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DESIGN AND DEVELOPMENT OF LOW COST GLUCOMETER USING SALIVA WITH CRITICAL MEDICAL ALERTS

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Abstract

Diabetes is a life changing condition that requires proper blood glucose management. It requires monitoring of blood glucose level several times a day based on the type of diabetes. If not managed properly,it may lead to severe health complications. It was roughly calculated in the year 2017 that around 629 million people all over the world would be suffering from the diabetes by the year 2045.This paper intends to discuss the design and development of low cost glucometer using saliva .Our prototype measures the blood glucose level using saliva as a medium .The proposed model is of low cost which can be easily affordable by everyone .Here the biosensor is used to sense the glucose from the saliva .The model is built with ESP8266 WiFi module and the programming is done as per the requirement.The results are shown on the display and stored in the cloud using WiFi .The stored data can be used for future analysis by caretakers and medical professionals .

Keywords— *Diabetes , non -invasive , Glucose monitoring , Saliva ,NODE MCU ESP8266.*

1. INTRODUCTION

Diabetes is a metabolic and lifelong disease that transpire when glucose levels in blood are too high which is called hyperglycemia .This takes place when our body does not produce enough insulin. It is a peptide hormone produced by β cells of pancreas to manage blood glucose levels. Some of the signs of having diabetes includes excess thirst and hunger , increased urination, fatigue ,fuzzy vision, insensibility in the feet and hands , weight reduction. Common types of this disease are type 1diabetes , type 2 diabetes and gestational diabetes .Among these the most usual type is type 2 diabetes .Improper management of this disease leads to some complications in the body such as damage to eye ,kidney and nerves and it also results in heart related problems .People with this disease are also likely to have problems related to skin , hearing and meloncholy .

As stated by World Health Organization(WHO) about 422 million people across the world are affected from diabetes The majority of the people affected from this are from underdeveloped and developing countries. Around 1.5 million people die due to diabetes every year. The number of cases and people suffering from this have been steadily increasing over the last few decades . The people having type 1 diabetes are recommended to take the glucose test 4-10 times in a day and in the case of type 2 diabetes it is suggested to take the test multiple times in a day based on the type and quantity of insulin secreted by the body .We need to take the test before and after meals or exercise. Several methods used for blood glucose monitoring are Glycated Haemoglobin(A1C) test , fasting blood glucose test , random blood glucose test and oral glucose tolerance test.Nowadays glucose monitoring at home using glucometer is widely used as it can be used wherever and the

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results can be obtained quickly and easily. There are variety of glucometers in market but patients need to prick their fingers using small and sharp needle called as a lancet. As diabetes management needs regular testing of blood glucose level, people find it painful due to the pain caused by finger pricking and is generally disliked which results in lesser tests and deficient blood glucose control. Thus impoverished glucose control results in higher risks and even greater management costs . This method is a major issue among patients of lower age group. Therefore , a non-invasive method of blood sugar monitoring is mandatory . It refers determination of blood glucose without causing any damage to human body . There are several methods of non- invasive test for monitoring blood glucose and are divided into optical , microwave and electrochemical methods .But these are only restricted to utilization of laboratory due to cost and complexity in its operation. Thus a non invasive, convenient, and inexpensive diagnostic method which is useful to the patient is highly demanded.

The paper is divided to VI sections, section I gives the introduction , section II outlines the literature review, section III presents our proposed methodology, advantages, applications of the proposed model and section IV presents the results , section V gives the conclusion and future scope.

2. LITERATURE REVIEW

In Reference paper[1] they have proposed a prototype called glucotect which is a painfree device which uses near infrared technology to monitor blood glucose without having to draw blood. In Reference paper[2] they have described about a novel non -invasive device which uses saliva to monitor blood glucose level. The various parameters which are considered in the proposed model here are pH , REDOX potential and conductivity. It is estimated that this model could predict diabetes with an accuracy of 75%. Reference paper[3] is intended to discuss the limitations and the challenges involved in the optical method of design and development of the non -invasive blood glucose monitoring device which would be easy for patients to opt for regular blood sugar tests which will subsequently improve patient's life .Reference paper[4] describes the challenges involved in recent years and development in research of Non – invasive blood glucose monitoring method . Based on the detection principle , it is divided into three types such as optics , microwave and electrochemistry. The advantages and limitations of invasive and non- invasive methods and electrochemistry , optics in non-invasive are compared horizontally here . In Reference paper[5] they have discussed about a device called glucometer which helps to detect blood glucose level in real time .This proposed meter is of very low cost than others available in the market so that it is easily affordable to poor people living in underdeveloped and developed countries . This model is built with the microcontroller ATMEGA8A AVR and the software part is done using the C programming in AVR studio. Reference paper[6] aims to present a novel non -invasive technique for blood sugar monitoring using saliva . In this paper they have discussed about the present study which tries to calculate the change in dielectric permittivity of saliva with blood glucose. Reference paper[7] intends to discuss whether saliva can be used as an medium for diagnosis of diabetes .Here in this paper, they have compared the glucose levels in saliva of a normal person and a diabetic person. And the results received were more desireable to use submandibular saliva and sublingual saliva for calculating glucose levels in blood as the daily variations in the correlation amid blood glucose level and parotid gland salivary glucose level in individuals were too high . When salivary glucose level of a non- diabetic person and diabetic persons were differentiated upon glucose loading , distinct difference were seen among them recommending that saliva can be used as a medium for blood glucose monitoring .

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3. PROPOSED METHODOLOGY

This section explains how the project will be executed and also how each component helps in the development of this project . The block diagram of the proposed system is given below.

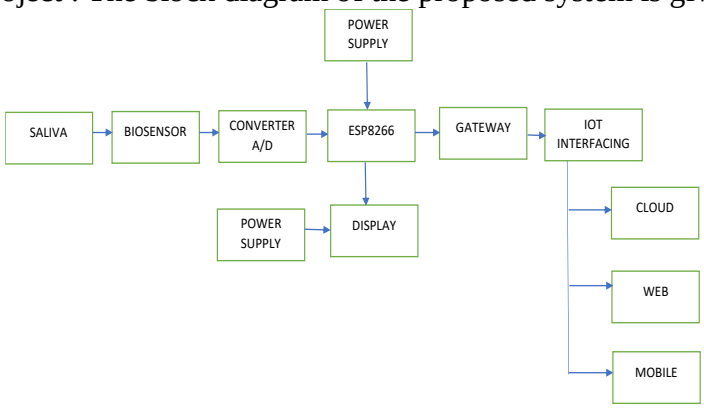

Figure 1. Block Diagram

COMPONENTS AND DESCRIPTION
The main components of our project are :

1. Test strip (Biosensor)
2. ESP8266
3. Op-Amps : LF356 ,LM358
4. LCD
5. Resistors: 82kΩ , 3.3kΩ , 1MΩ
6. Capacitor :1µF
7. Power Supply module : Three dc batteries of 9V are connected here .

1. TEST STRIP (BIOSENSOR):

Electrochemical sensors are a part of sensors in which transducer element is electrode. They are used for various applications ranging from detection of toxic gas to monitoring glucose levels . The aim of electrochemical sensors is to produce electrical signal (potential , current or impedance) which is propotional to chemical reactions such as concentration and presence of certain chemicals. They convert the information between an electrode and analyte .Electrochemical sensors are classified into three categories such as potentiometric sensor , amperometric or voltammetric and conductometric sensor.

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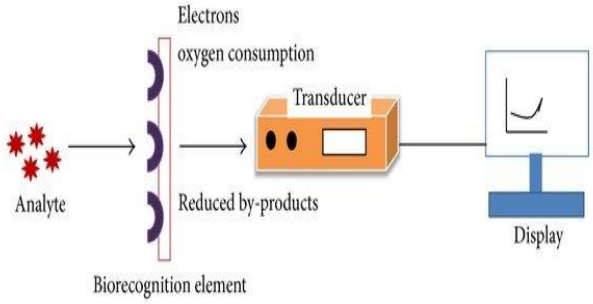


Figure 2.Diagrammatic representation of working principle of

Electrochemical sensor

The strips used in our designed model have three electrodes.

- Reference electrode
- Working electrode
- **Counter electrode**

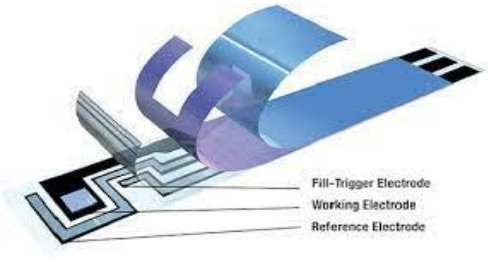
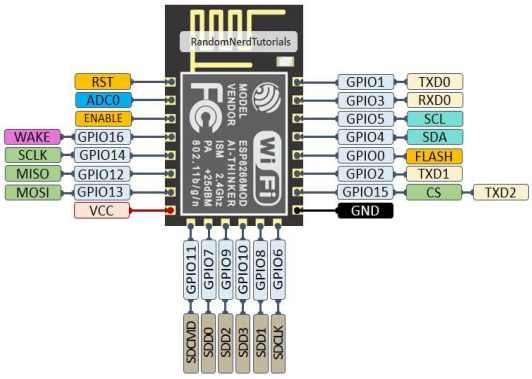


Figure 3. Actual Biosensor

2. NODEMCU ESP8266

NODEMCU ESP8266 is a WiFi module designed by Espressif systems .It is freely available development board for iot applications and based on Lua firmware. It is of very low cost , easy to operate and consumes less power . It supports both TCP/IP and serial protocol .It works at the operating voltage of 3V and maximum voltage upto 3.6V. If we are using 5V supply then an external logic converter is required. ESP8266 can easily be interfaced with microcontrollers board via serial port and has 17 general purpose input output pins which can be used for different requirements like I2C , I2S, UART , PWM etc . It permits us to code this NODEMCU ESP8266 with an easy programming language called LUA .



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3. OP-AMPS

a) LM358

Figure 4. LM358 OP-AMP

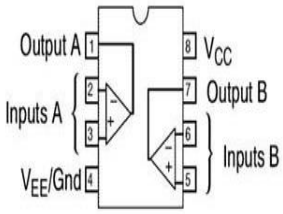

Figure 5. Pin Configuration of LM358

- It is a dual channel and low power IC .It consists of two unconventional and high gain op-amps with internal frequency compensation and it is specially used to operate from a single power supply over a wide range of voltages .It is used to give supply to the sensors.

b) LF356 OP-AMP

Figure 6. LF356 OP-AMP

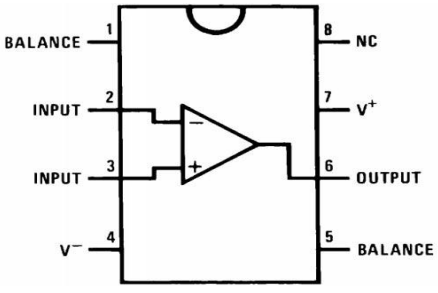

Figure 7.Pin Configuration of LF356

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- LF356 is an op -amp with monolithic JFET input. This IC has a very low voltage and current noise , wide bandwidth and fast setting time.

4. LCD

Figure 8 . LCD

- Liquid Crystal Display (LCD) is a 16*2 display module with yellow backlight . It operates with 5V DC Supply. It is used to display the output.

WORKING AND OPERATION

- Our prototype is used to monitor blood glucose using saliva.
- Our model is assembled with IC LM358,IC LF356, Biosensor,Capacitor ,Resistors, ESP8266 and LCD.
- 9V dc supply is connected to the system .
- The biosensor is used to sense the glucose. The sample is placed on the biosensor and it recognizes substance of glucose. Then it sends to a signal conditioning circuit , which converts the bio recognition element into measurable signal .
- Then it is sent to A/D Converter , which converts the analog sample into digital sample
- The signal is received by ESP8266 . It is a low cost WIFI microchip with built in TCP/IP software and microcontroller capability .It has 17 GPIO pins.
- LCD is used to display the output of the glucometer .
- Gateway connects the ESP8266 module to the cloud by iot interfacing , which is the process of connecting devices together so that they can exchange the information .
- The results are stored in the UBIDOTS cloud system ,web and mobile .
- When the test results are very low or above the normal blood glucose level then it is expected to send the alerts to concerned doctors and caretakers.

ADVANATAGES

- It is low cost
- It is painfree
- Blood glucose monitoring can be done anytime easily and the results are obtained within short period of time
- The data will be stored in clouds which can be used for future analysis
- The alert messages will be sent to the caretakers ,medical professsionals when there is a variation in the glucose level of a patient
- It is easy to use .

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APPLICATIONS

- It can be used by an individual for self monitoring
- This can be used in hospitals
- This can also be used in biomedical industries

4. RESULTS AND DISCUSSIONS

The blood sample and saliva sample of different individuals were collected and tested using our proposed model. The blood glucose ranged from 90mg/dl to 120 mg/dl whereas salivary glucose ranged from 4.6 mg/dl to 5.9 mg/dl. The correlation between blood glucose and saliva glucose have found statistically significant.

Table No. 1 TEST RESULTS

Patient name	Age/ Gender	Blood Sugar (RBS)	Blood Sugar (FBS)	Saliva Sugar (RSS)	Saliva Sugar (FSS)
Mahesh	42/M	_	108	5.4	_
Niranjan	23/ M	_	90	4.6	_
Hema	60/ F	120	_	5.9	_
Akash	35 /M	106	_	5.3	_

After the results ,we found that person with Random blood sugar (RBS) level as 120 mg/dl had the saliva sugar level as 5.9 mg/dl .And the person with RBS 106 mg/dl , the saliva sugar level was 5.3 mg/dl .Patients with Fasting Blood Sugar (FBS) level of 108 mg/dl had the salivary glucose as 5.4 mg/dl and with 90 mg/dl FBS level had the salivary glucose level as 4.6 mg/dl. So correlation between blood and salivary glycose can be concluded as , glucose concentration in saliva was approximately 20 times of glucose concentration present in blood .

5. CONCLUSION AND FUTURE SCOPE

In this paper , we have described about the design and development of low cost glucometer using saliva with critical medical alerts , which is a non -invasive method. The results show that there is significant correlation between salivary glucose and blood glucose. Our proposed model not only measures the glucose level using saliva but also allows to store the results for future references and sends the alert messages to concerned medical professionals or caretakers. Non-Invasive methods have a great advantage over other methods. The sensors which we have used is not enough sensible to the electrons which are produced by Saliva sample. The electrons produced by Saliva are very less as that of Blood. But highly sensitive sensors can achieve reliable results. Hence In future by concentrating on the design of sensor desirable results can be achieved.

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