Real Time Monitoring System for ECG Signal Using Virtual Instrumentation

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***ABSTRACT*:** The paper introduces the designed aspects of the real time monitoring of the ECG signal on virtual cardiograph. The designed system is consisting of four parts as below.

- ✓ Data acquisition of ECG signal
- ✓ Filtering of data logger
- ✓ Representations of Acquired ECG signal on virtual graphs.
- ✓ Making the data logger.

The 6013 E Analog card is used for the acquisition of ECG signal from ECG simulator and LabVIEW 7.0 professional development tool is used to designed the system. The designed system is advantageous in automatic removal of noises and filtration of acquired signal on virtual cardiographs.

Keywords: Data Acquisition, ECG, LabVIEW, Virtual instrumentation

I. INTRODUCTION

Real time monitoring plays an important role in biomedical engineering, Particularly in ECG, EMG, EEG etc. personal computer have become a standard platform for the needs of various measurement and test, standardization, performance and low cost. Use of PC in so called personal and virtual instrumentation developments enables realization of a new generation of superior devices. With their performance, this is becoming ever higher and with the increasing number of software applications they are widely accepted as an essential tool on desk of engineer[1,2]. The use of LabVIEW and data acquisition in biomedical makes the real time monitor systems with very high performance, low cost of development, more reliable and flexible. LabVIEW is general-purpose software for virtual instrumentation in which other products like dasylab, genie, and alligent vee are followed [3]. With LabVIEW the maintenance and reconfiguration of created instruments are reduced significantly. PC based virtual instrumentation as a testing platform enabling recording of real time ECG introduces identification of ECG and transmission of preprocessed data to a doctor through a distributed computation network has been proposed in [3,4]. PC based monitoring system has been proposed in [5]. In this GUI of the system has been developed in Microsoft .NET visual C++ but it lacks the simultaneous lead illustration of ECG waveform its selection and addition of intelligence for auto diagnose. The intelligent virtual ECG device by integrating dyadic wavelet algorithm for QRS detection, recording and identification with the facilities of the detection of heart rhythm and off line analysis of prerecorded ECG signal has been

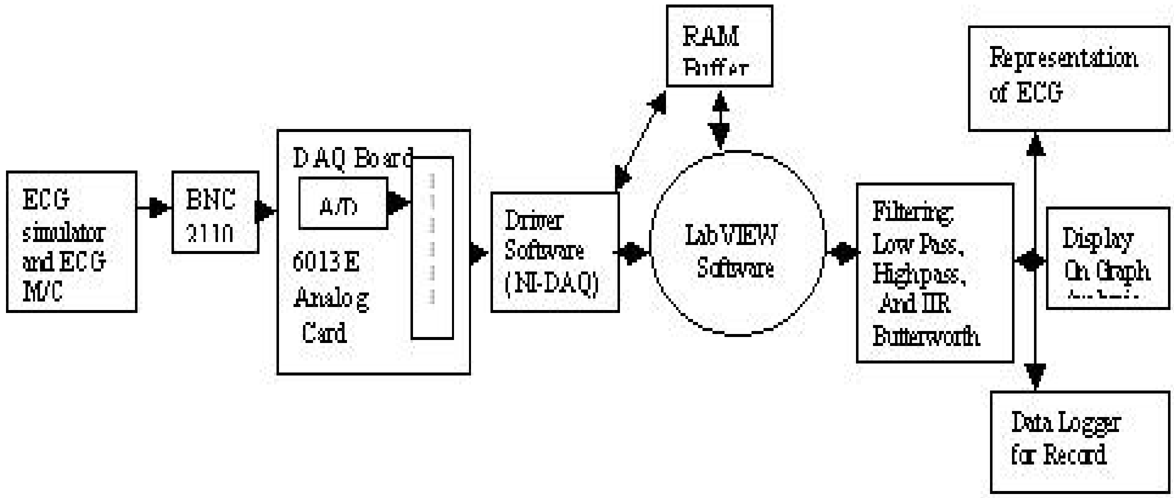

Fig.1 - Block Diagram for Designed Virtual Cardiograph

proposed in [6,7]. Besides all these development in biomedical engineering, the designed system in paper facilitates the automatic removal of noises and filtration of acquired signal on virtual cardiographs and this system can be used for analysis, identification of peak QRS and auto diagnose.

II. HARDWARE & ACQUISITION REQUIREMENTS

The proposed virtual cardiograph in this paper is based upon user suggested by cardiologist with respect to virtual instrumentation concept.

- ✓ Initialization of data acquisition hardware.
- ✓ GUI for interaction between user and instruments.
- ✓ Development of algorithms and procedure for filtering like low pass for smoothing and band pass.

The main user requirement for functional and control system.

- ✓ Selection of one of leads from 12 lead configurations from the ECG simulator.
- ✓ Display of beats/min.
- ✓ Detection of abnormality
- ✓ Possibility to calibrate & isolation from patient‘s body when signal is taken by electrodes.

III. ECG & DATA ACQUISITION

ECG is a quasi periodical, rhythmically repeating signal synchronized by the mechanical function of the heart. ECG Waveform is consisting of P, QRS, and T and U wave of particular amplitudes and duration as in **Figure (2)**. The P wave of atria depolarization that spreads from the SA node throughout the atria. The QRS complex is the result of ventricle depolarization. The T wave represents the ventricle repolarization. U wave may or may not be present in the ECG. PR interval is the time interval between the onset of atrial depolarization and the onset of ventricular depolarization. ST interval is the time interval in which the entire ventricle is depolarized. In biomedical signals there are three basic requirements viz. acquisition, processing and archiving. For this purpose we need an instrumentation system the first is to get the data

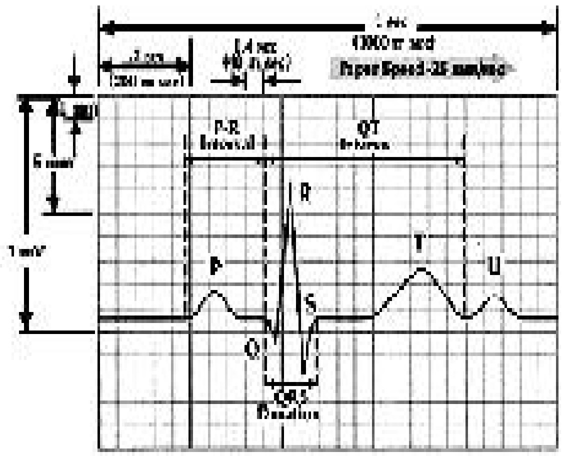

Figure (2) Normal ECG

in personal computer (PC) by using different types of sensors/ electrodes and leads and appropriate conditioning units like amplification and filtering. The second is the analysis of acquired signal in the time and frequency domain. The third involved the archiving which gives the clinical status of patient based on previously defined and extracted feature. ECG signal is acquired in the PC by using PCI 6013 E analog card and BNC 2110 at A0 channel of DAQ board through measurement and explorer (MAX) of National instruments. The shape of acquired ECG carries lot of information, both subjective and objective, and is useful for the cardiologist attempting to determine the activity by just putting the leads on the body of the patient using desired lead configuration. By identifying the ECG waveform, one can exploit the useful and predominant parameters like heart rate, PR interval, ST interval and QT interval and abnormalities like bradycardia, tachycardia, ischemia, rhythm, and blocks [8,9]. The important data that have to be processed in terms of interval and frequency or bandwidth of occurrence carries definite values or ranges. The typical values are taken as reference and are compared with the values of the signals received from the body of the patient to find out the kind of abnormalities in the functioning of heart. The standard values of cardiac cycle measured are as given in the **Table (1)**. The duration for which the data acquisition, reporting and interpretation are carried out is calculated from the number of samples divided by scan or sampling. By using LabVIEW one can perform the data acquisition by either analog card or digital cards like 6013E an analog card with 16 inputs /output channel with 128 KB/S speed and 6024E a Digital card with 200 KB/S & 16 I/O channels [10 11]. The ECG signal from the ECG simulator is given to the DAQ card through BNC connector where the signal is sampled and converted in to digital format. The sampling is done minimum at the nyquist rate (fs >2 fm) where fs is the sampling rate and fm is maximum frequency component in the signal. The output from DAQ board is given to the PC through buffers. These buffers provide the electrical isolation along with the unity gain to the signal. LabVIEW using driver software of National Instruments treats the signal received. The acquired data can be stored in memory or hard disk for future use as data logger **Table (2)**. The result can be displayed using graphs as analyzed waveforms. In LabVIEW user interface is known as front panel and we can add

Parameter	**Duration (sec)**	**Amplitude (mV)**
P wave	0.09	0.15
QRS complex	0.06	1.0
T wave	0.21	0.3
U wave	may be or	may not be exist

Table (1) - Standard Values for ECG

code-using icons of functions to control the front panel object. The block diagram contains the requisite code. The important point in the data acquisition is the rate at which measurement device samples the in coming signal. The sample rates or scan rate in NI-DAQ determines how often A/D or D/A conversion take place. Fast input sampling rates require more points in a given time and can form a better representation of original signal than a slow input sampling rate. Sampling too slowly results in aliasing, which is misinterpretation of original ECG signals. To avoid it, the signal should be sampled at a rate greater than or equal to twice the highest frequency component present in the signal. In our case the highest signal is 150Hz, so in order to avoid aliasing the signal is required to be sampled at a rate greater than 300 samples per second. In order to get better quality of signal, we sampled 1000 samples per second [12]. The maximum and minimum limit for voltage range was +4 v & -1 v respectively. In order to remove the noise from the acquired signal that may be due to external sources like 50 Hz A. C. or interference from power line frequency, we required a low pass filter of 50 Hz frequency and for rejection of high frequency noise we need low pass Butterworth filter of 4th order with some calculated forward and reverse coefficient and after that for removal of frequency higher than 100 Hz we need band pass filter.

IV. VIRTUAL CARDIOGRAPH

Virtual cardiograph has been designed using LabVIEW 7.0 software of National Instruments. The cardiograph is used for monitoring of the ECG signal [13, 14]. In our case the signal was taken from ECG simulator. The acquired signal from ECG simulator has been shown in **Figure (3)** for the case of 60 beats/min. the virtual cardiograph displays the acquired data and then filtered data and beats per minutes as we obtained from the simulator, which indicates the abnormality of bradycardia decides the abnormality. Similarly **Figure (4)** shows the same for the 30 beats/min **Figure (5)** shows the virtual cardiograph for 120 beats/min which shows the problem of tachycardia. Data logger can also be made that provides the numeric values of acquired numeric values of acquired waveforms in terms of

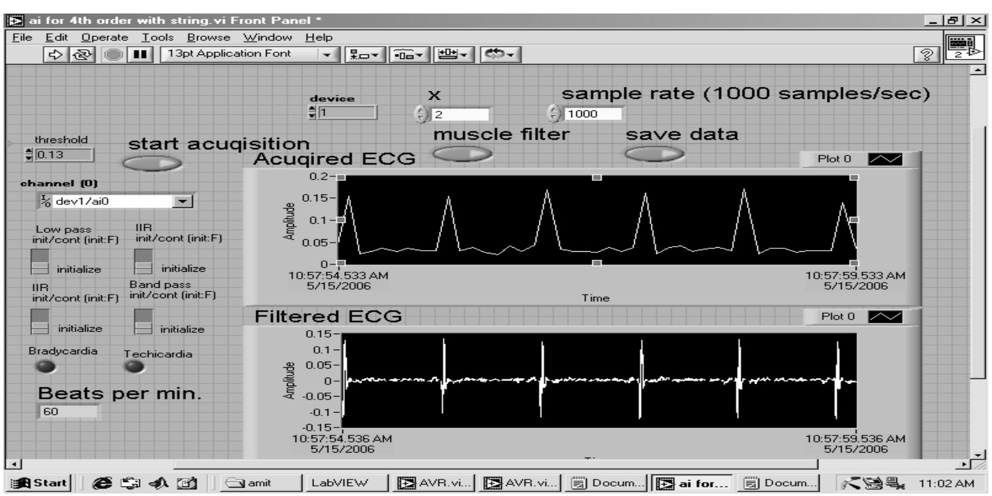

Figure (3) Virtual Cardiograph for 60beats/min

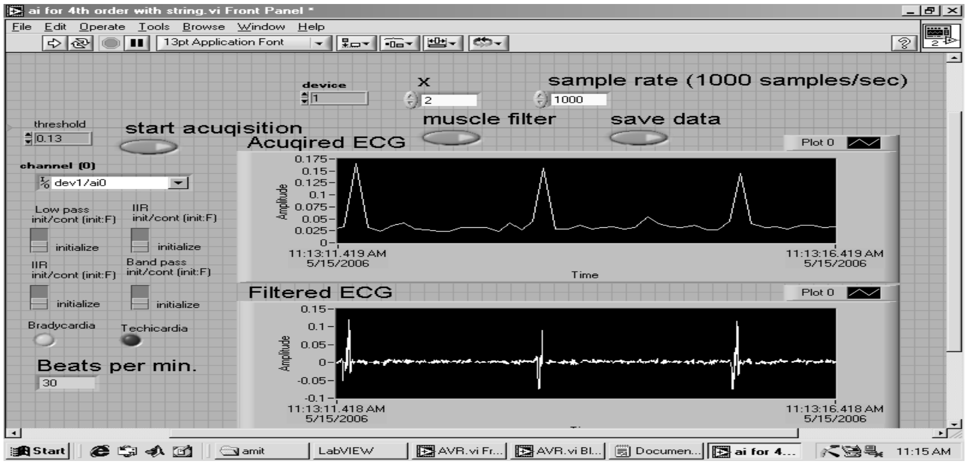

Figure (4) Virtual Cardiograph for 30 beats/min

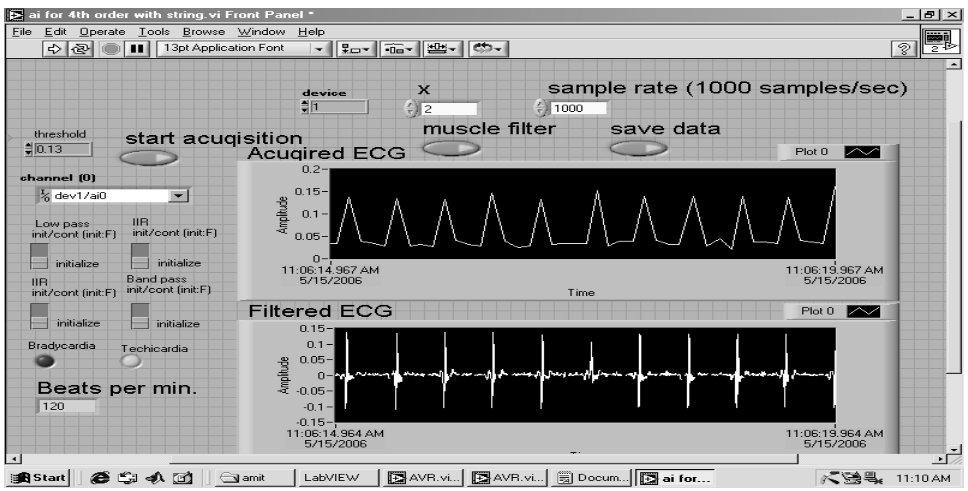

Figure (5) Virtual Cardiograph for 120 beats/min

Voltage and x values. The data logger for 60 beats/min. is shown in **Table (2),** which would be very helpful for the future record. The corresponding data can be read in terms of graph on LabVIEW. Cardiograph has provision to start acquisition and save data that gives more flexibility to the cardiologist.

LabVIEW Measurement
Writer_Version 0.92
Y_Unit_Label Volts
X_Dimension Time
X0 0.0000000000000000E+0
Delta_X 0.001000
Reader_Version 1
Separator Tab
Multi_Headings No
X_Columns Multi
Time_Pref Absolute
OperatorAdministrator
Date 2006/05/15
Time 11:23:36.876 ***End_of_Header***

Channels	1
Samples 1	
Date	2006/05/15
Time	11:23:36.889999
End_of_Header	
X_Value	Voltage (Positive Peak)
0.000000	0.046387
0.140625	0.036621
0.250000	0.041504
0.359375	0.031738
0.468750	0.053711
0.593750	0.041504
0.703125	0.048828
0.764532	0.053453

Table 2 - Data Logger for 60beats/min.

V. CONCLUSION

Virtual instrumentation is marriages of technologies by which we successfully designed the virtual cardiograph and further modifications may be

- ✓ Simultaneous monitoring of twelve leads.
- ✓ Some more functions may be added like for blocks, intervals like QT, PQ etc.
- ✓ Auto diagnosis or Virtual cardiologist.
- ✓ Remote monitoring.

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