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IoT Based Pulse Oximeter

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Abstract: In recent times, we have realized the importance of vital signs such as Oxygen saturation and heart rate i.e beats per minute (BPM) due to the covid-19 situation worldwide. SpO2 and BPM are being used as preliminary indicators for testing a person's health, the drop in the oxygen saturation is perceived as one of the symptoms of a person suffering from coronavirus. Oximeters are portable devices that are used to measure the SpO2 and BPM of a person. Timely measurements of oxygen saturation can aid in taking preventive measures. This paper discusses the construction and development of an IoT-based pulse oximeter that is capable of transmitting the reading obtained to any remote location wirelessly. The proposed system uses Arduino as the microcontroller which is used for signal processing and Esp-01 as the Wifi platform to enable remote data transmission. The data is communicated remotely through Blynk mobile application. This project is aimed at reducing the manual effort undergone in regularly updating the oxygen saturation to the doctor, in the case of a person undergoing home treatment. Though an oximeter is not a screening te
st, it is a primary indicator of a person's health.
Keywords: Heart rate, SpO2, IoT, Arduino, BLYNK server, Red, IR.

I. INTRODUCTION

Coronavirus is a pathogen responsible for causing COVID-19. This virus is found to enter the body through the respiratory system and affects the respiratory system of a person the most. This causes a direct injury to a person's lungs which impacts the natural mechanism of oxygen transfer into the bloodstream. This effect of reduced oxygen is encountered in several COVID cases.

The human body requires a regular supply of oxygen to maintain the oxygen balance in the body. This oxygen balance is signified by the term called oxygen saturation which is the ratio of oxygen-laden haemoglobin or oxygen saturated haemoglobin to the total haemoglobin in the blood. The oxygen saturation is expressed in terms of percentage. The typical oxygen saturation of a healthy person would come under the range of 95- 99%. The oxygen saturation level below the threshold leads to hypoxemia condition- which is low level of oxygen in the blood.

Another important parameter determined by the oximeter is the beats-per-minute. When a person's heart pumps blood into the body, this pumping or beating of the heart creates a pulse that can be felt or perceived on our wrist or neck. Then the number of pulses is counted for a minute which gives us the pulse rate. This means that when a heart contracts 72 times in one minute, then the person's pulse rate would be 72 beats per minute (BPM). This is termed as the heart rate. The normal heart rate lies between 60-100 beats per minute.

The pulse oximeter provides us the heart rate and oxygen saturation. The developed system aims to deliver the oxygen saturation and heart rate (beats per minute) to a remote doctor. This would prove to be highly beneficial for patients undergoing home treatment wherein the level of oxygen saturation is extremely important in undertaking important decisions. The system incorporates a mechanism to detect the drop in oxygen saturation and alert the doctor the same.

II. LITERATURE SURVEY

Oxygen saturation is an essential element of patient care. Oxygen is tightly regulated within the body because hypoxemia can lead to many acute adverse effects on individual organ systems. These include the brain, heart, and kidneys [1]. Pulse oximetry is ubiquitously used for monitoring oxygenation in the critical care setting. By forewarning the clinicians about the presence of hypoxemia, pulse oximeters may lead to a quicker treatment of serious hypoxemia and possibly circumvent serious complications [2]. Pulse oximeter technology has also expanded from measuring SpO2 and PR to measuring other hemoglobin species using multiwavelength analysis [3].

[4], [5] Proposes the use of a reflection type of oxygen saturation measurement system by using MAX30100 sensor. [6], [7] Proposes the use of a transmittance type of oxygen saturation measurement system.

The Internet of Medical Things is playing a vital role in the healthcare industry to increase the accuracy, reliability, and productivity of electronic devices [8].

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III. PROPOSED SYSTEM

The project was based on realizing IoT-based pulse oximeters where the oxygen saturation and heart rate were monitored to help the patients in the current situation. The device was based on Beer-Lambert's Principle of light absorption which stated that "The amount of light absorbed by a solution is directly proportional to its concentration '*c*' and pathlength '*l*' of the beaker". The RED and IR LED were used to measure the body heart rate SpO2 as the de-oxyhaemoglobin was sensitive to Red light and oxyhaemoglobin was sensitive to the IR rays. The absorption spectra of the Red light versus the IR light is as shown in the below graph.

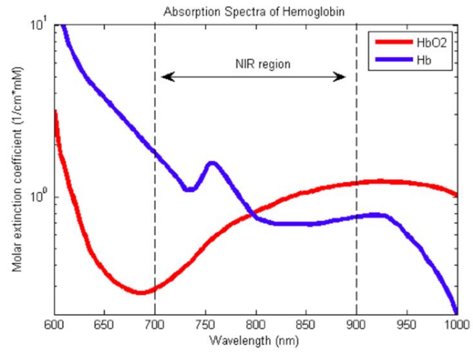

Fig. 1. Absorption spectra of IR vs RED.

A photodetector was used to measure the outcome radiation of both the LEDs used. Arduino was the processing unit, it collected the photodetector's output and performed the preset analysis and calculations. The data from the Arduino was presented on the LCD display. For remote reception of data and to realize IoT we had interfaced Esp-01 WiFi protocol and this was used for transmitting the heart rate and the SpO2 values, through this process the relevant patient's status is monitored remotely as well. Finally, the Blynk application forms the platform for data communication.

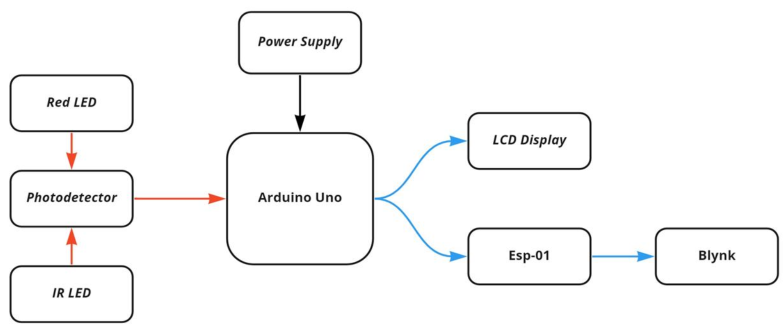

Fig. 2. Block diagram of the proposed system.

A. Algorithm

This is the path followed by the system:

1) *Step 1:* Start
2) *Step 2:* The red light and the IR light from Red LED and IR LED respectively are sensed/received by the photodetector.
3) *Step 3:* If the analog value of the IR wave and the RED wave is less than 700(analog value) the system responds by displaying "NO FINGER" on the LCD.
4) *Step 4:* If the analog value of the IR wave and the RED wave is greater than 700(analog) the system moves forward with execution.
5) *Step 5:* If the number of distinct positive peaks sensed is less than 4 then a "?" is displayed for both BPM and SpO2.
6) *Step 6:* If the number of distinct positive peaks sensed is greater than 4 then BPM and SpO2 are calculated and displayed on the monitor.
7) *Step 7:* The data of BPM and SpO2 is communicated to authorized smartphones through the BLYNK server.
8) *Step 8:* End.

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IV. DEVICE SPECIFICATIONS

A. Arduino

Arduino Uno is one of the most popular and easy to use microcontroller. It is a microcontroller based on ATmega328P. It uses C++ programming language with an addition of special methods and functions. The written code can be uploaded to the Arduino Uno board using Arduino IDE software.

B. ESP-01

The ESP-01 ESP8266 Serial WIFI Wireless Transceiver Module is a self-contained SOC with an 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. The ESP8266 module is an extremely cost-effective board with a huge, and ever-growing, community.

C. Red LED and IR LED

An LED is a semiconductor diode that has two terminals and emits radiation when current flows through it. The Red LED chosen in our project emits radiation that falls in the wavelength of 700 nm. The IR LED emits rays of wavelength around 940 nm.

D. Photo Detector

The photodetector is the primary sensing element that is used to measure the intensity of light. Since the pulse oximeter is based on the principle of differential absorption of red and infrared light, the intensity of light would offer us information about the absorption of light. The photodetector provides an output current, which is proportional to the intensity of the light.

E. Blynk Mobile Application

Blynk mobile application is an open-source platform for wireless data communication. It is widely preferred for IoT-based applications. It allows the hardware to be connected which provides us with the features of data acquisition, visualization, monitoring, and remote control of devices.

F. Arduino Ide

It is an open-source user-friendly software used to write code and upload it to the Arduino board. This software can be used with any Arduino board. It can run on multiple platforms like windows, mac os x, Linux.

G. Liquid Crystal Display(LCD)

LCD is an electronic display module. These displays are mainly preferred for multi-segment light-emitting diodes and seven segments. The main benefits of using this module are inexpensive; simply programmable, animations, and there are no limitations for displaying custom characters, special and even animations, etc.

V. METHODOLOGY

The IR LED's positive terminal was connected to one of the digital pins (4 in our case) in the Arduino through a 330Ω resistor and it was named IR input. The negative terminal was connected to the ground.

The Red LED's positive terminal was connected to another digital pin(5 in our case) in the Arduino through a 330Ω resistor and it was named RED input. The negative terminal was connected to the ground.

The KY-039 module's photodetector was used in the circuit as it detected both the IR and the Red light efficiently. The positive terminal of the detector was connected to the signal pin of the Arduino. A 10kΩ resistor was connected as feedback from the output signal pin to the source pin for making corrections in the occurrence of errors. The negative pin of the detector was grounded.

The Arduino board was interfaced with the photodetector where the output signal from the photodetector was connected to the analog pin(A0) of the Arduino. The LCD pins were connected to the digital ports of the Arduino.

The Esp-01 was used as a WiFi platform to connect the device to the internet. WiFi username and password were added to the code for the Esp-01 modem to establish a connection with the network.

The LCD display was powered with a suitable power supply and the digital pins were connected to the Arduino serial communication ports. The control pin was connected to a 10KΩ POT to vary the color contrast of the display. The register select pin was connected to the Arduino to differentiate the instruction from the Arduino to be a displayable statement or a command.

The BLYNK application's server was used to attain mobile communication of the heart rate and the oxygen saturation data. The Blynk app was installed in the smartphone to be connected and the login was done using a preferred email ID.

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An authorization mail was sent by the Blynk server to the registered email ID which consisted of the "auth" token. The auth token was added to the code so that only the authorized person receives the data regarding the measurement.

An alerting system was initiated in the Blynk app itself in order to send alert messages/emails/alarms in the event of low levels of heart rate or O2 saturation to the smartphone whose number is authorized in the code. The below shows the organization of the components in the circuit.

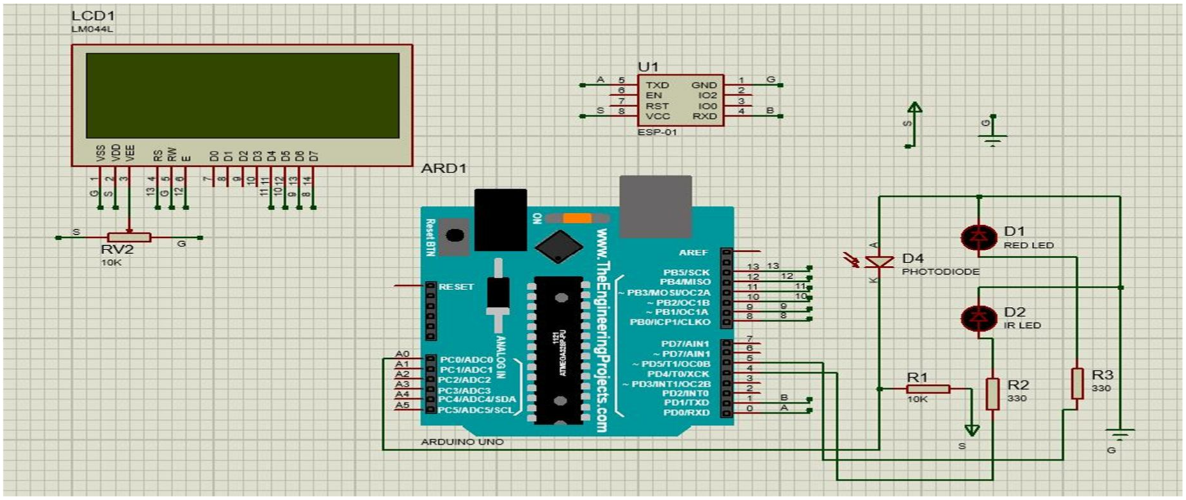

Fig. 3. Circuit diagram

VI. DISCUSSION AND RESULTS

The hardware was initialized by uploading the respective codes to the Arduino and the Esp-01 respectively. After initialization, the IR and the Red LEDs generated IR rays and Red rays respectively. When there was no finger placed in between the LEDs and photodetector the entire wave was detected untruncated by the photodetector, this resulted in a low analog value and a "NO FINGER?" label was printed on the display.

When the finger of the subject was placed between the sensor and the LEDs, a part of the waves was absorbed, scattered, which resulted in the generation of a PPG signal. The signal generated was filtered by applying software filters in the code and an undisturbed PPG signal was obtained.

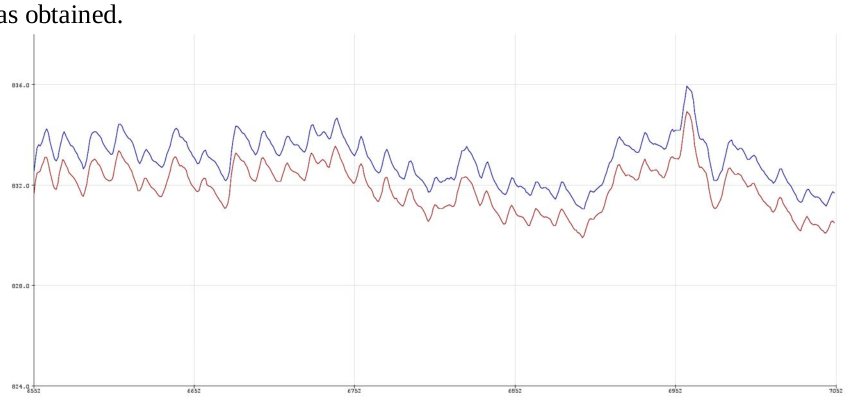

Fig. 4. PPG signal

The filtered output was used to perform the analysis and calculations of heart rate and SpO2. In order to account for accuracy and to bypass noise, a parameter named '*c*' was initialised which calculated the number of distinct positive peaks obtained in the PPG. SpO2 and heart rate calculations were performed only when a minimum of 5 distinct peaks were detected ($c > 4$).

After the calculation was performed the data of the heart rate and the SpO2 was displayed on the LCD display and communicated to the BLYNK server continuously through the Esp-01's Wifi modem. An alerting notification was sent to the registered smartphone if the SpO2 levels detected went below the preset threshold level(90% in our case).

Several trials were carried out on the hardware in order to correlate the output readings of it with a commercially available oximeter and the results obtained were as follows:

TABLE 1
Comparison of Test Results

Sl No.	Patient age	Gender	Commercial oximeter		Our Oximeter	
			SpO2	BPM	SpO2	BPM
1	15	F	96	94	98	95
2	21	M	97	86	98	88
3	43	F	97	72	97	75
4	51	M	95	75	96	78

When the finger of the subject was placed in between the sensor and LEDs the LCD board showed a "?" in front of BPM and SpO2 while the BLYNK server retained the previous value, until the value 'c' (number of distinct peaks) became greater than 4 as shown below in the figure.

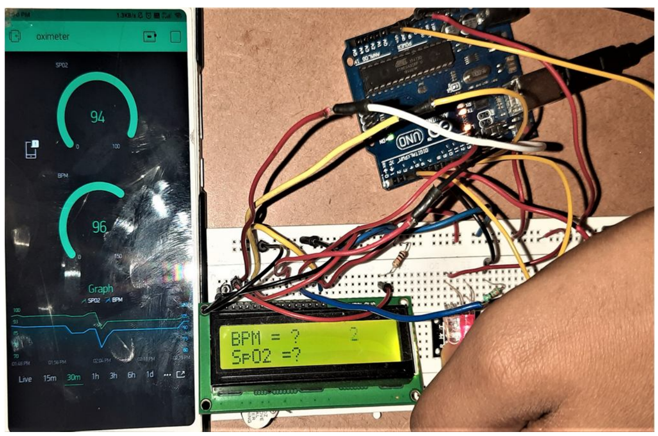

Fig. 5. Patient normal with (c < 4)

As the c value went above 4, a clear PPG wave was obtained and the SpO2 and heart rate values were calculated. These values along with *'c'* were displayed on the LCD and also updated to the BLYNK server as shown in the figure below.

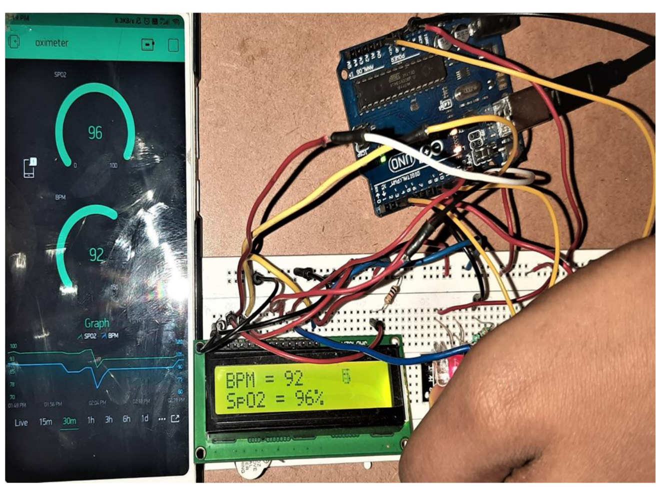

Fig. 6. Patient normal with (c > 4)

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Consequently, when the SpO2 levels of a patient fell below the threshold value(90%) the BLYNK server sent a notification to the registered smartphone quoting "Emergency" as shown in the figure below.

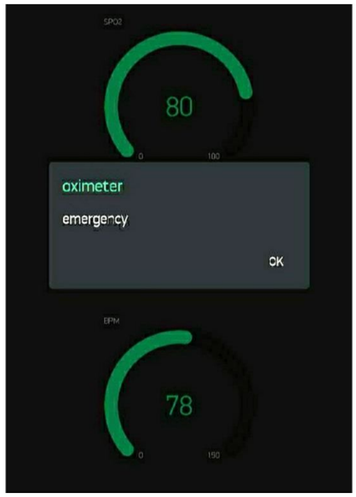

Fig. 7. Patient in critical condition

VI. CONCLUSION AND FURTHER SCOPE

The IoT Based Pulse Oximeter is found to be effective in measuring the major vitals to be monitored in patients with pulmonary diseases. It can communicate the data with doctors remotely hence it reduces the physical presence of the doctor.

As mentioned in the paper, the proposed system uses both Arduino, ESP01 for signal processing and wireless connectivity respectively. This could be further improved to include both the functions onto a single microcontroller which would reduce the form factor of the device.

Further, we could develop a mobile-based application dedicated to help the doctor or concerned people to monitor the oxygen saturation and heart rate of a patient. The requirements of the application would be - it should be able to perform in all the prominent operating systems, should consume minimum power, storage, and an alerting system should be included.

VII. ACKNOWLEDGMENT

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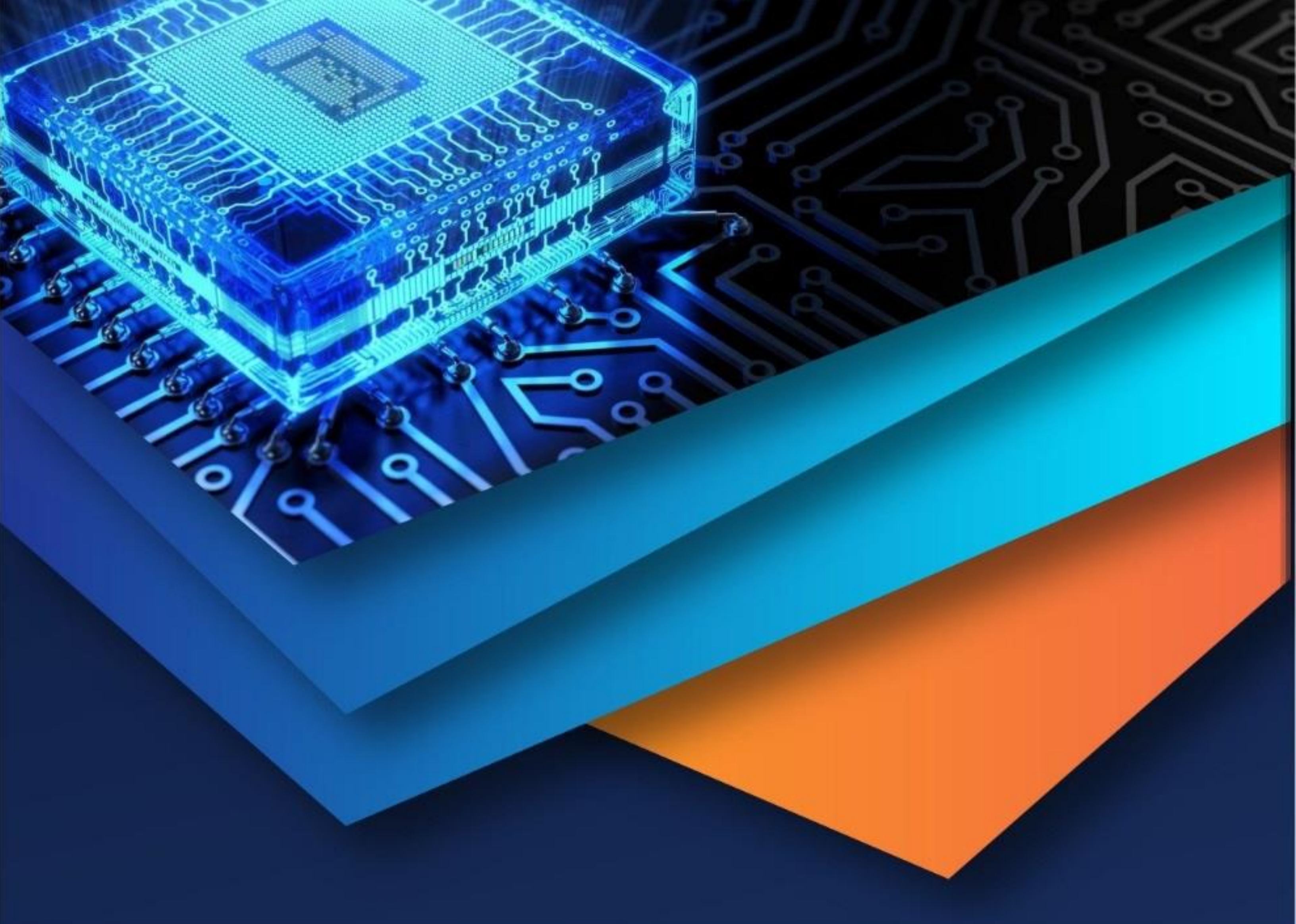
REFERENCES

[1] B. Hafen and S. Sharma, Oxygen Saturation. StatPearls Publishing, 2021.
[2] A. Jubran, "Pulse oximetry," Crit. Care, vol. 19, no. 1, Jul. 2015, doi: 10.1186/s13054-015-0984-8.
[3] M. Cannesson and P. Talke, "Recent advances in pulse oximetry," F1000 Med. Rep., vol. 1, p. 66, Aug. 2009, doi: 10.3410/m1-66.
[4] L. K. Hema, R. Mohana Priya, R. Indumathi, and G. Ii, "DESIGN AND DEVELOPMENT OF IOT BASED PULSE OXIMETER." Accessed: Jun. 24, 2021. [Online]. Available: http://www.acadpubl.eu/hub/.
[5] V. MIRON-ALEXE, "IoT PULSE OXIMETRY STATUS MONITORING FOR HOME QUARANTINED COVID-19 PATIENTS," J. Sci. Arts, vol. 20, no. 4, pp. 1029–1036, Dec. 2020, doi: 10.46939/j.sci.arts-20.4-c04.
[6] Y. Xie, Y. Gao, Y. Li, Y. Lu, and W. Li, "Development of Wearable Pulse Oximeter Based on Internet of Things and Signal Processing Techniques," 2017, doi: 10.1109/EMS.2017.49.
[7] R. R. Adiputra, S. Hadiyoso, and Y. Sun Hariyani, "Internet of things: Low cost and wearable SpO2 device for health monitoring," International Journal of Electrical and Computer Engineering, vol. 8, no. 2. Institute of Advanced Engineering and Science, pp. 939–945, Apr. 01, 2018, doi: 10.11591/ijece.v8i2.pp939-945.
[8] G. J. Joyia, R. M. Liaqat, A. Farooq, and S. Rehman, "Internet of Medical Things (IOMT): Applications, Benefits and Future Challenges in Healthcare Domain," doi: 10.12720/jcm.12.4.240-247.
[9] G. Pons, "Really Homemade Oximeter Sensor - Arduino Project Hub," May 13, 2020. [Online]. Available: https://create.arduino.cc/projecthub/giulio-pons/really-homemade-oximeter-sensor-7cf6a1 (accessed Jun. 25, 2021).
[10] "Pulse Oximetry Basic Principles and Interpretation | Iowa Head and Neck Protocols," University of Iowa Health Care. 2017, Accessed: Jun. 27, 2021. [Online]. Available: https://medicine.uiowa.edu/iowaprotocols/pulse-oximetry-basic-principles-and-interpretation.



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