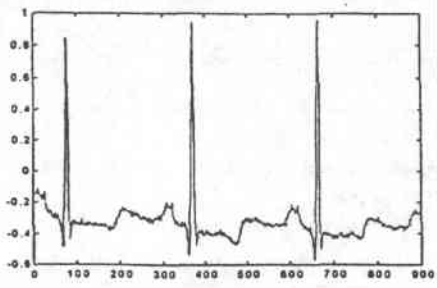

Fig.7:EKG1 signal

Artificial noisy signals with various amplitude and various variance were added to ECG1 signal . These input signal and before thresholding corresponding output of algorithm are shown in following figures.

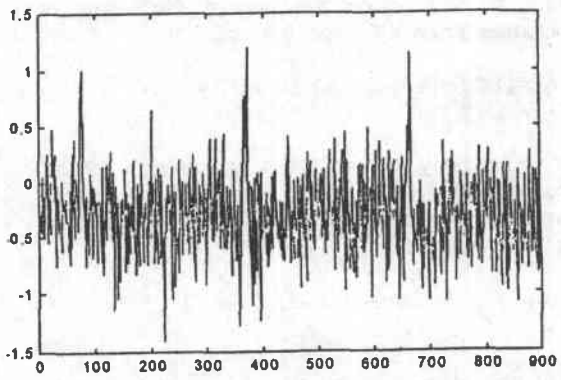

Fig 8 ECGN103 signal (σ =1, SNR=1,31 dB)

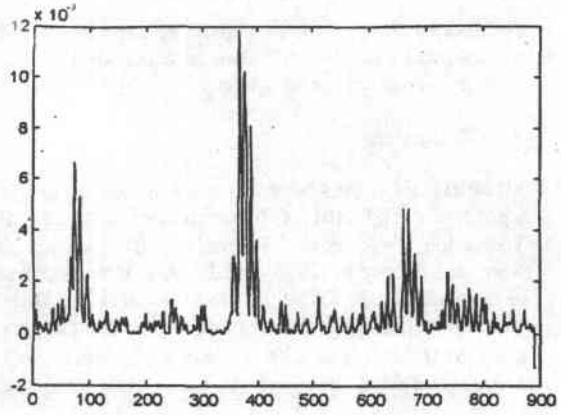

Fig.11.Output signal for EKGN202

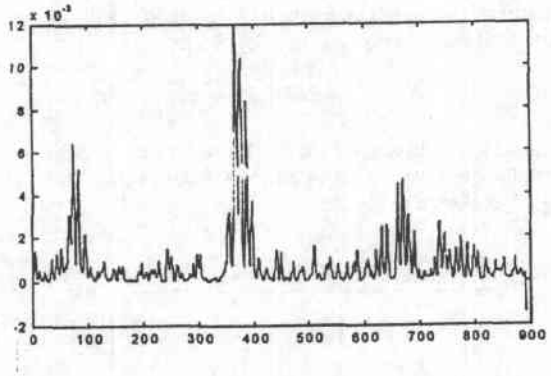

Fig.9Output signal (without thresholding) for EKGN103 signal

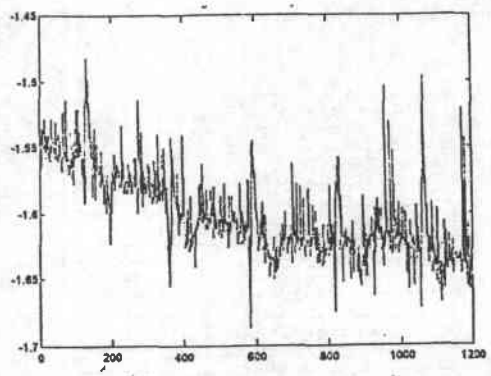

Fig.12 Real ECG signal

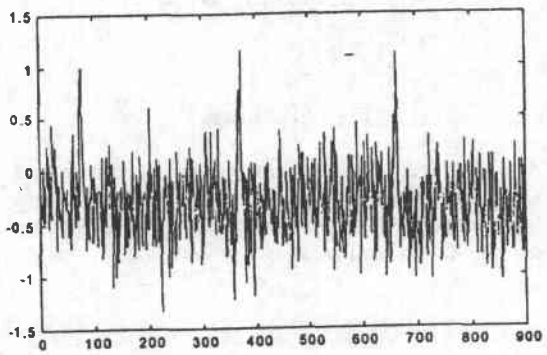

Fig.10 EKGN202 signal (σ =2,SNR=1,86dB)

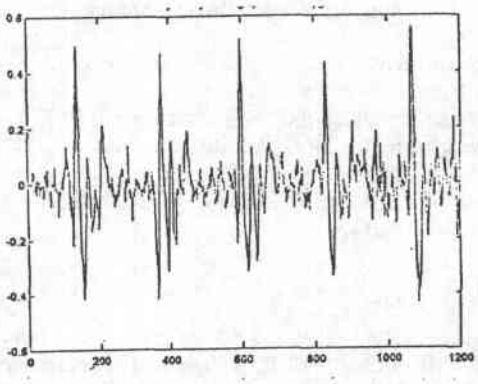

Figure13.Output for real ECG.

VII- DISCUSSION

A typical QRS wave has been affected following interference and/or noises. Those are muscle noises, electrode position effects, power line noises, base line shifting and high frequency effect of T wave. In our study first these effects have been eliminated as, much as possible Then , R wave detection process has been implemented. As a result, we can say that, R wave's location could be determined an very low SNR conditions.

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