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ACTIVITY BASED NON INVASIVE ASSESSMENT OF BLOOD FLOW LEVEL IN HEALTHY VOLUNTEERS USING IMPEDANCE PLETHYSMOGRAPHY

Mr.M.Ramkumar[1] Dr.C.GaneshBabu[2] Dr.R.Hari Kumar [3], Ms.K.SakthiPraneetha[4]
Assistant Professor [1]Sri Krishna College of Engineering and Technology, Coimbatore
Professor[2, 3], Bannari Amman Institute of Technology, Sathyamangalam
P.G Scholar [4]Sri Krishna College of Engineering and Technology, Coimbatore
ramcom09@gmail.com [1], bits_babu@yahoo.co.in [2], harikumarrajaguru@gmail.com [3], ksakthipranee@gmail.com [4]

Abstract— The project is mainly determined on the activity based measurement of the blood flow in humans. The objective of the project is to measure the blood flow in human limbs and to study the blood flow characteristics using an innovative methodology called Impedance plethysmography. It is otherwise called as impedance test or blood flow. It is the non-invasive process which uses monitoring of electrical signal in the form of resistance or change of impedance to measure blood flow in nerves (veins) of the leg. In a real time medical applications based on the test doctors used to detect deep vein thrombosis. Using conductive paste, the examiner strategically places two or four electrodes on the patient's calf. These electrodes are used to measure the impedance of the body and it is amplified. It is used to detect blood clots present in the nerves (veins) of the leg. Screened patients who have blood that is clotted in the leg, it leads to the detection of the source of clots in the lungs i.e., pulmonary emboli. It measures the blood volume changes in the human physiology which is used to detect the cardiovascular problems in the human. Initially the hardware implementation is made (i.e.) the circuit is constructed in a bread board and then the output is checked. Secondly, the circuit is simulated in MULTISIM software and then the output is measured. Finally, signal conditioning is made in Lab VIEW software and the output is measured. This output is checked with the help of NI ELVIS kit. In the third part, the signal conditioning device is made processed with the S12x microcontroller and the output is measured. Later the performance analysis is made by comparing the outputs from the three methods. Then the results are taken based on similarities of the mentioned methods.

Keywords— Non-invasive, Cardiovascular,plethysmography, Vein thrombosis, Thrombophlebitis

1. INTRODUCTION

In earlier days, External transducers were used for various measurements but at times instead of an external transducer, the living system itself can be made to modify an externally applied electrical signal. For such measurement, the living system may be termed as an active transducer [1]. The basic principle underlying the Plethysmography measurements are that the impedance of the body segments under study changes during respiration and cardiac activity.

Fundamental principles underlying the study of cardiovascular physiology can be determined by measuring the flow of blood and also to measure the resistance offered by the body and in turn we can also make an estimation of the diabetes level, which is the major contribution from our project.

Measurement of blood flow gives important information regarding the function of blood circulation and regulation of blood circulation. Blood flow is dependent on the varying resistance (R) [2]. Thus, the measurements of blood flow can determine the changes in heart beat rate. Even though in certain circumstances regional flow of blood might change independently of any changes in the cardiac output.

These physiological changes are resulted by the variety of stresses, including physical exercises, Dehydration etc. In this project we convert this into a function of resistance and deduce the other parameters that are essential for the measurement of blood flow [3] [1]. This Resistance undergoes minute changes when blood flow within the body changes. All these measurement are taken from a number of people and then we relate it to their corresponding body weights and physique, if the values are not found to be optimum then the patient is found to be having diabetes or not.

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2. EXISTING METHODS

The problem addressed in this communication concerns the availability of an appropriate instrument for non-invasive measurement of blood flow in human limbs [3]. The most common method used for determination of blood flow in humans is venous occlusion plethysmography, a technique used by physiologists for close to a century [7]. This method is an invasive method herein a dye is being introduced into the veins. This dye is tracked and blood flow is being monitored. Modern venography methods use electronic devices and monitors for the tracking of blood flow. Early plethysmography consisted of either or air-filled compartments in which the limb segment was sealed. These devices also have their respective advantages and disadvantages [8].

Changes in air volume are influenced by body temperature, therefore requiring a correction factor to enable accurate volume determination. The accuracy in blood flow measurements yielded by water plethysmograph and strain gauge plethysmograph is, however, not quantitatively different because air-filled plethysmograph may also be used to examine the influence of temperature perturbation on blood flow, we chose to explore this method in the present communication [3] [1].

Air-filled plethysmograph was traditionally constructed from glass or brass and other metals to form either conical or boxed-shaped designs. By use of these materials, some of which are no longer appropriate, the Air-filled plethysmograph would prove difficult to manufacture in great numbers [11].

A. Constraints in the Existing Methods

The venography method is an invasive method wherein it is inappropriate to be used for blood flow measurements among infants, aged people and weaker patients as this method needs to tear the vein [10]. Another major disadvantage is that this method needs good electronic infrastructure for and this adds up to the complexity. In the air filled plethysmography changes in air volume are influenced by body temperature, therefore requiring a correction factor to enable accurate volume determination [12].

Hence the accuracy is a major constrain here, but often we end up in circumstances where we need precise values. Firstly, PWA is determined by a number of hemodynamic factors including arterial inflow, venous outflow, cardiac stroke volume, venous return to the heart as well as alterations of autonomic neural control.

Finally, the agreement between baseline digital blood flow and PWA has been reported to vary to a great extent between Subjects [10].

Therefore, only within-subject changes in PWA during a limited time interval were evaluated in the current study In order to overcome these problems we developed a new methodology called Impedance Plethysmography – Blood Flow Measurement at Foot.

3. IMPEDANCE PLETHYSMOGRAPHY

Impedance plethysmography, also called impedance test or blood flow or impedance phlebography, is a non-invasive test that uses electrical monitoring in the form of resistance (impedance) changes to measure blood flow in veins of the leg. Information from this test helps doctors detect deep vein thrombosis (blood clots or Thrombophlebitis).

A. Description

Using conductive jelly, the examiner strategically places four electrodes on the patient's calf (the four-electrode configuration yields a more uniform and precise current density and consequent measurement result). These electrodes are connected to an instrument called a plethysmography, which records the changes in electrical resistance that occur during the test and produces a graph of the results.

The patient must lie down and raise one leg at 30 degree angle so that calf is above the level of the heart. The examiner then wraps a pressure cuff around the patient's thigh and inflates it to a pressure of 45-60 cm of water for 45 seconds. The plethysmograph records the electrical impedance that corresponds to change in the volume of blood in the vein at the time the pressure is exerted and again three seconds after the cuff is deflated.

This procedure is repeated several times in both legs. This test takes 30-45 minutes, costs an estimated $50-$100, and results can be available within a few minutes. Impedance plethysmography works by measuring the resistance to the transmission of electrical energy (impedance). This resistance is dependent upon the volume of blood flowing through the veins. By graphing the impedance, the doctor or technician can tell whether a clot is obstructing blood flow. In the first stage the voltage is measured with the help of an impedance circuitry and later it is replaced with electrodes and the voltage is measured.

Patients undergoing this test do not need to alter their diet, change their normal activities, or stop taking any medications. The patient may resume normal or postoperative activities after the test.

This method is very much helpful for biomedical purposes, because Plethysmography techniques do not necessitate any surgical work. This process is used in measuring the flow of blood for the infants or in new born because it is a non-surgical method and cause no pain, no blood loss [2] [3].

This method has advantage over the measurement of the lung volume changes and estimation of stroke volume changes in the aged peoples. The advantage is due to non-surgical method which will not cause any strain for the aged people [1] [3]. This is used to indicate the presence or the absence of venous thrombosis. It is an alternative to the venography method. This method is very convenient and easy to use.

4. BLOCK DIAGRAM

A. Lab VIEW Signal Processing device

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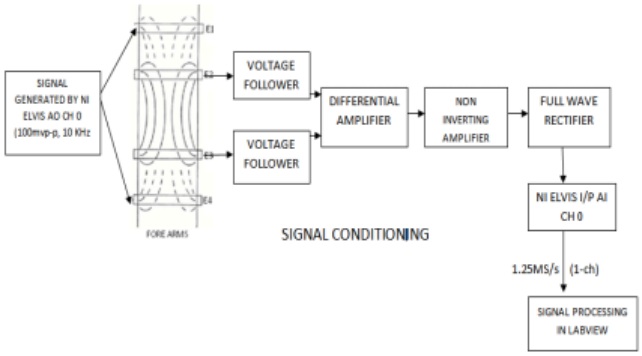

Figure 1. Block Diagram of Lab VIEW signal processing device

B. S12x Signal Processing device

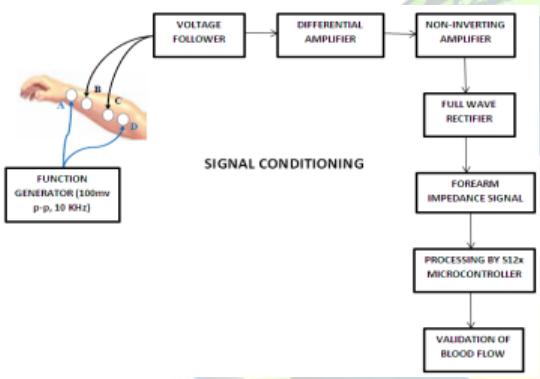

Figure 2. Block Diagram of S12x signal processing device

The interface between the hardware circuit and The Lab VIEW is made with the help of NI ELVIS. The NI ELVIS features are explained in the section 6.4. In the hardware implementation circuit, the first and forth electrode are connected to the analog output of the channel 0 with 100mv p-p and 10 KHz. The second and third electrodes are connected to the Voltage follower circuit followed by differential amplifier, non-inverting amplifier, and full wave rectifier.

The output of Full Wave Rectifier is connected to the NI ELVIS analog input channel 0. The signal conditioning is done in Lab VIEW. The Figure 6.1 explains the entire hardware interface block diagram with Lab VIEW.

The DAQ (Data Acquisition) device is used in the signal processing. The data is acquired in the form of voltage and the processing is made. The amplification process and the processing of the signal after acquiring are together represented as the signal conditioning. The peak amplitude is calculated from the Lab VIEW output and the blood flow is evaluated.

Finally the output of the signal conditioning device is given to the analog to digital convertor port of the controller board in the S12x microcontroller. The processing is made in the S12x microcontroller and the processed output is displayed in LCD. Finally the blood flow is evaluated.

C .The Non-inverting Op Amp

The non-inverting op amp has the input signal connected to its non-inverting input, thus its input source sees infinite impedance. There is no input offset voltage because VOS = VE = 0, hence the negative input must be at the same voltage as the positive input. The op amp output drives current into RF until the negative input is at the voltage, VIN. This action causes VIN to appear across RG.

The voltage divider rule is used to calculate VIN; VOUT is the input to the voltage divider, and VIN is the output of the voltage divider. Equation (1) is written with the aid of the voltage divider rule, and algebraic manipulation yields Equation (2) in the form of a gain parameter. When RG becomes very large with respect RF, (RF/RG) ⇒0 equation (1) reduces to equation (2).

$$V_{in} = V_{out}\frac{R_G}{R_G + R_F} \quad (1)$$

$$\frac{V_{out}}{V_{in}} = \frac{R_G + R_F}{R_G} = 1 + \frac{R_F}{R_G} \quad (2)$$

Under these conditions VOUT = 1 and the circuit becomes a unity gain buffer. RG is usually deleted to achieve the same results, and when RG is deleted, RF can also be deleted (RF must be shorted when it is deleted). When RF and RG are deleted, the op amp output is connected to its inverting input with a wire. Some op amps are self-destructive when RF is left out of the circuit, so RF is used in many buffer designs. When RF is included in a buffer circuit, its function is to protect the inverting input from an over voltage to limit the current through the input ESD (electro-static discharge) structure (typically < 1 mA), and it can have almost any value (20 k is often used). RF can never be left out of the circuit in a current feedback amplifier design because RF determines stability in current feedback amplifiers. Notice that the gain is only a function of the feedback and gain resistors; therefore the feedback has accomplished its function of making the gain independent of the op amp parameters. The gain is adjusted by varying the ratio of the resistors. The actual resistor values are determined by the impedance levels that the designer wants to establish. If RF = 10 k and RG = 10k the gain is two as shown in Equation 2, and if RF = 100 k and RG = 100 k the gain is still two. The impedance levels of 10 k or 100 k determine the current drain, the effect of stray capacitance, and a few other points. The impedance level does not set the gain; the ratio of RF/RG does.

D.Voltage follower with Differential Amplifier

The differential amplifier circuit amplifies the difference between signals applied to the inputs. Superposition is used to calculate the output voltage resulting from each input voltage, and then the two output voltages are added to arrive at the final output voltage. Op amp input voltage resulting from the input source, V_1, is calculated in Equations. The voltage divider rule is used to

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calculate the voltage, V_+, and the non-inverting gain equation is used to calculate the non-inverting output voltage, $V_{OUT}1$.

$$V_+ = V_1 \frac{R_2}{R_1 + R_2} \quad (3)$$

$$V_{out1} = V_+(G_+) = V_1 \frac{R_2}{R_1 + R_2}\left(\frac{R_3 + R_4}{R_3}\right) \quad (4)$$

The inverting gain equation is used to calculate the stage gain for VOUT2 in Equation. These inverting and non-inverting gains are added in Equation.

$$V_{out2} = V_2 \left(\frac{R_4}{R_3}\right) \quad (5)$$

$$V_{out} = V_1 \frac{R_2}{R_1 + R_2}\left(\frac{R_3 + R_4}{R_3}\right) - V_2 \frac{R_4}{R_3} \quad (6)$$

It is now obvious that the differential signal, $(V_1 - V_2)$, is multiplied by the stage gain, so the name differential amplifier suits the circuit. Because it only amplifies the differential portion of the input signal, it rejects the common-mode portion of the input signal. A common-mode signal is illustrated in Figure.

Because the differential amplifier strips off or rejects the common-mode signal, this circuit configuration is often employed to strip dc or injected common-mode noise off a signal.

The disadvantage of this circuit is that the two input impedances cannot be matched when it functions as a differential amplifier, thus there are two and three op amp versions of this circuit specially designed for high performance applications requiring matched input impedances.

E.The Full Wave Rectifier

The first building block in the dc power supply is the full wave rectifier. The purpose of the full wave rectifier (FWR) is to create a rectified ac output from a sinusoidal ac input signal. It does this by using the nonlinear conductivity characteristics of diodes to direct the path of the current. If we consider a simple, piece-wise linear model for the diode IV curve, the diode forward current is zero until Bias >= $V_{threshold}$, where $V_{threshold}$ is 0.6 V to 0.8 V. The current increases abruptly as V_{bias} increases further. Due to this turn-on or threshold Voltage associated with the diode in forward bias, we should expect a 0.6 to 0.8 V voltage drop across each forward biased diode in the rectifier bridge. In the case of the full wave rectifier diode bridge, there are two forward biased diodes in series with the load in each half cycle of the input signal. The maximum output voltage (across load) will be V_{in} - 2 $V_{threshold}$, or ~ Vin - 1.4 V. Since some current does flow for voltage bias below $V_{threshold}$and the current rise around is $V_{threshold}$is more gradual than the piece-wise model, the actual diode performance will differ from the simple model. In reverse bias (and neglecting reverse voltage breakdown), the current through the diode is approximately the reverse saturation current, Io. The voltage across the load during reverse bias will be V_{out} = Io R_{load}. In specifying a diode for use in a circuit, you must take care that the limits for forward and reverse voltage and current are not exceeded.

5. HARDWARE DESCRIPTION

The potential of the Ag/Agcl electrode is determined by the silver-ion activity in solution, which is inversely related to chloride activity through the solubility product. Any additional ion present in sufficient concentration to form an insoluble silver salt, such as may be found in solutions of biological origin, will contribute to the resultant potential. In Figure 1, the four electrodes (Ag/Agcl) are placed on the surface of the body (either on the surface of foot or hand).The first and fourth electrode is connected to function generator which acts as the current source. The function generator is set with 10KHZ frequency and 100 mill volt peak to peak. From the second and third electrode the input is generated and it is given to the voltage follower. Then the signal is amplified followed by Differential amplifier, Non Inverting amplifier and Full Wave Rectifier. Finally the output voltage is measured in CRO.

A.Description of NI ELVIS:

NI ELVIS is NI Educational Laboratory Virtual Instrumentation Suite. The NI ELVIS Traditional software, created in Lab VIEW, takes advantage of the capabilities of virtual instrumentation. Christo Ananth et al. [24] discussed about an eye blinking sensor. Nowadays heart attack patients are increasing day by day."Though it is tough to save the heart attack patients, we can increase the statistics of saving the life of patients & the life of others whom they are responsible for. The main design of this project is to track the heart attack of patients who are suffering from any attacks during driving and send them a medical need & thereby to stop the vehicle to ensure that the persons along them are safe from accident. Here, an eye blinking sensor is used to sense the blinking of the eye. spO2 sensor checks the pulse rate of the patient. Both are connected to micro controller.If eye blinking gets stopped then the signal is sent to the controller to make an alarm through the buffer. If spO2 sensor senses a variation in pulse or low oxygen content in blood, it may results in heart failure and therefore the controller stops the motor of the vehicle. Then Tarang F4 transmitter is used to send the vehicle number & the mobile number of the patient to a nearest medical station within 25 km for medical aid. The pulse rate monitored via LCD .The Tarang F4 receiver receives the signal and passes through controller and the number gets displayed in the LCD screen and an alarm is produced through a buzzer as soon the signal is received.DAQ device functions are routed directly to the prototyping board. The functions are Analog input, analog output, Counter I/O.

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B.Description of S12x Microcontroller

The MC9S12XD-Family is composed of standard on-chip peripherals including up to 512 Kbytes of Flash EEPROM, 32 Kbytes of RAM, 4 Kbytes of EEPROM, six asynchronous serial communications interfaces (SCI), three serial peripheral interfaces (SPI), an 8-channel IC/OC enhanced capture timer, an 8-channel,10-bit analog-to-digital converter, a 16-channel, 10-bit analog-to-digital converter, an 8-channel pulse-width modulator (PWM), five CAN 2.0 A, B software compatible modules (MSCAN12), two inter-IC bus blocks, and a periodic interrupt timer.

The MC9S12XD-Family has full 16-bit data paths throughout. The non-multiplexed expanded bus interface available on the 144-pin versions allows an easy interface to external memories.

The features include HCS12X Core, XGATE (peripheral coprocessor), PIT (periodic interrupt timer), CRG (clock and reset generator), Port H & Port J with interrupt functionality.

6. RESULTS AND DISCUSSIONS

A.TABULATION OF BLOOD FLOW

Table1: Analysis of Impedance Meter Error

Impedance (ohms)	*Calculated Amplifier O/P V_1(Volts)*	*Measured Value O/P V_2(Volts)*	*% of Error $((V_1-V_2)/V_1)x100$*	*Blood flow ΔV ml*
10	0.221	0.23	-4.07	3.56
13	0.31	0.30	3.22	4.64
15	0.442	0.34	23.07	5.26
20	0.4862	0.45	7.45	6.96
22	0.553	0.50	9.58	7.73
25	0.663	0.56	15.5	8.66
30	0.729	0.66	12.9	10.21
33	0.862	0.732	15.08	11.33
39	0.862	0.866	-0.46	13.36
44	0.972	0.98	-0.82	15.15
56	1.23	1.28	-4.06	19.79
69	1.518	1.50	1.18	23.15
76	1.672	1.68	-0.47	25.97
88	1.96	1.98	-1.02	30.60
99	2.17	2.19	-0.92	33.85
100	2.27	2.31	-1.76	35.70
120	2.39	2.45	-2.51	37.87
156	2.52	2.56	-1.58	39.57
160	2.63	2.69	-2.28	41.58
220	2.76	2.29	-1.08	35.39

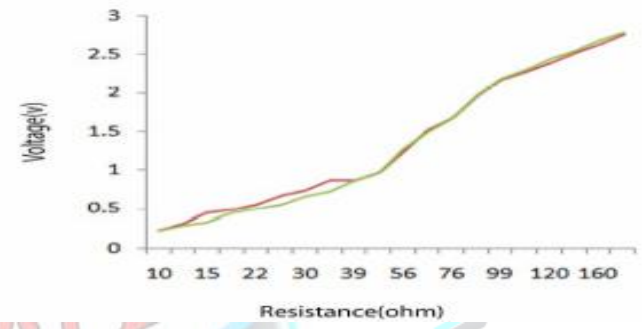
$$\Delta v = \frac{\rho L^2}{Z^2}\Delta z \qquad (7)$$

B.Data Analysis

Normally, inflating the pressure cuff will cause a sharp rise in the pressure in the calf because blood flow is blocked. When the cuff is released, the pressure decreased rapidly as the blood flows away.

If a clot is present; the pressure in the calf veins will already be high. It does not become sharply higher when the pressure cuff is tightened. When the pressure cuff is deflated, the clot blocks the flow of blood out of the calf vein.

The decrease in pressure is not as rapid as when no clot is present and the shape of the resulting graph is different, all of which is indicative of obstruction of major deep veins.



Graph 1: Response of Impedance Meter for various simulated Resistance Values

This Graph is plotted with resistance in x-axis and Voltage in Y-axis. This Graph is Plotted based on the above tabulated readings w.r.t the impedance in ohms and Calculated amplifier outputs V1 and V2. Figure 2 shows the Response of Impedance Meter for various simulated Resistance Values. This Graph 1 shows the nonlinearity in the resistance region of 30 ohms to 100 ohms. based on the above tabulated readings blood flow may be a turbulent one than a linear nature for standard atmospheric pressure.

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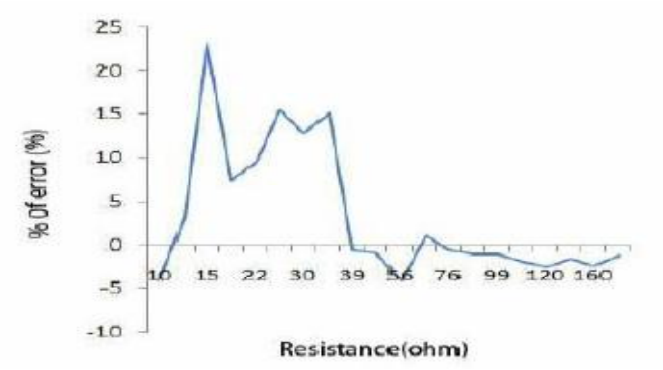

Graph 2: Error Plot for Simulated and Measured Resistance

Graph 3 is depicted the error Plot for Simulated and Measured Resistance. From the graph 3 it is also observed that more prominent error is in the measurable flow region. Hence a non-linear artificial intelligence based method is to predict the blood flow in the peripheral region of the body. The Graph is plotted with resistance in x-axis and % of error in Y-axis. The

Graph is Plotted based on the above tabulated readings w.r.t the impedance in ohms and % of error.

C.Multisim Scenario

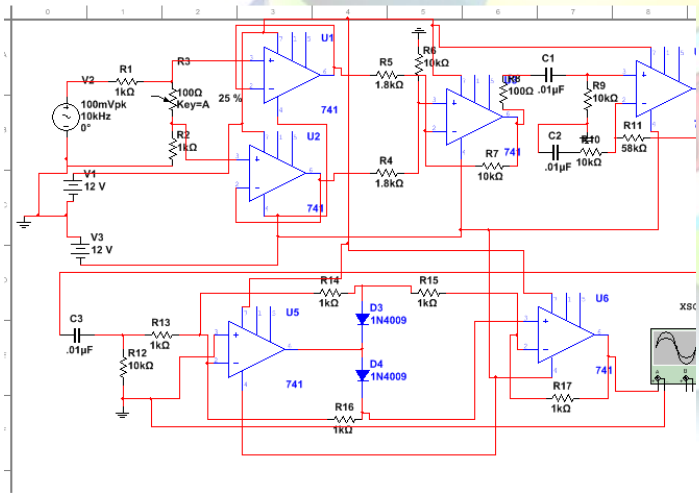

Figure3. Multisim simulation window

The blocks such as Impedance circuit, Voltage follower, Differential amplifier, Non Inverting amplifier and Full wave rectifier has been constructed and it is simulated with the help of MULTISIM. The simulated results are obtained based on the values of voltage and resistance. The Figure 5.2 represents the simulation window of Multisim.

D.Lab VIEW VI block diagram

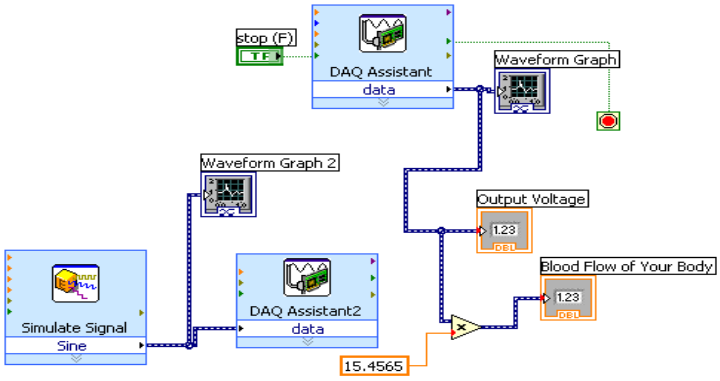

Figure 4. Lab VIEW VI Block Diagram

Figure 4 represents the Lab VIEW Virtual Instrumentation Block Diagram. Here the Assistants for signal processing are available. The VI for signal measurement and analysis using Assistants is represented in the Figure 3. The DAQ Assistant data is constructed along with the graphs. The acquired signal is in the form of voltage and it is given to the multiplier which is multiplied with the constant value of 15.4565. The output results in the blood flow measurement of the body.

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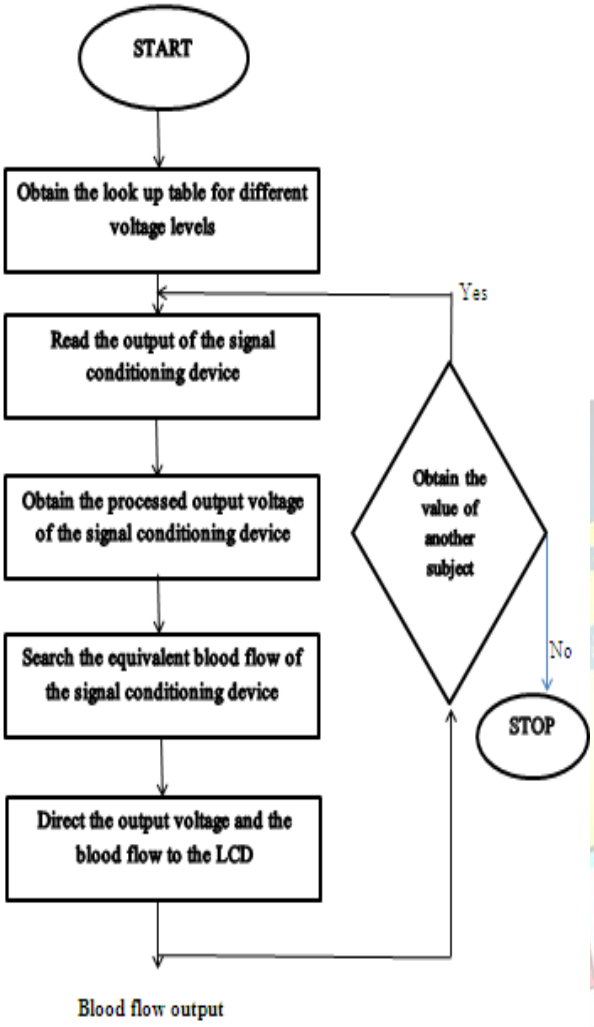

Figure 5. Flow chart for application programming calibration

The application programming calibration flow chart is represented in figure 5. By using S12x microcontroller the look up table has been created in which the voltage can be obtained from the subjects and the blood flow is calculated.

E.Lab VIEW SIMULATION

1.Normal measurement

The software is very much useful for processing the data and to create an interface with the sensors. The indicators are very much useful. It is used to create a database. A blood flow is measured for a normal person and the output window is represented in Figure 6.

After several minutes an activity based measurement of blood flow is carried out i.e. a person is allowed to run for few distance and the blood flow is measured. The output window is represented in the Figure 7.

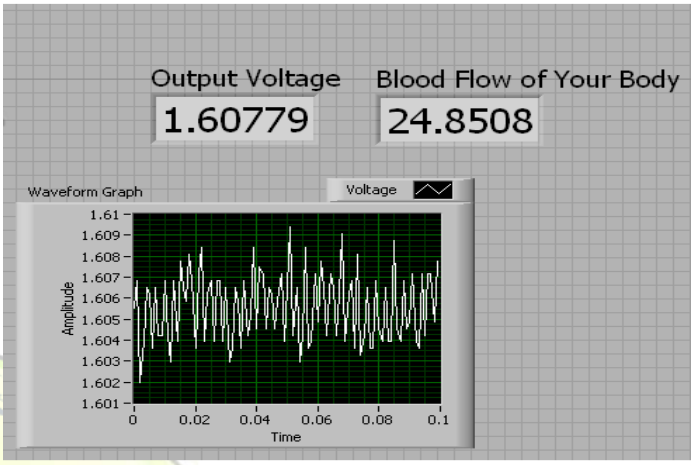

Figure 6. Normal measurement of blood flow

2.An activity based measurement

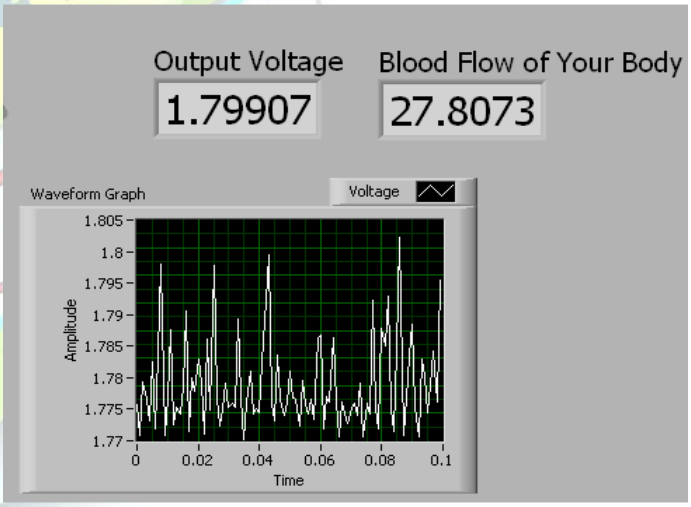

Figure 7. Activity based measurement of blood flow

For a person the blood flow is measured in two cases. One is the normal measurement and the other is the activity based measurement.

The output voltage for the normal measurement is 1.60779V. The output voltage for the activity based measurement is 1.79907V. The correspondent blood flow measurement is made.

F.TABULATION OF BLOOD FLOW BASED ON ACTIVITIES FOR 18 SUBJECTS

Table 2: Effect of physical factors on various measurements

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Normal Measurement (volts)	*Activity based measurement(volts)*				
	Dehydration	**Breathe hold**	**Physical exercise**	**Cool skin**	**Warm skin**
1.36	1.32	1.84	1.33	1.38	1.30
1.39	1.36	1.89	1.36	1.43	1.32
1.42	1.38	1.90	1.39	1.48	1.34
1.52	1.42	1.92	1.44	1.52	1.46
1.58	1.44	1.96	1.46	1.58	1.48
1.63	1.50	1.99	1.50	1.62	1.55
1.68	1.53	2.03	1.52	1.69	1.59
1.72	1.58	2.08	1.57	1.73	1.63
1.74	1.63	2.10	1.60	1.79	1.68
1.79	1.65	2.15	1.64	1.82	1.73
1.83	1.72	2.20	1.69	1.87	1.78
1.92	1.79	2.24	1.73	1.99	1.82
2.18	1.83	2.39	1.76	2.21	1.88
2.24	1.92	2.48	1.84	2.25	1.95
2.35	1.94	2.53	1.89	2.33	1.96
2.39	2.06	2.62	1.93	2.38	2.05
2.42	2.14	2.68	1.99	2.46	2.11
2.45	2.16	2.72	2.01	2.48	2.10

The blood flow for 18 subjects has been measured both in the normal conditions and the activity based conditions. The various activities carried out for the measurement are Dehydration, 30 second breathe hold manuver, Physical exercise, cool skin and warm skin. Based on the voltage obtained from the above mentioned activities the blood flow is determined.

The signal conditioning device is interfaced with the S12x microcontroller and the values are obtained. The experimental analysis is done for 18 subjects with an average age of 22.1±0.9 years, an average height of 174.1±3.3 cm, an average weight of 72.6±9.8 kg and an average heart rate of 79.6±12.2(from 60 to 95) beats per minute.

On the analysis of resistivity the activity of dehydration varies by 60±2 ohms, 30 second breathe hold manuver varies by 82±3 ohms, Physical exercise varies by 58±2 ohms, cool skin varies by 64±3 ohms and warm skin varies by 59±3 ohms from the normal measurement of 69±3 ohms.

On the analysis from Lab VIEW the determination of the voltage is based on the maximum amplitude in the series of cycles. When the voltage and the blood flow is measured from the S12x microcontroller it linearly correlates with the value analysed from the Lab VIEW software.

The Impedance plethysmography method involves the measurement of the electrical parameters of the body and then this value is directly transduced into an equivalent desired value as per our requirements thus the accuracy of the measurement is high. Using water as a medium for displacement lends itself to studies concerned with temperature perturbation that are more difficult to conduct using mercury strain gauge plethysmography or air plethysmography. One example of such a study is to examine the influence of local temperature changes on predominantly skin blood flow in different body positions. The technique of limb plethysmography has many more applications for both research and teaching. The instrument proves to be robust, accurate, and inexpensive to manufacture in numbers with the assistance of a standard University workshop. Students evaluated use of the plethysmograph positively as an aid to learning.

There are limitations to all experimental techniques and the one presented here is no exception. The main limitation of our simple plethysmograph design is lack of a mechanism to control water temperature, which is known to influence forearm blood flow measurement. Other investigators have built plethysmography complete with an external water bath into which cold or warm water is added without affecting the volume of water in the plethysmograph. This design would, however, complicate the construction procedure tremendously and make it difficult to produce the device in any great numbers.

7.Conclusion

Measurement of compartmental blood flow by finger plethysmography provides a tool for continuous non-invasive assessment of changes in digital blood flow. This project is an alternative way to measure the blood flows in a very accurate manner and it is less expensive. This method will be robust and accurate. This simple plethysmograph design is an alternative to other commercially available equipment. Thus we made a hardware design by placing the electrodes (Ag/Agcl) on our body surface (either foot or hand surface) and the change in output voltage is checked with various persons. It gets varied according to the age of person and it is determined on the basis of rate of blood flow. The variations in the blood flow can be analysed based on various activities such as (walking, running, sleeping etc). Finally the value of change in voltage is converted to blood flow in ml with respect to length of the vein (e.g. 3ml for 5cm). Thus the results are analysed from hardware design implementation. Later it is analysed with the help of Multisim software and the voltages are obtained for the respective resistances. The signal conditioning device is interfaced with the Lab VIEW software and the maximum amplitude is obtained from the series of cycles. It gets varied based on the breathing activity. Later the signal conditioning device is interfaced with the S12x free scale microcontroller and the signal processing is made in it i.e., analog to digital conversion is made and the signal is processed in which the processed value of output voltage and the blood flow is displayed in the LCD. The normal and the various activity based measurements are made and the results are analysed. The results i.e., the maximum amplitude obtained from the Lab VIEW software and the results are linearly correlated with the values obtained from the S12x microcontroller. Thus on

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the real time platform the blood flow can be measured and analysed with the less complexity electronic device.

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