LABVIEW BASED ECG SIGNAL ACQUISITION AND ANALYSIS

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Abstract— **The system "LabVIEW based ECG signal acquisition and analysis" is developed to assist patients and doctors in health care. An arrhythmia is an abnormal heart rhythm. It may be so brief that it doesn't change the overall heart rate, but it can cause the heart rate to be too slow or too fast. When arrhythmias are severe or last long enough, the heart may not be able to pump enough blood to the body. This can cause the patient to feel tired, lightheaded or may make him pass out. It can also cause death. Before treatment, it's important for the doctor to know where an arrhythmia starts in the heart and whether it's abnormal. An electrocardiogram (ECG) is often used to diagnose arrhythmias. "LabVIEW based ECG signal acquisition and analysis" is meant to acquire ECG signals from the patient and analyze it to detect and classify its anomalies and abnormalities. This is achieved by extracting amplitudes and durations of parameters of ECG waveform such as P wave, QRS complex, RR interval, and PR durations. These parameters are compared with the normal values to determine the type of abnormality- Tachycardia or Bradycardia. The database of the patient is maintained for further use by the doctor.**

The objective of LabVIEW based ECG signal acquisition and analysis aims at acquiring and analyzing temporal parameters of ECG signal such as P wave, QRS complex, RR interval, PR durations and amplitudes of the P wave, ST wave, identification of cardiac arrhythmia using LabVIEW. The research work has helped us to explore various features of LabVIEW like signal processing and automated database generation.

Keywords— arrhythmia, Bradycardia, ECG, Lab VIEW, tachycardia

I. INTRODUCTION

ECG or EKG is short for electrocardiogram and is called both an ECG and an EKG, as abbreviations for the word electrocardiogram (derived from the Greek electro for electric, cardio for heart, and graph for "to write") and the German word electrocardiogram. An initial breakthrough came when Willem Einthoven, working in Leiden, the Netherlands, used the string galvanometer he invented in 1901. This device was much more sensitive than both the capillary electrometer Waller used and the string

galvanometer that had been invented separately in 1897 by the French engineer Clement Ader. Rather than using today's self-adhesive electrodes Einthoven's subjects would immerse each of their limbs into containers of salt solutions from which the ECG was recorded. Einthoven assigned the letters P, Q, R, S, and T to the various deflections, and described the electrocardiographic features of a number of cardiovascular disorders. In 1924, he was awarded the Nobel Prize in Medicine for his discovery. Though the basic principles of that era are still in use today, many advances in electrocardiography have been made over the years. The instrumentation, for example, has evolved from a cumbersome laboratory apparatus to compact electronic systems that often include computerized interpretation of the electrocardiogram.

ECG conveys information regarding the electrical function of the heart, by altering the shape of its constituent waves, namely the P, QRS, and T waves. ECG Feature Extraction plays a significant role in diagnosing most of the cardiac diseases. One cardiac cycle in an ECG signal consists of the P-QRS-T waves. This feature extraction scheme determines the amplitudes and intervals in the ECG signal for subsequent analysis. The amplitude and interval of the P-QRS-T segment determine the function of the heart. Cardiac Arrhythmia shows a condition of abnormal electrical activity in the heart which is a threat to humans.

II. LITERATURE SURVEY

1. A Review Paper on Analysis of electrocardiograph (ECG) Signal for the detection of Arrhythmia Abnormalities

By Anand Kumar, Joshi Arun Tomar, Mangesh Tomar

The aim of this paper presents analyses of cardiac disease in Electrocardiogram (ECG) Signals for Cardiac Arrhythmia using analysis of resulting ECG normal & abnormal waveforms. This paper presents a method to analyze electrocardiogram (ECG) signals, extract the features, for the classification of heartbeats according to different arrhythmia. Cardiac arrhythmia found are Tachycardia, Bradycardia, Supraventricular Tachycardia, Incomplete Bundle Branch Block, Bundle Branch Block, Ventricular Tachycardia, hence abnormalities of the heart may cause sudden cardiac arrest or cause damage of the heart. The early detection of arrhythmia is very important for cardiac patients. Electrocardiogram (ECG) feature extraction

system has been developed and evaluated based on the multi-resolution wavelet transform.

2. Research on a Practical Electrocardiogram Segmentation Model

By Jianjian Wang, Zheying Li

A practical ECG segmentation model is introduced in this paper, which is built on-time processing. With the model, the ECG signal is divided into several pieces. Each piece has an adjustable sampling time interval and can be processed in a time sequence. Also, the signal amplitude can be adjusted. This is very useful in practical application. According to the sampling theorem, by changing the different sampling time intervals, simple data compression and signal extending in time coordinates are realized. Subsequent interpolation is to retain the original information and characters used for observation and analysis after extending.

3. Temporal Analysis of ECG using LabVIEW

By Prof. Amruta Mhatre, Prof. Sadhana Pai, Prof. Manita Rajput

"Temporal analysis of ECG using LabVIEW" is meant to acquire ECG signal from

patient and analyze it to detect and classify its anomalies and abnormalities. This is achieved by extracting amplitudes and durations of parameters of ECG waveform such as P wave, QRS complex, RR interval, and PR durations. These parameters are compared with the normal values to determine the type of abnormality. The database of the patient is maintained for further use by the doctor.

4. Labview Based ECG Patient Monitoring System for Cardiovascular Patient Using SMTP Technology

By Om Prakash Singh, Dawit Mekonnen, and M. B. Malarvili

This paper leads to developing a LabVIEW based ECG patient monitoring system for a cardiovascular patient using Simple Mail Transfer Protocol technology. The designed device has been divided into three parts. The first part is the ECG amplifier circuit, built using an instrumentation amplifier (AD620) followed by a signal conditioning circuit with the operation amplifier (lm741). Secondly, the DAQ card is used to convert the analog signal into digital form for the further process. Furthermore, the data has been processed in LabVIEW where the digital filter techniques have been implemented to remove the noise from the acquired signal. After processing, the algorithm was developed to calculate the heart rate and to analyze the arrhythmia condition. Finally, SMTP technology has been added in our work to make the device a more communicative and much more cost-effective solution in telemedicine technology which has been key-problem to realize the tele diagnosis and monitoring of ECG signals. The technology also can be easily implemented over already existing Internet.

III. DESIGN CONCEPT

3.1 Introduction:

The ECG device detects and amplifies the tiny electrical changes on the skin that are caused when the heart muscle depolarizes during each heartbeat. At rest, each heart muscle cell has a negative charge, called the membrane potential across its cell membrane. Decreasing this negative charge towards zero, via the influx of the positive cations, Na+ and Ca+, is called depolarization, which activates the mechanisms in the cell that cause it to contract. During each heartbeat, a healthy heart will have an orderly progression of a wave of depolarization that is triggered by the cells in the Sino atrial node, spreads out through the atrium, passes through the atrioventricular node and then spreads all over the ventricles. This is detected as tiny rises and falls in the voltage between two electrodes placed either side of the heart, which is displayed as a wavy line either on a screen or on paper. This display indicates the overall rhythm of the heart and weaknesses in different parts of the heart muscle.

To capture the tiny electrical impulses on the skin, we use Electrodes. They are attached to the patient's body and are connected by wires to the front-end hardware. After capturing and processing the signal, we will receive a P-Q-R-S-T waveform:
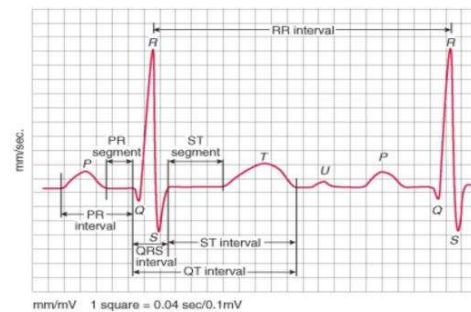

Figure: 1

We can now analyze this signal and come to a conclusion on the condition of the patient's heart by comparing its values with reference values of a person with a normal heart condition.

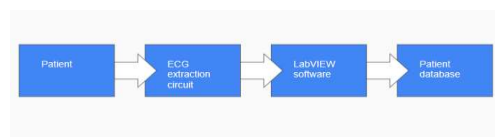### 3.2 Block diagram of the system

Figure: 2

The figure below shows the blocks in the ECG extraction circuit. It consists of sensor electrodes, filters, and amplifiers. It starts with the patient to whom the electrodes are attached. This research work offers an ECG monitoring platform based on a 3-lead system.
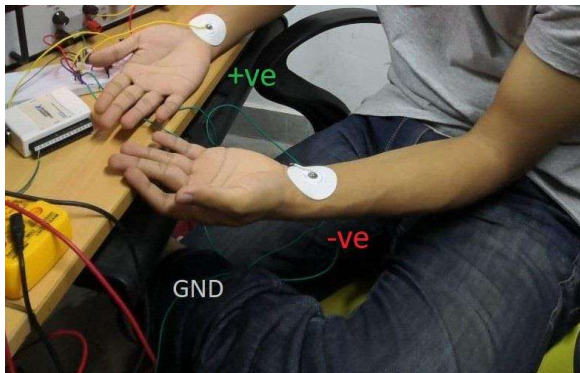
Figure: 3

A total of 3 electrodes are attached (one on each) on the wrist of right hand, left hand and left leg. The ECG data is collected via an ECG extraction circuit and to convert the signal from analog to digital, it is passed through the DAQ (NI 6008) card connected to the PC/laptop. The signal is then filtered and processed through LabVIEW and transmitted to the end user (physician) through SMTP to analyze the patient condition.
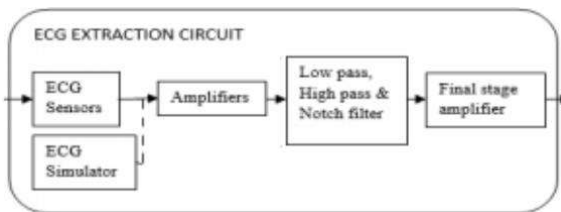

Figure: 4

The figure 4 shows the ECG Extraction Circuit which consists of the electrodes mentioned earlier which act as the sensors, various filters and amplifiers.
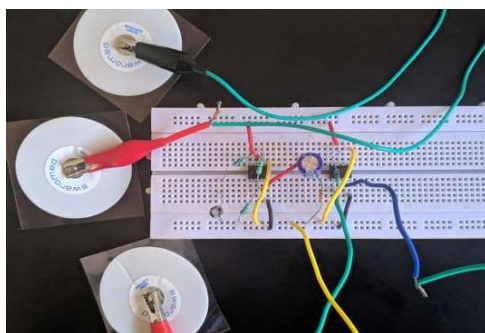

Figure: 5

3.3 Procedure

The objective of **LabVIEW based ECG signal acquisition and analysis** aims at capturing ECG signal or P-Q-R-S-T

and analyzing temporal parameter-RR interval, to calculate beats per minute and for identification of cardiac arrhythmia using LabVIEW. The research work has helped us to explore various features of LabVIEW like signal processing and automated database generation.

-Acquire ECG signal

-Amplify the acquired signal

-Design front end hardware to block the undesired frequencies and only bypass the desired range of frequencies

-Convert captured signal into a suitable form to be processed by LabVIEW

-Filter the signal on LabVIEW and acquire an accurate P-Q-R-S-T wave

-Calculate the Heart rate (beats per minute) with the help of value of RR interval

-Find whether the patient has normal heart condition or arrhythmia

-Conclude whether the abnormality is Tachycardia or Bradycardia

IV. IMPLEMENTATION AND EXPERIMENTATION

4.1 Steps

1. Choice of appropriate electrodes. The chosen electrodes can be either of ring electrodes, sticky patch electrodes or the classic 12 lead electrodes.

2. Designing lowpass and high pass filters and thus choosing the classic resistor and capacitor values for the same.

3. Verification of results via spice simulations and formation of PCB layout.

4. Synthesizing PCB, mounting components and testing the hardware circuit.

5. Using NI DAQ 6008 for interfacing the analog and digital components of the project.

6. Development of the virtual instrumentation system on LabVIEW using the classic blocks available.

7. Setup of DAQ Assistant, choosing the appropriate ports of the DAQ and accurate mapping of the pins.

8. Display the output on the front panel and then send that report to the physician via a Simple Mail Transfer Protocol communication.

4.2 Signal Acquisition Hardware

4.2.1 Theory and calculations Electrodes:

The ECG consists of several electrodes that are attached to the body of the patient and are connected by

wires to the device. The device itself consists of a graphing device (originally paper, although electronic recorders are becoming more common). Each one of the sensors can detect a change in electrical charge in the skin that can only be the result of the impulses that are traveling through the heart and on to the rest of the body.

This impulse travels very quickly and is also transmitted to the cells surrounding the heart as it dissipates throughout the   body. This forms a very regular pattern that establishes control for patients that do have heart problems, such as arrhythmia. The signal recorded as a difference between two potentials on the body surface is called "ECG lead". Each lead is said to look at the heart from a different angle.

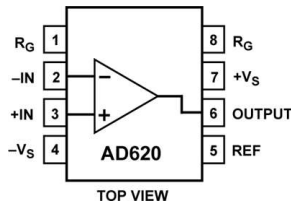### 4.2.2 AD620 instrumentation amplifier:

Figure: 6

The AD620 is a low cost, high accuracy instrumentation amplifier that requires only one external resistor to set gains of 1 to 10,000. Furthermore, the AD620 features 8-lead SOIC and DIP packaging that is smaller than discrete designs and offers lower power (only 1.3 mA max supply current), making it a good fit for battery-powered, portable (or remote) applications.

The AD620, with its high accuracy of 40 ppm maximum nonlinearity, the low offset voltage of 50 μV max, and offset drift of 0.6 μV/°C max, is ideal for use in precision data acquisition systems, such as weigh scales and transducer interfaces. Furthermore, the low noise, low input bias current and low power of the AD620 make it well suited for medical applications such as ECG and noninvasive blood pressure monitors.

4.2.3 Operational Amplifier

It is the basic building block of analog electronic circuits that accomplish different types of analog signal processing tasks. These ICs use exterior feedback to regulate their functions and these components are used as a multipurpose device in various electronic instruments. It consists of two inputs and two outputs, namely inverting and non-inverting terminals. This 741 IC is most commonly used in various electrical and electronic circuits. The main intention of this 741 op-amp is to strengthen AC & DC signals and for mathematical operations. The applications of an operational

amplifier mainly involve filters, comparators, pulse generators, oscillators, etc.

In this system, we use an op-amp as a filter to bypass only the selected range of frequencies.
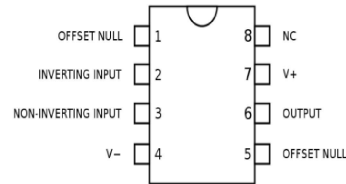

Figure: 7

4.2.4 Calculations

Calculations of High pass and Low pass filter:

- High Pass Filter:

$$f = \frac{1}{2\pi RC}$$

$$= \frac{1}{2\pi \times 56K \times 1000u}$$

$$= 0.02Hz$$

- Low Pass Filter:

$$f = \frac{1}{2\pi RC}$$
$$= \frac{1}{2\pi \times 1K \times 1u}$$

$$= 159Hz$$

4.2.5 PCB Design

Autodesk EAGLE software was used to design the PCB layout required for the signal extraction hardware that is used to acquire the crude ECG signal from the patient.
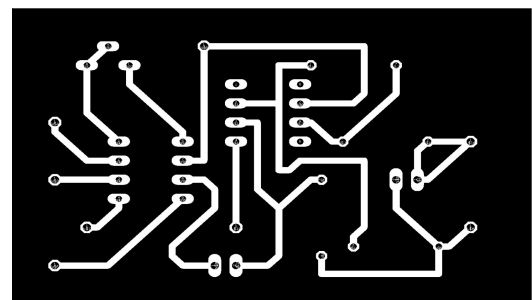

Figure: 8

The layout has been magnified for easy readability but the actual circuit after being synthesized will be roughly 6cm X 4cm in the chip area. The designed PCB will function after being supplied with a dual power supply of +- 5 volts. The output obtained will be in the analog form and will certainly have a noise component and this will then be connected to the input terminals of the DAQ.
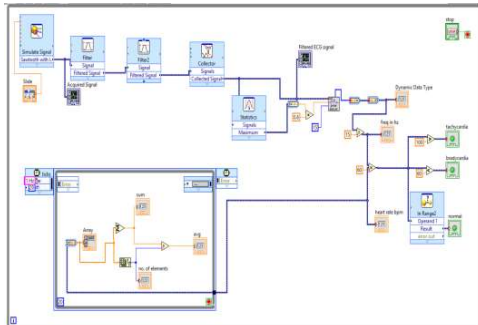
4.2.6   Block diagram in Labview

Figure: 9

Simulate Signal: It is used to simulate the sawtooth wave that will be replaced by the DAQ assistant block once the DAQ has been connected. There is a slider to control the frequency to simulate a non-uniform wave. Noise is added to simulate a real-time signal.

Filter blocks: They are used to act as lowpass and high pass filter to further filter out the noise from the signal. We can choose the filter type and the cutoff frequency for the same.

Collector Block: The collector collects the most recent number of outputs from the filter blocks. We can enter a value in the range of 10000-150000.

Statistics Block: It is an arithmetic block which helps us to determine the type of signal characteristic we want to study. For arrhythmia, we are concerned with the QRS complex so we will choose to monitor the maximum extreme value.

Graph Properties: It allows us to alter the parameters of the front panel waveform to fit our needs.

Waveform Peak Detection: It is an inbuilt block that helps us to detect the peaks and produce a count on them.

Numeric Blocks: Various arithmetic operators can be selected from the set of numeric blocks. Each block can additionally have a control or a constant as one of the inputs.

Comparison Blocks: They are used for determining the heart condition depending upon the prespecified range.

Boolean Indicator: If the condition connected to it is true then the LED will light up thus indicating the correct heart condition for that heart rate.

While Loop: This will continuously run the process in loop without any pauses to ensure a streamlined flow of data at all times.

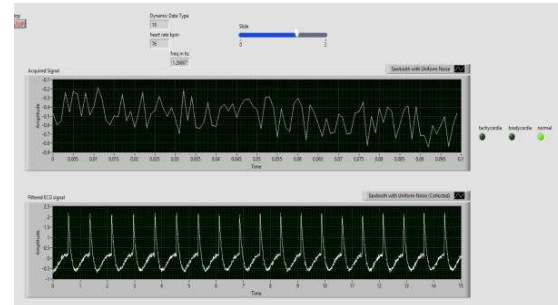### 4.2.7   ECG signal analysis

Figure: 10

The front panel of the LabVIEW project will be indicated as shown in the figure 9. The slider will allow the user to change the frequency in order to demonstrate the 3 conditions. Bradycardia LED will be indicated when the heart rate is below 60, the Tachycardia indicator will glow when the heart rate exceeds the 100 bpm value. In all other cases, a normal heart condition is indicated as the heart rate is in the range of 60 to 100 bpm.
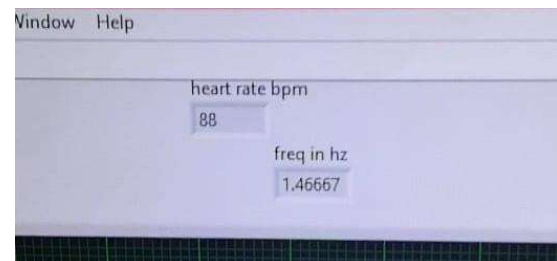

Figure: 11

V.   CONCLUSION

In this report, the hardware implementations using commercially available devices and the software written in the LabVIEW program for continuously monitoring ECG data have been described.

This system aims to acquire and analyze the ECG signals and measure the rate and regularity of heartbeats. It focuses on acquisition and analysis of ECG signal, identification of cardiac arrhythmia and database maintenance using LabVIEW. This system will help cardiologists and health care systems in the diagnosis of various types of Arrhythmia.

VI.   SCOPE AND FUTURE WORK

The proposed system will be modified by interfacing it with SMTP technology. SMTP allows sending the data quickly

through emails from LabVIEW to a health care center or a physician. It can be used to send an image file of an acquired ECG signal through Email Express VI.

Further analysis of the P-QRS-T wave will be performed to detect these abnormalities:

Long QT syndrome (LQTS): It is a heart disease in which there is an abnormally long delay between the electrical excitation (and depolarization) and relaxation (depolarization) of the ventricles of the heart.

Short QT syndrome: Short QT syndrome is a genetic disease of the electrical system of the heart. It consists of a constellation of signs and symptoms, consisting of a short QT interval on EKG (≤ 300 ms).

First-degree heart block: First-degree heart block (PR interval >200 ms) is a disease of the electrical conduction system of the heart. It may be due to conduction delay in the AV node

Second-degree block: Occasional absence of QRS and T after a P wave of sinus origin.

Third-degree block: Absence of any relationship between P waves of sinus origin and QRS complexes (AV dissociation)

VII. ACKNOWLEDGEMENTS

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