Design And Development of Medical Sensors for a Portable Device

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Abstract— The work presented in this paper is to design and integration of medical sensors in a portable device. Mostly conventional methods are used to calculate haemoglobin and blood glucose level. These methods involve pricking of blood with needle and sending it to laboratory for further analysis. This process involves delay in getting results. So for the purpose of convenient diagnosis we have proposed a device which will detect the different diseases of human body like Hypertension, Diabetes and Anaemia on the spot. All the sensors are integrated with single microcontroller pic16f877a and the results are displayed on the LCD.

Keywords—*Blood Pressure Monitor, Blood Glucose Monitor, PPG Sensor, Microcontroller,LCD.*

I. INTRODUCTION

Blood pressure is the pressure exerted by flowing blood on the blood vessel walls. Blood pressure is usually expressed as the systolic (maximum) over diastolic (minimum) and the pressure is measured in millimetres of mercury (mm hg). Pulse rate is also sensed during systolic pressure. Haemoglobin is the protein in red blood cells that carry oxygen to the body. Low level of haemoglobin can be due to disease like anemia and high haemoglobin level may be due to polycythemia Vera. The level of sugar concentration in blood or glucose in the blood is the amount of glucose in the blood of a human being. The body naturally closely regulates glucose level in the blood as part of the metabolic homeostasis. With few exceptions, glucose is the main energy source for the cells of the body, and blood lipids are primarily a compact energy store.

Sensor is a device that responds to a physical stimulus (as heat, light, sound, pressure, or a particular motion) and transmits a resulting impulse. Particularly medical sensor responds to biological elements like enzymes, tissues, antibodies, microorganisms etc. and transmits resulting impulse to physiological detector. Detection procedure involves transducers or the detector element which transforms the signal resulting from the interaction of an analyte with the biological element into another signal that can be more easily measured or quantified.

II. THEORY OF DIGIATL BLOOD PRESSURE MONITOR

At present, oscillometric method is used to calculate the value of blood pressure by most of electron sphygmomanometer, the principle of this method is to record the pulse wave and pressure. It needs cuff to block the blood flow and detects the wave of gas pressure in the process of deflating the gas. The oscillatory wave ripple component that is continuously recorded in the process makes the envelope of the parabolic line approximation. The key point of the oscillometric method is to find out the envelope of the pulse wave and its relationship with arterial blood pressure. The pulse wave disappears when the cuff pressure is much higher than the systolic blood pressure and as the pressure of the cuff drops, the pulse wave begins to appear. When the pressure in the cuff falls below the systolic blood pressure, the pulse wave can suddenly increase and the amplitude reaches its maximum in the mean arterial pressure, and then decrease with the drop of the pressure in the cuff. [1]

III. THEORY OF GLUCOSE OXIDASE ELECTRODE SENSOR

Current blood glucose sensors can be divided into two approaches: electro-enzymatic and optical [2]. The electro enzymatic sensors, based on the polarographic principles, using the phenomenon of oxidation of glucose with a glucose oxidase enzyme. This chemical reaction can be measured by amperometrically, or potentiometrically. Many sensors use an electrode/oxidation method to determine the blood glucose level [3]. The sensor uses a platinum electrode and a silver electrode to form a part of an electric circuit in which hydrogen peroxide is electrolyzed. The hydrogen peroxide is produced as a result of the oxidation of glucose on a glucose oxidase membrane as shown in eq (1), and the current through the circuit provide a measure of the concentration of hydrogen peroxide, and therefore the glucose concentration, in the vicinity of the sensor is; [3].

$$X_6H_{12}O_6 + O_2 \longrightarrow X_6H_{10}O_6 + H_2O_2 \qquad (1)$$

The sensor of the handheld blood glucose meter used is based on glucose oxidase electrode. Glucose oxidase is immobilized on an activated platinized carbon electrode and the enzyme electrode was used for the amperometric determination of glucose in injection by the electrochemical detection of enzymically producing hydrogen peroxide. The sensor is in the form of a composite electrode comprising electrodes, a layer of glucose oxidase membrane, a polyurethane film which is permeable to glucose, oxygen and hydrogen peroxide. [4]

Using amperometric determination method with constant potential, which is 0.3V used in the portable measuring apparatus, the current response of the sensor is found to be linear with the glucose concentration in the range of 5 to 30mmol/ L with fast response time of about 20 seconds. Fig.2 show the relationship between oxidase electrode response current and blood glucose concentration. [4]

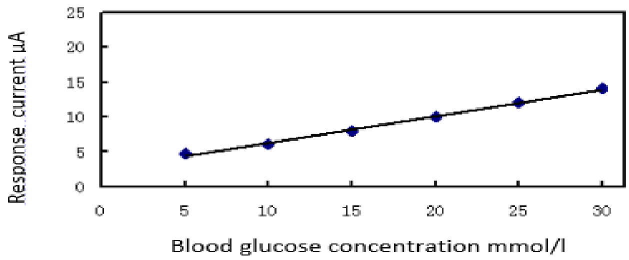


Fig. 1. Relationship between oxidase electrode response current and blood glucose Concentration.

IV. THEORY OF HEMOGLOBIN SENSOR

The absorption of whole blood in the visible and near infrared range is dominated by the various hemoglobin derivatives and the blood plasma which consists mainly of water. [5]

The changes in blood volume in tissue can be observed by measuring the transmission or reflection of light through the blood volume. This method of diagnosis is known as photo-plethysmography (PPG). [6] The measurement of non-invasive Hb is based on radiation of near monochromatic light, emitted by Light Emitting Diodes (LED) of 670 nm, through an area of skin on the finger. The Hb sensor developed for this research is fully integrated into a wearable finger clip. An area of skin on the finger is converted illuminated by monochromatic light emitted by LED of 670 nm. It is well known that the arteries contain more blood during systolic phase of the cardiac cycle than they do during the diastolic phase. This phenomenon is due to the greater diameter of the arteries during the systolic phase and occurs only in arteries but not in veins. As a result the absorption of light in tissues, during systolic phase, is greater due to a large amount of haemoglobin (absorber) is present. Systolic phase which further increases more light passes through a length of longer optical path through the arteries during the absorption. These changes in light absorption are the waves called PPG. PPG waves can be described as containing a DC component, which is time independent variable and due to venous blood, and an AC component, which is variable as a function of time and due to the pulsation of blood flow in the arteries. In such system light transmitted through the tissue is detected non-invasively by photo diodes. The blood hematocrit value can be measured by double near infrared wavelength [6].

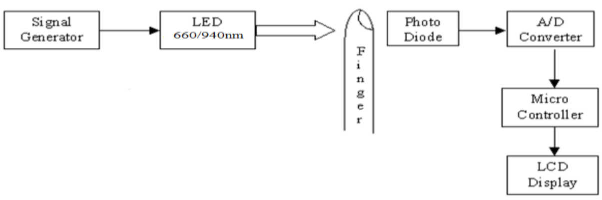
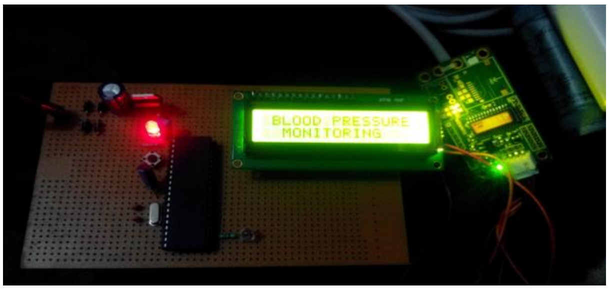


Fig. 2. Block diagram of Hemoglobin sensor

V. HARDWARE DESCRIPTION

The portable device consists of integration of medical sensors like sphygmomanometer (blood pressure sensor), blood glucose meter, and Photoplethysmogram (hemoglobin) sensor. All the sensors are connected with pic16f877a microcontroller. The sphygmomanometer (blood pressure sensor) gives serial output so it is directly connected to the USART pin of the microcontroller. The PPG (Hemoglobin) sensor has DB9 type male connector for output, out of which three pins are used. This PPG sensor is serially connected to the controller for transmission.



A. Blood Pressure Module Integration of medical sensors

When device is turned ON LCD display the message “Integration of medical sensors” on the screen.

Fig. 3. Integration of medical sensor

Later on “Select Sensor” message will be displayed on the screen. The device will ask for which sensor we want to select.

Fig. 4. Select sensor

B. Blood Pressure Monitoring

After that Blood Pressure Module is turned on by pressing the “Blood Pressure” button from the device. As the blood pressure button is pressed, the device will calculate the blood pressure and display it on the screen.

Fig. 5. Blood Pressure Button Pressed

During the calculation of blood pressure, the device will also calculate the heart rate. The sign of heart shape indicates that the device is calculating heart rate. Figure 7.4 shows the calculation of heart rate.

Fig. 6. Calculating Heart Rate

Same result will be displayed on the screen of LCD as well as on the blood pressure module.

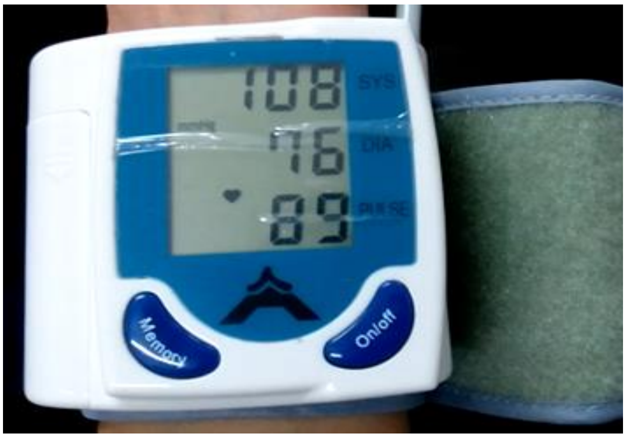


Fig. 7. Blood Pressure Module Readings

Fig. 8. Result of blood pressure

C. Haemoglobin Monitoring

After the calculation of blood pressure, haemoglobin level is also detected by the same device. To calculate the hemoglobin level, place the sensor strap on the finger and press button "Haemoglobin" from the device. By pressing the button Hb it will start to calculate the hemoglobin level and display the result on the LCD.

Fig. 9. Calculating haemoglobin

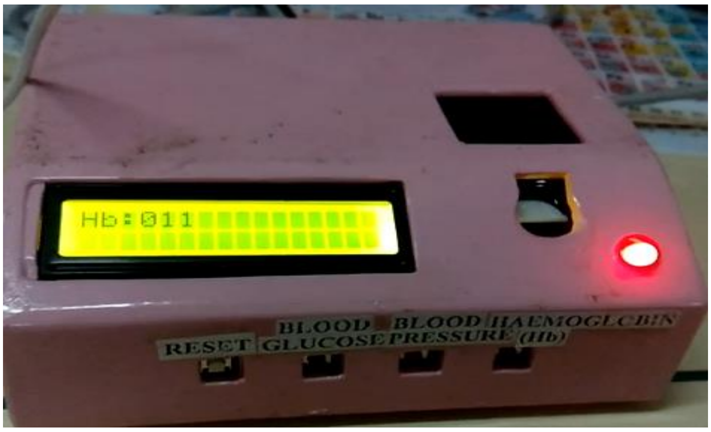


Fig. 10. Results of Haemoglobin

D. Blood Glucose Monitoring

Blood glucose level is measured by the pressing button "Blood Glucose" from the same device. To calculate the blood glucose, strip is inserted into the device.

Fig. 11. Glucose Button Pressed

After inserting the strip into the device it will ask for the blood sample then place the blood sample on the strip. After placing blood sample on test strip the device calculates glucose level and results are displayed on the screen.

Fig. 12. Results of Blood glucose meter

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