Title: Physiological parameter monitoring system using Arduino nano, OLED and node MCU

Submitted in partial fulfilment of the requirements for the degree of

Bachelor of Technology Programme by Addisu Amare.

Supervisor: Dr. Sathya p

Vellore Institute of Technology, India

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DECLARATION

I am hereby declare that the thesis entitled **Physiological parameter monitoring system using Arduino nano, OLED and node MCU** submitted by me , for the award of the degree of Bachelor of Technology in Programme to VIT is a record of bonafide work carried out by us under the supervision of Dr Sathya p. we further declare that the work reported in this thesis has not been submitted and will not be submitted, either in part or in full, for the award of any other degree or diploma in this institute or any other institute or university.

Place : Vellore

Date : 03/04/2022

Signature of the Candidate

Addisu   Amare

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Abstract

The development of portable non-invasive health monitoring systems is very important to improving both personal and preventive health care through telemedicine. This work describes research and development as well as validation of an innovative integrated device designed to allow individuals to obtain four critical physiological readings (heart rate (HR), blood oxygen saturation (SpO_2), glucose level, and body temperature) using only their fingertips with no invasion whatsoever. The system is built using multiple types of sensors such as the MAX30100 pulse oximeter for measuring HR and SpO_2 and the MLX90614 infrared sensor for measuring body temperature. For obtaining glucose level estimates, we created a new custom near-infrared (NIR) optical module. The embedded core of our system consists of an Arduino microcontroller and a NodeMCU (ESP8266) which perform all the required operations of the system including real-time signal acquisition, filtering, sensor fusion, and data processing of the measured data. Upon processing, the system sends the processed data wirelessly via Wi-Fi to a special application running on an Android device allowing for quick access to the user's health data, tracking of health data over time, and providing users with the ability to store, manage, and review their health data. Experimental data from our prototype indicates that it successfully measures real-time data and provides accurate measurements of HR, SPO_2, and body temperature as well as a promising correlation between the use of NIR technology and estimating trends in glucose level. Overall, we successfully built a low-cost and user-friendly prototype that provides a comprehensive non-invasive method for users to monitor multiple physiologic parameters and represents an important advance towards developing comprehensive point-of-care diagnostics in the future.

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List of Abbreviations

LED	Light emitting diode
OLED	Organic light emitting diode
MCU	Micro controller unit

IR	infrared
Spo2	peripheral capillary oxygen saturation
BPM	Beat per minute
MFrs	Maximum frequencies
DC	Direct current
NIR	Near infrared
PCB	Printing circuit board
UV	ultraviolet
PD	photodiode
Mg/l	Mill gram per litre

1 Introduction

1.1 Objective

The main objective of this project is to design and demonstrate non-invasive multiphysiological parameter monitoring system by using IR sensor, pulse oximetry sensor, and IR temperature sensor.

1.2 Motivation

The main problem during the pandemic time like COVID19 is crowded hospitals. In such a situation, the hospitals don't have the capacity for holding large number of patients that come to hospitals. Covid has killed millions, and millions more are being infected every day. Severe infection causes Pneumonia associated with high pulse and breathing rates, and low blood oxygen. [6]. Pulse rate and blood oxygen are two parameters that doctors use to diagnose and measure Pneumonia and Bronchitis. A non-invasive medical device incorporated with embedded software and IoT need to be designed to monitor the patient remotely (without contact.) IoT based low-cost remote pulse rate and blood oxygen monitoring has also received attention for telemedicine [8]. In this project we are proposing a low cost, IOT based wearable pulse oximeter non-invasive medical device. helping patients whose blood oxygen levels need to be monitored 24×7, for example, covid patients or any other patients who are on the ventilator. With this, we can build our own simple low-cost pulse oximeter. On the other hand,

Fever is one of our body first reaction to infection and it is common in illnesses like influenza and Covid – 19. Non-Contact Thermometer lets us check the body temperature without even touching the body which is very important considering for the current pandemic! situation. It is being used for monitoring body Temperature even at healthy condition to detect the disease early. IR Temperature sensor gives inaccurate and different results depending on distance. We will solve this inaccuracy & limitation of MLX90614 IR temperature sensor by using a Proximity Sensor that only allows temperature measurement from a fixed/pre-defined distance. Our product will be more accurate, simpler and cheap in cost.

Diabetes is usual chronic diseases all over the world. The maximum typically used technique to degree glucose stage in blood is an invasive technique that is painful, steeply-priced and chance in spreading infectious diseases. Over an extended term, the invasive technique effects in harm of finger tissues. As an alternative, the noninvasive technique can be used which enables common testing, relieves ache and pain because of common finger pricks. A noninvasive technique of glucose stage size is proposed in this project.

1.3 Literature Review

In 2018, researchers designed a pulse oximeter using infrared and visible (red) light detection from light passing through a patient's finger via an emitter. Absorption levels indicate blood flow through the finger and the proportion of oxygen-rich blood. The analog circuit's output feeds into a Node microcontroller, which computes pulse rate and oxygen saturation from these signals. The system is designed for accessibility and portability. By connecting to the internet, it uploads values to a ThingSpeak cloud host, allowing remote doctors to monitor patient conditions via the web. Results are also available live on the patient's mobile device[1].

According to 2018 research, the device's heart rate accuracy reached 96.9% compared to a fingertip pulse oximeter across normal, bradycardic, and tachycardic conditions. Data communication speed for remote monitoring depends on internet quality. The DC voltage sensor, used to calculate battery capacity, has an input range of 0-12 V and output range of 0-3.3 V. Most importantly, the system provides real-time alarms to alert users when the patient enters a critical condition. The device's accuracy for reading and displaying battery voltage is 95.4%[2].

Researchers applied a comb filter method to separate fetal signals from maternal ones in non-invasive fetal pulse oximetry, enabling estimation of the unborn child's oxygen levels and well-being. Based on finite element simulations and phantom measurements, they demonstrated the feasibility of extracting fetal PPG from mixed signals using comb filters tuned to the fetal heart rate. The method performs even at high maternal-to-fetal ratios up to 80 dB. Future work will build on these findings by developing comb filters with real-time adaptation of peak frequencies[3].

Another study introduced an IoT system based on powerline technology for oximeter monitoring in large hospitals where Wi-Fi is unavailable. This powerline communication system enables remote data reading and control via a dual-link transmission setup[4].

To reduce hospital visits and disruptions to daily activities, researchers developed a home-care device using an Android smartphone's LED light and camera to measure pulse rate. The process involved data acquisition via video imaging and processing in MATLAB. Readings were compared to a standard pulse oximeter, yielding a student's t-test p-value of 0.6, indicating similarity for normal and hypertensive patients[5].

In 2021 research, a low-cost device measured pulse rate (BPM) and blood oxygen (%SpO2) using an Atmel ATmega328P MCU and MAX30100 sensor kit. Tested on 12 subjects and compared to the commercial Rossmax SB150 oximeter, it showed minimal deviations of 0.8175% for pulse rate and 0.425% for blood oxygen, validating the algorithm's accuracy. Cost analysis indicated implementation at about US$12[6].

By the end of 2018, researchers demonstrated that camera flash illumination, while even across bands, reduces contrast in reflections. Instead, they proposed capturing pulses using the front-facing camera and illuminating with the phone's display as a selective light source in red, green, and blue bands. This novel approach enables camera oximetry on commodity smartphones without modifications or added components. By using display light instead of flash, it illuminates narrower bands better suited for distinguishing reflections from deoxyhemoglobin [7].

Based on 2018 research, pulse oximeters operate simply in two main types:

1. **Transmissive**: Light sensed after transmission through body tissue, ideal for precise patient-monitoring systems.
2. **Reflective**: Light sensed from tissue reflections, common in sophisticated wearable fitness trackers.

The system's portability enables easy clinician access and tandem screenings. This functionality delivers reliable information and accuracy for heart rate-specific fitness goals[8].

One study employed multi-stage stratified cluster sampling to select participants, revealing low blood glucose monitoring adherence among diabetic patients in Shandong Province, China. Patients with lower education levels showed reduced adherence, highlighting the need for physicians to prioritize monitoring in this group. The authors recommended government reimbursement for laboratory testing, blood glucose meters, and strips[9].

Blood glucose testing includes two main methods: invasive and non-invasive monitoring. Non-invasive methods enable continuous (24/7) real-time monitoring, overcoming limitations of traditional invasive meters that require repeated fingertip pricks. This allows diabetics convenient self-management with broad market potential. Current non-invasive approaches fall into three categories: optical, microwave, and electrochemical. Optical and microwave methods excel in high non-invasiveness and continuous monitoring without discomfort[9].

According to 2021 research, a non-contact thermometer was designed for deployment at gate terminals, stations, airports, and malls, operable without close-range officer intervention. Using cloud-based IoT technology, it integrates with nearby hospitals for immediate first aid for COVID-19 exposures. The hardware features an LED running text display for real-time body temperature and an alarm for readings exceeding 37.5°C. The software employs Wi-Fi and HTTP POST protocols to transmit sensor data to a cloud server for mobile or web app monitoring. The CTM-IoT system achieved 99.8% precision and 99.6% accuracy[10].

Limitations: The device is not handy/portable. Works only in internet coverage areas**.**

Based on the research paper written by the end of 2019, researchers present the remote monitoring of human body temperature (HBT) wirelessly by means of Arduino controller with different sensors and open-source internet connection.
The proposed monitoring system uses an internet network via wireless fieldity (wifi) connection to be linked with online portal on smart phone or computer.
Arduino controller, LM-35 (S1), MLX-90614 (S2) temperature sensors and ESP-wifi shield module. Skin Temperature can be calculated in both contact and contactless (using S1, and S2 sensors)

The obtained result has shown that real time temperature monitoring data can be transferred to authentic observer by utilizing internet of things (IoT) applications. The findings from this research indicates that the difference of average temperature in between Sensor S1 and S2 is about 15°C. This prototype is not suitable to use on large scale applications due to the designing limitation. This research only limited with temperature measurement using Arduino.It can be scaled into smart measurement using smart watches and thermoregulator tools[12].

In this work, the tool is used for screening the body temperatures of people at the entrances of hospitals, airports, train stations, churches, schools, shops, sports centres, offices, and public places in general. To restrict the access to the public indoor places based on the persons body temperature.They used TECNIMED Visio Focus PRO 0648, FLUS IR-805B, Axillary mercury-based analogical thermometer, Berrcom JXB-178, They demonstrated that the working of distance , angle of inclination , and light conditions can strongly impact temperature measurements of body using non-contact infrared point thermometer which could invalidate the screening result. Slightly incorrect use of angle of inclination an infrared thermometer can lead to substantially unreliable measurements of body temperature, Light conditions influence the measurements, acquiring measurements without carefully monitoring the working distance and angle of inclination can lead to a large discrepancy between subsequent body temperature estimations[13].

Elevated body temperature (fever) can be a common symptom of a medical condition, such as a viral or bacterial infection, including SARS-CoV-2 or influenza. Non-contact infrared thermometers are able to measure forehead temperature in a timely manner and were used to perform a fast fever screening in a population.

They used Acquisition modalities and sensor calibration and Correction of environmental perturbations'

They gathered N = 18024 measurements of temperature during a period of five weeks, using the same device, but in 6 different locations.

and they computed statistics of the ensemble data for all locations as well as individual locations. they observed an average forehead temperature of 35.49 ± 0.80 ◦C.

the alert might be triggered if the temperature outside is very low and the subject is warmed by an external source like a car heating. Hence, the challenge presented in, is only partially settled. Finally, like with any fever screening method, they cannot exclude some form of examiner bias[14].

Design to determine accuracy of infrared thermometer for detection of fever as compared to mercury thermometer. All willing adult patients reporting to the fever desk were selected by consecutive sampling. Exclusion criteria included any dermatological condition affecting forehead and unwillingness. Forehead temperature was first checked twice using Kinlee FT3010 infrared thermometer. There were 538 patients, including 251 (46.65%) males and 287 (53.35%) females, aged 46.76 ± 12.44 years. Median temperatures recorded with infrared and mercury thermometers were 97.00°F (interquartile range: 95.10- 97.80°F) and 98.30°F (interquartile range: 98.00- 98.90°F) respectively ($p<0.001$). Intra-class correlation was 0.143 (95% CI -0.052, 0.323).The results of this study have shown that the IRT significantly under estimates skin temperature and has only a weak correlation with values obtained by mercury thermometer[15].

This work analyzes noncontact body temperature measurement issues from both clinical and metrological points of view with the aim to

(i) improve body temperature measurements accuracy;

(ii) estimate the uncertainty of body temperature measurement on the field;

(iii) propose a screening decision rule for the prevention of the spread of COVID-19.
Both the traditional instrumental uncertainty sources and clinical–medical ones related to the subjectivity of the measurand.A proper screening protocol for body temperature measurement considering the role of uncertainty is essential to correctly choose the threshold temperature value and measurement method to access critical places during COVID-19 pandemic emergency.
Measurement has to be taken based on (frontal forehead, inner canthus). This values are corresponds to Core temperature values **[16].**

This work illustrates the implementation and design of multi physiological parameter monitoring system. The architecture for this system is based on smart devices and wireless sensor networks for real time analysis of various parameters of patients. This project is aimed at introducing a set of modules which can make easier the diagnosis in hospital. It also help for continuous investigation of the patient for emergencies looked over by attendees and caregivers. A set of wireless and wired sensors are used to monitor the health condition of the patient. The sensor data is then send to the mobile app using wifi network. The health workers can monitor the patient in real time through the data received using mobile.

2 Project Description and Goals

This project focuses on developing a non-invasive, portable system for monitoring key physiological parameters in diabetic patients, with an emphasis on blood glucose prediction. The system is designed to be cost-effective, user-friendly, and capable of delivering rapid results.

Core Technique and System Overview

At the heart of the glucose monitoring technique is the irradiation of the fingertip with Near Infrared (NIR) light, a safe, non-ionizing form of radiation. As this light interacts with blood

and tissue, its transmission characteristics are modulated by glucose levels. This optical signal is captured, amplified, and then transmitted to the system's processing units: an Arduino Nano and a Node MCU. These microcontrollers function as the central processing hub for signal analysis and data management.

To provide a more comprehensive health snapshot, the system integrates additional sensors:

- A body temperature sensor
- A reflectance pulse oximeter sensor (for heart rate and blood oxygen saturation)

The use of a reflectance-based oximeter allows the device to be worn comfortably on the wrist, enhancing its practicality as a wearable monitor.

Data Output and Connectivity

All processed sensor readings—glucose levels, heart rate (BPM), blood oxygen saturation (SpO2%), and body temperature—are displayed in real-time on an Organic Light Emitting

Diode (OLED) screen. The data is simultaneously transmitted via the Node MCU to a laptop computer for storage and further analysis, and to the Blynk IoT platform for remote monitoring.

Project Goals:

1. To design and prototype a low-cost, multi-parameter physiological monitoring device.

2. To implement a smart, wearable pulse oximeter using reflectance sensing for accurate, real-time heart rate and oxygen saturation measurement.

3. To investigate a non-invasive optical technique for blood glucose level prediction using NIR light.

4. To create an integrated system that displays data locally on an OLED and transmits it wirelessly for remote access and storage (via Blynk and laptop interface).

Sensor Methodology: Transmittance vs. Reflectance

Transmittance Sensor: In this configuration (Fig. 1a), the LED and photodiode are positioned opposite each other (e.g., on either side of a fingertip). Light of a specific wavelength is emitted through the tissue, and the portion that penetrates it is detected by the photodiode. Precise alignment is crucial to maximize signal detection.

Reflectance Sensor: This design (Fig. 1b), employed in our project for wrist-wearability, places the LED and photodiode side-by-side on the same skin surface. Emitted light penetrates the tissue and blood, where it is partially absorbed and scattered. The photodiode then detects the portion of light that is reflected back to the surface.

Significance

This integrated device is vital for empowering patients, particularly those with diabetes, by providing immediate, accessible insights into their glucose levels, blood oxygen concentration, heart rate, and temperature. This facilitates better daily health management and awareness of their overall physiological condition.

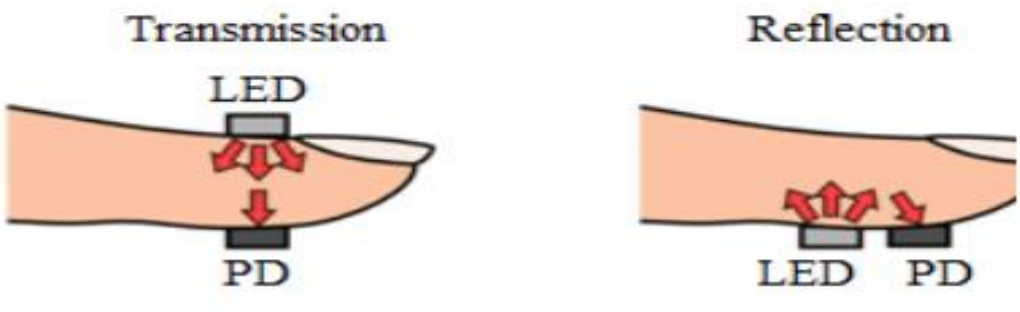


Fig 1: Transmission and Reflection type of pulse oximeter.

3 TECHNICAL SPECIFICATION

In this project different kinds of hard wares are used specifically:

i. Esp8266 Node MCU
ii. Pulse oximeter heart rate sensor module(Max30100)
iii. Connecting wire
iv. Bread board.
v. IR Temperature Sensor(MLX90614)
vi. Proximity Sensor (APDS-9960)
vii. organic light-emitting diode (OLED Display)
viii. Arduino Nano
ix. Piezo Buzzer
x. Photoelectric IR Sensor
xi. - Voltage Regulator
xii. - Capacitor (100microfarad and 1000microfarad)
xiii. - LED
xiv. – PCB
xv. Resistor(220 ohm and 10k)
xvi. Transistor(547bc)
xvii. Potentiometer(10k)

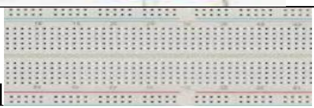
Software requirement:

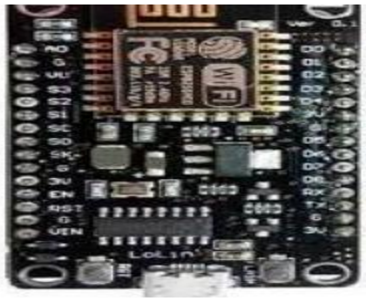
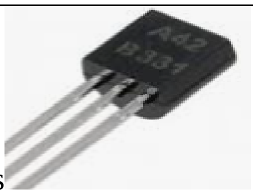
i. Blynk mobile app
ii. Arduino software
iii. Excel

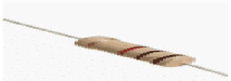
4 DESIGN APPROACH AND DETAILS .

4.1 Design Approach / Materials & Methods

4.1.1 materials used /hard ware requirement

component name	Description and use
1 power supply	Power supply is used to initiate the circuit by supplying power.
1 Arduino nano 	It is the kinds of Arduino board having size around half of Arduino uno. It's operating voltage is 5v. it has 22 digital and 8 analog pin. It used to process the signal.
3 IR sensor 	It consists of two main part one is Ir led and the second is photodiode. The photodiode is black in color which acts as receiver and IR led used as transmitter.
4 OLED 	The OLED display that we used in this project is the 0.96-inch SSD1306 mode with 128×64 pixels as shown in the figure. The OLED display doesn't require a backlight, due to which there is a very nice contrast in dark environments. Additionally, it consumes less power when compared to other displays. The display we're using has four pins. It works with an I2C communication protocol.
5 voltage regulators 	7805 is a voltage regulator that **outputs +5 volts**. Like most other regulators in the market, it is a three-pin IC; input pin for accepting incoming DC voltage, ground pin for establishing ground for the regulator, and output pin that supplies the positive 5 volts
6 cylindrical capacitor 	It is two terminal device that used as filtering noise by blocking dc current.
7 switches	Switch used here for on and of the circuit
8 led 	It is two terminal component used as indicator.
9 bread board 	Bread board is used to connect the electronics component either in parallel or series way.
10 IR temperature sensor 	▪ This is one of the main sensor we used for our project MLX90614 non contact IR temperature sensor. ▪ It has range of Temperature measuring from -20 to 120°C or -4 to 248°F ▪ Resolution: 0.14 °C or 32.252°F ▪ Operating voltage 3 to 5V from external DC supply.

11 proximity sensors 	It has the following feature:- • Ambient Light and RGB Sensing, Proximity Sensing, and Advance Gesture Detection. • Operating Voltage: 2.4V to 3.6V. • Operating current: 0.2mA. • Communication protocol: 400KHz • Highly sensitive Ambient and RGB sensing through UV and IR blocking filters. • For gesture sensing there are four photodiodes, which are sensitive to different to next directions so that it can detect complex gestures easily.
12 piezo buzzers 	piezo buzzer is a type of electronic device that's used to produce a tone, alarm or sound. It has two terminal one is anode and the other is cathode. The anode is mainly connected with vcc and cathode is connected with ground.
13 node MCU 	• The ESP 01 ESP8266 Serial WIFI Wireless Transceiver Module is a self-contained SOC with integrated TCP/IP protocol stack that can give any microcontroller access to your WiFi network. • The ESP8266 is capable of either hosting an application or offloading all Wi-Fi networking functions from another application processor. • Each ESP8266 module comes pre-programmed with an AT command set firmware, meaning, you can simply hook this up to your Arduino device and get about as much WiFi-ability as a WiFi Shield offers (and that's just out of the box)! • The ESP8266 module is an extremely cost-effective board with a huge, and ever growing, community
14 pulse oximeter sensors 	The MAX30100 sensor is a simple module that communicates in the I2C interface with the microcontroller. It provides the SpO2 and pulse information to the connected microcontroller (the sensor is also used for identifying oxygen saturation). Features of MAX30100 Pulse Oximeter • Consumes very low power (operates from 1.8V and 3.3V) • Ultra-Low Shutdown Current (0.7µA, type) • Fast Data Output Capability
15 connecting wires	Connecting wires are used to connect same or different electronics component
 16 transistors	Transistor is three leg electronics component . the three legs are base, collector and emitter. It is used to amplify signal.
17 potentiometer	10 k ohm potentiometer is used to adjust the distance of sensing in infrared sensor.

	
19 resistor 	In this project three resistors are used namely two 220 ohm and 10 ohm resistor.

4.1.2 Methodology

In this project we used Reflectance methodology of pulse oximeter sensor. • In this approach, on the inbuilt pulse oximeter sensor the LED and photodiode (PD) are placed side by side on the skin surface in the reflectance sensors. • The LED will emit light with a specific wavelength through the tissue and blood. • Light is absorbed by blood, and then some part of the light reflected and accepted by the photodiode. • We interface MAX30100 Pulse Oximeter with NodeMCU ESP8266 WIFI Module. • The Best part of this project is that we can connect this device to an Android application Blynk that will record and regularly update the data for both Arterial SPO2 & BPM on the Blynk Dashboard. • It is a non-invasive methodology finally will be used to measure oxygen concentration and heart rate (SpO2 and BPM).The system consist of three main part pulse oximeter system, glucose monitoring system and body temperature monitoring system. It is a non-invasive methodology will be used to measure glucose level, oxygen concentration, body temperature and heart rate. It measures body temperature, glucose level, oxygen concentration and HR by placing   finger on it.

This project will use transmissive methodology. In this approach, a sensor device is placed on a thin part of the patient's body, usually a fingertip or earlobe, or an infant's foot. Fingertips and earlobes have higher blood flow rates than other tissues, which facilitates heat transfer. We will interface MAX30100/MAX30102 Pulse Oximeter with Nodemcu ESP8266 Wifi Module.

For glucose measuring we are going to use polynomial regression equation   based non-invasive methodology.To obtain polynomial regression equation, 24 diabetic individuals including both genders are considered. Glucose level of these individuals is measured in the laboratory by the invasive method and at the same time the analog voltage corresponding to their glucose.19[ ]

The polynomial equation relating the analog voltage and the glucose level is computed by using regression tool and shown below. $\mathbf{y = (8*10^{-5})\, x^{2} + 0.1873x + 46.131}$

where x and y are analog voltage (mV) and glucose level (mg/dl) respectively.

The calculation is based on the following table

S.No	Analog Voltage (mV)	Glucose Level (mg/dl)	S.No	Analog Voltage (mV)	Glucose Level (mg/dl)
1	499	142	13	607	196
2	509	146	14	627	191
3	519	156	15	695	167
4	519	157	16	735	220
5	548	177	17	612	244
6	524	159	18	847	247
7	543	209	19	833	248
8	568	133	20	867	276
9	573	179	21	935	302
10	583	224	22	999	321
11	592	175	23	1136	338
12	597	187	24	1538	516

Table1: Analog Voltage and the Glucose Level of Samples

4.1.2.1Block diagram

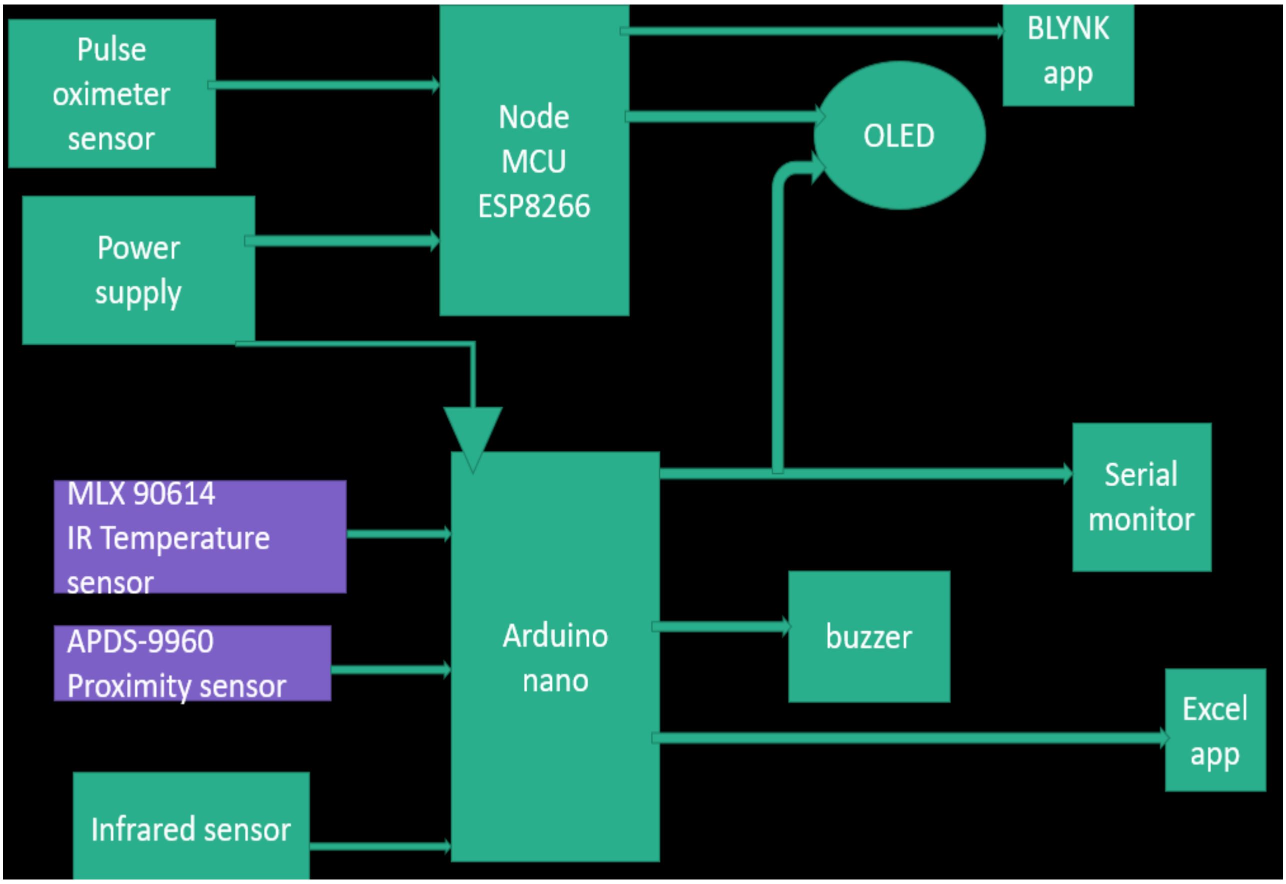


Figure2: block diagram

For this project we used power supply for initiating whole circuit. As shown from the above figure pulse oximeter sensor is connected to node MCU esp8266, and node MCU is connected to organic light emitting diode. Blynk app is connected with node MCU using Wi-Fi.

MLX90614 IR temperature sensor, APDS-9960 proximity sensor, and InfraRed sensor connected with Arduino Nano from input side. Serial monitor and Excel app is connected from output side.

4.1.2.2 Circuit diagram

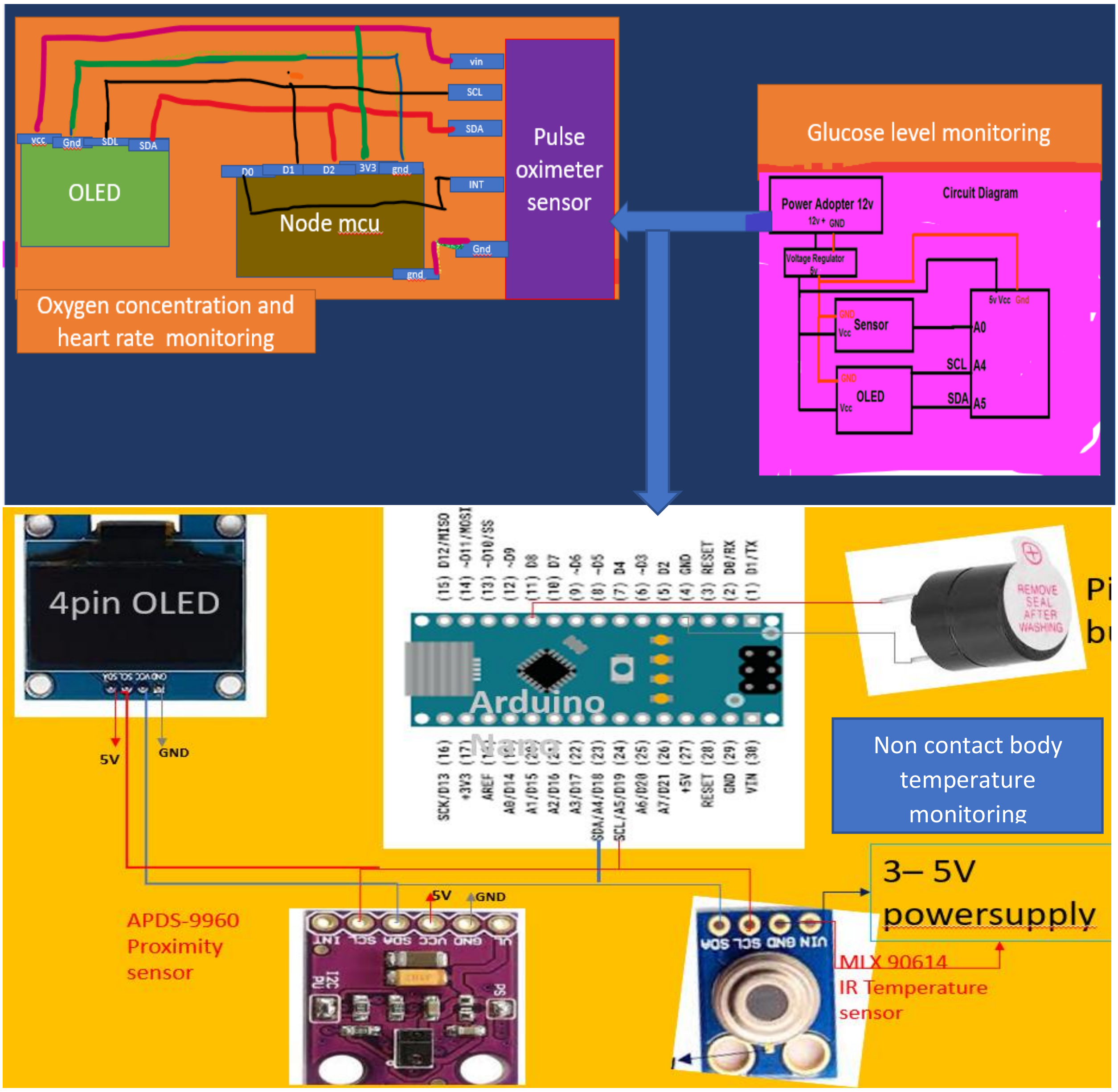


Figure3- circuit diagram

As shown from above figure, it consists of three sub circuit integrated together in one board. the first sub circuit is oxygen concentration and pulse rate monitoring part. In this sub circuit part, the three main component OLED, Node MCU, and pulse oximeter sensor connected with one another.

The second sub circuit is glucose monitoring part which consists of Oled, Ir sensor, and Arduino nano connected one another.

The third sub circuit is non-contact body temperature monitoring circuit which consist of proximity sensor, IR temperature sensor, Oled and Arduino nano as main component.

4.1.2.3 Working principle of IR sensor

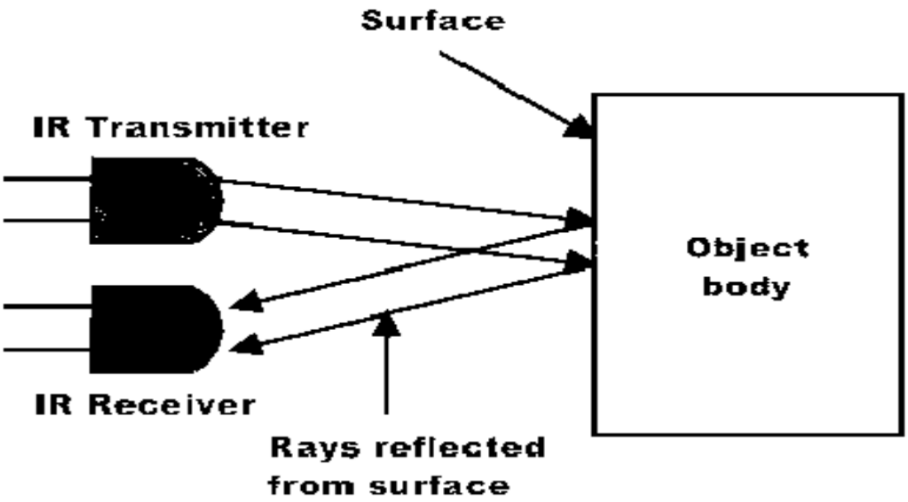
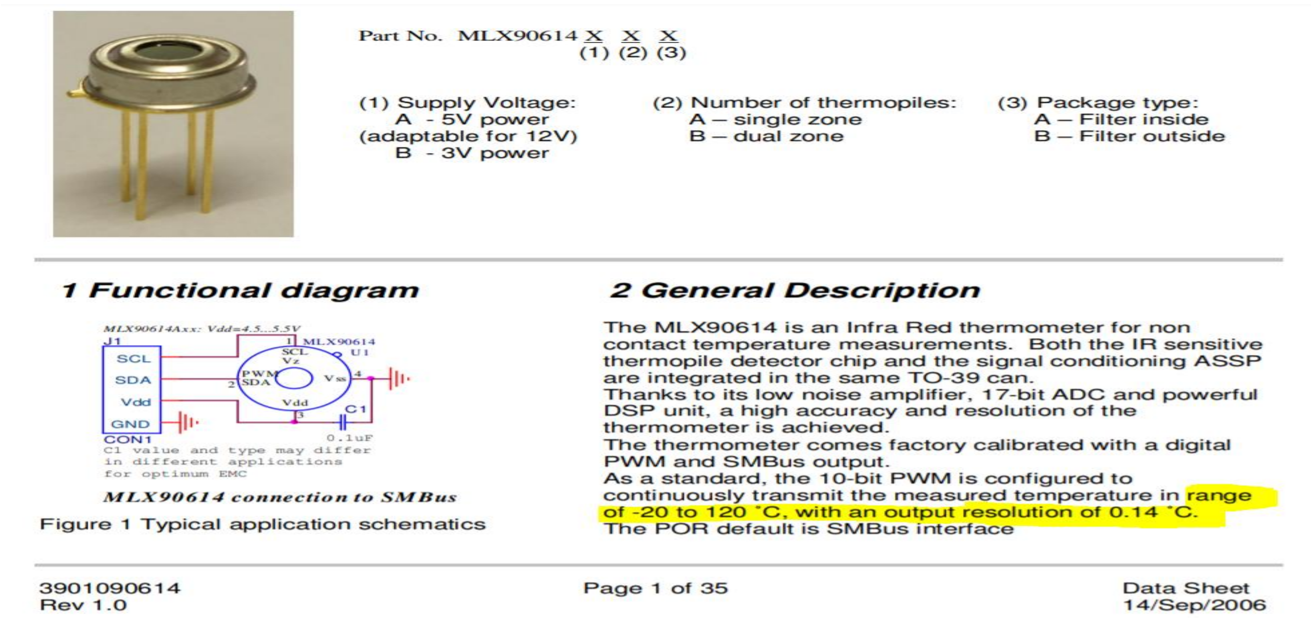


Figure 4:IR sensor working

The principle of an IR sensor acting as an object detection sensor can be explained using the above figure. The infrared sensor consists of an infrared LED and an infrared photodiode. When the IR emitter emits radiation, it hits an object and some of the radiation is reflected back to the IR receiver. Based on the receiving intensity of the IR receiver, the output of the sensor is determined.**[17]**

4.1.2.4 Working principle of non-contact infrared temperature sensor.

This is the main sensor we used for our project MLX90614 non-contact IR temperature sensor. It has range of Temperature measuring from -20 to 120°C or -4 to 248°F Resolution: 0.14 °C or 32.252°F. Operating voltage 3 to 5V from external DC supply.



Part No. MLX90614 X X X
(1) (2) (3)

(1) Supply Voltage:
A - 5V power
(adaptable for 12V)
B - 3V power

(2) Number of thermopiles:
A – single zone
B – dual zone

(3) Package type:
A – Filter inside
B – Filter outside

1 Functional diagram

MLX90614Axx: Vdd=4.5...5.5V

J1 SCL SDA Vdd GND CON1

MLX90614 U1 SCL Vz PWM SDA Vss Vdd C1 0.1uF

C1 value and type may differ in different applications for optimum EMC

MLX90614 connection to SMBus

Figure 1 Typical application schematics

2 General Description

The MLX90614 is an Infra Red thermometer for non contact temperature measurements. Both the IR sensitive thermopile detector chip and the signal conditioning ASSP are integrated in the same TO-39 can.
Thanks to its low noise amplifier, 17-bit ADC and powerful DSP unit, a high accuracy and resolution of the thermometer is achieved.
The thermometer comes factory calibrated with a digital PWM and SMBus output.
As a standard, the 10-bit PWM is configured to continuously transmit the measured temperature in range of -20 to 120 ˚C, with an output resolution of 0.14 ˚C.
The POR default is SMBus interface

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Rev 1.0

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Data Sheet
14/Sep/2006

Source: Data sheet of MLX90614

https://www.sparkfun.com/datasheets/Sensors/Temperature/MLX90614_rev001.pdf

- Similar to visible light, it is also possible to focus, reflect, or absorb infrared light. Infrared thermometers employ a lens to focus the infrared light emitting from the object onto a detector known as a thermopile.
- The thermopile is nothing but thermocouples connected in series or parallel. When the infrared radiation falls on the thermopile surface, it gets absorbed and converts into heat. Voltage output is produced in proportion to the incident infrared energy. The detector uses this output to determine the temperature, which gets displayed on the screen.
- It takes only a few seconds for the infrared thermometer to record the temperature and display on the desired unit.
- It is very important to consider the Accuracy and Temperature Range/Field of view of any IR Thermometer.

4.1.2.5 Working of MAX30100 Pulse Oximeter and Heart-Rate Sensor.

The device has two LEDs, one emitting red light, another emitting infrared light. For pulse rate, only the infrared light is needed. Both the red light and infrared light is used to measure oxygen levels in the blood. When the heart pumps blood, there is an increase in oxygenated blood as a result of having more blood. As the heart relaxes, the volume of oxygenated blood also decreases. By knowing the time between the increase and decrease of oxygenated blood, the pulse rate is determined. It turns out, oxygenated blood absorbs more infrared light and passes more red light while deoxygenated blood absorbs red light and passes more infrared light it reads the absorption levels for both light sources and stored them in a buffer that can be read via I2C.

4.2 Codes and Standards

Code for pulse oximeter:

```
#include <Wire.h>
#include<MAX30100_PulseOximeter.h>
#define BLYNK_PRINT Serial
#include <Blynk.h>
#include <ESP8266WiFi.h>
#include <BlynkSimpleEsp8266.h>
#include <Wire.h>
#include <Adafruit_GFX.h>// core graphic library
#include <OakOLED.h>
#define REPORTING_PERIOD_MS 1000
OakOLED oled;
char auth[] = "zC6WZ0nVRMjzZUhoJ_X0qzNn-8Sv3Z-q";
char ssid[] = "Tewahdo"; // WiFi credentials.
char pass[] = "0941addisu";

// Connections: SCL PIN - D1 , SDA PIN - D2 , INT PIN - D0
PulseOximeter pox;
float BPM, SpO2;
uint32_t tsLastReport = 0;
//drawing bitmap of heart
const unsigned char bitmap [] PROGMEM=
{
0x00, 0x00, 0x00, 0x00, 0x01, 0x80, 0x18,
0x00, 0x0f, 0xe0, 0x7f, 0x00, 0x3f, 0xf9, 0xff,
0xc0,
0x7f, 0xf9, 0xff, 0xc0, 0x7f, 0xff, 0xff, 0xe0,
0x7f, 0xff, 0xff, 0xe0, 0xff, 0xff, 0xff, 0xf0,
0xff, 0xf7, 0xff, 0xf0, 0xff, 0xe7, 0xff, 0xf0,
0xff, 0xe7, 0xff, 0xf0, 0x7f, 0xdb, 0xff, 0xe0,
0x7f, 0x9b, 0xff, 0xe0, 0x00, 0x3b, 0xc0,
0x00, 0x3f, 0xf9, 0x9f, 0xc0, 0x3f, 0xfd, 0xbf,
0xc0,
0x1f, 0xfd, 0xbf, 0x80, 0x0f, 0xfd, 0x7f, 0x00,
0x07, 0xfe, 0x7e, 0x00, 0x03, 0xfe, 0xfc,
0x00,
```

Done compiling.

```
void loop()
{
 pox.update();
 Blynk.run();
 BPM = pox.getHeartRate();
 SpO2 = pox.getSpO2();
 if(millis() - tsLastReport > REPORTING_PERIOD_MS)
 {
// Serial.print("Heart rate:");
 Serial.print(BPM);
 // Serial.print(" bpm / SpO2:");
 Serial.print(SpO2);
 Serial.println(" %");
 Blynk.virtualWrite(V7, BPM);
 Blynk.virtualWrite(V8, SpO2);
```

Code for non -contact body temperature monitoring

```
#include <Adafruit_MLX90614.h>
#include <Adafruit_GFX.h>
#include <Adafruit_SSD1306.h>
#define OLED_RESET 4
Adafruit_SSD1306 display(OLED_RESET);
SparkFun_APDS9960 apds = SparkFun_APDS9960();
uint8_t proximity_data = 0;
Adafruit_MLX90614 mlx = Adafruit_MLX90614();
void setup() {
  mlx.begin();
  apds.init();
  apds.enableProximitySensor(false);
  display.begin(SSD1306_SWITCHCAPVCC, 0x3C);  // initialize with the I2C addr 0x3C
  Serial.begin(9600);
}
void loop() {
  String temperature = "";
    Serial.print("Ambient ");
    Serial.print(mlx.readAmbientTempC());
    Serial.print(" C");
    Serial.println();
    Serial.print("Target  ");
    Serial.print(mlx.readObjectTempC());
    Serial.print(" C");
    Serial.println();
  apds.readProximity(proximity_data);
  if (proximity_data == 255 && mlx.readObjectTempF() < 100) {
    temperature = String(mlx.readObjectTempC(), 1);
    Serial.print(" Body Temperature:");
    Serial.println(mlx.readObjectTempC());
    display.clearDisplay();
    display.invertDisplay(false);
    display.setTextSize(2);
    display.setTextColor(WHITE);
    display.setCursor(8, 0);
```

Done compiling.

Code for glucose monitoring:

```
#include <SPI.h>
#include <Wire.h>
#include <Adafruit_GFX.h>
#include <Adafruit_SSD1306.h>
Adafruit_SSD1306 display(-1);
const int parameter = A0;
int ir1=0;
int ir2=0;
int vout=0;
int xout=0;
int yout=0;
int zout=0;
int gluco=0;
int a=0;
void setup()
{
// initialize with the I2C addr 0x3C
display.begin(SSD1306_SWITCHCAPVCC, 0x3C);
// Clear the buffer.
display.clearDisplay();
pinMode(parameter,INPUT);
Serial.begin(9600);
// Display Text
display.setTextColor(WHITE);
// Scroll part of the screen
display.setCursor(0,0);
display.setTextSize(1);
display.println("GLUCOSE LEVEL");
display.println("MONITOR SYSTEM");
display.display();
display.clearDisplay();
delay(3000);
}
void loop()
{
Done compiling.
```

.

6 Project Demonstration

The demonstration of the project is given below with sample output.

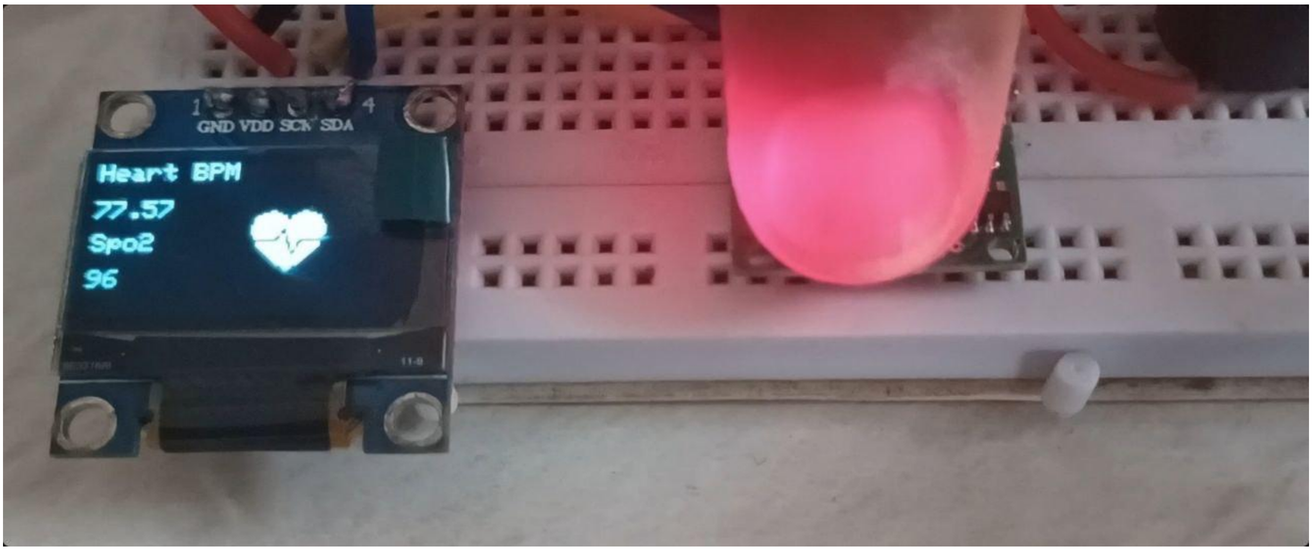


Figure 5: pulse oximetry output on OLED

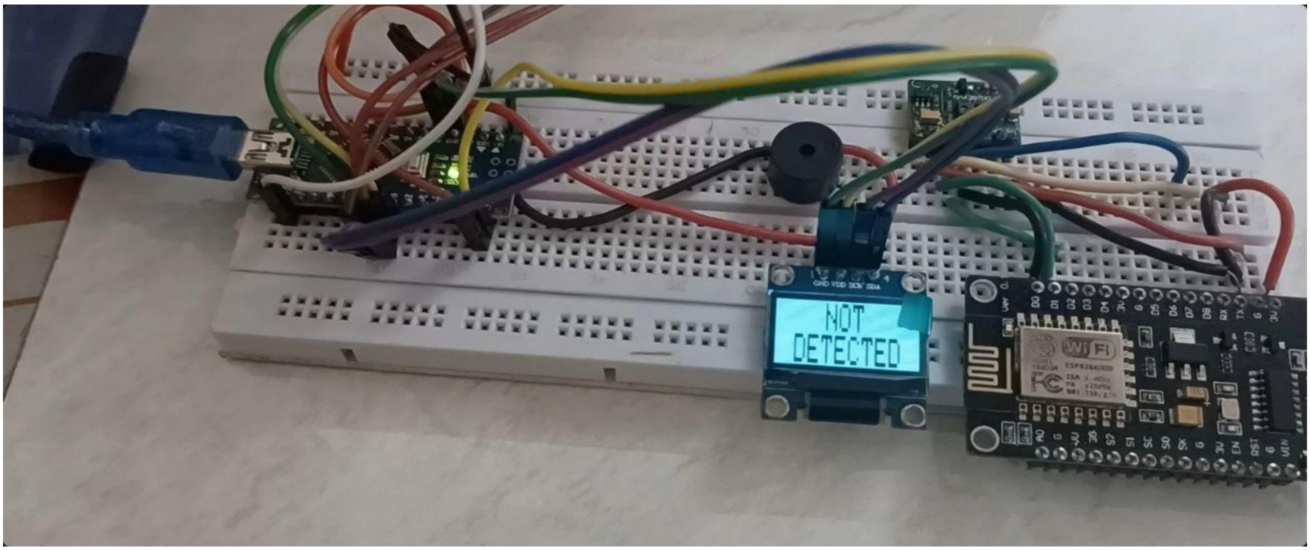
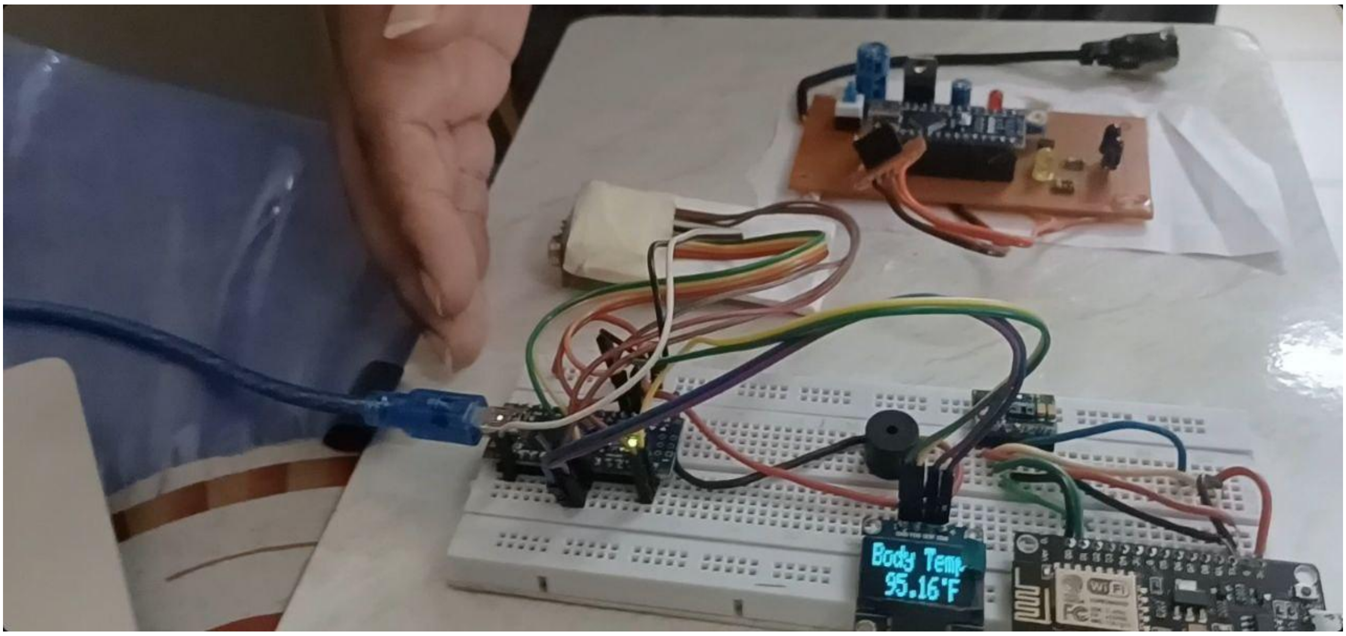


Figure 6: body temperature sample output with no detection

As shown in the above figure the output displayed as not detected. This indicates unless nearby our finger or head to temperature will not be detected. Since proximity sensor is used in our project , the Ir temperature sensor can sense within distance of 2cm-5cm between sensor and finger.



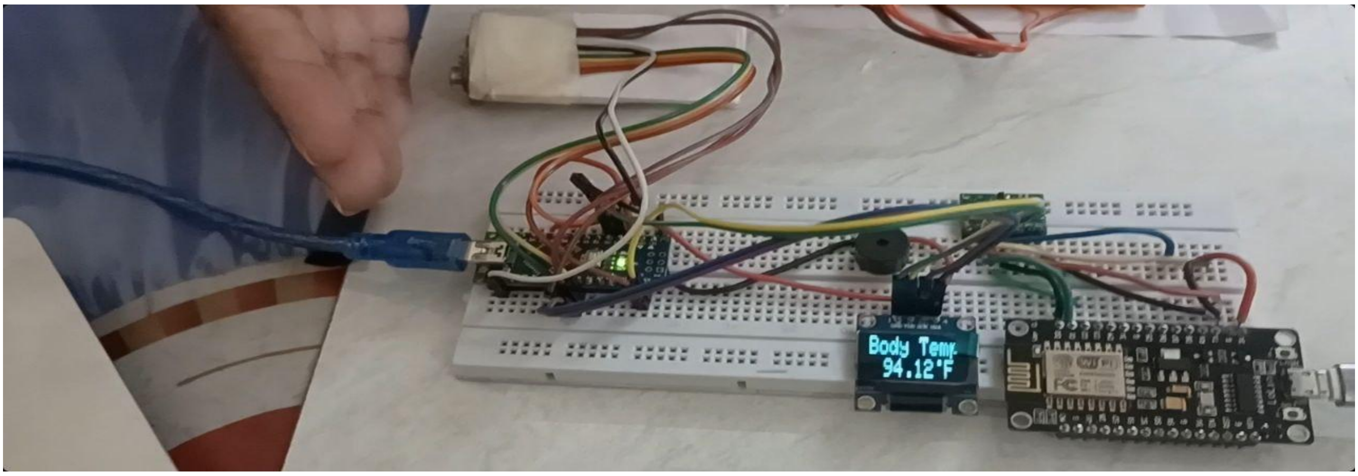


Figure7 : sample output of detected body temperature.

figure-8: sample out put for glucose level detection.

Figure9-sample output of spo2 and pulse rate on blynk app

7 Results, Discussion and Cost analysis (as applicable)

7.1 Results

As shown in the below in the table, glucose the measurement is done for six student. According to the standard of normal glucose level after eating. We can say that all of them have normal glucose level which lies in normal range.

S no	Name of person	Glucose value measured after lunch(mg/L)
1	Yonas	115 mg/L
2	Tilahun	110 mg/L
3	Gebeyaw	120mg/L
4	Zewudu	105 mg/L
5	Tamiru	102mg/L
6	Maru	100mg/L

Table2: sample output taken during glucose level measurement non invasively.

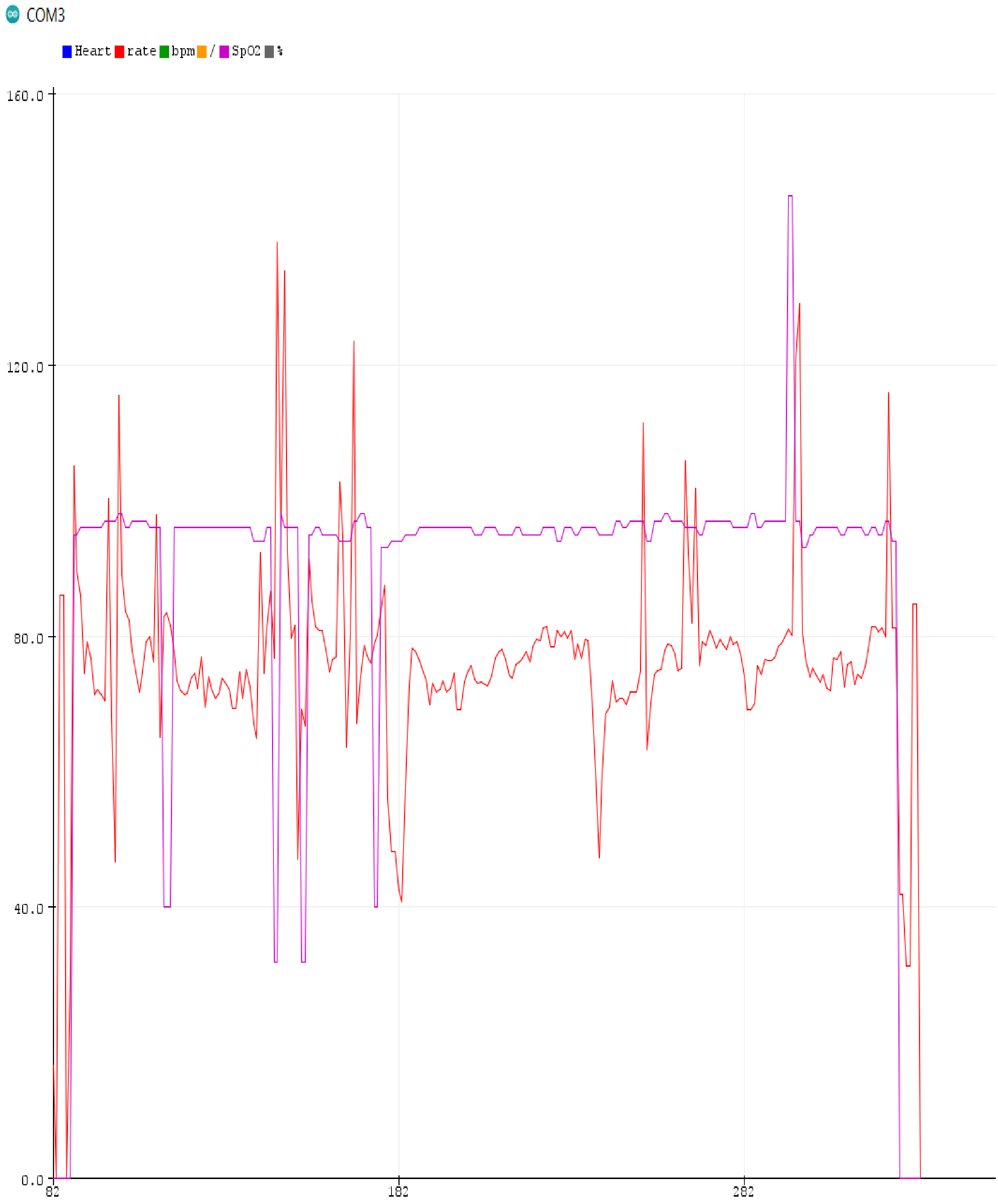


Figure 10: pulse oximetry graphical output using serial plotter.

From the above graph the red colour indicates: pulse graphical output

The pink colour indicates :blood oxygen graphical output.

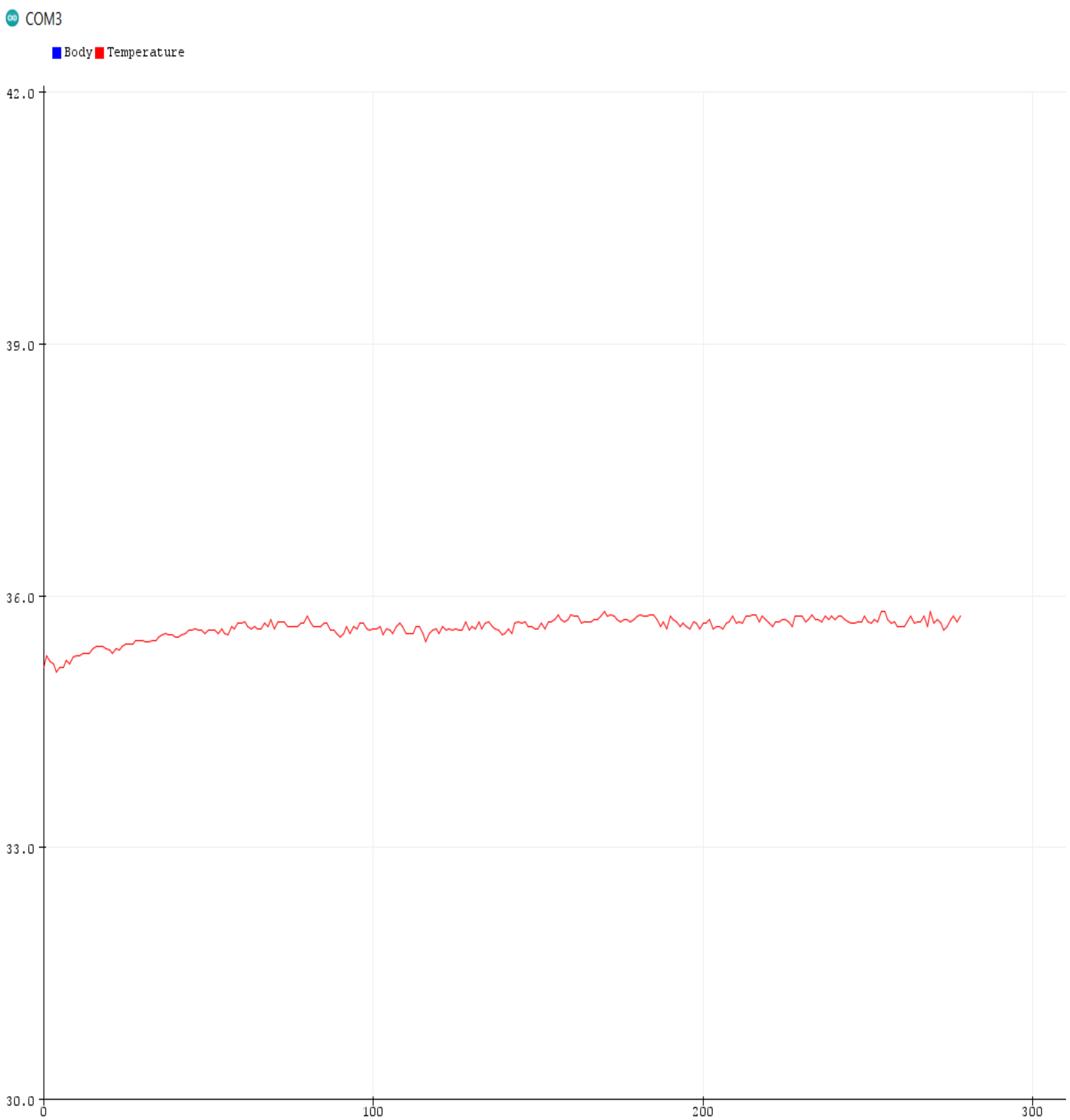


Figure11:-body temperature graphical output using serial plotter.

```
COM3

Beat Detected!
Beat Detected!
Heart rate:70.03 bpm / SpO2:95.00 %
Beat Detected!
Heart rate:73.68 bpm / SpO2:95.00 %
Beat Detected!
Heart rate:74.69 bpm / SpO2:95.00 %
Beat Detected!
Heart rate:71.81 bpm / SpO2:95.00 %
Beat Detected!
Beat Detected!
Heart rate:74.91 bpm / SpO2:95.00 %
Beat Detected!
Heart rate:74.07 bpm / SpO2:95.00 %
Beat Detected!
Beat Detected!
Heart rate:79.19 bpm / SpO2:94.00 %
Beat Detected!
Heart rate:79.93 bpm / SpO2:94.00 %
Beat Detected!
Heart rate:76.54 bpm / SpO2:94.00 %
Beat Detected!
Beat Detected!
Heart rate:76.43 bpm / SpO2:97.00 %
Beat Detected!
Heart rate:70.90 bpm / SpO2:97.00 %
Beat Detected!
Heart rate:71.37 bpm / SpO2:97.00 %
Beat Detected!
Beat Detected!
Heart rate:73.75 bpm / SpO2:97.00 %
Beat Detected!
Heart rate:70.95 bpm / SpO2:96.00 %
Beat Detected!
Heart rate:72.95 bpm / SpO2:96.00 %
```

```
COM3

Body Temperature:35.01
Body Temperature:35.69
Body Temperature:35.69
Body Temperature:35.55
Body Temperature:35.59
Body Temperature:35.35
Body Temperature:35.29
Body Temperature:35.43
Body Temperature:35.29
Body Temperature:35.69
Body Temperature:35.69
Body Temperature:35.67
Body Temperature:35.61
Body Temperature:35.61
Body Temperature:35.75
Body Temperature:35.75
Body Temperature:35.63
Body Temperature:35.67
Body Temperature:35.63
Body Temperature:35.77
Body Temperature:35.71
Body Temperature:35.63
Body Temperature:35.69
Body Temperature:35.71
Body Temperature:35.69
Body Temperature:35.75
Body Temperature:35.63
Body Temperature:35.77
Body Temperature:35.77
Body Temperature:35.63
Body Temperature:35.63
Body Temperature:35.61
Body Temperature:35.59
```

Figure12: sample out put physiological parameters on serial monitor.

7.2 Discussion

According to medical website information the normal range of some physiological parameter is given below[18].

BLOOD SUGAR LEVEL CHART

	FASTING	JUST ATE	3 HOURS AFTER EATING
NORMAL	80-100	170-200	120-140
PRE-DIABETIC	101-125	190-230	140-160
DIABETIC	126+	220-300	200+

Table3: glucose level range table

Observation	Oxygen saturation (SpO2) %	Pulse rate (bpm)	Temp (°C)
Normal readings	96% or more	40-100	36.5-37.5
Acceptable to continue home monitoring	95%	101-109	38

Table4: oxygen saturation, pulse rate and temperature range table

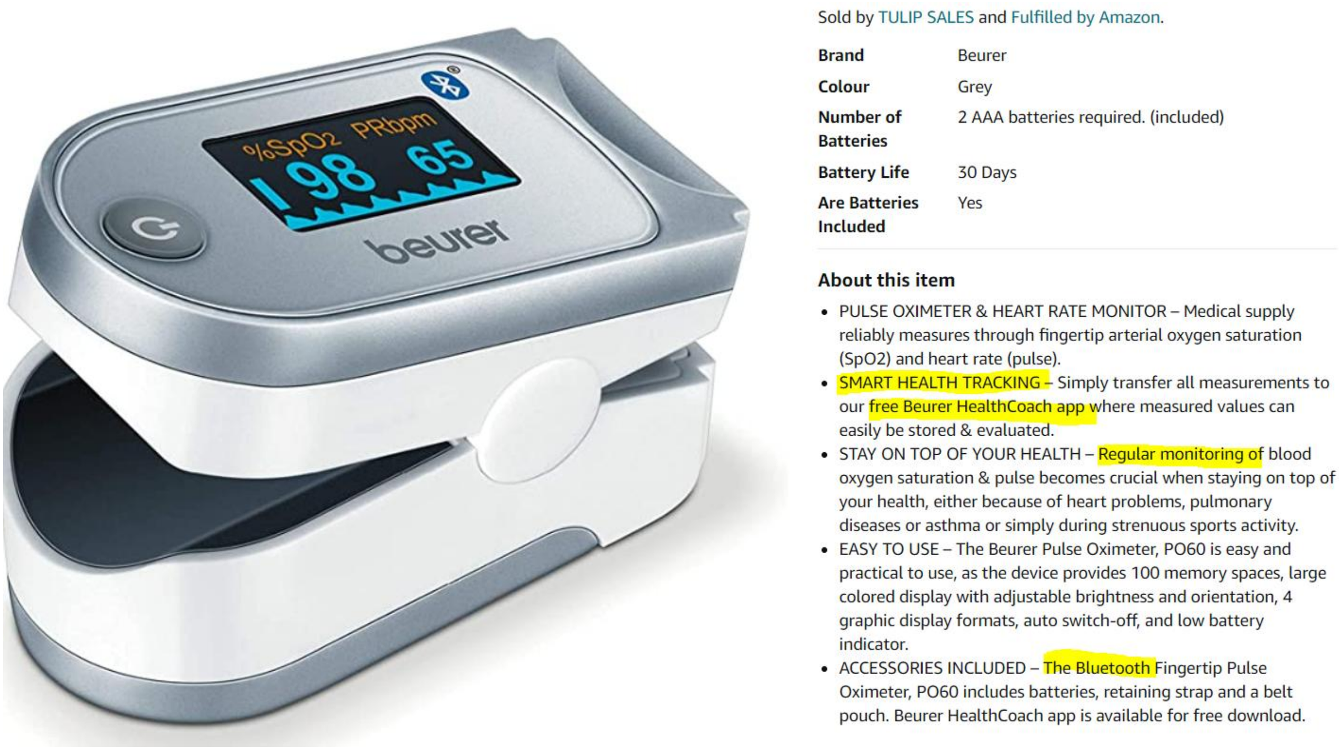
7.3 Cost analysis.

Glucometer monitoring component= (2 capacitor, Arduino nano ,led , oled , resistor, pcb , connecting wire):cost=298

Body Temperature measuring component=(ir temperature sensor , Arduino, nano, proximity senor ,connecting wire , Bread board,cost=1237 rupee

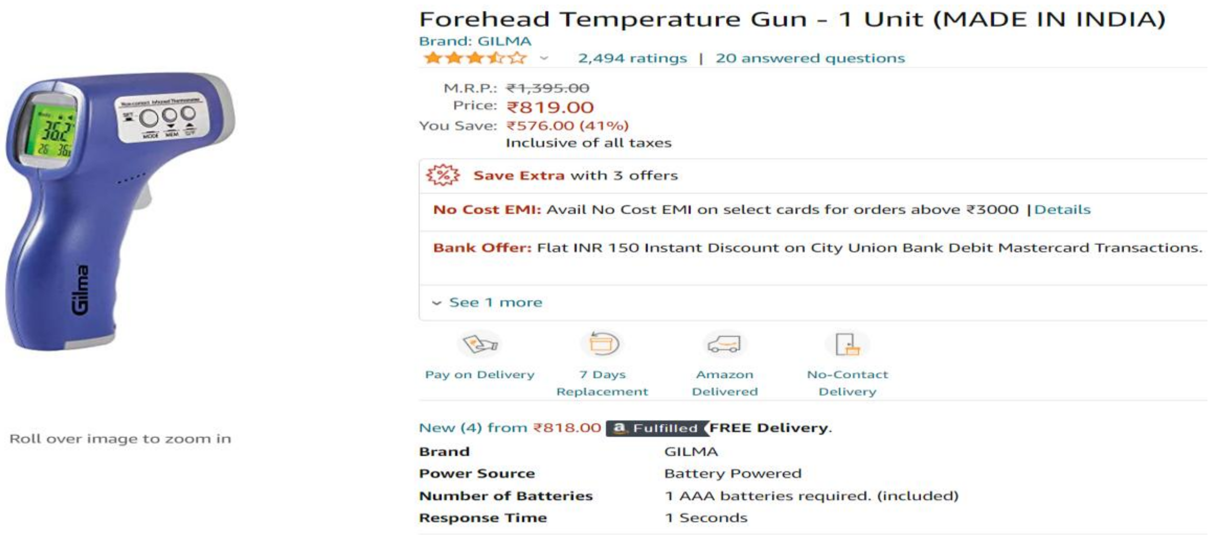
Spo2 and pulse rate monitoring component=(pulse oximeter sensor, small bread board, oled , connecting wire, node mcu) cost=580,Total cost= 2115 rupee.

Cost comparison:



According to present marketing in amazon , the cost of pulse oximeter is more than 3000 rupee. But our pulse oximeter component costs around 580 rupee.

On the other hand IR based temperature monitoring device in amazon cost is given below.



Where as our temperature monitoring component costs around=1237 rupee.

In case of body temperature monitoring our device is costy.

Our Glucose monitoring component costs:298 rupee

On the other hand ,In amazon market the cost is

Generally in our project we used cost effective component to design.

7.4 Future scope:

Patient Monitoring The developed device can be commercially deployed for monitoring patients. With the availability of telemedicine, wireless health monitoring systems have good potential in healthcare.

Telemedicine Application Several organizations may come up with telemedicine programs. Such a tool has many possibilities to be incorporated as a remote data monitor in telemedicine. [8]

Blood pressure changes can be felt during each heartbeat when sensing heart pulses through the artery in the wrist [2].

- ✓ The perceived pulse is actually a wave of blood pressure that travels from the heart to all the arteries.
- ✓ A wave that formed by blood pressure would be compared with the ECG waveform.

Biomedical Innovation for Larger Application by increasing parameter. This project can also be expanded as part of larger biomedical applications. Several sensors for other health parameters can be integrated. In places like offices or schools, real time facial recognition system using image processing can be included along with this IR thermometer so that each employee is identified and their temperature readings could get automatically recorded under their name. This would eliminate the need for a user to stay close to the person and take the reading every time. This device can be IOT platforms and CLOUD based for Patient Monitoring applications, Telemedicine & wireless health monitoring systems .This device can be incorporated with large Biomedical innovation for health care applications. As it is non-contact , if we want to automate the health care system, contact less temperature checking will be the one parameter which the doctor needs. The project can be extended by adding more and more parameter.

8 Summary

This work presents discrepancy ways that can be utilize to predict multiphysiological parameters such as blood glucose, body temperature ,blood oxygen concentration and pulse rate. the methodology is non-invasive way of measuring the parameter. This kinds of methodology avoids pain . on the other hand the invasive test is not affordable and painful during measurement. So in this paper NIR system that can measure different physiological parameter presented. This system utilizes Arduino nano, node MCU and near-infrared o measure blood glucose, body temperature, and pulse oximetery. and it has feature’s of non-invasiveness, quick, and easy. Generally ,the monitoring system is cost effective and easily meet the needs of the customer.

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Appendix A

Arduino code for glucose monitoring

```
#include <SPI.h>
#include <Wire.h>
#include <Adafruit_GFX.h>
#include <Adafruit_SSD1306.h>
Adafruit_SSD1306 display(-1);
const int parameter =  A0;
int ir1=0;
int ir2=0;
int vout=0;
int xout=0;
int yout=0;
int zout=0;
void setup()
{
  pinMode(soil,INPUT);
  Serial.begin(9600);
// initialize with the I2C addr 0x3C
display.begin(SSD1306_SWITCHCAPVCC, 0x3C);
delay(500);
}
void loop()
{
ir1state=analogRead(soil);
ir2state=(8*10^-5)*ir1^2;
xout=0.1873*ir1;
yout=ir2state+xout+46.131;
vout=yout*(-1);
zout=vout/100;
```

```
Serial.print("GLUCOSE LEVEL\n");
Serial.print("GLUCOSE in mg/dl: ");
Serial.println(zout);
display.clearDisplay();
display.setCursor(0,0);
display.print("GLUCOSE LEVEL");
display.setCursor(0,1);
display.print("MONITOR SYSTEM");
delay(1000);
if ((ir1state<=300)&&(ir1state>=20))
{
  // Display Text
display.setTextColor(WHITE);
// Scroll part of the screen
display.setCursor(0,0);
display.setTextSize(1);
display.println("GLUCOSE LEVEL");
display.println("VERIFY");
display.display();
display.clearDisplay();
delay(2000);
// Display Text
display.setTextColor(WHITE);
// Scroll part of the screen
display.setCursor(0,0);
display.setTextSize(1);
display.println("GLUCOSE in mg/dl:");
display.println(zout);
delay(2000);
}
```

```
else
{
display.clearDisplay();
display.setCursor(0,0);
display.print("GLUCOSE LEVEL");
display.setCursor(0,1);
display.print("MONITOR SYSTEM");
delay(1000);
}
}
```

Appendix B

Arduino code for non-contact body temperature monitoring

```
#include <Wire.h>
#include <SparkFun_APDS9960.h>
#include <Adafruit_MLX90614.h>
#include <Adafruit_GFX.h>
#include <Adafruit_SSD1306.h>
#define OLED_RESET 4
Adafruit_SSD1306 display(OLED_RESET);
SparkFun_APDS9960 apds = SparkFun_APDS9960();
uint8_t proximity_data = 0;
Adafruit_MLX90614 mlx = Adafruit_MLX90614();
void setup() {
  mlx.begin();
  apds.init();
  apds.enableProximitySensor(false);
  display.begin(SSD1306_SWITCHCAPVCC, 0x3C);  // initialize with the I2C addr 0x3C (for the 128x32)
  Serial.begin(9600);
}
```

```
void loop() {
 String temperature = "";
  Serial.print("Ambient ");
  Serial.print(mlx.readAmbientTempC());
  Serial.print(" C");
  Serial.println();
  Serial.print("Target  ");
  Serial.print(mlx.readObjectTempC());
  Serial.print(" C");
  Serial.println();
 apds.readProximity(proximity_data);
 if (proximity_data == 255 && mlx.readObjectTempF() < 100) {
  temperature = String(mlx.readObjectTempC(), 1);
  Serial.print(" Body Temperature:");
  Serial.println(mlx.readObjectTempC());
  display.clearDisplay();
  display.invertDisplay(false);
  display.setTextSize(2);
  display.setTextColor(WHITE);
  display.setCursor(8, 0);
  display.clearDisplay();
  display.println("Body Temp:");
  display.setCursor(25, 18);
  display.print(mlx.readObjectTempF());
  display.setCursor(85, 8);
  display.print(".");
  display.setTextColor(WHITE);
  display.setCursor(85, 18);
  display.print(" F");
  display.display();
```

```
  delay(1000);
}
if (proximity_data == 255) {
  if (mlx.readObjectTempF() > 102) {
    noTone(5);
    // play a note on pin 8 for 500 ms:
    tone(8, 523, 500);
    display.clearDisplay();
    display.invertDisplay(false);
    display.setTextSize(2);
    display.setTextColor(WHITE);
    display.setCursor(20, 0);
    display.clearDisplay();
    display.println("CRITICAL");
    display.invertDisplay(true);
    display.setTextSize(2);
    display.setTextColor(WHITE);
    display.setCursor(20, 0);
    display.clearDisplay();
    display.println("CRITICAL");
    display.invertDisplay(true);
    display.setTextColor(WHITE);
    display.setCursor(20, 0);
    display.clearDisplay();
    display.println("CRITICAL");
    display.invertDisplay(false);
    display.setTextSize(2);
    display.setTextColor(WHITE);
    display.setCursor(20, 0);
    display.clearDisplay();
```

```
    display.println("CRITICAL");
    display.invertDisplay(true);
    display.setTextSize(2);
    display.setTextColor(WHITE);
    display.setCursor(20, 0);
    display.clearDisplay();
    display.println("CRITICAL");
    display.invertDisplay(true);
    display.setTextColor(WHITE);
    display.setCursor(20, 0);
    display.clearDisplay();
    display.println("CRITICAL");
    display.invertDisplay(false);
    display.setTextSize(2);
    display.setTextColor(WHITE);
    display.setCursor(20, 0);
    display.clearDisplay();
    display.println("CRITICAL");
    display.setCursor(23, 18);
    display.print(mlx.readObjectTempF());
    display.setCursor(93, 8);
    display.print(".");
    display.setTextColor(WHITE);
    display.setCursor(93, 18);
    display.print(" F");
    display.display();
    delay(1000);
  }

}
```

```
  if (proximity_data == 255) {
    if (mlx.readObjectTempF() > 100) {


      display.setCursor(93, 8);
      display.print(".");
      display.setTextColor(WHITE);
      display.setCursor(93, 18);
      display.print(" F");
      display.display();
    }
  }
  else if (proximity_data <= 255) {
    delay(1000);
    display.clearDisplay();
    display.invertDisplay(true);
    display.setTextSize(2.8);
    display.setTextColor(WHITE);
    display.setCursor(45, 1);
    display.clearDisplay();
    display.println("NOT");
    display.setCursor(17, 17);
    display.print("DETECTED");
    display.display();
    digitalWrite(5, LOW);
  }
}
```

Appendix C

Arduino code for pulse oximetery:

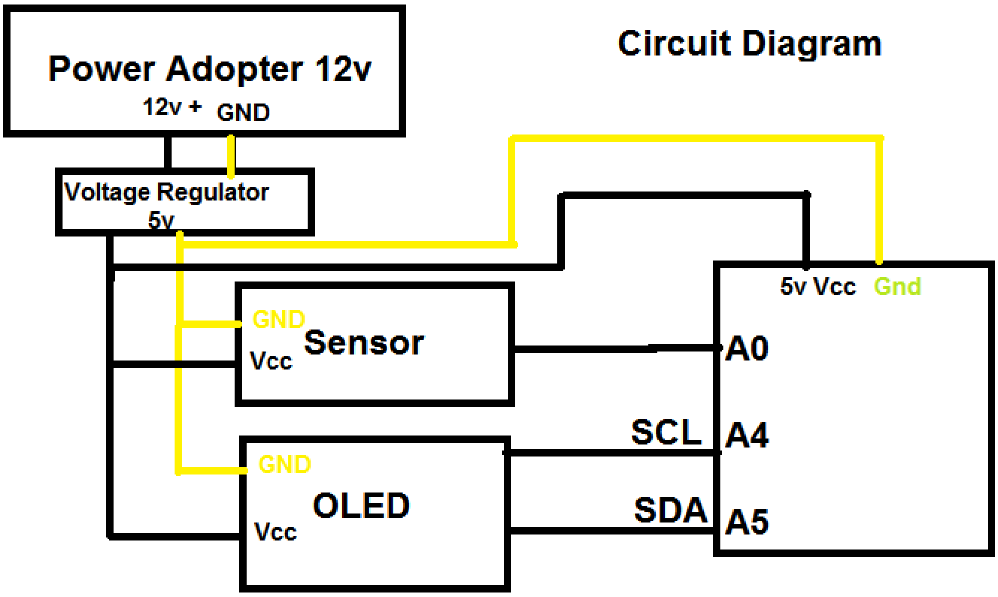
```
#include <Wire.h>
#include "MAX30100_PulseOximeter.h"
#define BLYNK_PRINT Serial
#include <Blynk.h>
#include <ESP8266WiFi.h>
#include <BlynkSimpleEsp8266.h>
#include "Wire.h"
#include "Adafruit_GFX.h"
#include "OakOLED.h"
#define REPORTING_PERIOD_MS 1000
OakOLED oled;
char auth[] = "N-81lOStH83VwUeNuKHOzpLVzqjFXhHO";            // You should get Auth Token in the Blynk App.
char ssid[] = "Tewahdo";                                    // Your WiFi credentials.
char pass[] = "0941addisu";
// Connections : SCL PIN - D1 , SDA PIN - D2 , INT PIN - D0
PulseOximeter pox;
float BPM, SpO2;
uint32_t tsLastReport = 0;
const unsigned char bitmap [] PROGMEM=
{
0x00, 0x00, 0x00, 0x00, 0x01, 0x80, 0x18, 0x00, 0x0f, 0xe0, 0x7f, 0x00, 0x3f, 0xf9, 0xff, 0xc0,
0x7f, 0xf9, 0xff, 0xc0, 0x7f, 0xff, 0xff, 0xe0, 0x7f, 0xff, 0xff, 0xe0, 0xff, 0xff, 0xff, 0xf0,
0xff, 0xf7, 0xff, 0xf0, 0xff, 0xe7, 0xff, 0xf0, 0xff, 0xe7, 0xff, 0xf0, 0x7f, 0xdb, 0xff, 0xe0,
0x7f, 0x9b, 0xff, 0xe0, 0x00, 0x3b, 0xc0, 0x00, 0x3f, 0xf9, 0x9f, 0xc0, 0x3f, 0xfd, 0xbf, 0xc0,
0x1f, 0xfd, 0xbf, 0x80, 0x0f, 0xfd, 0x7f, 0x00, 0x07, 0xfe, 0x7e, 0x00, 0x03, 0xfe, 0xfc, 0x00,
0x01, 0xff, 0xf8, 0x00, 0x00, 0xff, 0xf0, 0x00, 0x00, 0x7f, 0xe0, 0x00, 0x00, 0x3f, 0xc0, 0x00,
```

```
0x00, 0x0f, 0x00, 0x00, 0x00, 0x06, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00,
0x00
};
void onBeatDetected()
{
  Serial.println("Beat Detected!");
  oled.drawBitmap( 60, 20, bitmap, 28, 28, 1);
  oled.display();
}
void setup()
{
  Serial.begin(115200);
  oled.begin();
  oled.clearDisplay();
  oled.setTextSize(1);
  oled.setTextColor(1);
  oled.setCursor(0, 0);
  oled.println("Initializing pulse oximeter..");
  oled.display();
  pinMode(16, OUTPUT);
  Blynk.begin(auth, ssid, pass);

  Serial.print("Initializing Pulse Oximeter..");

  if (!pox.begin())
  {
    Serial.println("FAILED");
    oled.clearDisplay();
    oled.setTextSize(1);
    oled.setTextColor(1);
    oled.setCursor(0, 0);
```

```
        oled.println("FAILED");
        oled.display();
        for(;;);
    }
    else
    {
        oled.clearDisplay();
        oled.setTextSize(1);
        oled.setTextColor(1);
        oled.setCursor(0, 0);
        oled.println("SUCCESS");
        oled.display();
        Serial.println("SUCCESS");
        pox.setOnBeatDetectedCallback(onBeatDetected);
    }
}
void loop()
{
    pox.update();
    Blynk.run();
    BPM = pox.getHeartRate();
    SpO2 = pox.getSpO2();
     if (millis() - tsLastReport > REPORTING_PERIOD_MS)
    {
       Serial.print("Heart rate:");
       Serial.print(BPM);
       Serial.print(" bpm / SpO2:");
       Serial.print(SpO2);
       Serial.println(" %");
       Blynk.virtualWrite(V7, BPM);
```

```
        Blynk.virtualWrite(V8, SpO2);
        oled.clearDisplay();
        oled.setTextSize(1);
        oled.setTextColor(1);
        oled.setCursor(0,16);
        oled.println(pox.getHeartRate());
        oled.setTextSize(1);
        oled.setTextColor(1);
        oled.setCursor(0, 0);
        oled.println("Heart BPM");
        oled.setTextSize(1);
        oled.setTextColor(1);
        oled.setCursor(0, 30);
        oled.println("Spo2");
        oled.setTextSize(1);
        oled.setTextColor(1);
        oled.setCursor(0,45);
        oled.println(pox.getSpO2());
        oled.display();
        tsLastReport = millis();  }
}
```

Appendix B



Glucose monitoring circuit