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Blood Oxygen Saturation Level and Heart Rate Monitoring System

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***Abstract* —** *This research paper presents the design and implementation of an internet of things (IoT) based smart framework for human blood oxygen saturation level and heartbeat rate monitoring system. Percentage of oxygen in blood plays an essential function as a parameter in determining one's health circumstance. This paper specializes in the powerful monitoring of someone's oxygen attention in blood thereby obtaining and transmitting the records by way of wireless conversation to a personal cloud storage. The cause is to examine how heart rate and the oxygen saturation of difficulty is measured from finger after which processed and displayed. The design, is small in size, smooth to use, permits a non-invasive, real time technique to offer information regarding health. Pulse oximetry is a useful device inside the evaluation of an affected person's oxygenation popularity and may be used automatically in many regions of scientific practice. The heart rate monitoring machine's objective is of detecting the heartbeat of the patient that allows you to monitor the risk of heart assault and additionally the regular checkup. The records received from heart charge module and blood oxygen sensor may be stored and regarded for further scientific usage.*

Keywords *— Pulse oximetry, Blood oxygen sensor, Healthcare, Health Monitoring, Max-30102.*

I. Introduction

Oxygen, being one of the compounds in the earth's environment plays a vital role in the lives of every single organism known. The significance of oxygen generally is of much greater value. When considering lives of humans, oxygen serves as the fuel for each cell on the body performing their respective functions for the better function of the human body. So, the concentration of oxygen in blood serves as an important parameter in the efficient working of body.

The measurement of concentration of oxygen in the blood determines the health condition of the patient. Now the rise in cost of healthcare services increased the pressure of middle class & poor people in obtaining the effective and efficient healthcare along with the cost of day-to-day fees in maximum of the developing nations. In this day and age, it is now difficult for one to be conscious about their health. As healthcare goes unnoticed and untreated, people become more susceptible to health issues.

Healthcare is the maintenance and monitoring of health through prevention, diagnosis and treatment. In this project, we seek to monitor a person's heart rate using heart rate sensor and blood-oxygen level using a pulse oximeter. The system used here is the heart rate monitoring model, this can be used in almost all the hospitals as well as for general purposes like residential area. In this system, we have used pulse sensor to find the nearby or the actual value of heart beat rate of a normal person. Whenever problem arises in one's heart functioning, in order to check the heart rate value this method is considered as the best method. When there is a low heart rate functioning happens, we call it as bradycardia. The lower of heart beat may be either an unstable issue or every now and it takes place to normal man or woman. The main objective of our project is to provide a simple and easy heart rate monitoring system and pulse oximeter so that it could be useful to everyone.

Photoplethysmography (PPG) is a low-cost optical technique that is able to detect volumetric changes in blood flowing through capillaries from the surface of skin. Photoplethysmography was developed in the late 1800s when scientists observed real-time blood flow using light bulbs. It was in the late 1930s that the term "photoplethysmography" was named by scientists. With advancement in technology, PPG developments now focus on consumer applications using wearable devices like fitness watches. These devices are usually connected to a peripheral device to interpret the results obtained. Today, those peripheral devices have been replaced by phones to deliver data to consumers in a user-friendly manner. Interfacing with smart phones is usually done using Bluetooth technology in case of smart watches but we are going to use Wi-Fi connection technology with our sensors.

II. Literature Review

Some of the existing methodologies for the heart rate monitoring system and pulse oximeter are described as below, In XAMPP platform and ESP8266 WI-FI Module method Pulse sensor is connected to ESP8266 WIFI module, the pin (Vcc) of the pulse sensor is connected to 3.2 v of WIFI module, ground pin is then connected to ground pin of WIFI module, the signal pin is then connected to analog pin of WIFI module. The data from the ESP is stored into the local database, the database is created using XAMPP platform. [1].

In Node MCU (ESP32) and Pulse oximetry sensor MAX 30100 method sensors are used. Arduino is an open-source platform used for developing this electronic system. Appropriate libraries for both the sensors and OLED have been downloaded from online sources. Code is developed in Arduino platform and uploaded into the Node MCU. Now sensors have been connected to the subjects and data displayed on OLED display. [2].

In MyRio and gateway server (cloud database IoT-IBM) The MyRio device is then connected to the GSM module. Now with the connection between MyRio and GSM module, the obtained data from the patient's body are then transmitted to the required database i.e., base station (cloud database IoT-IBM). The data received from the base station is stored in the form of files for further use. With correct access codes for the cloud storage, one can access the account to obtain a patient's data for various analyses. The transmission and storage of data in cloud storage is achieved by the use IoT platform. The last part of the architecture is used to store, analyze and present the received data in text and graphical format. T [3].

In QTPI Rio board and MAX30102 method the sensor is interfaced with the QTPI Rio board. The photo detector present in the sensor collects the IR Raw data and sends to the PC using I2C protocol.[4].

In AT mega 2560 CPU, CMS50D pulse oximeter, it uses DI-524 Wireless router, RN-171 shield, Monitoring software running on the computer is developed using Lab Windows CVI programming environment. This system also gives an advantage of portability where a person can check the heart rate from anywhere and anytime in the form of wearable devices, unlike the ECG signal diagnosis. [5].

III. METHODOLOGY

A. *Components*

1. Max 30102 Sensor
   The MAX30102 Sensor by Maxim is a pulse oximetry and heart rate monitor module in one. Internal LEDs, photodetectors, optical components, and low-noise circuitry with clime light desertion are all included in the MAX30102.

2. LM 35 Sensor
   The LM35 is a temperature sensor with precession whose output voltage fluctuates depending on the temperature surrounding it. It's a small, inexpensive IC that can measure temperatures ranging from -55°C to 150°C.

3. Node MCU
   It is an open-source software and hardware development environment for which open-source prototyping board designs are available. The name "Node MCU" is a combination of the word "node" and "MCU" (micro-controller unit).

4. Liquid Crystal Display I2C
   LCD (Liquid Crystal Display) is a type of flat panel display which uses liquid crystals in its primary form of operation. We have used an I2C module with our display.

5. Breadboard
   The purpose of the breadboard is to make quick electrical connections between components like resistors, LEDs, capacitors, etc. So that you can test your circuit before permanently soldering it together

6. LED's
   Light is produced when current passes through a Light Emitting Diode (LED). Electrons reunite with electron holes in the semiconductor, producing energy in the form of photons. For beeping light warning danger, LED is employed as a buzzer.

7. Software Requirements
   a. Arduino IDE
   b. Embedded C
   c. Tinker cad
   d. VS Code
   e. FTP Client

B. *Block Diagram*

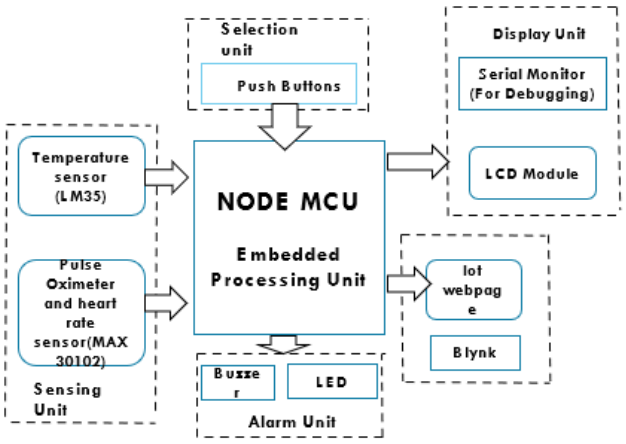

Fig. 1. Block Diagram

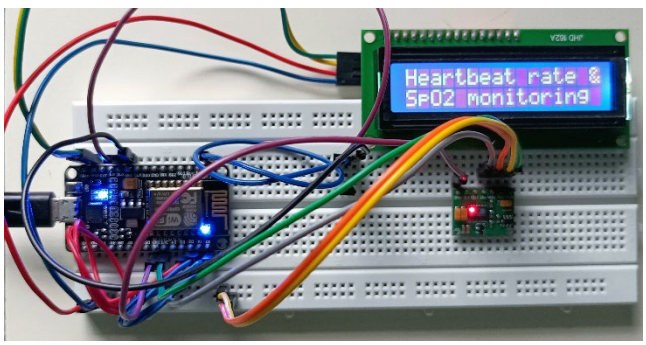

Fig. 2. Components Assembly

C. *Working*

We have used NodeMCU which is the heart of this project it is an open-source firmware which also has an inbuilt Wi-Fi module ESP-8266. We take input from MAX 30102 and LM35 and the output is displayed on LCD display, Serial Monitor, IoT webpage and Blynk App. Heartbeat rate and pulse-oximetry sensor that is utilized in this project (MAX30102) is a non-invasive optical device used for achieving two main functions, detecting the heartbeats and peripheral capillary oxygen saturation (Spo2). There are two non-invasive methods for calculating the heart rate and Spo2 values, one is the transmitted mode and other is in the reflected mode. The red light has a wavelength of 650 nm and the infrared light (IR) has a wavelength of 950 nm. Oxygen-saturated haemoglobin (oxygenated blood) and non-oxygen-saturated haemoglobin (deoxygenated blood) absorb different amounts of each light. So, the reflected light will be received by the sensor and through an algorithm, the final value for the Spo2 will be deducted.

For calculating the heart beats per minute or BPM another approach is used. The blood needs high pressure to be pumped out of the heart to other body parts. It occurs with the heartbeat and it causes the arteries to feel an amount of strain (blood pressure) when the blood flows in them. Arteries are responsible for carrying the blood out of the heart. So, the blood pressure leads to swelling and contracting of arteries, therefore the volume of the artery in the body parts (fingertip in this project) increases and reduces. When the volume increases, there will be more haemoglobin in the section area and consequently, the amount of absorbed infrared light will rise and the reflected signal back to the heart rate sensor will be reduced. These variations in the reflected light will result in a fluctuated signal called photoplethysmogram (PPG).[6]

We also measure temperature using this system. LM 35 sensor is used to measure temperature, it outputs an analog signal proportional to the instantaneous temperature. The output voltage can be easily interpreted to obtain a temperature in degree centigrade, it does not require any external calibration. The output from MAX 30102 and LM35 is then converted to required values by coding NodeMCU accordingly. We also use LCD display with I2C converter for displaying the output also we have made an IoT webpage which will run locally on the devices that are connected to the Wi-Fi network to which the NodeMCU is connected. We can also see the output on the Blynk mobile application anywhere in the world by pasting the authentication code.

IV. Results and Discussions

The system to monitor pulse oxygen and heart rate is successfully being made and runs with minimum number of errors and high accuracy. It is very important to monitor our heart rate and oxygen saturation regularly. This system measures heart rate using heart rate sensor and oxygen saturation using pulse oximetry sensor. It is easy to operate and can be used in hospital as well as at home. Non-professional person also can operate it easily which makes easy for people to measure heart rate and oxygen saturation and need not to go to hospital frequently for this. It contained MAX30102 sensor which is an integrated pulse oximeter and heart rate monitor sensor. It also contains LM35 temperature sensor which measures temperature of body along with heart rate and oxygen saturation. Several tests were conducted for to test each component. Several trials were conducted on each specific components and system as whole. We can get readings of heart rate in three phases- Low pulse rate when the BPM is in range 40 and 60 beats per minute, Normal pulse rate when BPM is in range of 60 to 100 beats per minute, High pulse rate when BPM is in range of 100 to 150 beats per minute. This device was tested with adult's finger in normal testing conditions. The result from our project are displayed in Figure 3, Figure 4, Figure5.

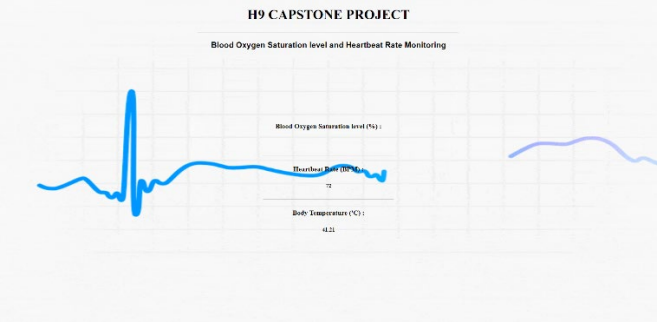

Fig. 3 IOT Webpage.

Fig. 4 Blynk mobile application.

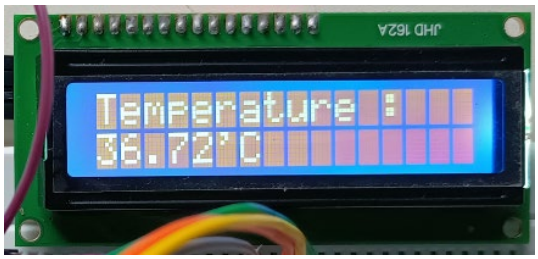

Fig. 5.a. LCD display displaying Temperature

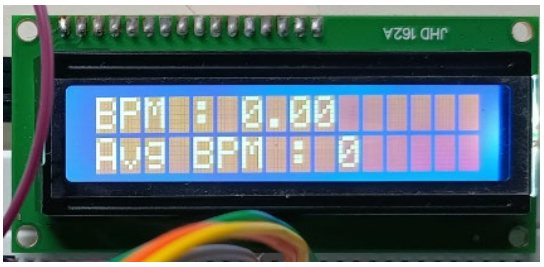

Fig. 5.b. LCD display displaying Heartbeat

V. LIMITATIONS

However, there are not many limitations to our project but few limitations to our project are:

- It becomes less accurate when oxygen saturation is below 80%
- Does not contains battery so cannot be used everywhere.
- bigger in size which makes it difficult to carry.

VI. FUTURE SCOPE

In future our system can be upgraded as to:

- Interface different sensors to measure different health factors like sugar.
- Design globally accessible server using IOT and upload data of heart rate and oxygen saturation on it.
- Setting an alert system on server which will notify nearby ambulance and hospital in case of emergency if the values of heartbeat rate or blood oxygen saturation cross a certain threshold limit.
- Make it smaller in size for ease in carrying it and embedding it in smart wearables.
- A battery will be attached to a device for portability.

VII. CONCLUSION

In today's world heart related problems are very common but neglecting them or not monitoring them regularly can be fatal. As we know oximeter and heart rate monitoring devices in market are expensive and the designed device is much cheaper than those. It is light weight and consumes less power. It is made in the way that it is easily operatable and any non-professional person can operate it easily.

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