COMPACT HEALTH CARE SYSTEM

A PROJECT REPORT

Submitted by

SUWETHA I G (RA1611004020052)

Under the guidance Of

Mr. R. VEERA AMUDHAN

(Asst Professor, Department of Electronics & Communication Engineering)

In partial fulfillment for the award of the degree

of

BACHELOR OF TECHNOLOGY

in

ELECTRONICS AND COMMUNICATION ENGINEERING

of

FACULTY OF ENGINEERING AND TECHNOLOGY

Ramapuram, Chennai, Tamil Nadu – 600 089

JUNE 2020

SRM Institute of Science & Technology

(Deemed to be University u/ s of U GC Act, 1956)

Ramapuram, Chennai-600 089

Tamil Nadu

BONAFIDE CERTIFICATE

Certified that this project report titled "**COMPACT HEALTH CARE SYSTEM**" is the bonafide work of " **SUWETHA .I.G [Reg No. RA1611004020052]**", who carried out the project work under my supervision. Certified further, that to the best of my knowledge the work reported herein does not form any other project report or dissertation on the basis of which a degree or award was conferred on an earlier occasion on this or any other candidate.

SIGNATURE
Mr. R VEERA AMUDHAN
GUIDE
Assistant Professor
Dept of Electronics and communication Engineering
SRM Institute of Science and Technology
Ramapuram
Chennai-600089

SIGNATURE
Dr. PHANI KUMAR POLASI
HEAD OF THE DEPARTMENT
Professor and head
Dept of Electronics and communication Engineering
SRM Institute of Science and Technology
Ramapuram
Chennai-600089

Submitted for the project Viva-Voce held on _____ at SRM Institute of Science and Technology, Ramapuram.

INTERNAL EXAMINER EXTERNAL EXAMINER

ACKNOWLEDGEMENT

We would like to place on regard our deep sense of gratitude to our beloved Chancellor **Dr.T.R.PACHAMUTHU**, for providing us with the requisite infrastructure throughout the course.

We extend our hearty thanks to our Chairman **Dr.R.SHIVA KUMAR**, for his constant encouragement.

We convey our sincere thanks to our Director **Dr. V. SUBBIAH BHARATHI** and Dean **Dr.G.SELVA KUMAR** for their interest and support.

We thank our Vice Principal (Academic),**Dr. K. N. SRINIVAS**, for his interest and support in completion of the project.

We thank the Head of the Department **Dr. PHANI KUMAR POLASI** for his constant suggestions, support and Encouragement towards the completion of the project with perfection.

We thank our guide **Mr. R. VEERA AMUDHAN** , for his timely help and guidance throughout the overall process of the project.

We thank to all of our staff members of the Department of Electronics and Communication who gave many suggestions from time to time that made our project work better and well finished.

Also, we thank our parents, all our friends for their moral support and guidance in finishing our project.

ABSTRACT

The never-ending list of diseases is growing each day. It has become important for us to monitor our health condition regularly as it not only helps us to prevent diseases but also detect diseases which do not have any visible symptoms. One such main disease is diabetes which is a real test for the current century. The conventional method of measuring blood glucose is uncomfortable and painful as individuals need to poke their finger to draw blood regularly for calculating glucose concentration. Non-invasive blood glucose measurement can diminish this pain and also reduce the cost of measurement as non-invasive glucometer does not need fresh testing strips for each test. In the proposed project, we have designed a system that can measure the blood glucose level with the help of NIR spectroscopy. A NIR Led is used to pass IR radiations into the finger, the intensity of this radiation depends on glucose concentration in the blood. The IR light passes through the finger, after amplification and filtering we get output voltage signals. Using regression analysis, the unknown glucose value is determined from the unknown voltage level. It then communicates the detected blood glucose level into the smartphone through the wireless channel for output monitoring. Along with this infrared temperature monitoring unit and heart rate monitoring units have also been employed to help achieve the monitoring of different health parameters in the same system.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

I0	Intensity of incident light
I	Intensity of transmitted light
T	Transmittance of solution
A	Absorbance of the solution
GOx	glucose oxidase
O2	Oxygen
H2O	Water
H2O2	Hydrogen peroxide
ATP	Adenosine-tri-phosphate
ADP	Adenosine-di-phosphate
G6P	Glucose(6)phosphate
NAD	Nicotinamide adenine di-nucleotide
NADH	Nicotinamide-adenine-di-nucleotide-reduced
NIRS	Near-Infrared Spectroscopy
SMBG	Self-monitoring of blood glucose
CGM	Continuous monitoring of glucose
BLE	Bluetooth low energy
ADC	Analog to digital convertor
DAC	Digital to analog convertor

GPIO	General purpose input output
CLK	Clock
MISO	Master in slave out
MOSI	Master out slave in
GND	Ground
RX	Receiver
TX	Transmitter
IR	Infrared
LED	Light emitting diode
NC	No connection
I/P	Input
O/P	Output
UART	Universal Asynchronous Receiver/Transmitter
SPI	Serial peripheral interface
IDE	Integrated development environment
API	Application program interface
GUI	Graphical user interface

LIST OF SYMBOLS

π	Pie
F	Frequency in Hz
R	Resistance in Ohm
C	Capacitance in Farad
A	Absorbance
T	Transmittance
ε	Molar absorption coefficient
c	Molar concentration
l	Optical path length

CHAPTER 1

INTRODUCTION

1.1 OVERVIEW

The food we eat contains several essential nutrients such as proteins, fats, vitamins, carbohydrates and minerals. During digestion, a carbohydrate which is a macronutrient is broken down into glucose, for this glucose to enter body cells we require a hormone known as insulin which is secreted by the pancreas. Diabetes is a health condition which occurs when the pancreas cannot secrete insulin leading to abnormal blood sugar levels. Diabetes is categorised as type 1, type 2 and gestational. Type 1 is an autoimmune response where the patient's body destroys its insulin-producing cells known as islets of Langerhans. This type is not because of the patient's diet or lifestyle and has no cure. The patient needs to administer insulin dose via syringe or pump regularly. Type 2 diabetes occurs comparatively at an older age and is because of an unhealthy diet, lack of physical activity and lifestyle changes. Depending on the level of blood sugar, they can keep this under control by using medications or by administering insulin doses. Gestational diabetes occurs in pregnant women and causes complications to both mother and child. This usually is cured after pregnancy, but women who had gestational diabetes are at greater risk of developing type 2 diabetes. Diabetes can lead to serious outcomes such as a heart attack, blindness, kidney failure and stroke and should be monitored and treated accordingly. According to reports by the World Health organisation and International Diabetes Federation, 463 million people in the world are diabetic patients, which are 1 in 11 people. 1 in 2 adults with diabetes are undiagnosed (223 million). [1] To combat diabetes along with healthy food (low carb levels), proper exercise, losing weight one needs to properly monitor blood glucose levels regularly. Determining one's sugar level is known as-Self Monitoring of Blood Glucose (SMBG). It is important to perform structured self-testing of blood glucose as it would help them achieve better glycemic control, detect and prevent hypoglycemia and hyperglycemia, analyse and understand body response to exercise, blood sugar variation after meals and diabetic drugs. Testing of blood sugar alone is not enough to bring glycemic levels to a normal range. Along with it, one also needs to document the results so they can test what is working for them and what is not. With diabetes, structure leads to success and the first step towards improvement is measuring the blood sugar levels. One of the most common techniques used in medicine to

determine if an individual is affected by some disease is to measure that person's body temperature. Fever is an immediate response of the body if it is infected by the external pathogen. So measuring body temperature can tell a lot about a person's health condition. Heart rate is a common parameter used to determine a person's heart function as it can help determine cardiac output and stroke volume. Thus in this project, we propose a system which can determine three parameters which are body temperature, heart rate, blood glucose level and also displays it in a mobile interface.

1.2 THE BEER-LAMBERT LAW

The Beer-Lambert law is the primary principle behind non-invasive blood glucose determination. It gives the link between the characteristic of a material and the way light gets attenuated when it passes through it.

Let us consider that the light passed into solution is monochromatic

Let the incident light strength be I0.

Let I be the intensity light that is to be transmitted.

The transmittance of the solution is given by the variable T.

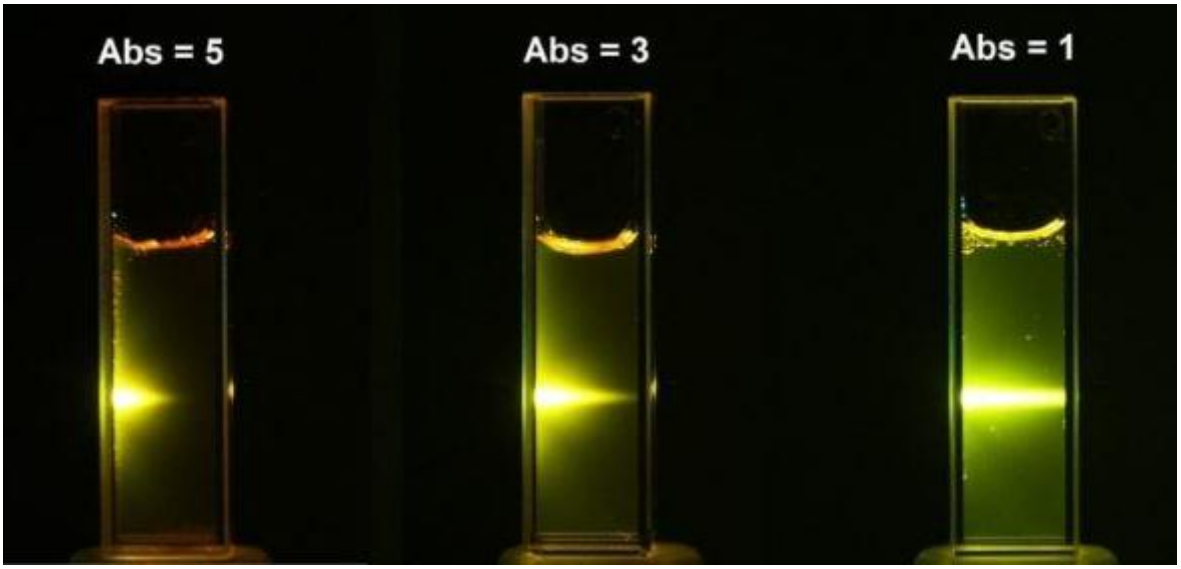

Fig 1.1 Monochromatic laser passing through Rhodamine 6G solution having different absorbance values

Transmittance is defined as the ratio of I and I0 and has a value between the range 0 and 1. It is generally expressed in terms of percentage.

$$T = I/I0$$

$$T(\text{Percentage}) = (I/I0) \times 100$$

The absorbance of the solution is given by the variable A. It is logarithmically related to the transmittance of the solution.

$$A = \log_{10} (I/I0)$$

$$A = -\log_{10} (I/I0)$$

$$A = -\log_{10} (T)$$

If a solution has an absorbance of 0% then it has a transmittance of 100%, If a solution has a transmittance of 10% then it has an absorbance of 1%.

The following table describes the relationship between absorbance and transmittance for some values:

ABSORBANCE	TRANSMITTANCE(%)
0	100
1	10
2	1
3	0.1
4	0.01
5	0.001

Table 1.1 Relationship between absorbance and Transmittance

The law which gives a linear and proportional relationship between optical path length, Molar absorption coefficient, Optical path length and Absorbance is known as Beer-Lambert Law.

$$A = \varepsilon cl$$

Where A is absorbance, ε (M^{-1} cm^{-1}) is Molar absorption coefficient, c (M) is Molar concentration and l (cm) is Optical path length.

Thus it states that there is a linear relationship between the concentration of the solution and absorbance, enabling us to determine the concentration of blood sugar by calculating absorbance of light passed through it.

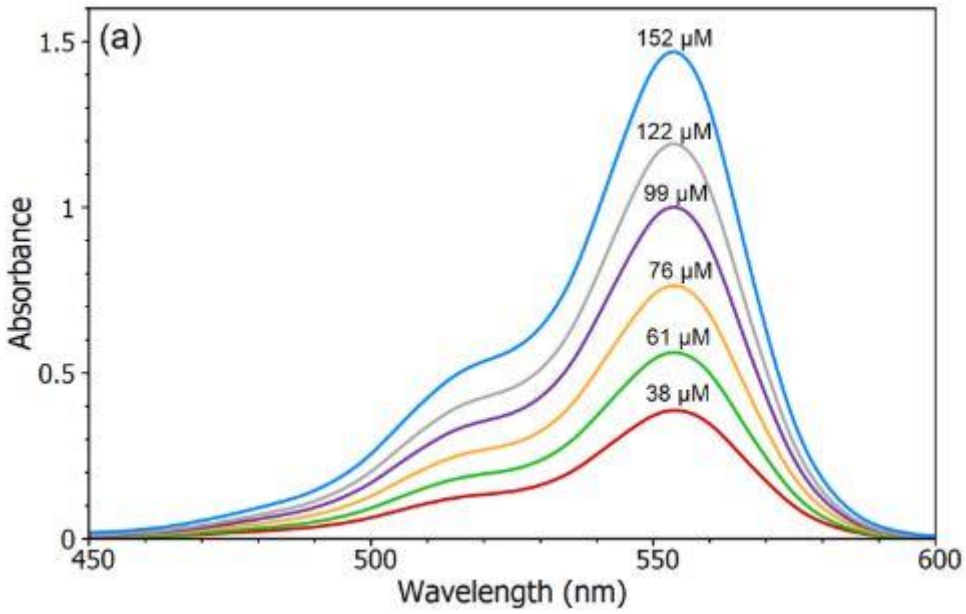

Fig 1.2 Variation of absorption spectra (Rhodamine B) with the wavelength

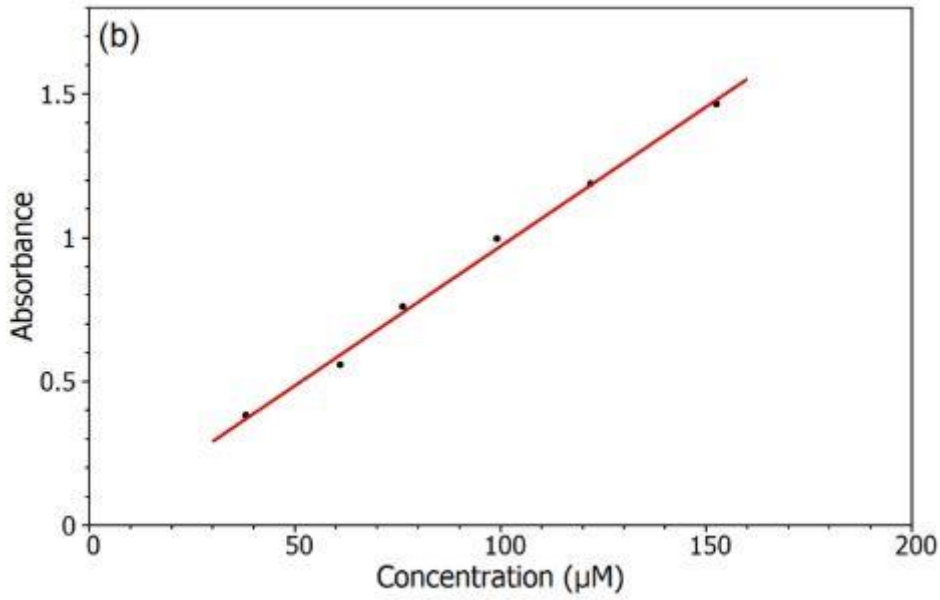

Fig 1.3 Variation of absorption with relation to the concentration

CHAPTER 2

LITERATURE SURVEY

The concept of our project is to create a Compact health care system, which can monitor different health parameters in a single unit. The detected parameters are body temperature, heart rate and blood glucose. The following papers have been studied for analysing and implementing the project. In this paper [5] they have built a cheap wearable system for monitoring blood glucose non-invasively. The paper is based on the theory that change in blood volume in arteries leads to a change in blood glucose levels. They have opted for Vis-Nir spectroscopic technique in the wrist region as it provides better resolution. They have placed IR Led and photodiode on the same side making it diffused reflectance-based design for determining output. Several output spectra have been obtained by performing in-vivo experiments on 12 patients and resultant values are documented. In paper[2] the glucose level of the blood is determined using a diffused reflectance method. They have designed a system that takes measurements from the finger using 940nm IR led and detector pair placed opposite to each other. The output data is filtered using a notch filter, processed and analyzed using Arduino microcontroller. The final signal is displayed using an LCD module. The paper [3] they have studied the different available glucose measurement techniques such as invasive, non-invasive and minimally invasive options. In paper [4] they have reviewed the various continuous glucose monitoring techniques. They have discussed the purposes, problems, accuracy and outcomes of systems based on continuous glucose monitoring systems. In paper [6] Near-infrared (NIR) technique is used for designing blood glucose monitoring unit. At first 940 nm wavelength optical signal in the IR region of the electromagnetic spectrum is passed through the arm, the earlobe and the finger using a NIR led. Arduino Uno microcontroller then processes the signal and produces the output. It is then sent to a web server via GSM module, simultaneously the patient also gets SMS notification along with appropriate medical advice regarding blood glucose levels. In paper[14] 650nm laser light has been used to determine blood glucose levels non-invasively. The theory behind this concept is that the refractive index of changes per the glucose levels of the blood. Red laser has been chosen as an optimum light source as it is most transmissible through the blood. The output is then displayed in the open-source thingspeak platform. The results are verified for both laboratory and practical cases.

CHAPTER 3

HISTORY OF GLUCOSE TESTING METHODS

Blood sugar concentration can be measured by using whole blood, serum or plasma. The latter two are recommended as sugar levels in the blood are 15 per cent lower due to cell water content. Therefore, normal methods require some amount of blood for monitoring and are invasive.

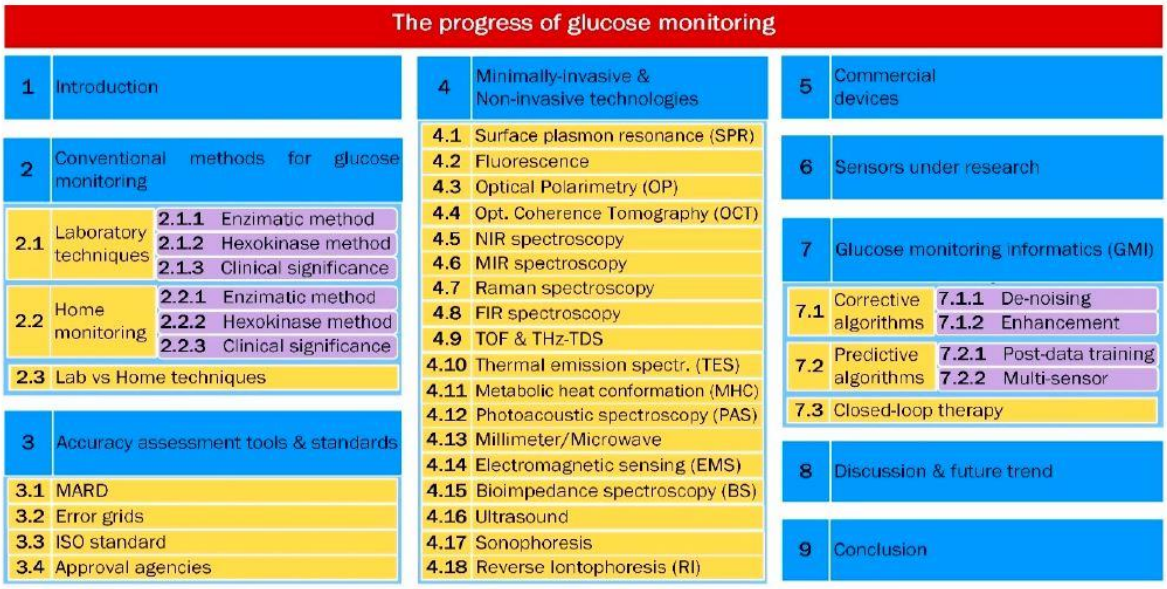

Fig 3.1 The progress of glucose monitoring

3.1 LABORATORY TECHNIQUES

The preferred methods for calculating blood glucose concentrations in laboratories are the enzymatic-amperometric and hexokinase.

3.1.1 ENZYMATIC-AMPEROMETRIC METHOD

Glucose has an enzyme known as GOx- glucose oxidase unique to it. In this method, glucose is oxidised in the using oxygen-O2, GOx and water-H2O to give hydrogen peroxide-H2O2 and gluconic acid.

At the anode of an electrochemical probe, the hydrogen peroxide is then electrochemically oxidized, creating a current signal in ampere corresponding to the glucose content in the sample.

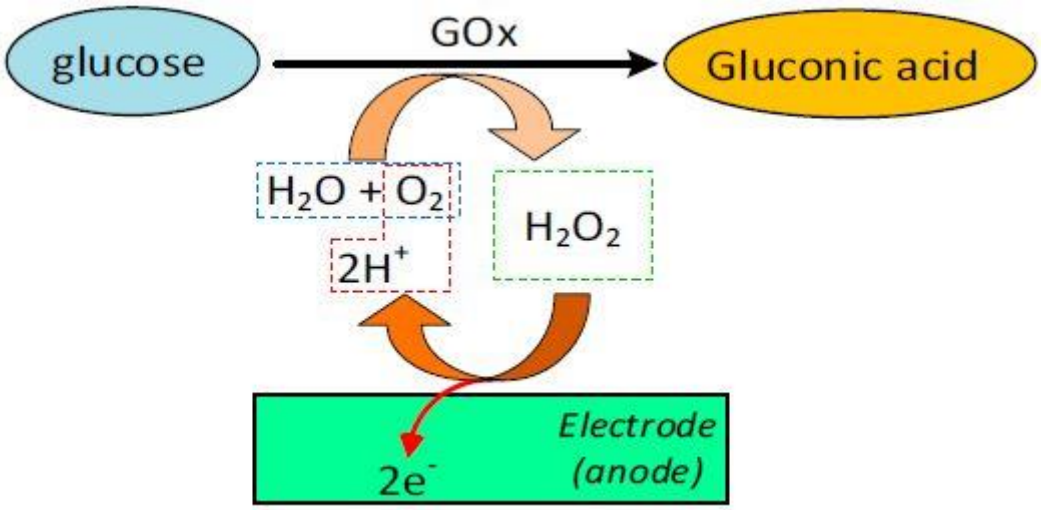

Fig 3.2 Enzymatic-amperometric method

3.1.2 HEXOKINASE METHOD

Hexokinase procedure is also known as the photometric technique. This method comprises a sequence of chemical equations and reactions as depicted in the below figure.

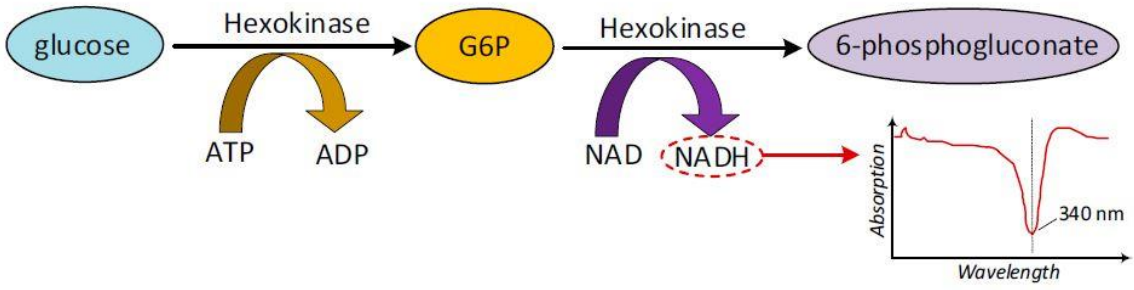

Fig 3.3 Hexokinase method

In the first step, the glucose interacts with the hexokinase enzyme, to generate G6P-glucose(6)phosphate and ADP- adenosine-di-phosphate. This is done in the presence of magnesium ions and ATP-adenosine-tri-phosphate. During the second level, G6P-glucose(6)phosphate and NAD-nicotinamide adenine di-nucleotide are oxidised with glucose(6)phosphate dehydrogenase until it reduces itself and becomes (6)phosphogluconate and NADH-nicotinamide-adenine-di-nucleotide-reduced. The amount of NADH in the

sample is equal to the quantity of glucose in the sample, and it can absorb light at a wavelength of 340 nm. The level of absorption is relative to the amount of NADH, indicating that using normal spectrophotometric techniques, glucose can be determined.

3.2 MONITORING TECHNIQUES WHICH CAN BE EMPLOYED IN HOME

There are two types of systems for individual use and self-assessment: non-continuous monitoring (NCGM) and constant monitoring of glucose (CGM).

3.2.1 SELF-MONITORING BLOOD GLUCOSE

SMBG machines are conventional glucometers that need a lancing device to prick a finger to attain vascular blood. The method for the calculation of glucose is essentially the same electrochemical technique as described above. The main difference, though, is that the complete process and calculation takes place in the glucose check strip connected to the sensor. When the blood sample drops on the screening test, in the availability of an enzyme, the glucose oxidizes to produce some value of current equivalent to the concentration of glucose. The electrons then move to the instrument containing the I (current)to V (voltage) generator to create a voltage that is analogous to the glucose amount.

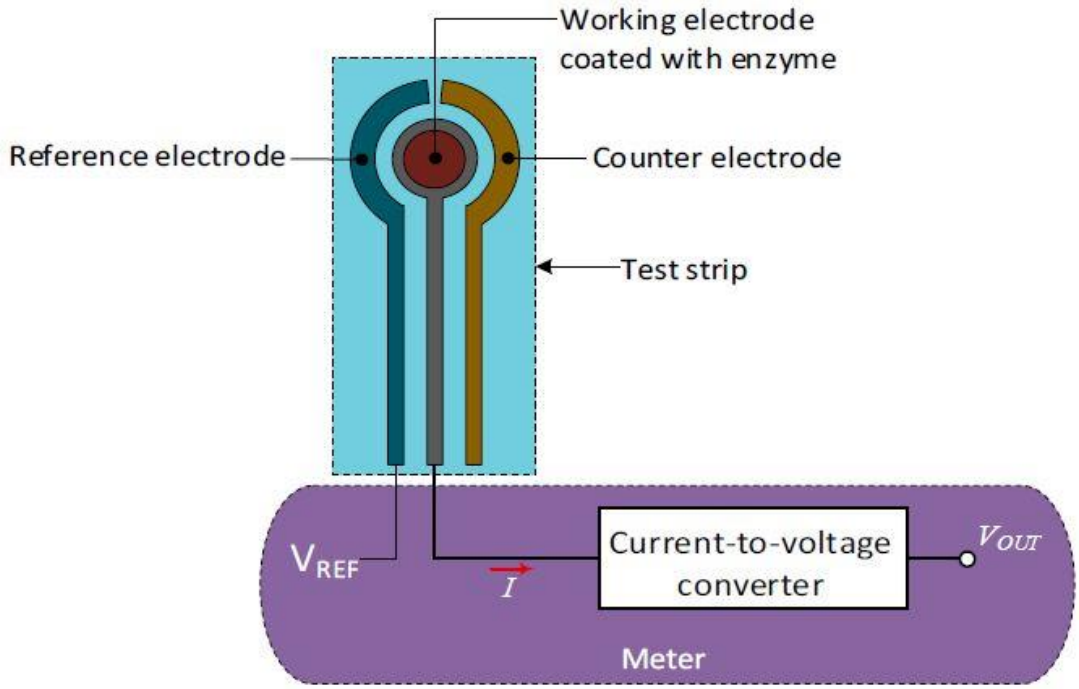

Fig 3.4 SMBG

3.2.2 CONTINUOUS MONITORING OF GLUCOSE

The CGM devices consist of three key components: a portable receiver, a detector and a transmitter. The recipient is fitted with a screen displaying the glucose interpretation. The sender is installed on the detector and transfers the measured data to the recipient via Radio wave. The detector is a tiny analysis tool embedded in the skin surface, attempting to reach so far as the fluid of the intestine: ISF is concerned. The detector now employs the combo of the chemical and electrical technique of GOx to provide with hydrogen the sugar found in the ISF, much like the check strip in SMBG products. The created peroxide communicates with platinum to generate an electrical signal that moves via a slender cord to the sender outside the exposed skin. If the recipient collects details from the sender, they must analyze the data and calculate the volume of glucose.

3.3 LABORATORY VS HOME-MONITORING

As shown in figure below, the main limitations are pervasiveness and duration connected. It also inflicts discomfort to patients, and raise significant threats of misdiagnosis and infection of the specimen. Nonetheless, one‘s amount of specificity and consistency still makes them the most comprehensive approach for glucose measurement.

CHARACTERISTICS	LABORATORY	SELF-MONITORING
Accuracy	Very good	Good
Measurement time	Long	Quick
Sample type	Blood, Serum, Plasma, Urine	Blood, ISF
Sensitivity	Very good	Good
Trained laboratory personnel	Yes	No
Blood extraction method	Invasive	Invasive

Fig 3.5 Laboratory techniques vs Home-monitoring techniques

3.4 MINIMALLY-INVASIVE AND NON-INVASIVE

Rigorous research focused on tools for the analysis of glucose without pain, discomfort, pervasiveness and dangers comparison with existing methodologies has been conducted out lately. Therefore, they may be classified into two major groups: minimally invasive : MI and non-invasive: NI types. MI techniques are the one's that enable any form of fluid to be extracted from the body (e.g. intercellular fluid and tears) to assess the level of

sugar by reactions of hormones.In the same way, approaches of glucose detection can be split into 4 subcategories: light, heat, electricity and Nano-technology. Optical, in a broader sense, encompasses all techniques used to work in IR and visual spectrum bands, taking account of the mirroring, transmitting and dispersing qualities of light when flowing through body tissues. Thermal methods track glucose by identifying physiological attributes that are related to the glucose molecule's metabolic heat generation property. Utilizing small quantities of electromagnetic radiation, current and ultrasound, electrical methods manipulate the dielectric properties of glucose at low frequencies. Lastly, there is the latest nanotechnology market. At the moment, in conjunction with optical techniques, only two techniques have begun to investigate these new venues thoroughly (SPR and fluorescence). However, much other technology, like tubes of carbon in nano size can indeed be created, and now they're in a fairly inexperienced period of development, with plenty of theoretical progress.

3.4.1 NIRS

Near-Infrared Spectroscopy (NIRS) technique is due to the scattering and absorption characteristics of electromagnetic spectrum wavelength in 780 nm to 2500 nm range. It is observed that in this range there is molecular vibration and bond rotation present in the molecule. NIRS employs the following three different types of measurement: transmission, reflectance technique including diffuse reflectance and interactance. At first light source is used to emit polychromatic light. This is irradiated into the sample during the transmittance mode. On the other side, a diffraction grating is used to separate the received radiation. The radiation is divided into its constituent wavelengths. The distinct wavelengths are then passed into a detector which detects and analyses it with the help of a computer.

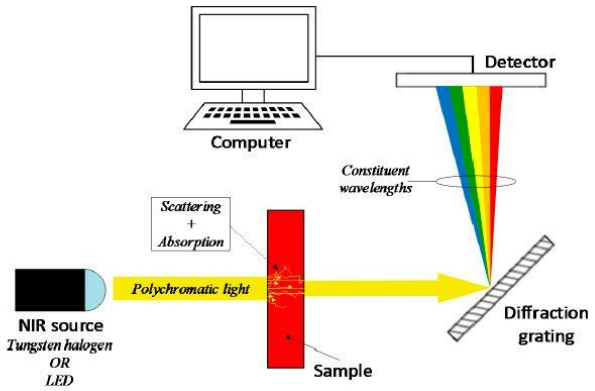

Fig 3.6 Transmittance mode

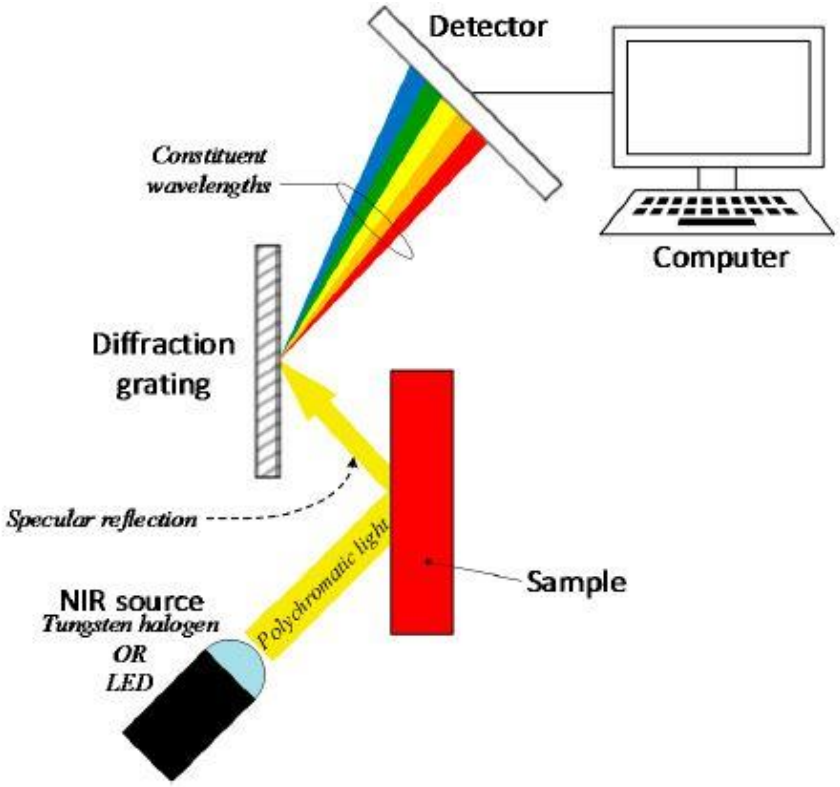

Fig 3.7 Reflectance mode

For reflectance mode, the diffraction grating used to split light and detector used to analyse light are positioned along the same side as that of the source. This is done to detect reflection at a definite angle which is also known as specular reflection.

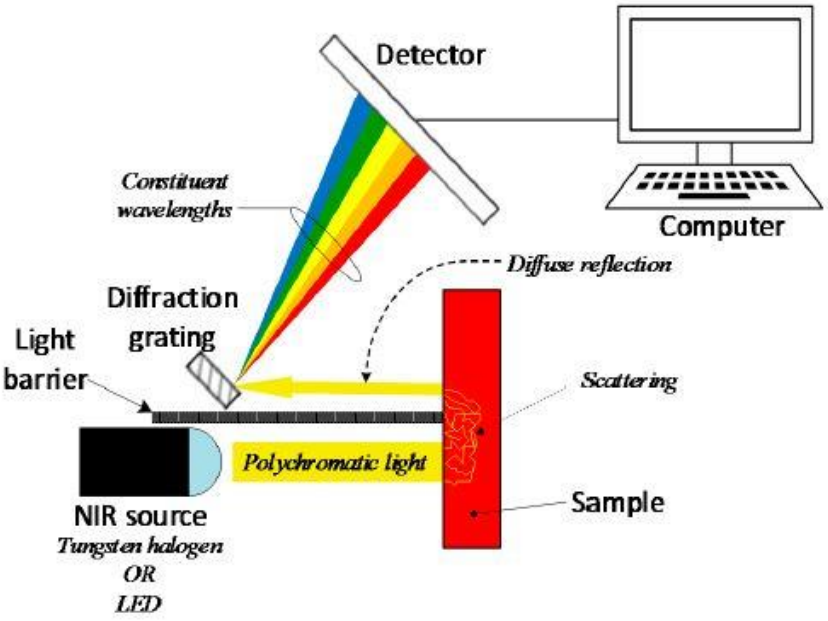

Fig 3.8 Interactance mode

Similarly, the interactance mode also senses the sample's reflected light. Unlike the other two modes, this uses light obstacle between the light source beam and the mirrored beams to distinguish the visual system of the detector from that of the illuminated area. Each mode is ideal for calculating sample absorption/transmittance and scattering, and the selection of one of them is based solely on media form. For instance, the transmission mode is recommended for fluid analysis, and very thin or clear samples, Meanwhile hard solids or dense samples are chosen for reflectance and interactance

3.4.2 ADVANTAGES OF NIR SPECTROSCOPY

- NIR band is transparent to water.
- Relatively inexpensive materials required.
- The amplitude of a signal is proportionate to the analyte concentration.
- Minimal treatment of samples needed.
- The approach also works when intervening objects, like glass or plastic containers, are present.

CHAPTER 4

PROPOSED SYSTEM

4.1 BLOCK DIAGRAM

The proposed system of determining blood glucose level non-invasively can be elucidated with the help of the following block diagram:

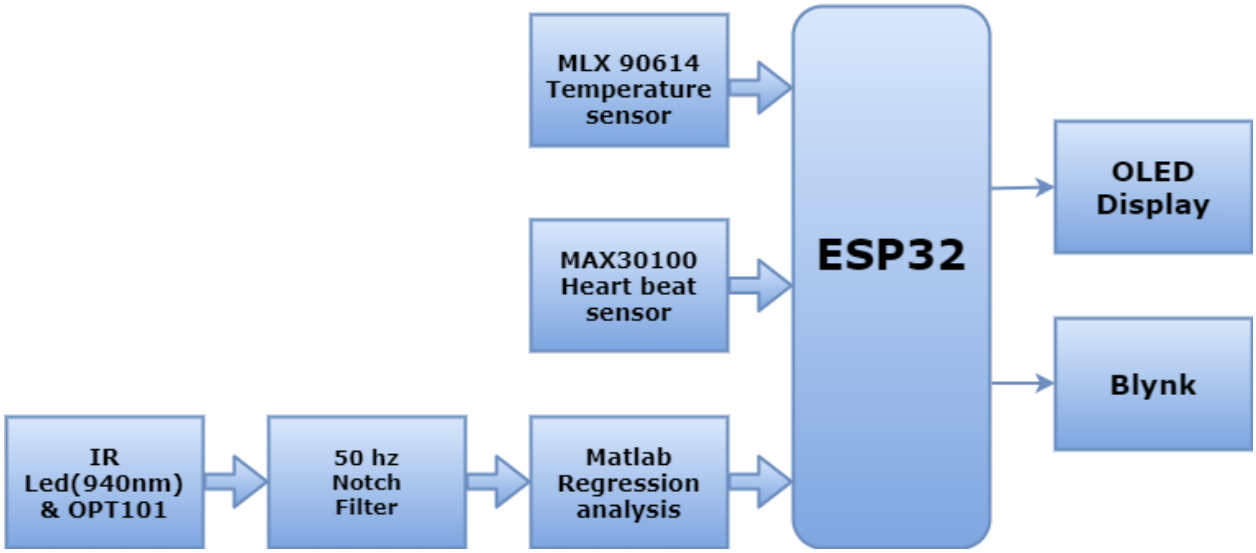

Fig 4.1 Block diagram

The proposed system can be used for monitoring three health parameters which are Blood glucose (Non-invasive measurement), Body temperature and Heart rate.

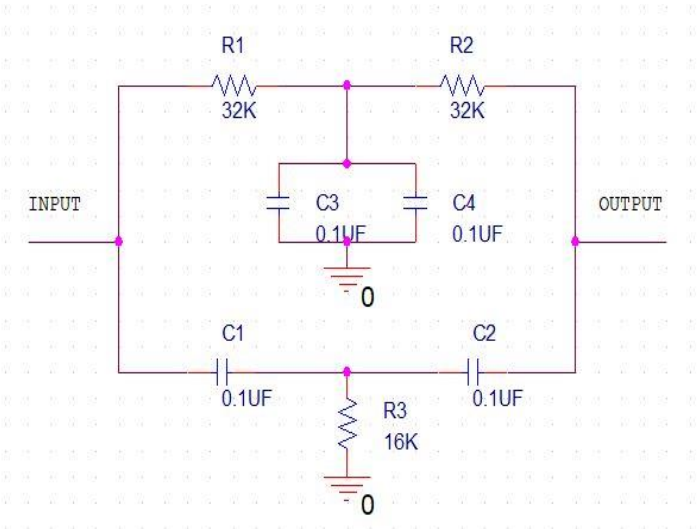

Fig 4.2 Notch filter design

For blood glucose measurement NIR led to 940nm wavelength and OPT101 photodiode have been employed. 940nm led has been chosen as it has a maximum absorption peak in the NIR region of the electromagnetic spectrum. They can either be placed opposite to each other or adjacent to each other with a separation of 4mm. There should be a minimum possible gap between the two when placed opposite to each other to maximise the efficiency of the system. The output of the photodiode is then fed to 50hz notch filter. This was integrated into the system to remove noise due to power line. To determine R, C values:

$$F=(1/4\pi RC)$$

$$F=50\ Hz$$

Let C=0.1uf

$$50=1/(4(3.14)(R)(0.1*10\text{-}6))$$

$$R=1/(50)(4)(3.14)(10\text{-}7)$$

$$R=15.923KOhm$$

$$R=16KOhm$$

The ADC output from the filter is then fed to the general-purpose input-output pin of the ESP32 microcontroller. It is a microcontroller with inbuilt Wi-Fi and Bluetooth capability thus eliminating the need for additional peripherals. It also has AI on-chip, making it ideal for future machine learning applications. At first, the ADC output values are collected and a database is made for corresponding ADC output and blood sugar levels by manually monitoring using an invasive system. This data is fed to Matlab and regression model is obtained for data. This is fed into the microcontroller and the final result is obtained. Body temperature is measured using non-contact MLX90614. It is a non-contact IR temperature sensor. It has an accuracy of 0.5°C thus making it highly suitable for body temperature measurements. Heart rate is determined using MAX30100 sensor. All parameters can be monitored using a single unit. The determined level is then wirelessly communicated to a mobile interface. The user can then monitor the user-friendly representation of the glucose level, the temperature and heart rate in the output device. Outputs are also remotely displayed on OLED display attached to the unit.

CHAPTER 5

HARDWARE USED

5.1 ESP32

ESP32 is a Bluetooth and Wi-Fi (2.4 GHz) combination chip equipped with 40 nm TSMC ultra-low-power tech. It was developed to deliver the optimum power and RF output, in a broad range of uses and control scenarios with robustness, flexibility and dependency. The ESP32 chip series includes ESP32-D0WDQ6-V3, ESP32-D2WD, ESP32-D0WD, ESP32-D0WD-V3, ESP32-D0WDQ6, and ESP32-S0WD, among which ESP32-D0WDQ6-V3, ECO V3 and ESP32-D0WD-V3 are wafer-based.

Fig 5.1 ESP32

Designed for handheld phones, portable computer systems and other IoT devices, ESP32 provides excellent performance with very low power usage. ESP32 also has creative innovations including accurate clock gating, various power modes and robust power scaling. ESP32 will operate reliably for industrial applications with an operating temperature of-40oCto + 125oC. ESP 32, supported with advanced tuning circuits, can dynamically remove external circuit defections and respond to environmental changes. ESP32 can function as an all-in-one or slave-based system to an MCU host, reducing the overhead stack of the main application processor. It's SPI / SDIO or I2C / UART interfaces allow ESP32 to communicate with other systems to provide Wi-Fi and Bluetooth functionality. ESP32 is fully integrated

with built-in antenna switches, RF baluns, power amplifiers, low-noise receiving amplifiers, filters and power-management systems.

5.1.1 TECHNICAL SPECIFICATIONS OF ESP32

NUMBER OF CORES	2
WI-FI	2.4GHz to 150Mbit/s
BLUETOOTH	BLE & Bluetooth
ARCHITECTURE	32 bits
CLOCK FREQUENCY	Up to 240Mhz
RAM	512KB
PINS	39
PERIPHERALS	ADC,DAC,SPI,I2C,UART,PWM,Capacitive touch and more.

Table 5.1 Specifications of ESP32

5.1.2 PIN CONFIGURATION OF ESP32

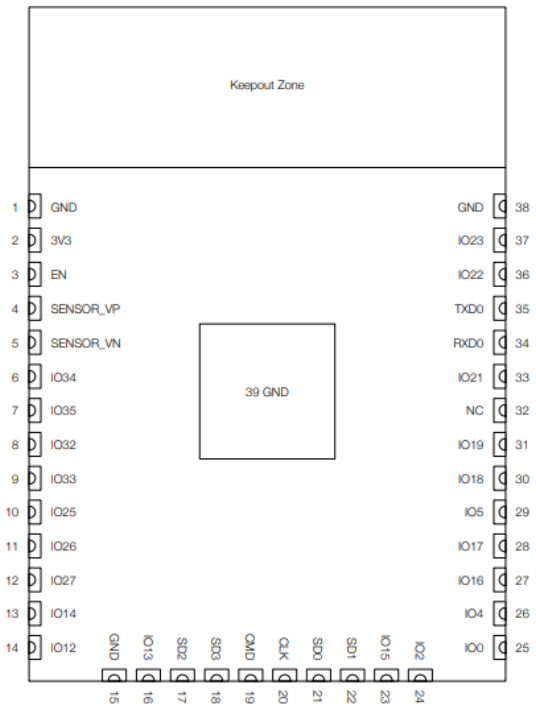

Fig 5.2 ESP32 Pin details

TYPE OF PIN	NAME OF PIN	DESCRIPTION
POWER	Micro-USB	It is used for powering the ESP32 and programming it.
POWER	5V	Input pin which can be supplied with 5v regulated input.
POWER	3.3V	Input pin which can be supplied with 3.3v power.
POWER	GND	It is used for grounding the peripherals.
DAC	DAC1 & DAC2	These are used for converting a digital signal into analog signals.
ENABLE PIN	EN	It is used for resetting ESP32.
ANALOG INPUT	ADC10 to ADC15, ADC20 to ADC29	It is an analog input pin which can be provided with input up to 3.3V.
GENERAL PURPOSE INPUT(OR) OUTPUT PINS	GPIO0 to GPIO39	Pin 0 to 33 can be used as both input and output while 34 to 39 can be used only as input.
AREF	AREF	It gives reference voltage for input.
IIC	GPIO21-SDA GPIO22-SCL	I2C
VSPI	GPIO23-MOSI GPIO19-MISO GPIO18-CLK GPIO05-CS	SPI-1
HSPI	GPIO 13- MOSI GPIO 12 - MISO GPIO 14 - CLK	SPI-2

	GPIO 15 - CS	
PULSE WIDTH MODULATION	ALL GPIO	PWM can be initiated using the software.
CAPACITIVE TOUCH	T0-T9	Pin used to enable in built capacitive touch pads.
SERIAL	RX, TX	Serial communication.
INTERRUPTS (EXTERNAL SOURCE)	EVERY GPIO PIN	Software IDE can be used to trigger interrupt in any pin.

Table 5.2 Pin description of ESP32

5.2 IR LED

Fig 5.3 IR LED

An Infrared light-emitting diode is a special function LED emitting wavelengths of 700 nm to 1 mm of infrared rays. It is a Solid-state device. Different IR LEDs can emit various wavelengths of infrared light, just as separate LEDs can produce different colours of light. IR They are usually used as sensors in complement to IR receivers. An IR LED has the same design as a typical LED. As the naked eye of humancan never see the IR radiation, a person can not determine whether an IR LED is working. The IR LEDs allow Infrared light to be generated cheaply and efficiently. Since IR LEDs can be used in combination with a variety of different sensor types, they are popular in Machine-to-Machine (M2 M) and Internet of Things (IoT) environments.

5.2.1 PIN CONFIGURATION OF IR LED

Infrared LED has a polarity that is it has both positive and negative. The tall pin is the positive pin or anode and the short pin is the negative pin or cathode.

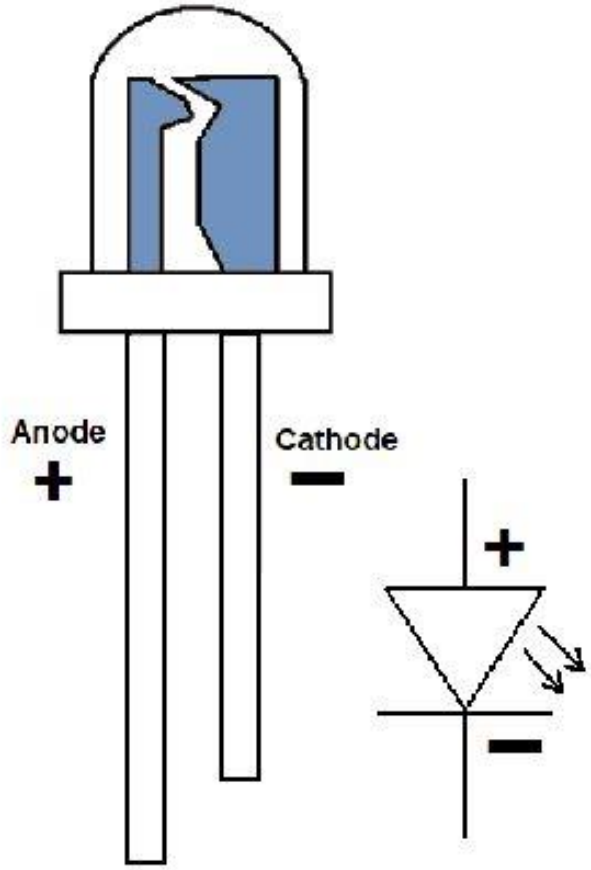

Fig5.4 IR LED Pinout and Symbol

5.2.2 FEATURES OF IR LED

- Strong reliability
- Low forward voltage
- Increased radiant strength
- Lead spacing is 2.54mm
- Wavelength is 940nm
- Simple to use with a breadboard
- It is free of lead
- Certified by RoHS

5.2.3 TECHNICAL SPECIFICATIONS OF IR LED

CHARACTERISTIC	VALUE
Forward current	Minimum -100mA Maximum - 300mA
Surge forward current	1.5A
Forward voltage	1.24V – 1.4V
Storage temperature and operation temperature	-40 degree C to 100 degree C
Temperature during soldering	260 degree C
Dissipated power	150Mw
Spectral bandwidth	45nm
Viewing angle	30 to 40 degree

Fig 5.5 Technical specifications of IR Led

5.2.4 USES OF IR LED

- Gesture recognition
- Health monitoring and biometrics
- Home interior and exterior- Remote control, CCTV, IR Communication, door control.
- Surveillance
- Machine vision and safety

5.3 OPT101

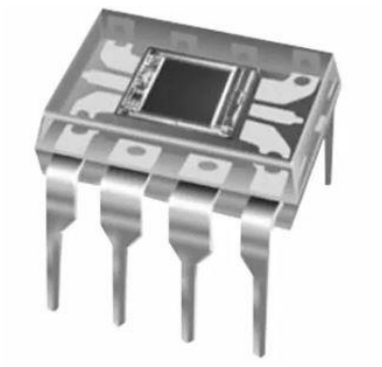

Fig 5.6 OPT101

The OPT101 is photodiode that is monolithic with trans-impedance amplifier integrated in its chip. The unified arrangement of the amplifier with trasns impedance properties and photodiode in one chip removes the typical issues found in designs that are discrete , like current errors due to leakage electrons, gain peak due to stray capacitance and noise pick-up. With light intensity, the output voltage rises linearly. The amplifier is built for use with single or double power supply. For improved linear properties and lwss dark current, the 0.09 × 0.09 in inch , operates in photo-conductive mode. It performs deliveries from 2.7 Volt to 36 Volt. The present at Quiescent is just 120uA. It is surface mounted in transparent 8pin PDIP plastic. Temperatures vary between 0 °C and 70 °C.

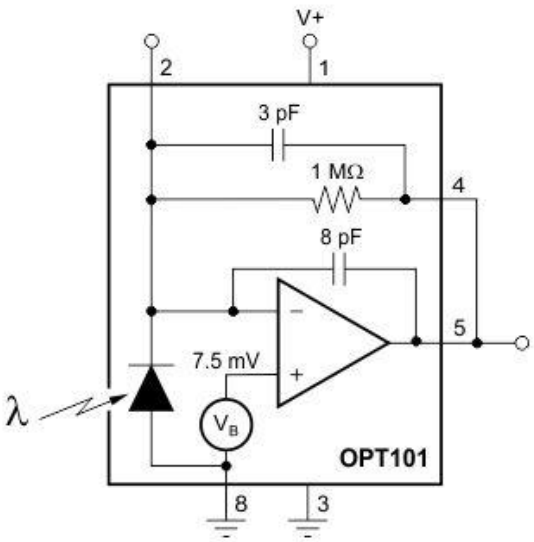

Fig 5.7 Functional block diagram of OPT101

5.3.1 FEATURES OF OPT101

Single supply	2.7V to 36V
Size	2.29mm× 2.29 mm
Feedback resistor	1MΩ
Responsivity	650nm
Bandwidth	14Khz
Package	8-pin DIP and J-Led SOP

Table 5.3 Features of OPT101

5.3.2 PIN CONFIGURATION AND FUNCTIONS OF OPT101

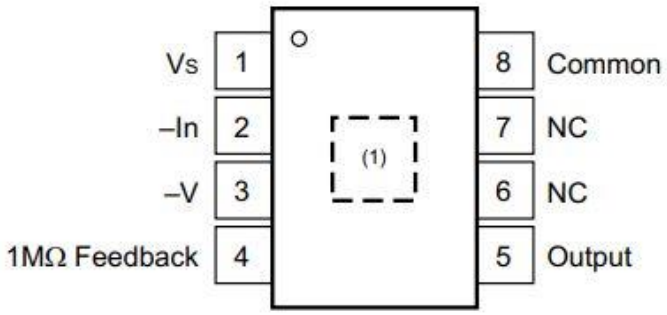

Fig 5.8 Pinout of OPT101

NO.	NAME OF PIN	I/O	PIN DETAIL
1	Vs	Power	Pin used to provide input power
2	-ln	Input	No connection(Cathode)
3	-V	Power	Ground
4	1 Mega Ohm Feedback	Input	It is the circuit for feedback present internally. It is connected to Output pin five.
5	O/P	O/P	Output pin of the system
6	NC	-	No connection
7	NC	-	No connection
8	Common	Input	Ground(Anode)

Table 5.4 Pin Functions of OPT101

5.3.3 APPLICATIONS OF OPT101

- Medical instrumentation
- Currency changers
- Position sensor
- Laboratory instrumentation
- Proximity sensor
- Barcode scanners
- Photographic analyzers
- Smoke detectors

5.4 MAX30100

Fig 5.9 MAX30100

The MAX30100 is an integrated sensor system for heart rate and pulse oximetry display. To monitor pulse oximetry output and rate of heart signals in beats per minute, it incorporates 2 LEDs, advanced optics, a photo detector, and processing of anaog signal with low noise content. The MAX30100 works from 1.8 Voltage and 3.3 Voltage of power supply and can be switched down by marginal standby current software, allowing the power supply to stay attached at all hours

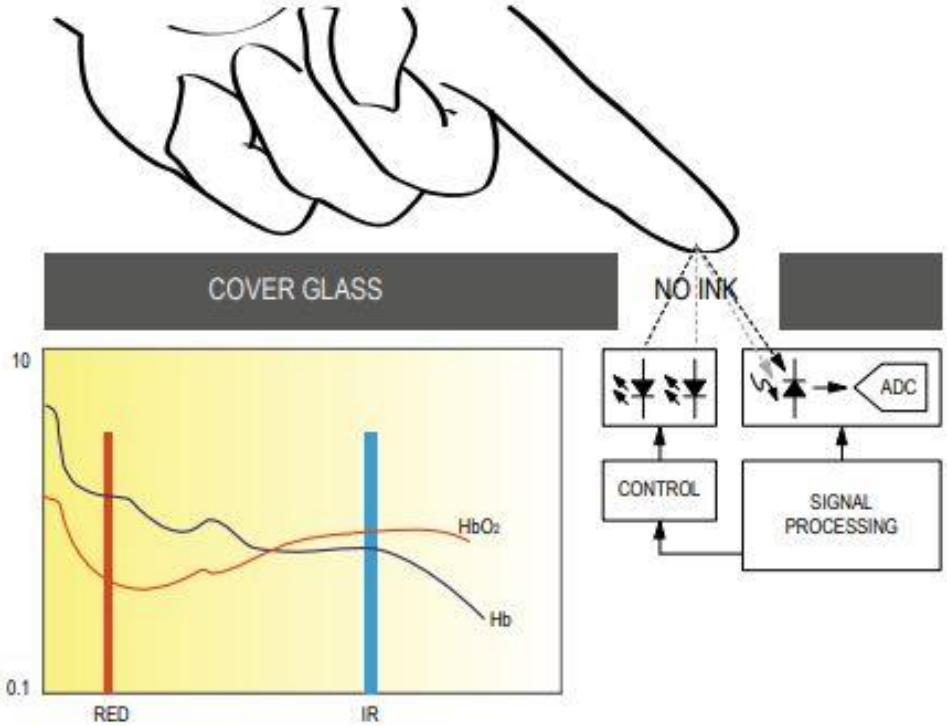

Fig 5.10 System block diagram of MAX30100

5.4.1 APPLICATIONS OF MAX30100

- Wearable devices
- Fitness Assistant Devices
- Medical Monitoring Devices

5.5 MLX90614

Mlx90614 sensor has opted for temperature sensing. It is a non-contact IR temperature sensor. It is a small size, a low-cost sensor which is easy to integrate with any module. It has an accuracy of 0.5°C thus making it highly suitable for body temperature measurements. It has an ambient temperature range (-40-125)°C and objects temperature range (-70-380)°C. It works using I2C communication protocol and thus uses minimum wiring in the circuit.

Fig 5.11 MLX90614 Temperature sensor

5.5.1 PIN FUNCTIONS OF MLX90614

PIN TYPE	PIN FUNCTION
VIN	Input voltage supply
Ground	Ground pin
Serial pin for clock	Clock for I2C communication
Serial pin for data	Data for I2C communication

Table 5.5 Pin Functions of MLX90614

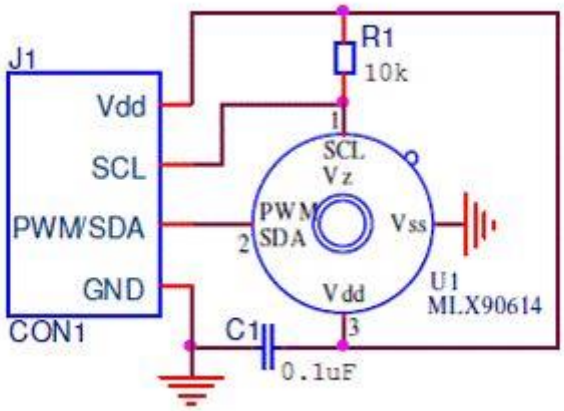

Fig 5.12 Functional diagram of MLX90614

5.5.2 FEATURES OF MLX90614

FEATURE	DESCRIPTION
Size and Cost	Small, Low
Voltage (Input)	3V & 5V
Resolution	0.02°C
Temperature range	ambient - (-40-125)°C , objects (-70-380)°C
Accuracy	0.5°C
Grade	Automotive-grade

Table 5.6 Features of MLX90614

5.5.3 APPLICATIONS OF MLX90614

- Body temperature measurement
- Used in relay for thermal systems
- Detection of movement
- Monitoring of livestock
- Healthcare
- The temperature control unit of Home appliances
- Defogging of windshield
- Used as a temperature sensor for Industrial. Residential and Commercial air conditioning units
- Used in copiers and printers as a temperature control unit

CHAPTER 6

SOFTWARE USED

6.1 ARDUINO IDE

Fig 6.1 Arduino Logo

A multi-platform application based on java platform is the Arduino IDE: Integrated Development Environment. This is available on Windows, Linux and macOS systems. It has a code editor with features such as code editing, data search and replacement, smart formatting, brace maps, syntax emphasis. It provides quick only one-click procedures for programme compilation and uploads to an Arduino board. Includes a message field, a toolbar with standard task buttons, a screen interface to code and a hierarchy for the action menu. It encourages the usage of a special application structuring laws for C and C++ languages. The Arduino IDE offers a wiring project software library that provides a variety of basic input and output procedures. Only two simple functions are required for the code written by the developer. These are obtained and connected to the main stub software used by the operating GNU toolchain, which includes the IDE allocation, the startup code and the primary software loop into a workable cyclical executive system. The Arduino IDE transforms the program code to a word document using the avrdude programme, which itself is hexadecimal encrypted in the device firmware.

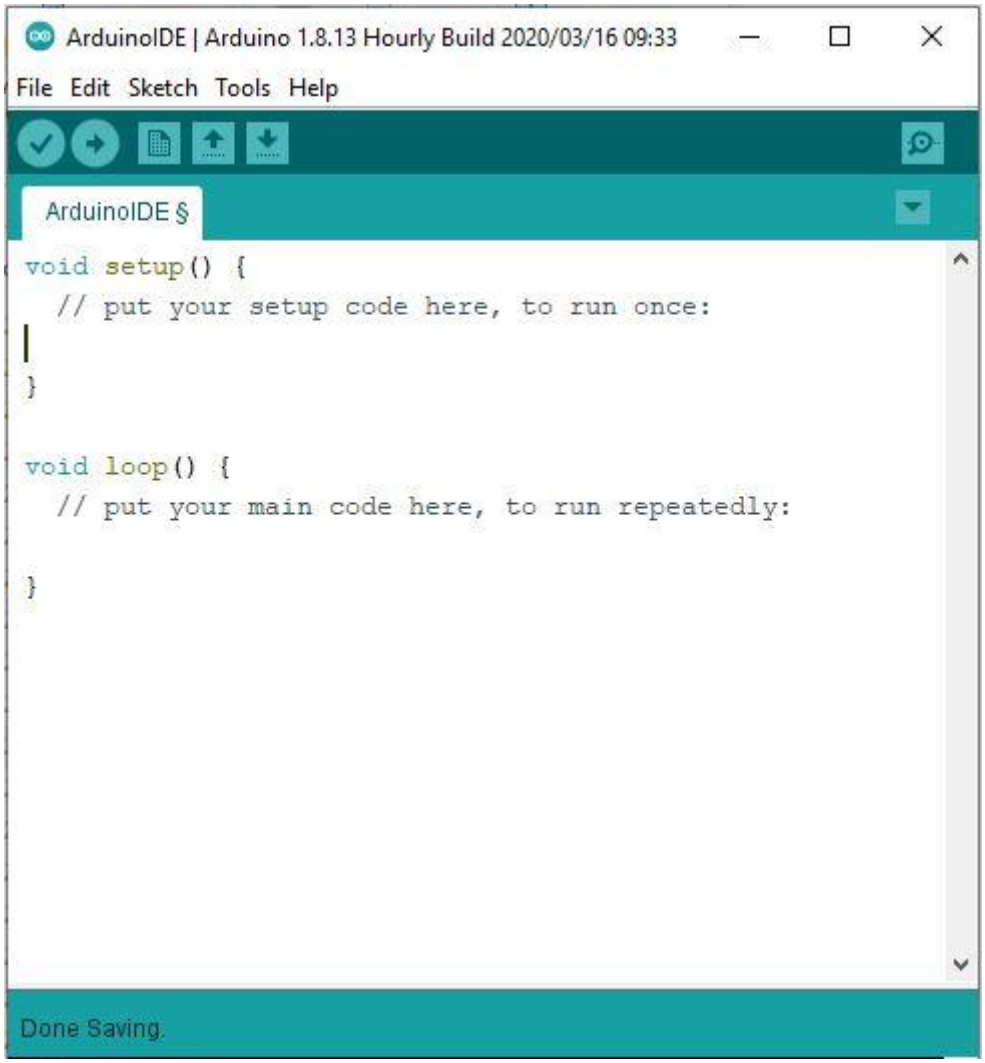

Fig 6.2 Arduino software

The principal advantages of Arduino interface are its ability to function on-site and as an online editor, integrated library, direct configuration and board modules. The benefits users can expect from the device are specifically:

- Board interface choices -The platform is fitted with a board management app, whereby coders can select which board to use. You can pick another alternative from the dropdown menu if another board is required. Whenever adjustments are made on the board or a new board is selected, the PORT data is changed automatically.
- Direct Arduino IDE Sketching -This feature enables users to create sketches from their text editor. The method is quick and fast. The text editor also has additional features that encourage a more immersive experience.
- Documentation -The tool provides its users with the possibility of recording their works. This function helps you to monitor your advancement and to be informed of

any updates. Furthermore, documentation enables other coders to use sketches on their custom boards.

- Sharing of Sketch-Arduino IDE facilitates its coders to share their program code with other developers. Every sketch has its own online connection to share with friends and colleagues. Only in cloud version is the above function accessible.
- Presence of Integrated libraries-Hundreds of integrated libraries is present in Arduino IDE. The Arduino community made these libraries and freely shared them in this platform. Users may use this without private party installations for their custom projects.
- Support for External Hardware- Although the platform is primarily for Arduino boards, it does have foreign board hardware communication service. It assures the Arduino IDE is used widely from being bound to its specific boards.

6.2 MATLAB

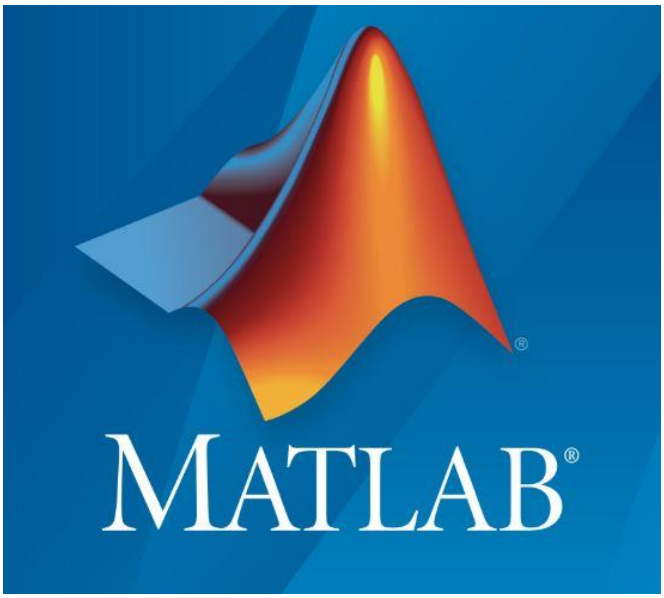

Fig 6.3 Matlab Logo

MATLAB is a MathWorks-designed software application for coding. The computer language began as a matrix programming software, where linear algebra scripting was easy. It can be operated both as collaborative and batch work sessions. MATLAB allows matrix development, algorithm execution, interfacing with programs written in other languages, function and data analysis and designing user interfaces. While MATLAB is meant principally for digital computing, the MuPAD symbolic engine for exposure to symbolic

computing functions is used as an optional toolbox. Simulink provides an additional kit, including multi-domain graphic simulation and modelling for complex and embedded systems.

6.2.1 FEATURES OF MATLAB

1. High-Level Language-It is a high-level programming language, with output and inputs, data structures, functions, flow control, and object-oriented programming. It allows both quick development of programs and the production of robust, complicated and extensive applications.
2. Interactive environment-MATLAB offers an immersive platform that facilitates iterative research, design and integrated environments for solving problems. A programmer can use several tools present in Matlab environment to create iterating codes which have handling capabilities for workspace variables and import/export data. It even comprises of tools for MATLAB files to be created, managed, debugged and profiled.
3. Graphics Handling-It provides integrated graphics that are useful for visualizing of data, as well as tools to create custom plots. MATLAB provides high-level guidelines for producing graphics, animations, image analysis and interactive displays, two- and three-dimensional data visual. It gives instructions at a low level which allow users to change completely the graphic appearance thorough MATLAB GUI.
4. Mathematical Functions Library -It provides the Mathematical Functions Library. A vast number of mathematical functions required for statistical computation, quantitative integration, linear algebra, filtering, analytical data, optimization and normal differential equations are available.
5. Application Program Interface (API) -Programmers can write C, Fortran and C++ programs with specific interfaces with Matlab APIs(application program interface (API)) Those are options to call MATLAB (dynamic connecting) or as computing engine and to read and write MAT-files. MEX API and Matrix API functions can be used by creators to communicate in the MATLAB workspace with data.

6.3 BLYNK

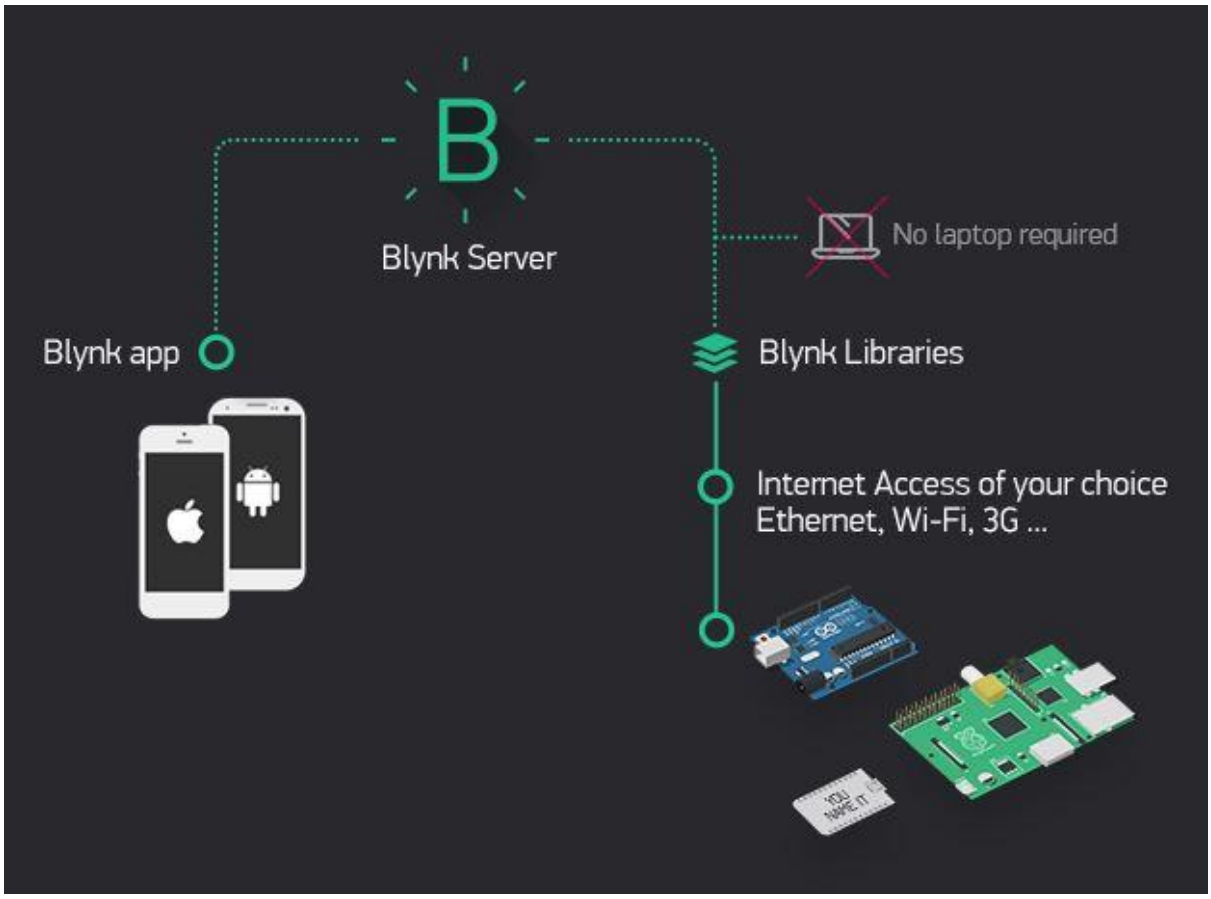

Fig 6.4 Blynk

Blynk is a mobile application planned primarily for the Internet of Things. The program can be used for remotely controlling external hardware, accessing, collecting and displaying sensor data. The framework consists of three key elements:

- Blynk App- It allows everyone to make stunning user interface with numerous packages.
- Blynk Server - It is accountable for all contact between smartphones and equipment. You may use the Blynk Space or the specific Blynk dedicated server. It has a proprietary API, it can accommodate thousands of machines quickly, and it can even be managed through an open-source RPI
- Blynk Library - This library offers links to the registry and manages both inlet and outlet functions for all common device types.

CHAPTER 7

EXPERIMENTAL OUTPUT

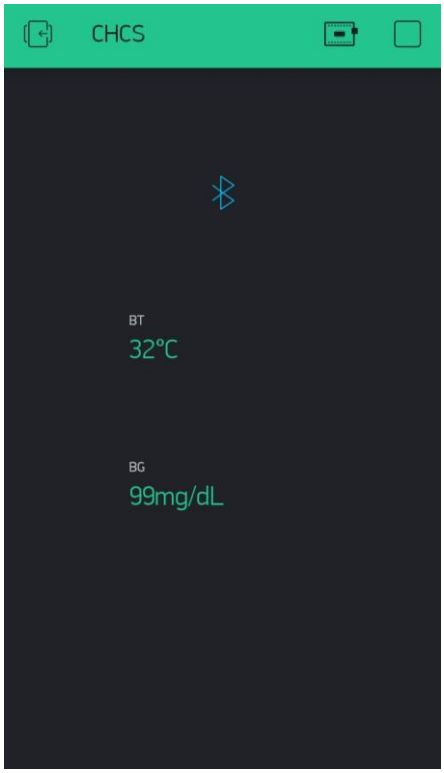

Fig 7.1 Blynk Output

Fig 7.2 OLED Output

CHAPTER 8

ADVANTAGES AND CONCLUSION

8.1 ADVANTAGES

- Non-invasive in nature and requires no pricking or injections, pain-free
- A cost-effective system which does not require multiple strips for measurement
- No biomedical waste is generated
- Portable and environment-friendly
- Real-time data is available in both web and mobile platform
- Probability of human error is reduced
- Self-diabetes management is easier
- Documentation of data is automated thus requires less human effort
- Biotelemetry is easier for medical analysis of data

8.2 CONCLUSION

In this project, we have designed a Compact Health Care System that can non invasively monitor blood sugar using the near-infrared technique, body temperature and heart rate.The monitored data is displayed to the user using the mobile application interface- Blynk and also OLED display attached to the system. As the system is simple it can inturn also be developed into a wearable device. This prototype is developed using ESP32 microcontroller, making this a unique cost-effective device

REFERENCES

1. IDF, https://idf.org/aboutdiabetes/what-is-diabetes/facts-figures.html

2. Mohammed Shahriar Arefin, Adnan Hossain Khan, and Rabiul Islam, " Non-invasive Blood Glucose Determination using Near-Infrared LED in Diffused Reflectance Method" in 10th International Conference on Electrical and Computer Engineering 20-22 December 2018, Dhaka, Bangladesh

3. David C.Klonoff "Continuous Glucose Monitoring Roadmap for 21st-century diabetes therapy" in DIABETES CARE, VOLUME 28, NUMBER 5, MAY 2005

4. Raju Poddar, Joseph Thomas Andrews, Pratyoosh Shukla, Pratima Sen "Non-invasive Glucose Monitoring Techniques: A review of current trends " in arXiv:0810.5755v1 [physics.med-ph] 31 Oct 2008

5. Vega Pradana Rachim, Wan-Young Chung "Wearable-band Type Visible-Near Infrared Optical Biosensor for Non-invasive Blood Glucose Monitoring" in Sensors and amp; Actuators: B. Chemical (2019), https://doi.org/10.1016/j.snb.2019.01.121

6. Md. Mahbub Alam, Swapnil Saha, Proshib Saha, Fernaz Narin Nur, Nazmun Nessa Moon, Asif Karim and Sami Azam " D-CARE: A Non-invasive Glucose Measuring Technique for Monitoring Diabetes Patients " in Uddin M., Bansal J. (eds) Proceedings of International Joint Conference on Computational Intelligence. Algorithms for Intelligent Systems. Springer, Singapore

7. M. S. Asekar, "Development of Portable Non-Invasive Blood Glucose Measuring Device Using NIR Spectroscopy," 2018 Second International Conference on Intelligent Computing and Control Systems (ICICCS), Madurai, India, 2018, pp. 572-575.

8. C. Sreenivas and S. Laha, "Compact Continuous Non-Invasive Blood Glucose Monitoring using Bluetooth," *2019 IEEE Biomedical Circuits and Systems Conference (BioCAS)*, Nara, Japan, 2019, pp. 1-4.

9. B. Sargunam and S. Anusha, "IoT Based Mobile Medical Application for Smart Insulin Regulation," *2019 IEEE International Conference on Electrical, Computer and Communication Technologies (ICECCT)*, Coimbatore, India, 2019, pp. 1-5.

10. Saina Sunny, S.Swapna Kumar "Optical Based Non-Invasive Glucometer with IoT" in *2018 International Conference on Power, Signals, Control and Computation (EPSCICON)*, Thrissur, 2018, pp. 1-3.

11. K. T. Sithara Surendran and T. Sasikala, "Sensor system based Non-Invasive System to Measure Glucose Level in Human Body," 2019 3rd International Conference on Computing Methodologies and Communication (ICCMC), Erode, India, 2019, pp. 203-207.
12. K. Lawand, M. Parihar and S. N. Patil, "Design and development of infrared LED based non-invasive blood glucometer," 2015 Annual IEEE India Conference (INDICON), New Delhi, 2015, pp. 1-6.

13. B. L. Priya, S. Jayalakshmy, R. Bhuvaneshwar and J. K. Kumar, "Non – Invasive Blood Glucose Monitoring based on Visible LASER Light," 2018 3rd International Conference on Communication and Electronics Systems (ICCES), Coimbatore, India, 2018, pp. 938-941.

14. Ozaki Y. Near-infrared spectroscopy--its versatility in analytical chemistry. Analytical Sciences: the International Journal of the Japan Society for Analytical Chemistry. 2012;28(6):545-563. DOI: 10.2116/analsci.28.545.

15. Omar S Khalil, Spectroscopic and Clinical Aspects of Noninvasive Glucose Measurements, *Clinical Chemistry*, Volume 45, Issue 2, 1 February 1999, Pages 165–177

APPENDIX

Software Code:

Arduino IDE:

```
int sensorValue = 0;
float out_average = 0;
const int pin = 34;
float value;
long sum = 0;
int i = 0;
/*********************************BG*********************************/
#include <Wire.h>
#include <Adafruit_MLX90614.h>
Adafruit_MLX90614 mlx = Adafruit_MLX90614();
/*********************************BT*********************************/
#include <Wire.h>
#include "MAX30100_PulseOximeter.h"
#define REPORTING_PERIOD_MS 1000
PulseOximeter pox;
uint32_t tsLastReport = 0;
/*********************************HR*********************************/
#define BLYNK_PRINT Serial
#define BLYNK_USE_DIRECT_CONNECT
#include <BlynkSimpleEsp32_BT.h>
#define PIN_1 V5
#define PIN_1 V4
#define PIN_1 V3
char auth[] = "MY4T3RAdKOQWDf92tZ15jRsN2pLCrjwI";
```

```
/*********************************BL*********************************/
#include <SPI.h>
#include <Wire.h>
#include <Adafruit_GFX.h>
#include <Adafruit_SSD1306.h>
#define SCREEN_WIDTH 128
#define SCREEN_HEIGHT 64
#define OLED_MOSI   23
#define OLED_CLK    18
#define OLED_DC    27
#define OLED_CS    5
#define OLED_RESET 0
Adafruit_SSD1306 display(SCREEN_WIDTH, SCREEN_HEIGHT,
                         OLED_MOSI, OLED_CLK, OLED_DC, OLED_RESET, OLED_CS);
#define LOGO_HEIGHT   16
#define LOGO_WIDTH    16
static const unsigned char PROGMEM logo_bmp[] =
{ B00000000, B11000000,
  B00000001, B11000000,
  B00000001, B11000000,
  B00000011, B11100000,
  B11110011, B11100000,
  B11111110, B11111000,
  B01111110, B11111111,
  B00110011, B10011111,
  B00011111, B11111100,
  B00001101, B01110000,
```

```
  B00011011, B10100000,
  B00111111, B11100000,
  B00111111, B11110000,
  B01111100, B11110000,
  B01110000, B01110000,
  B00000000, B00110000
};
/*********************************OL*********************************/
void setup()
{
  Serial.begin(115200);
  Serial.println("Waiting for connections...");
  Blynk.setDeviceName("Blynk");
  Blynk.begin(auth);
  /*********************************BL*********************************/
  Serial.println("Adafruit MLX90614 test");
  mlx.begin();
  /*********************************BT*********************************/
  Serial.print("Initializing pulse oximeter..");
  if (!pox.begin())
  {
    Serial.println("FAILED");
    //for (;;);
  }
  else
  {
    Serial.println("SUCCESS");
```

```
  }
  /*********************************HR*********************************/
  if (!display.begin(SSD1306_SWITCHCAPVCC)) {
    Serial.println(F("SSD1306 allocation failed"));
    for (;;);
  }
  display.display();
  delay(2000);
  display.clearDisplay();
  display.drawPixel(10, 10, SSD1306_WHITE);
  display.display();
  delay(2000);
  /*********************************OL*********************************/
}
void loop()
{
  for (i = 0; i < 100; i++)
  {
    sensorValue = analogRead(pin);
    sum = sum + sensorValue;
    delay(1);
  }
  out_average = sum / 100;
  Serial.print("ADC Value:");
  Serial.println(sensorValue);
  Serial.print("Sum:");
  Serial.println(sum);
```

```
Serial.print("Average:");
Serial.println(out_average);
delay(5000);
/*********************************BG*********************************/
Serial.print("Ambient = ");
Serial.print(mlx.readAmbientTempC());
Serial.print("*C\tObject = ");
Serial.print(mlx.readObjectTempC());
Serial.println("*C");
Serial.print("Ambient = ");
Serial.print(mlx.readAmbientTempF());
Serial.print("*F\tObject = ");
Serial.print(mlx.readObjectTempF());
Serial.println("*F");
Serial.println();
delay(500);
sum = 0;
/*********************************BT*********************************/
pox.update();
Serial.print("Heart rate:");
Serial.print(pox.getHeartRate());
Serial.print("bpm / SpO2:");
Serial.print(pox.getSpO2());
Serial.println("%");
//tsLastReport = millis();
/*********************************HR*********************************/
Blynk.run();
```

```
BLYNK_READ(PIN_1)
{
  int  sensorData1 = mlx.readObjectTempC();
  Blynk.virtualWrite(PIN_1, sensorData1);
}
BLYNK_READ(PIN_2)
{
  int  sensorData2 = out_average;
  Blynk.virtualWrite(PIN_2, sensorData2);
}
BLYNK_READ(PIN_3)
{
  int  sensorData3 = pox.getHeartRate();
  Blynk.virtualWrite(PIN_3, sensorData3);
}
/*********************************BT*********************************/
display.clearDisplay();
display.setTextSize(2);
display.setTextColor(SSD1306_WHITE);
display.setCursor(0, 0);
display.print(a);
display.println("*C");
display.setTextSize(2);
display.setTextColor(SSD1306_WHITE);
display.print(b);
display.println("mg/dl");  display.setTextSize(2);
display.setTextColor(SSD1306_WHITE);
```

```
  display.print(c);
  display.println("bpm");
  display.display();
  delay(2000);
  /*******************************OL*********************************/
}
```

Matlab:

```
>> clear all
>> x = [ 130, 69, 110, 124, 145]

x =

   130    69   110   124   145

>> y = [ 435, 325, 406, 423, 479]

y =

   435   325   406   423   479

>> p1 = polyfit(y,x,1)

p1 =
0.5091  -94.9555
```

VEERA

by Hod ECE

Submission date: 25-May-2020 05:13PM (UTC+0530)
Submission ID: 1270394899
File name: REPORT_V1.docx (1,010.67K)
Word count: 5204
Character count: 28345

VEERA

ORIGINALITY REPORT

8%	4%	4%	3%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	www.mdpi.com Internet Source	3%
2	www.edinst.com Internet Source	1%
3	Wilbert Villena Gonzales, Ahmed Mobashsher, Amin Abbosh. "The Progress of Glucose Monitoring—A Review of Invasive to Minimally and Non-Invasive Techniques, Devices and Sensors", Sensors, 2019 Publication	1%
4	Submitted to University of Nottingham Student Paper	<1%
5	Submitted to Universiti Malaysia Pahang Student Paper	<1%
6	Submitted to Institute of Research & Postgraduate Studies, Universiti Kuala Lumpur Student Paper	<1%
7	Submitted to Cardiff University Student Paper	<1%

8	Submitted to KUMARAGURU COLLEGE OF TECHNOLOGY Student Paper	<1%
9	www.bthin.co.uk Internet Source	<1%
10	Submitted to Universiti Malaysia Perlis Student Paper	<1%
11	Submitted to University of Northampton Student Paper	<1%
12	Submitted to International Institute of Information Technology, Hyderabad Student Paper	<1%
13	drugsideeffects-info.com Internet Source	<1%
14	Submitted to Monta Vista High School Student Paper	<1%

Exclude quotes	Off	Exclude matches	< 10 words
Exclude bibliography	On		

KCG
COLLEGE OF TECHNOLOGY
(A Unit of Hindustan Group of Institutions)

International Conference on
INTEGRATION OF ADVANCED TECHNOLOGIES FOR INDUSTRY 4.0
SPONSORED BY AICTE, NEW DELHI

CERTIFICATE
OF PRESENTATION

This is to certify that **Ms. I G. Suwetha** has participated / presented the paper titled **Compact Health Care System** in the **AICTE Sponsored Virtual Conference on Integration of Advanced Technologies for Industry 4.0 (ICIATI)** held on 12th and 13th June 2020 organised by KCG College of Technology, Chennai, India

Dr. Deepa Jose
General Chair

Dr. G. Prabhakaran
Principal

A+ NAAC | NBA NATIONAL BOARD OF ACCREDITATION CSE / MECH / ECE / IT | nirf NATIONAL INSTITUTIONAL RANKING FRAMEWORK Ranked 13 in Chennai | Ranked 39 in Tamilnadu

International Journal of Advance Science and Technology
Vol. 29, No. 10S, (2020), pp. 6950-6954

Compact Health Care System

Dr. Phani Kumar Polasi[1], R. Veera Amudhan[2], Dr.D.Manoj Kumar[3], Suwetha .I. G[4]
[1,2,3,4]Electronics and Communication Engineering, SRM Institute of Science and Technology, Ramapuram, Chennai, India
phanikup@srmist.edu.in[1], veeraamr@srmist.edu.in[2], manojkud1@srmist.edu.in[3], suwetha_il@srmuniv.edu.in[4]

Abstract
The never-ending list of diseases is growing each day. It has become important for us to monitor our health condition regularly as it not only helps us to prevent diseases but also detect diseases which do not have any visible symptoms. One such main disease is diabetes which is a real test for the current century. It is a disease which is non-infectious and non-transmissible and is a major contributor to stroke, kidney disease, vision loss, vascular disease and heart disease. It's a rapidly-growing condition, approximately 500 million people around the world, including Fifty million Indians, are diabetes victims. The conventional method of measuring blood glucose is uncomfortable and painful as individuals need to poke their finger to draw blood regularly for calculating glucose concentration. Non-invasive blood glucose measurement can diminish this pain and also reduce the cost of measurement as non-invasive glucometer does not need fresh testing strips for each test. In the proposed project, we have designed a system that can measure the blood glucose level with the help of NIR spectroscopy. A NIR Led is used to pass IR radiations into the finger, the intensity of this radiation depends on glucose concentration in the blood. The IR light passes through the finger, after amplification and filtering we get output voltage signals. Using regression analysis, the unknown glucose value is determined from the unknown voltage level. It then communicates the detected blood glucose level into the smartphone through the wireless channel for output monitoring. Along with this infrared temperature monitoring unit and heart rate monitoring units have also been employed to help achieve the monitoring of different health parameters in the same system.

Keywords: *Health monitoring, Diabetes, Non-invasive glucometer, Regression analysis, ESP32, Body temperature, Heart rate.*

1. INTRODUCTION

The food we eat contains several essential nutrients such as proteins, fats, vitamins, carbohydrates and minerals. During digestion, a carbohydrate which is a macronutrient is broken down into glucose, for this glucose to enter body cells we require a hormone known as insulin which is secreted by the pancreas. Diabetes is a health condition which occurs when the pancreas cannot secrete insulin leading to abnormal blood sugar levels. Diabetes is categorized as type 1, type 2 and gestational. Type 1 is an autoimmune response where the patient's body destroys its insulin-producing cells known as islets of Langerhans. This type is not because of the patient's diet or lifestyle and has no cure. The patient needs to administer insulin dose via syringe or pump regularly. Type 2 diabetes occurs comparatively at an older age and is because of an unhealthy diet, lack of physical activity and lifestyle changes. Depending on the level of blood sugar, they can keep this under control by using medications or by administering insulin doses. Gestational diabetes occurs in pregnant women and causes complications to both mother and child. This usually is cured after pregnancy, but women who had gestational diabetes are at greater risk of developing type 2 diabetes. Diabetes can lead to serious outcomes such as a heart attack, blindness, kidney failure and stroke and should be monitored and treated accordingly. According to reports by the World Health Organization and International Diabetes Federation, 463 million people in the world are diabetic patients, which are 1 in 11 people. 1 in 2 adults with diabetes are undiagnosed (223 million). [1] To combat diabetes along with healthy food (low carb levels), proper exercise, losing weight one needs to properly monitor blood glucose levels regularly. Determining one's sugar level is known as-Self Monitoring of Blood Glucose (SMBG). It is important to perform structured self-testing of blood glucose as it would help them achieve better glycemic control, detect and prevent hypoglycemia and hyperglycemia, analyze and understand body response to

exercise, blood sugar variation after meals and diabetic drugs. Testing of blood sugar alone is not enough to bring glycemic levels to a normal range. Along with it, one also needs to document the results so they can test what is working for them and what is not. With diabetes, structure leads to success and the first step towards improvement is measuring the blood sugar levels. One of the most common techniques used in medicine to determine if an individual is affected by some disease is to measure that person's body temperature. Fever is an immediate response of the body if it is infected by the external pathogen. So measuring body temperature can tell a lot about a person's health condition. Heart rate is a common parameter used to determine a person's heart function as it can help determine cardiac output and stroke volume. Thus in this project, we propose a system which can determine three parameters which are body temperature, heart rate, blood glucose level and also displays it in a mobile interface.

2. LITERATURE SURVEY

In this paper [5] they have built a cheap wearable system for monitoring blood glucose non-invasively. The paper is based on the theory that change in blood volume in arteries leads to a change in blood glucose levels. They have opted for Vis-Nir spectroscopic technique in the wrist region as it provides better resolution. They have placed IR Led and photodiode on the same side making it diffused reflectance-based design for determining output. Several output spectra have been obtained by performing in-vivo experiments on 12 patients and resultant values are documented. In paper[2] the glucose level of the blood is determined using a diffused reflectance method. They have designed a system that takes measurements from the finger using 940nm IR led and detector pair placed opposite to each other. The output data is filtered using a notch filter, processed and analyzed using Arduino microcontroller. The final signal is displayed using an LCD module. The paper [3] they have studied the different available glucose measurement techniques such as invasive, non-invasive and minimally invasive options. In paper [4] they have reviewed the various continuous glucose monitoring techniques. They have discussed the purposes, problems, accuracy and outcomes of systems based on continuous glucose monitoring systems. In paper [6] Near-infrared (NIR) technique is used for designing blood glucose monitoring unit. At first 940 nm wavelength optical signal in the IR region of the electromagnetic spectrum is passed through the arm, the earlobe and the finger using a NIR led. Arduino Uno microcontroller then processes the signal and produces the output. It is then sent to a web server via GSM module, simultaneously the patient also gets SMS notification along with appropriate medical advice regarding blood glucose levels.

3. HARDWARE DESIGN

The proposed system of determining blood glucose level non-invasively can be elucidated with the help of the following block diagram:

- The NIR region of electromagnetic spectrum can be in turn divided into three regions-region 1(800-1200nm), region 2(1200-1800nm) and region 3(1800-2500nm)[14]. Led of 940nm wavelength has been selected as OPT101 Photodiode has an absorption peak in this region and this wavelength does not interfere with absorption peaks of water(1450nm, 1787nm), protein(2174nm,2288nm) and fat(2299nm, 2342nm)[15, [16]. The led is placed opposite to the photodiode in an enclosure with a minimum possible gap between the two exactly enough to place a finger to maximize the accuracy of the system.

- OPT101 monolithic photodiode has been chosen as a suitable photodiode for this project. It is a lightweight and low-cost module with a built-in trans-impedance amplifier. This eliminates the need for additional amplification circuitry. It is sensitive to a wide range of electromagnetic spectrum with the absorption peak being at the infrared region. Thus it should be enclosed completely to prevent other wavelengths from interfering in the output.

- The following 50hz notch filter was integrated into the module to eliminate noise due to power line:

  To determine R, C values:

$$F=(1/4\pi RC)$$
$$F=50\ Hz$$
Let C=0.1uf
$$50=1/(4(3.14)(R)(0.1*10-6))$$
$$R=1/(50)(4)(3.14)(10-7)$$
$$R=15.923KOhm$$
$$R=16KOhm$$

- Mlx90614 sensor has opted for temperature sensing. It is a non-contact IR temperature sensor. It is a small size, a low-cost sensor which is easy to integrate with any module. It has an accuracy of 0.5°C thus making it highly suitable for body temperature measurements. It has an ambient temperature range of (-40-125) °C and objects temperature range of (-70-380) °C. It works using I2C communication protocol and thus uses minimum wiring in the circuit.

- Max30100 sensor has been chosen as the ideal option for heart rate sensing as it is a low-cost sensor which can also be used for pulse oximetry measurements. It uses a combination of 2 LEDs and a photodetector. It has an operating voltage range of 1.8-3.3v thus providing better battery performance to the entire system. For it to operate properly in a system having input voltage greater than 1.8v, the onboard SMD resistors have to be unsoldered and external pull-ups of 4.7v needs to be used in sda,scl and int pins for it to operate properly.

- ESP32 has been chosen as a microcontroller for this system as it is low cost and low power system. It has inbuilt Wi-Fi and Bluetooth connectivity with 30 GPIO pins. It supports a wide range of communication protocols like I2C, SPI, UART thus making it suitable for this project. It can be interfaced and coded using Arduino IDE so it is easy to program and attach peripherals. For all of the above benefits and as a system can be made compact if this microcontroller is employed this has been chosen for our design.

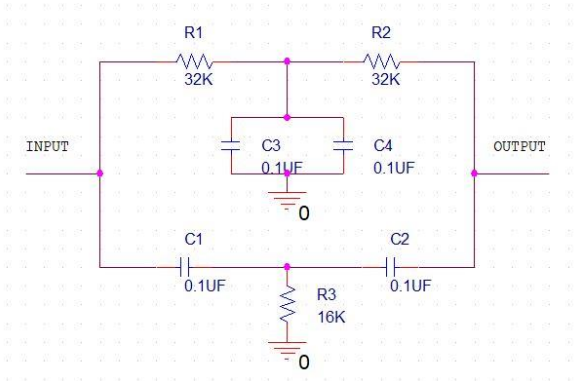

Fig. 1. Notch Filter Circuit diagram

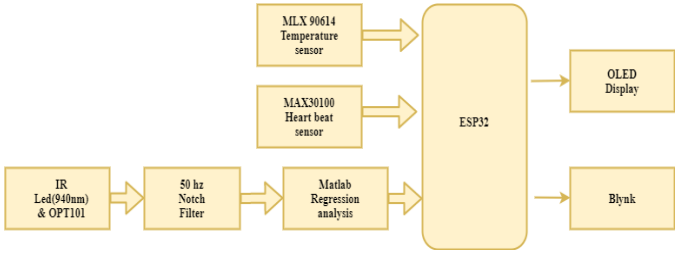

Fig. 2. Block diagram of the proposed system

The proposed system measures and determines the blood glucose level with the help of regression analysis. Body temperature is measured using non-contact MLX90614. Heart rate is determined using MAX30100 sensor. All parameters can be monitored using a single unit. The determined level is then wirelessly communicated to a mobile interface. The user can then monitor the user-friendly representation of the glucose level, the temperature and heart rate in the output device.

4. ADVANTAGES

- Non-invasive in nature and requires no pricking or injections, pain-free
- A cost-effective system which does not require multiple strips for measurement
- No biomedical waste is generated
- Portable and environment-friendly
- Real-time data is available in both web and mobile platform
- Probability of human error is reduced
- Self-diabetes management is easier
- Documentation of data is automated thus requires less human effort
- Biotelemetry is easier for medical analysis of data

CONCLUSION

In this paper, we have designed a health care system that can non invasively monitor blood sugar using the near-infrared technique, body temperature and heart rate. As the system is simple it can inturn also be developed into a wearable device. This prototype is developed using ESP32 microcontroller, thus making this a unique cost-effective device.

REFERENCES

[1] IDF, https://idf.org/aboutdiabetes/what-is-diabetes/facts-figures.html
[2] Mohammed Shahriar Arefin, Adnan Hossain Khan, and Rabiul Islam, " Non-invasive Blood Glucose Determination using Near-Infrared LED in Diffused Reflectance Method" in 10th International Conference on Electrical and Computer Engineering 20-22 December 2018, Dhaka, Bangladesh
[3] David C.Klonoff "Continuous Glucose Monitoring Roadmap for 21st-century diabetes therapy" in DIABETES CARE, VOLUME 28, NUMBER 5, MAY 2005
[4] Raju Poddar, Joseph Thomas Andrews, Pratyoosh Shukla, Pratima Sen "Non-invasive Glucose Monitoring Techniques: A review of current trends " in arXiv:0810.5755v1 [physics.med-ph] 31 Oct 2008
[5] Vega Pradana Rachim, Wan-Young Chung "Wearable-band Type Visible-Near Infrared Optical Biosensor for Non-invasive Blood Glucose Monitoring" in Sensors and amp; Actuators: B. Chemical (2019), https://doi.org/10.1016/j.snb.2019.01.121
[6] Md. Mahbub Alam, Swapnil Saha, Proshib Saha, Fernaz Narin Nur, Nazmun Nessa Moon, Asif Karim and Sami Azam " D-CARE: A Non-invasive Glucose Measuring Technique for Monitoring Diabetes Patients " in Uddin M., Bansal J. (eds) Proceedings of International Joint Conference on Computational Intelligence. Algorithms for Intelligent Systems. Springer, Singapore
[7]M. S. Asekar, "Development of Portable Non-Invasive Blood Glucose Measuring Device Using NIR Spectroscopy," 2018 Second International Conference on Intelligent Computing and Control Systems (ICICCS), Madurai, India, 2018, pp. 572-575.
[8] C. Sreenivas and S. Laha, "Compact Continuous Non-Invasive Blood Glucose Monitoring using Bluetooth," *2019 IEEE Biomedical Circuits and Systems Conference (BioCAS)*, Nara, Japan, 2019, pp. 1-4.

[9] B. Sargunam and S. Anusha, "IoT Based Mobile Medical Application for Smart Insulin Regulation," *2019 IEEE International Conference on Electrical, Computer and Communication Technologies (ICECCT)*, Coimbatore, India, 2019, pp. 1-5.
[10] Saina Sunny, S.Swapna Kumar "Optical Based Non-Invasive Glucometer with IoT" in *2018 International Conference on Power, Signals, Control and Computation (EPSCICON)*, Thrissur, 2018, pp. 1-3.
[11]K. T. Sithara Surendran and T. Sasikala, "Sensor system based Non-Invasive System to Measure Glucose Level in Human Body," 2019 3rd International Conference on Computing Methodologies and Communication (ICCMC), Erode, India, 2019, pp. 203-207.
[12]K. Lawand, M. Parihar and S. N. Patil, "Design and development of infrared LED based non-invasive blood glucometer," 2015 Annual IEEE India Conference (INDICON), New Delhi, 2015, pp. 1-6.
[13]B. L. Priya, S. Jayalakshmy, R. Bhuvaneshwar and J. K. Kumar, "Non – Invasive Blood Glucose Monitoring based on Visible LASER Light," 2018 3rd International Conference on Communication and Electronics Systems (ICCES), Coimbatore, India, 2018, pp. 938-941.
[14]Ozaki Y. Near-infrared spectroscopy--its versatility in analytical chemistry. Analytical Sciences: the International Journal of the Japan Society for Analytical Chemistry. 2012;28(6):545-563. DOI: 10.2116/analsci.28.545.
[15]Omar S Khalil, Spectroscopic and Clinical Aspects of Noninvasive Glucose Measurements, *Clinical Chemistry*, Volume 45, Issue 2, 1 February 1999, Pages 165–177
[16] D Ramesh, D Jose, Keerthana, V Kishnaveni, Detection of pulmonary nodules using thresholding and fractal analysis, Computational Vision and Bio Inspired Computing, Pages, 937-946, 2018

Veera amudhan

by Hod ECE

Submission date: 11-Mar-2020 11:27AM (UTC+0530)
Submission ID: 1268852036
File name: Paper.docx (46.36K)
Word count: 2183
Character count: 12165

Veera amudhan

ORIGINALITY REPORT

5%	2%	2%	1%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Mohammed Shahriar Arefin, Adnan Hossain Khan, Rabiul Islam. "Non-invasive Blood Glucose Determination using Near Infrared LED in Diffused Reflectance Method", 2018 10th International Conference on Electrical and Computer Engineering (ICECE), 2018 Publication	1%
2	www.bthin.co.uk Internet Source	1%
3	Submitted to University of Northampton Student Paper	1%
4	www.cardinalhealth.co Internet Source	1%
5	B. Sargunam, S. Anusha. "IoT Based Mobile Medical Application for Smart Insulin Regulation", 2019 IEEE International Conference on Electrical, Computer and Communication Technologies (ICECCT), 2019 Publication	1%

Komal Lawand, Mahesh Parihar, Shital N. Patil.

6 "Design and development of infrared LED based non invasive blood glucometer", 2015 Annual IEEE India Conference (INDICON), 2015

Publication

1%

Exclude quotes	Off	Exclude matches	< 10 words
Exclude bibliography	On		