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Prick Free Glucometer

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***Abstract*—Diabetic people must have their blood glucose levels checked regularly. Common glucometers work by puncturing the finger, which can lead to skin infections and discomfort. As a result, there is a need to build a low-cost non-invasive glucometer that can constantly monitor blood glucose without causing issues, therefore near-infrared optical measurement is used to address the problems that happened during the invasive approach. The gadget is made up of an infrared LED with a wavelength range of 750 to 2500 nm in the electromagnetic spectrum, which allows light to penetrate the skin beyond 0.5mm with low-intensity radiation. The presence of glucose molecules in the blood boosts NIR light absorption, which peaks at a certain wavelength.An application is developed to display the glucose levels.The BEER LAMBERT LAW is utilized mathematically to solve the problem.**

***Index Terms*—Diabetes, Noninvasive, Intensity, Regression and Beer Lambert law, MIT App Inventor.**

I. Introduction

Diabetes is a condition in which your blood glucose, often known as blood sugar, is too high. Your major source of energy is blood glucose, which comes from the food you eat. Insulin, a hormone produced by the pancreas, aids glucose absorption into cells for use as energy. Type 1 diabetes needs daily insulin injections to stay alive. Type 2 diabetes necessitates daily insulin injections in order to stay alive. People with Type 2 diabetes have a body that does not produce or utilize insulin properly. Type 2 diabetes may strike anyone at any age, even children. Type 2 diabetes is the most common. Some women acquire gestational diabetes during pregnancy. Currently, millions of individuals are affected by diabetes. Many people are also unaware that they have diabetes. One in four adults over the age of 65 has diabetes. Type 2 diabetes is the most common type of diabetes in adults, accounting for 90-95 percent of cases.

High blood glucose levels can contribute to a variety of issues over time, including illness of the heart stroke renal failure difficulties with the eyes illness of the teeth injury to the nerves difficulties with the feet People use a variety of pills to treat diabetes. However the majority of these medications cause negative effects. As a result, diabetes is a chronic illness that needs frequent blood glucose testing to maintain a normal blood glucose level. A glucometer is a gadget that is used to test glucose in the blood and is available on the market. The most popular and traditional glucometers need pricking to get a drop of blood, which is then used to test glucose levels. As a diabetic, you must monitor your blood glucose levels on a regular basis. However, there are several disadvantages to utilizing an intrusive glucometer. It is really painful. It may result in non-compliance. It poses a risk of infection. It may affect your skin. Possibilities of cross-infection NON-INVASIVE GLUCOMETER are being developed to prevent these issues.

The non-invasive glucometer in this case provides glucose readings without the need for a finger puncture. As a result, we created a non-invasive glucometer that uses a NIR led. This approach is quite easy and produces reliable readings. The NIR approach is utilized here because the NIR LEDs penetrate deeper into the skin and use regression analysis to calibrate the glucose levels in the body. The glucose levels are obtained by performing a regression analysis between the output of the IR sensor and the respective glucose levels using a near-infrared LED sensor with a wavelength of 940 nm. The IR rays penetrate the blood and the glucose levels are obtained by performing a regression analysis between the output of the IR sensor and the respective glucose levels. By using ESP32 , an interface is created to view the glucose levels on an application. As a result, this procedure does not need any finger puncturing and is simple to implement.

II. Block Diagram

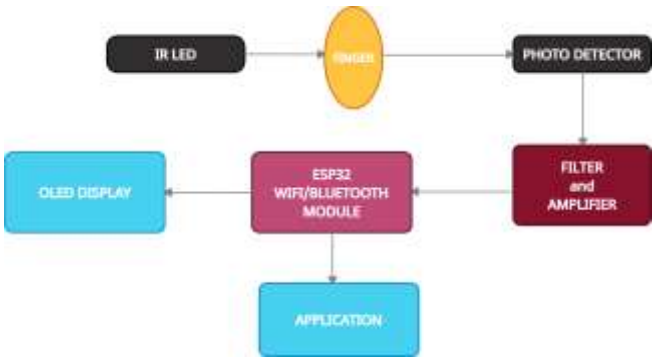

Fig. 1. Block Diagram

The Block Diagram of the non invasive glucometer consists of an IR led , photo detector, a low pass filter, amplifier, esp32, application and OLED display.The IR LED transmits IR signals into the skin.The photo detector detects the absorbed IR signal.The low pass filter removes the noise present in the

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output signal and the amplifier amplifies the signal.ESP32 acts as an interface between the application and hardware as shown in Fig.1.

III. Hardware Components

An IR LED is a solid-state lighting (SSL) device that emits light in the infrared region of the electromagnetic radiation spectrum (infrared light emitting diode). Infrared LEDs enable the production of infrared light, which is electromagnetic radiation with wavelengths ranging from 700 nm to 1mm, at a cheap cost and with great efficiency.

Photo diode is used instead of photo transistor because response time of photodiode is faster than that of phototransistor as shown in Fig.2.

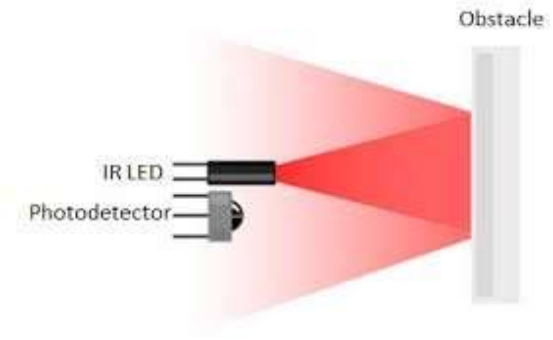

Fig. 2. working of IR LED

The wavelengths of infrared employed for this purpose are 940 nm. We use the technology of emitting an infrared wavelength that passes through the finger. The wavelength that travels through it is then picked up by a photodiode, which functions as a photosensor. The voltage rises in proportion to the rise in glucose concentration. Since we'd opted to employ IR light transmission (since we'd determined that IR light with a wavelength of 940 nm is ideal for glucose absorption), For amplification of the signal received by the light diode, we used a 741 IC OpAmp in this project. We used an inverting amplifier with a gain often. The goal is to turn a low-value output into a high-value output. A low pass filter is a stage that allows a desired signal and frequencies to pass while rejecting and attenuating undesirable signals such as noise.

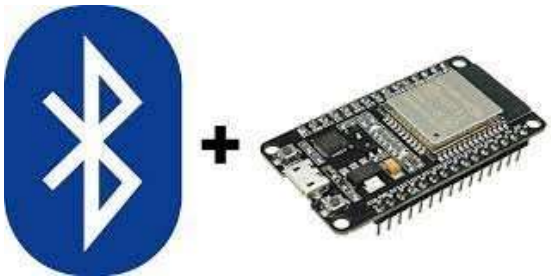

Fig. 3. ESP32 WIFI/BLUETOOTH MODULE

ESP32 is a family of low-power microcontrollers with built-in Wi-Fi and dual-mode Bluetooth shown in Fig.3.

By using esp 32 , an app named "PFG" is created for observing glucose readings.

Fig. 4. OLED DISPLAY

An organic light-emitting diode (OLED or organic LED) with an emissive electroluminescent layer(shown in Fig.4), also known as an organic electroluminescent (organic EL) diode, is a film of organic compound that produces light in response to an electric current. This organic layer is sandwiched between two electrodes, with at least one of them being transparent in most cases. OLEDs are used to create digital displays in devices such as television screens, computer monitors, and portable systems such as smartphones and handheld gaming consoles. A important area of research is the development of white OLED devices for use in solid-state lighting applications.

IV. Software Used

- App Inventor is a cloud-based tool that lets you use a blocks-based programming language to create your own mobile apps through bluetooth application of esp32
  Using a web browser and either a connected phone or an emulator, App Inventor allows you to create Android apps. The App Inventor servers maintain track of your projects and store your work.
- MIT App Inventor is a tool for teaching computational thinking in a number of educational environments, and it teaches individuals how to develop apps to solve issues in their communities.
  MIT App Inventor is a user-friendly visual programming environment that lets anybody, even children, create fully working apps for smartphones and tablets.
- Regression analysis is a sophisticated statistical technique for examining the connection between two or more variables of interest. While there are many different forms of regression analysis, they always focus on the impact of one or more independent variables on a dependent variable.
- The open-source Arduino Software (IDE) simplifies the process of writing code and uploading it to the board. This program is compatible with any Arduino board.
  The ESP32 may function as a stand-alone system or as a slave device to a host MCU, eliminating communication stack overhead on the primary application CPU.

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V. METHODOLOGY

Methodology is nothing more than the operation of the PFG gadget. To begin, we will insert a finger between the IR LED and the Photodiode. The photodiode monitors glucose levels via spectroscopy and provides an output in volts. AMP741 is used to amplify the voltage value. To decrease noise after amplification, we employ a low pass filter. The LPF's output will be forwarded to the ESP32 (WIFI / Bluetooth module). For Bluetooth connection, we utilize ESP32 as a microcontroller. Using MIT App Inventor, we designed an app that allows us to download the test report in pdf format and also displays the glucose levels on the screen.

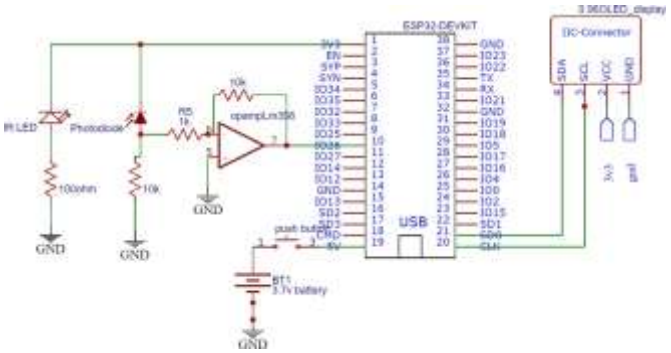

Fig. 5. Schematic Diagram of Non Invasive Glucometer

VI. FLOWCHART

- When the device is turned on,Bluetooth connection need to be established between the device and the application through ESP32 .
- If the Bluetooth is initialized, the application displays "the Bluetooth device is ready to pair"and "welcome" is displayed in the OLED display. Else if any error occurred it will display "Bluetooth is uninitialized" as shown in Fig.6.
- When "MEASURE" is clicked in the application,a command(M) is send to ESP32 the device starts reading the values.
- The values are stored into an array and calculates the sum , average and voltage conversion.
- If the voltage is greater than 3.57,it will display the respective glucose levels by performing regression analysis.Else it will display "Finger is not placed " in both OLED and application.
- If the glucose value that is obtained is in between 80mg/dL and 140mg/dL,it displays "Glucose level is normal".Else if the value is greater than 140mg/dL, it displays "Glucose levels are High".Else it displays "Glucose levels are low" as shown in Fig.6 .

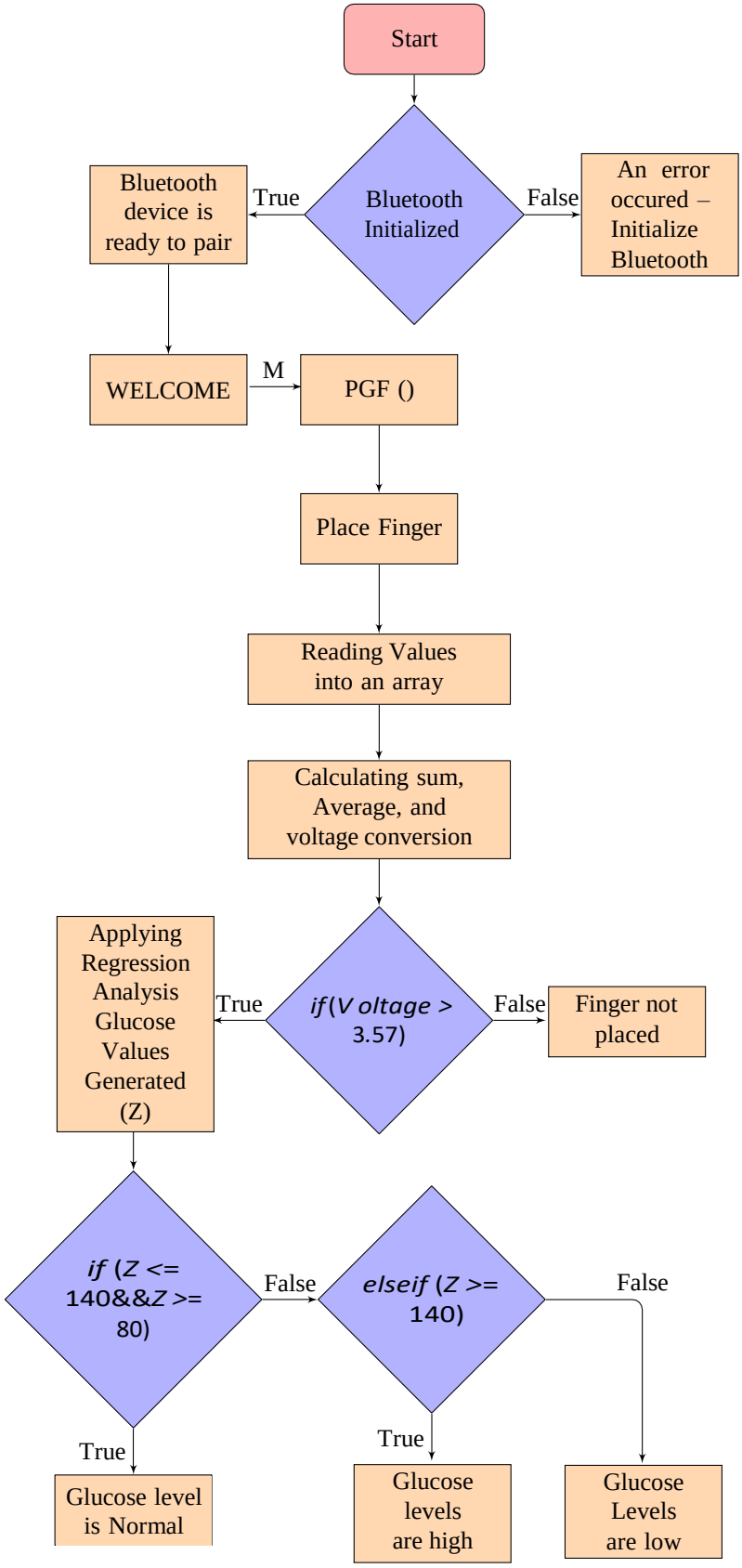

Fig. 6. Flowchart

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VII. EQUATIONS

Considering parameters x and y:

Below mentioned equation(1) is used calculate the glucose levels in the body. Here, x is the voltage level and y is the glucose levels. The below equation (1) is obtained by performing the regression analysis.

$$y = 111.65 * x + 55.74 \quad (1)$$

Coming to the x, Wavelengths will be passed through the finger which is produced by IR LED. Then the passed wavelengths will be received by the photo detector then the photo detector gives the voltage value. We will be substituting the voltage value that is nothing but x in the below equation(1). Then we get the value of glucose level that is y parameter.

VIII. EXPERIMENTAL ANALYSIS

Fig.7 shows the hardware circuit of prick free Glucometer.When the blueetooth connection is established using ESP32 ,a message alert "Welcome" is displayed as shown in Fig.7.

Fig.8 shows the oled display of glucometer when the finger is placed .when the the app is connected to the device through bluetooth and when the measure button is tapped the devices records the value of glucose levels in the blood which is shown in Fig.9.

Once the save button is pressed it will direct to Fig.10 .After filling the details of the person by pressing generate report button shown in Fig.10 ,it will direct to Fig.11. This is how the application functions.If STOP button is pressed ,the app will stop recording the values and shows us a constant value.

Incase finger is not placed in the device , it shows that finger is not placed. In oled display it also shows whether the glucose levels are normal or high or low.

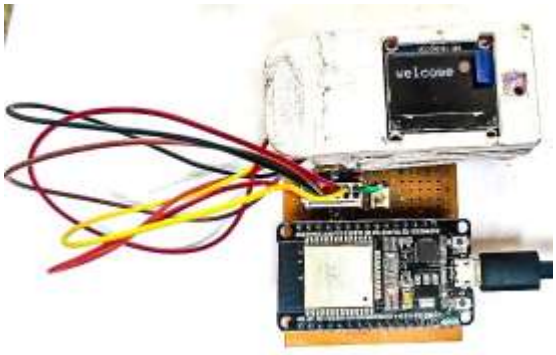

Fig. 7. Hardware Circuit

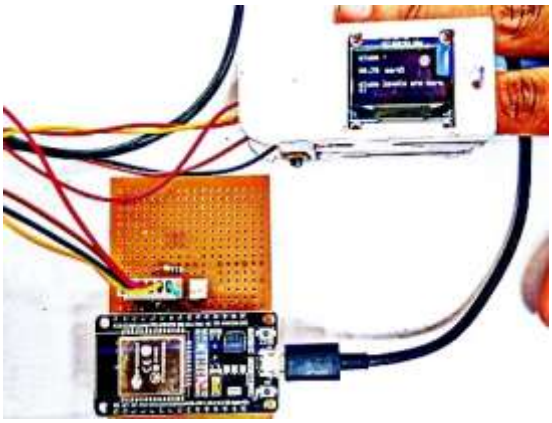

Fig. 8. OLED Display of glucommeter reading

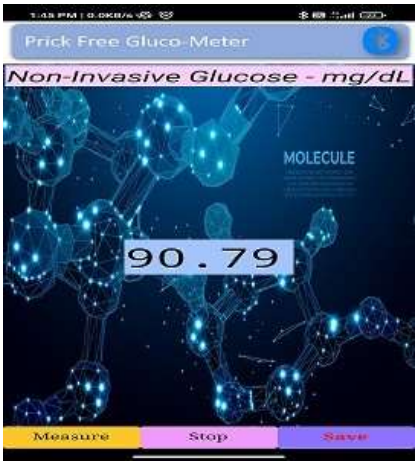

Fig. 9. Displaying the values on app

Fig. 10. Patient Details

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Fig. 11. Report

TABLE I
DATA SAMPLES OF SOME PEOPLE

SNo	Voltage(v)	Glucometer(mg/dL)
I	0.56	111
II	0.30	97
III	0.41	104
IV	0.15	65
V	0.42	106

TABLE II
PREDICTED VALUES OF GLUCOSE LEVELS

SNo	Voltage(v)	Glucometer(mg/dL)	Predicted Value(mg/dL)
I	0.56	111	105
II	0.30	97	92
III	0.41	104	110
IV	0.15	65	70
V	0.42	106	104
VI	0.22	89	80.6
VII	0.20	98	78
VIII	0.55	111	102
IX	0.36	97	107

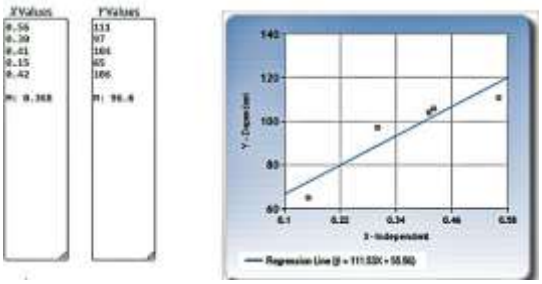

Fig. 12. Regression Analysis

Based upon the linear regression equation which is obtained from table 1 data set we get the predicted values which are shown in table2.

IX. CONCLUSION

Glucose testing that requires invasive procedures is unpleasant, uncomfortable, and expensive. It also poses an infection risk and can't be continually checked. This work proposes a noninvasive alternative for blood glucose testing that employs near-infrared LED's to solve the aforementioned drawbacks. Both the LCD display and the built-in mobile app show the glucose level in the blood taken from the photo detector. Error grid analysis is used to validate the proposed approach. This noninvasive portable blood glucose monitor is an excellent approach for diabetics to stay healthy. This can be used to monitor a patient's blood glucose level at home or at a health care facility.

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[12] Design and Implementation of a Noninvasive Blood Glucose Monitoring Device Kamol Sarkar, Dhrubo Ahmad, Suvojit Kumar Singha, Mohiuddin Ahmad.
From this reference we came to know by using infrared led and photodiode we can obtain voltage values for glucose level.
[13] Reflection Near-infrared Spectroscopic Method For Non-invasive Blood Glucose Measurement Kirill V. Pozhar,Evgeniia L.Litinskaia, Mikhail O.Mikhailov, Elizaveta A. Polyakova .
From this reference we came to know that in our blood glucose will be present it will absorbs some amount of wavelength which we are transmitting from the IRLED and a specific wavelength we need to send i.e.,1440nm for the accuracy and also by reflection we can obtain voltage values.
[14] Non-Invasive Glucometer Prof. Shalabh Gupta.
From this reference we came to know that after obtaining the voltage values we have to amplify the voltage for better calculations for regression analysis.