Non Invasive Saliva Acetone Glucometer using Atmega328

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Abstract— This paper is a design of non-invasive instrument for measuring the glucose level in the body using saliva acetone. In this method, the electric current which is equivalent to the acetone level present in the body is converted into voltage using the sensor. This voltage has a negative correlation with the blood glucose level. Thus, it is converted into glucose level by programming done using ATMEGA328 processor which is displayed in LCD. This is a painless procedure with low energy consumption. It is a handheld device and it is cost effective.

Key words: Saliva, Acetone Sensor, Negative Correlation, Glucose, ATMEGA328

I. INTRODUCTION

Diabetes is the disease that causes serious condition of reduction in the ability of the body[9] to produce insulin which is a hormone produced by the pancreas that helps in the conversion of the blood glucose into energy needed for the body cells for their metabolic activities. Diabetes can be treated easily when it is diagnosed in the early stage. If left untreated, it leads to severe complications such as heart diseases, stroke, kidney damage, nerve damage and even death [1]. As per the diabetes statistics report by WHO, Globally, an estimated 422 million adults were living with diabetes in 2014, compared to 108 million in 1980. The global prevalence (age-standardized) of diabetes has been doubled hiking from 4.7% to 8.5% in the adult population since 1980 [2]. In the year 2030, about 90-95% of diabetics will suffer from Type 2 diabetes [10-11]. There are three main types of diabetes which are type 1, type 2 and gestational diabetes. The type 1 diabetes is called as juvenile diabetes, which is developed mostly in young people. In this type of diabetes, insulin is not produced in the enough amount due to the destruction of the insulin producing cells in the body by the own body's immune system. The type 2 diabetes is also called as adult-onset diabetes, which can affect people of any age. This type of diabetes occurs due to the insulin resistance. Gestational diabetes develops in the pregnant woman. It occurs due to the hormonal imbalance that causes insulin resistance [3]. Hence, Glucose testing is an important part of a diabetic's daily health care. For that testing process, a glucometer is used. It is a device used for measuring the approximate level of glucose in the blood. It determines the concentration of glucose in the blood sample taken. Previous generation of glucometers have used electro-chemical methods [4] like colorimetric and amperometric methods [5-6]. But because of the fact that they are painful process, non-invasive methods of monitoring blood glucose were introduced. Some of the non-invasive procedures are Near-Infrared [9], Mid-Infrared, Stimulated Emission, Terahertz Spectroscopy, Photoacoustic Spectroscopy and Optical Rotation procedures [5].

II. EXISTING SYSTEM

There are two methods of detection of blood glucose level. They are

1) Invasive
2) Non invasive

Invasive method involves the use of blood glucose strips which is made up of plastic. The tip of the finger is pricked by using this and the quantity of blood required for this test is 1µl to 2µl. The end of the strip with glucose oxidase or glucose dehydrogenase that chemically reacts with glucose in the blood and converts into voltage by analog to digital convertor. With the help of C programming the microcontroller drives the LCD which displays the glucose level. This method is pain and cause discomfort to the patient for every time. To avoid such painful process non-invasive techniques were developed [12].Non-invasive system includes many methods. They are NIR spectroscopy, Raman spectroscopy, electrical impedance, etc,. In NIR spectroscopy the near infrared light at a wavelength of 750-2500nm is passed through blood. The molecular formula for glucose is $C_6H_{12}O_6$ which consists of C-H, O-H &C=O bonds. This causes the absorption of NIR light in blood. Then the IR detector detects the amount of IR light. The Beer Lambert's law allows the calculation of absorption of a sample from the concentration and thickness. The sensor output is collected and converted into voltage by analog to digital convertors. The data is interfaced with LABVIEW Arduino module which is then displayed on LCD [13]. In Raman spectroscopy, the laser light is transmitted through a fibre optic cable to the optical probe, which contains an optical filter to select a desired line. After that the Raman Effect occurs when it irradiates the sample. The probe collects the Raman light and transmitted onto a spectrometer where it is split into separate wavelength and detected on CCD camera. These optical methods of detection of blood glucose do not achieve the absolute accuracy. After that breath analysis came into account [14]. The breath analysis involves the use of gas sensor which detects the glucose level in the blood from the exhaled breath. Acetone is one of the volatile organic compound present in the exhaled breath which is the metabolic product of fat burning. For diabetic patients, there is an increased level of acetone in the blood because of the breakdown of excess acetyl-CoA. The breath acetone concentration ranging from 1.7ppm to 3.1ppm can be detected in diabetic patients. For healthy patients it ranges between 0.3ppm and 0.9ppm. Here TGS (SnO2) sensor is used as an acetone sensor. The resistance of this sensor varies depends on the concentration of the acetone present and can be detected by potential divider circuit. They used the Artificial Neural Network (ANN) to calculate the blood glucose level [15].

III. PROPOSED SYSTEM

The proposed system consists of

- Hardware setup
- Software setup

A. Hardware Setup

We have proceeded with the following blocks which would help us in the detection of blood glucose level. First comes the Acetone sensor, which we have chosen is Figaro TGS822, following this, a microcontroller named ATMEGA328, to control and process, then to display, LCD is used.

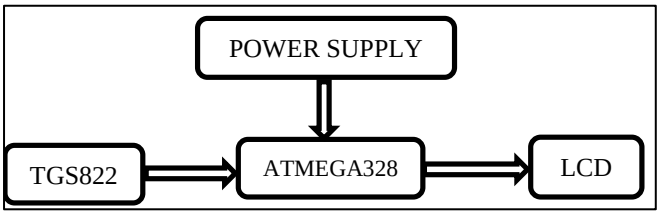

Fig. 1. Block Diagram of the Hardware.

B. TGS822 sensor

During the normal metabolism in human body, Acetone occurs as a natural indispensable product and it gets disposed off. Diabetes patient produces it in larger amounts [17]. Acetone, a volatile organic compound [15] also exists in saliva. This saliva is sensed by the Figaro TGS822 sensor. It is a gas sensor having good conductivity towards acetone and other organic compounds [15]. The TGS822 sensor has a semiconductor Tin oxide coated on its top surface. The cap and sensor base is formed of nylon66. The conductivity of the sensor depends on the concentration of the acetone present [18]. This sensor finds its application in many fields, say, medical, pharmacy, industries, etc.

Fig. 2: TGS822 Sensor.

C. Atmega328

The features of Arduino ATMEGA328/P are given below:

In-System Programmable Flash with Read-While-Write capabilities of 32Kb, Electrically Erasable Programmable Read Only Memory of 1Kb, Static Random Access Memory of 2Kb, 23 general purpose Input/output lines, 32 general purpose working registers, Real Time Counter (RTC), three flexible Timer/Counters with compare modes and PWM, 1 serial programmable USARTs , 1 byte-oriented 2-wire Serial Interface (I2C), a 6- channel 10-bit ADC (8 channels in Thin Quad Flat Package and Quad Flat No-lead/Micro Lead Frame packages) , a Watchdog Timer with internal Oscillator which can be programmed, an SPI serial port, and six software selectable power saving modes. The Idle mode stops the CPU while allowing the Static Random Access Memory, Timer/Counters, Serial Port Interface port, and interrupt system to continue functioning. The Oscillator is paused during the Power-down mode irrespective of that, it saves the register contents, disabling all other chip functions until the next interrupt or hardware reset. The asynchronous timer continues to work, in Power-save mode, allowing the user to maintain a timer base while the rest of the device is sleeping. The Analog Digital Convertor Noise Reduction mode halts the Central Processing Unit and all the Input/output modules but it continues the working of asynchronous timer and ADC to minimize switching noise during ADC conversions. The crystal/resonator oscillator is working in Standby mode, while the rest of the device is sleeping. This allows very fast start-up combined with low power consumption.

D. LCD

LCD (Liquid Crystal Display) screen is an electronic display device with wide range of applications. A 16x2 LCD display is beginner level module and is very commonly used in various devices and circuits. These modules are preferred over seven segments and other multi segment LEDs.

E. Software Setup

For the development of digital blood glucometer, the ATMEGA328 is programmed using Embedded C.

This microcontroller will be easy to program needed for the calculation of glucose values as well as to communicate with the LCD display to get the results in the visual form. This program has been written in “EMBEDDED C” and transferred to the microcontroller with the help of the ISP programmer.

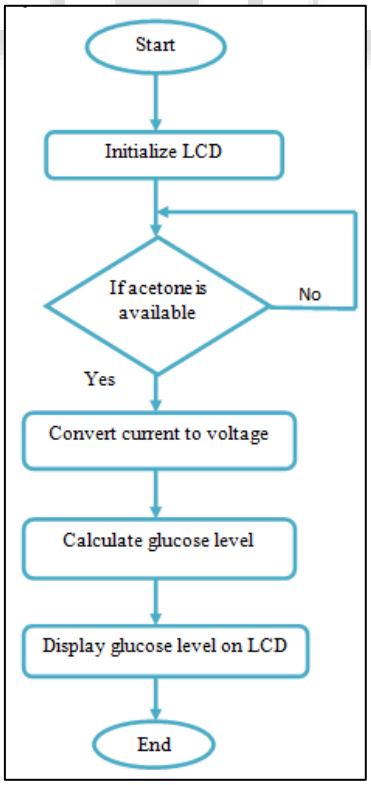

Fig. 3: Flowchart of the program

Embedded C Programming is the soul of the processor functioning inside each and every embedded

system we come across in our daily life, such as mobile phone, washing machine, and digital camera. Each processor is associated with embedded software. The embedded software plays a significant role in deciding the functioning of the embedded system. Embedded C language is most frequently used to program the microcontroller.

IV. WORKING

The saliva from the patient is taken as the sample and placed over the sensing element of the sensor. The sensor is much sensitive to acetone because of the SnO_2 element present in it. The driver converts the sensed acetone into voltage and is fed into the ATMEGA328. The correlation between saliva acetone and blood glucose is assessed and programmed in the controller. The value of glucose is then displayed in LCD.

V. RESULTS & DISCUSSION

The acetone sensed from the saliva is converted into voltage and is being programmed to display the glucose level. The acetone concentrations have been studied with and without temperature effect. From the results, it is observed that voltage and resistance are playing important role in non-invasive glucose measurements.

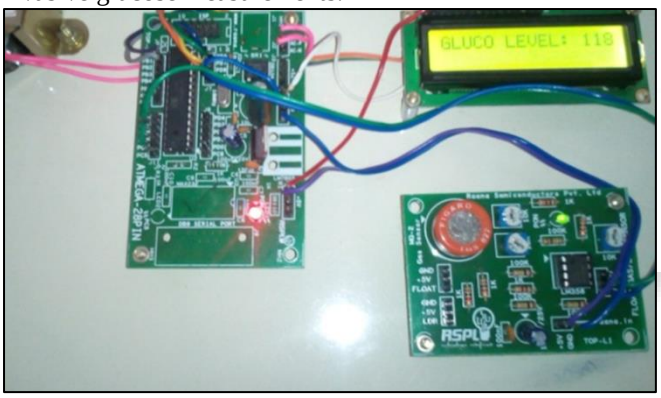

Fig. 4: Experimental Setup for glucose measurement

Our proposed system is tested with several saliva samples and compared with the normal glucometer results.

S.No	Actual glucose values mg/dl	Standard glucometer value mg/dl	Our designed glucometer mg/dl
1	82	82	80
2	95	95	93
3	113	113	110
4	137	137	138
5	141	141	140
6	122	122	123
7	175	175	172

Table 1: Blood glucose values

The blood glucose values were taken from the standard glucometer using the blood sample. Temperature is considered an important parameter in our proposed design. The results of our proposed design fell good with the standard glucose values. The Microcontroller which is fed with the embedded c program converts the voltage values into corresponding glucose level inculcated in the programming.

VI. CONCLUSION

In this paper, we designed and developed a system to determine the concentration of glucose level in the body using programming which is developed in "Embedded C" language. This system is quite useful for the measurement of glucose level with an accuracy of ±2%. We used a gas sensor to sense the acetone in the saliva. When we place the saliva in the sensor, it is converted into voltage. With the help of programming using Embedded C in the ATMEGA328 microcontroller, the glucose level is determined and it is displayed in LCD.

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