

# LabVIEW Based Determination of Oxygen Saturation from ECG Signals

G.Nalinashini, N.Padmavathi, M.Aravindan

**Abstract:** This research paper demonstrates the measurement of oxygen saturation (SAO<sub>2</sub>) from the ECG signal using LabVIEW 11.0. SAO<sub>2</sub> is the percentage of hemoglobin molecules that contain oxygen. The optimum level of SAO<sub>2</sub> in a human being should be 92%. When it goes below 90% it causes hypoxemia (anemia). When SAO<sub>2</sub> reduces below 65%, it will cause damage in the functioning of mental activity. When it reduces below 55% it causes unconsciousness. Hence sustaining the optimum value of SAO<sub>2</sub> is crucial. Hence maintaining optimum level of SAO<sub>2</sub> is important. The latest technology which utilizes pulse oximeter has its own drawbacks. To overcome these disadvantages, a new methodology by which SAO<sub>2</sub> can be measured from ECG signals is proposed. The ECG signal from the patient is acquired by NI USB 6211 DAQ module. By determining the pulse numbers from the ECG waveform, the SAO<sub>2</sub> level can be determined by suitable mathematical computations. Diagnostics and implementing control action can be done with the support of LabVIEW software.

**Keywords :** SAO<sub>2</sub>, ECG signal, LabVIEW 11.0, NI USB 6211.

## I. INTRODUCTION

ECG being the important electric potential of our body. Any heart abnormalities and disfunctioning can be diagnosed using this ECG [1, 2] To do this task different types of oximeters are used. But still it suffers from noise characteristics and bias inaccuracies [4]. Several manufacturers designed pulse oximeters to determine %SaO<sub>2</sub> values [5] & [6]. Pulse oximetry has become the standard clinical method for monitoring patient's blood oxygen saturation and heart rate. Therefore hospitals need a straightforward means to check the accuracy of pulse oximeters. Commercial pulse oximeter testers often cannot be afforded since they are costly [7].

This project work demonstrates that ECGs are used to not only determine the parameters of cardiac system but also the respiratory parameter. A new methodology is proposed to determine SAO<sub>2</sub> from ECG signal. SAO<sub>2</sub> is the short form for blood oxygen saturation. The percentage of hemoglobin molecules that contain oxygen can be measured. If the value goes down, then it means that the blood holds insufficient oxygen to properly oxygenate tissues. It normally depends on

the person and the problem. Most people have SAO<sub>2</sub> >92%. A level of SAO<sub>2</sub> below 88% is not normal. To obtain the SAO<sub>2</sub> in arterial blood from ECG signal, we have established a relationship between heart rate and SAO<sub>2</sub> with the help of applied mathematics. A standard ECG signal is shown in the Figure 1.

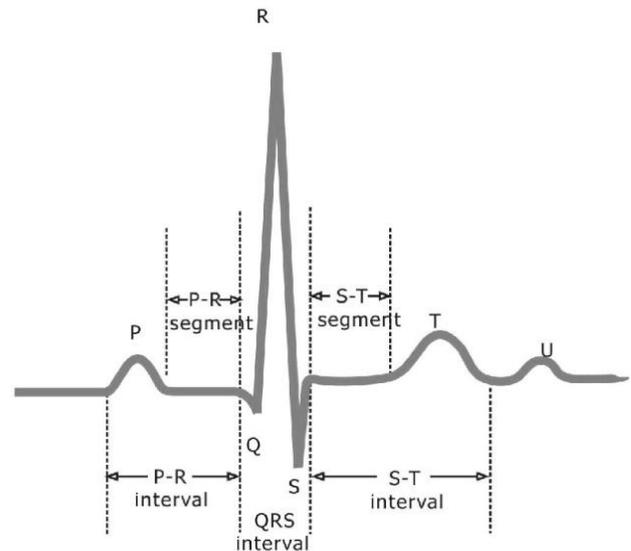


Fig.1 Typical ECG Signal.

## II. DETERMINATION OF SAO<sub>2</sub>

### Important Terminologies

1) Heart Rate (HR): Number of times our heart beats per minute. The normal heart rate of a normal healthy adult person/human is around 70-72 beats/min.

Cardiac Output (CO): The amount of blood the heart delivers through the circulatory system in a minute. If the average heart rate is 70-72 per minute then cardiac output is 5Lpm. This will increase during the workouts.

2) Stroke volume (SV): The amount of blood delivered by every shrinkage of the ventricles is the stroke volume. Stroke volume is increased when the escalated blood supply is required to meet requirements of the sufficient oxygen and nutrients.

3) SAO<sub>2</sub>: Oxygen saturation is the ratio of cumulative effects of concentration of oxyhemoglobin and concentration of haemoglobin to the concentration of oxyhaemoglobin

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2.2. Mathematical Calculations

$$VO_2 = SV * HR \tag{1}$$

$$CO = SV * HR \tag{2}$$

Where

SV → Stroke Volume in ml

HR → Heart Rate in beats/min

PR → Pulse Rate in beats/min

CO → Cardiac Output in lit/minute

Comparing equation [1] & [2], we get

$$VO_2 \Rightarrow CO \tag{3}$$

Taking the HR as 72 beats/min as a standard value, the value of CO will be 5lit/min.

So for ‘X’ pulses (condition during heart irregularity) we can determine the value of CO as,

$$VO_2 = X * (5 \div 72) \tag{4}$$

$$CO = X * (5 \div 72) \tag{5}$$

Similarly, Considering the normal HR as 72 beats/min the SAO2 is 100%. So for ‘X’ heart beats (diseased condition) we can determine the SAO2 by

$$SAO_2 \Rightarrow X * (100 \div 72) \tag{6}$$

The above equation can still be made more accurate. If a surgery is anticipated for any patient, then the heart rate (HR) and oxygen saturation (SAO2<sub>normal</sub>) has to be measured. Hence Equation [6] can be modified as shown below.

$$SAO_2 \Rightarrow X * (SAO_{2normal} \div HR) \tag{7}$$

Hence SAO2 can be studied using Equation [7]

3. LabVIEW based determination of SAO2

The basic block diagram representing acquisition of ECG signal is given in Figure 2



Fig.2 Acquisition of ECG Signal

3.1 Electrodes:

Various types of “ECG electrodes” are available in market, but the most simplest and common one is Surface electrodes which is been used in this project. The electrodes will sense the bio potentials from the body. These signals are amplified by the amplifier so that the signals are measurable

3.2 Data Acquisition Module:

The National Instruments USB-6211 is a multifunction data acquisition (DAQ) module which is bus powered and with high sampling rates. It handles 16 analog inputs; 250 kS/s single-channel sampling rate; two analog outputs; four

digital input lines; four digital output lines; four programmable input ranges (±0.2 to ±10 V) per channel; digital triggering; and two counter/timers. The NI USB-6211 is used for mobile applications. Plug-and-play installation reduces the installation and configuration time. Connection through direct screw-terminal reduces the costs and simplifies connections of the signal. This product does not require external power

3.3 LabVIEW:

LabVIEW (short for Laboratory Virtual Instrument Engineering Workbench) is a system-design platform and development environment for a visual programming language from National Instruments. The acquired ECG signal is fed into the system which supports LabVIEW 11.0 software to proceed with the display of the signal and further mathematical calculations. NI-DAQmx driver is installed. It provides measurement services software. The signal processing is done using Biomedical tool kit and Advanced signal processing toolkit.

3.4 Block Diagram:

The ECG signals are simulated by using the LabVIEW measurement file. One - dimensional data can be expressed with the LabVIEW Measurement (.lvm) format. The unfiltered ECG signals are filtered using the Notch filter, Bandpass filter and Wavelet denoise Express VI’s. The Heart rate is obtained by further calculations and transformations. The Oxygen saturation is calculated using the equation [6]. The assumed values of normal Heart rate and Oxygen saturation is substituted in Equation [7] to measure the SAO2 value. The Block diagram is shown below

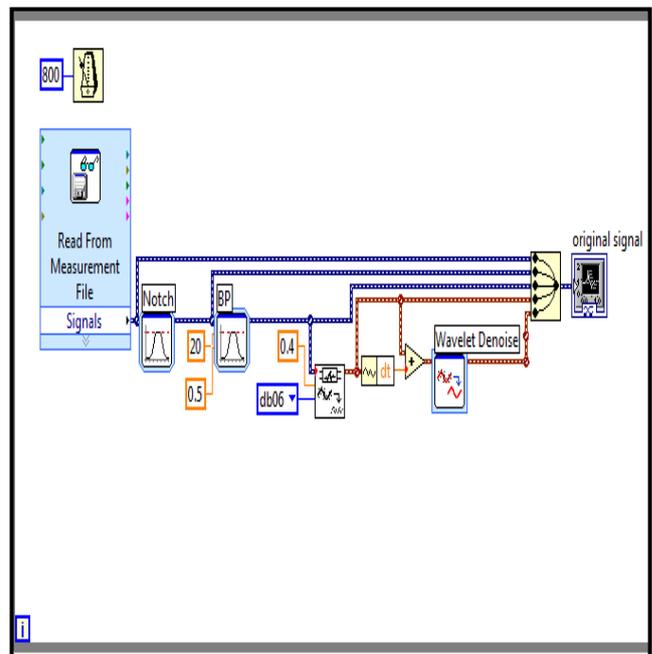


Fig 3. Reading ECG Signal data from the measurement file

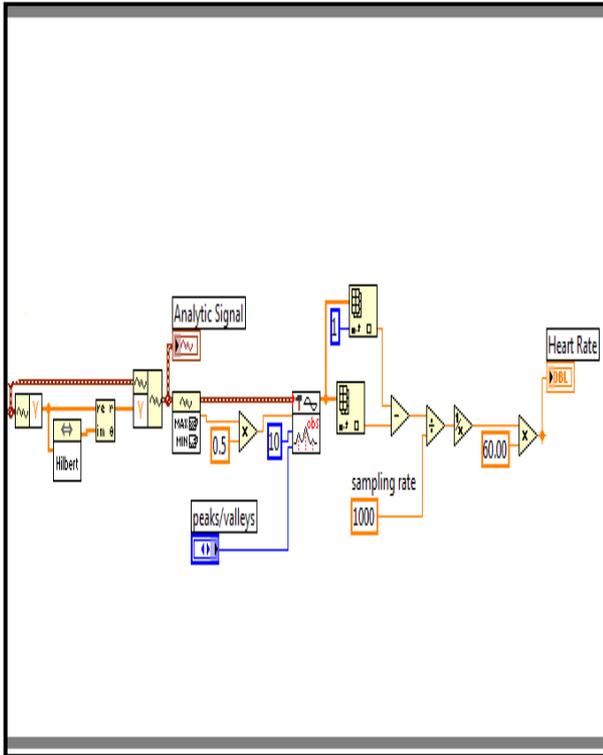


Fig4. Determination of Heart rate

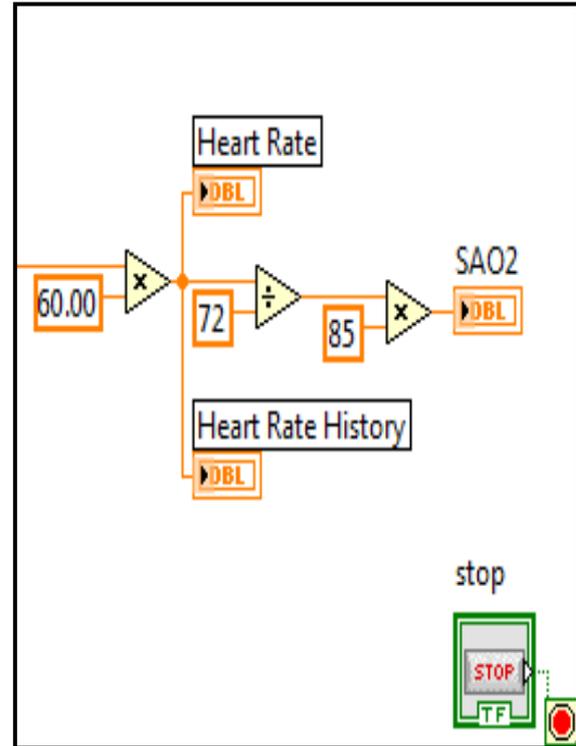


Fig 5. Block diagram of VI

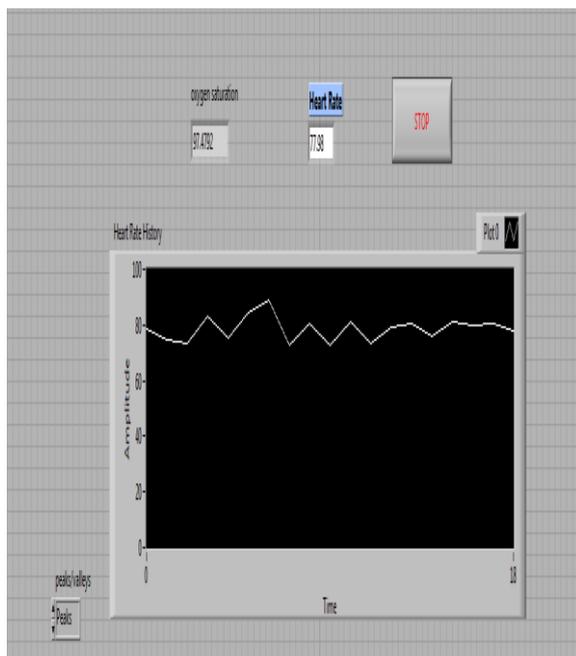


Fig 4. Front panel of VI showing the values of Heart rate and SAO2

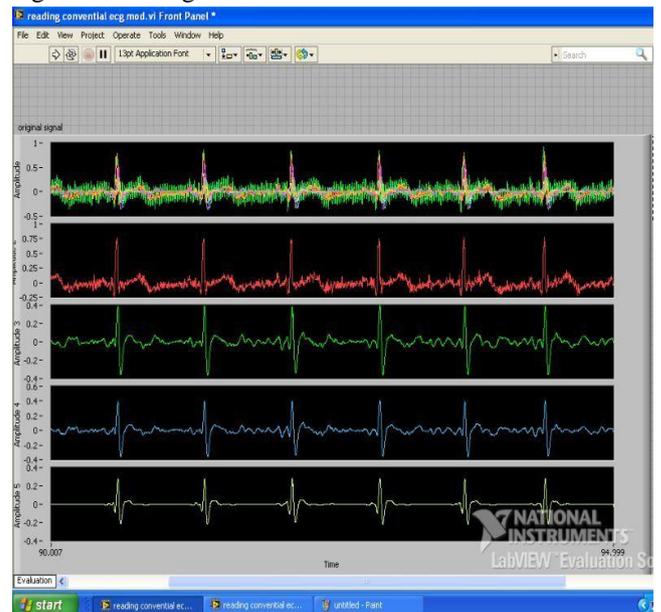


Fig 6 Front panel of VI showing ECG signal

The Front panel shows the filtered ECG signals. Every stage of filtering is shown in the merged graph. The continuous numeric display of the Heart beat rate per minute and Oxygen Saturation is also shown.

### VIII. CONCLUSION

Thus a detailed process of LabVIEW based acquisition of ECG signal and measuring the amount of SAO2 from ECG has been discussed in this paper. Apart from determining SAO2, Heart rate, Cardiac Output, Volume of oxygen uptake and saturation pressure of oxygen can be determined

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