

# Infant Oxygen Supply Automatic Monitoring System

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## Abstract

Infants and young children, especially those born prematurely or with breathing problems, often struggle to breathe properly because their lungs are not fully developed. Oxygen therapy is essential to help them survive and grow. However, manually checking their oxygen levels takes time and leads to human errors. These mistakes can cause serious complications like hypoxia (too little oxygen) or oxygen toxicity (too much oxygen), which may affect the child's long-term health. To reduce the risk, developed the Infant and Child Oxygen Supply Automatic Monitoring System. This system is designed to continuously monitor vital signs such as heart rate, oxygen saturation (SpO<sub>2</sub>), and temperature in real-time. It is built using the MAX30102 sensor, ESP32 microcontroller, and piezoelectric sensor, which helps provide the right amount of oxygen based on the child's health condition. The system also includes a mobile app that allows caregivers and patients to view live data and receive alerts if there are any irregularities, so can take quick action even from a distance. This smart system offers better support in neonatal and pediatric care especially in settings where proper oxygen monitoring tools are lacking. It helps reduce the workload for healthcare staff and gives families peace of mind.

## 1. Introduction

Infants and children, especially those born prematurely or with medical complications, are highly vulnerable due to their underdeveloped body systems particularly the respiratory system. Premature babies often require oxygen therapy and detailed monitoring to survive. However, managing oxygen levels in young patients is delicate and more to monitor because too much oxygen can lead to complications such as retinopathy of prematurity (ROP), which may cause blindness, while too little oxygen can result hypoxia, a life-threatening condition [1]. The nurses adjust oxygen therapy manually by monitoring oxygen saturation (SpO<sub>2</sub>) levels, heart rate, and temperature level. While this method is commonly used, it is time-consuming, heavily dependent on staffing levels, and does not provide a continuous response to sudden changes in a child's condition. These limitations can result in inconsistent oxygen delivery and increase the risk of harmful outcomes. To address these challenges, automated systems are needed to provide the more accurate, stable, and responsive oxygen therapy [2].

In addition, an automatic oxygen supply system for infants and children works by continuously monitoring vital signs such as SpO<sub>2</sub>, heart rate and temperature. It automatically adjusts the fraction of inspired oxygen to maintain optimal oxygen and temperature levels. This is made possible by a closed-loop system that combines advanced sensors, microcontrollers, and mobile applications, adapting in real-time to the child's changing condition. Automation helps to improve therapy accuracy, reduce the workload for healthcare staff, and lower the risk of human error, ultimately leading to better health outcomes [3]. This allows a more personalized and

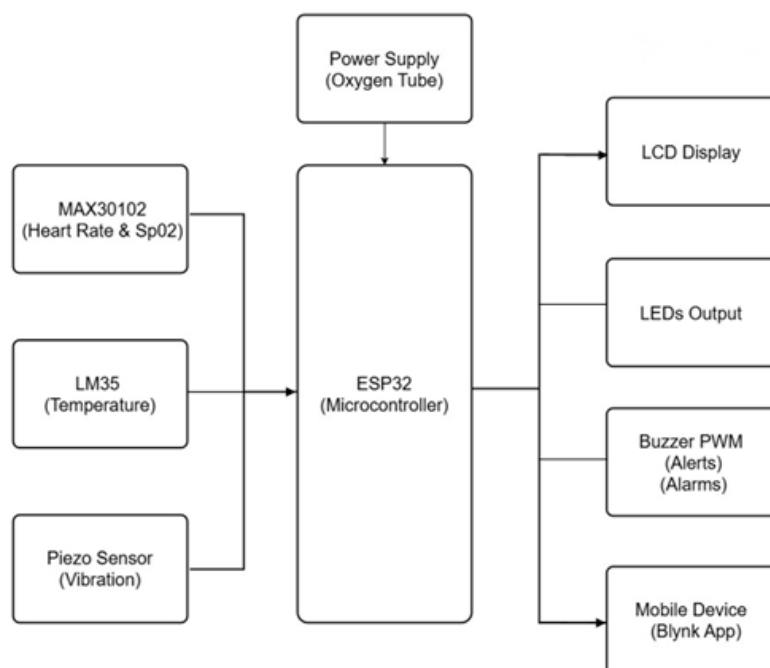
adaptive approach to oxygen therapy, with real-time monitoring of multiple physiological signals. The system is designed to achieve several key goals is continuous monitoring of SpO<sub>2</sub>, heart rate, temperature, real-time HRV analysis, automatic adjustment of oxygen levels, and timely alerts for healthcare providers if signs of distress are detected. The use of multiparametric HRV analysis, including time-domain, frequency-domain, and nonlinear methods, offers a complete picture of the child's heart function [4].

In conclusion, automated respiratory support systems represent a major step forward in neonatal and pediatric care. An automatic oxygen monitoring and delivery system not only addresses the shortcomings of manual methods but also aligns with the broader healthcare goal of using technology to improve patient care. By enabling accurate, continuous, and individualized therapy, this system can greatly improve survival and development outcomes for infants and children. It also reduces the physical burden on families and healthcare teams to ensure that our youngest and most vulnerable patients are safety.

## 2. Methodology

### 2.1 Overview

Fig. 1 shows a block diagram above illustrates a complete and systematic for infants and children. This system is designed to continuously monitor vital signs such as heart rate, oxygen saturation (SpO<sub>2</sub>), body temperature, movement and to respond automatically when abnormal conditions are detected. The center of the system is the ESP32 microcontroller, which functions as the main control unit, receiving data from sensors and all output components [5]. The main sensors are connected to ESP32 to monitor the condition of infants and children. The MAX30102 sensor measures heart rate and oxygen saturation (SpO<sub>2</sub>) which are essential parameters in health monitoring [6]. The LM35 sensor detects body temperature to ensure it remains within the normal range [7]. Additionally, the Piezoelectric sensor is used to detect vibrations or movements which may indicate respiratory activity or physical motion of the infant and child [8]. The processed by ESP32, important information is displayed on an LCD screen for the caregiver's reference [9]. If the readings indicate a risk condition, the LED indicator will light up according to the alert level and a PWM Buzzer will sound like an audible alarm [10][11]. The system is also connected to a mobile device via the Blynk application, allowing remote monitoring through a smartphone [12].

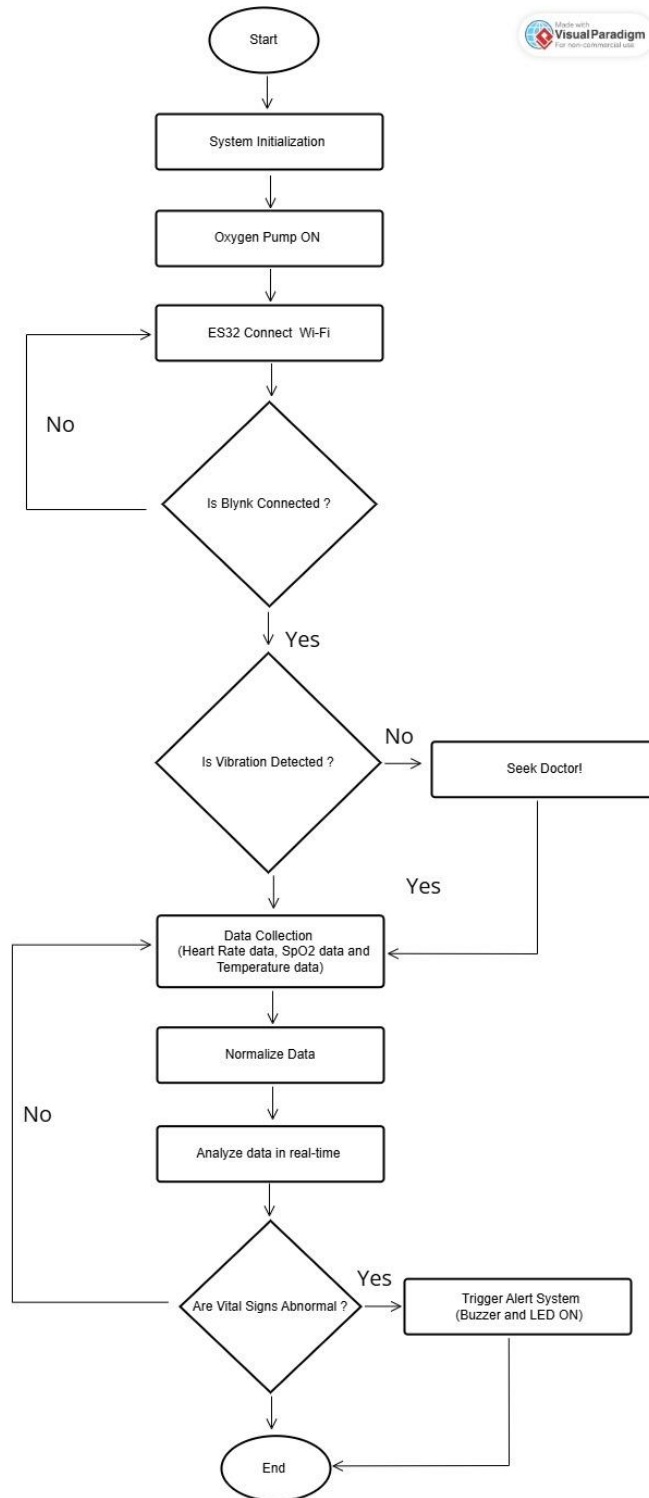


**Fig.1** Block diagram of the proposed system

### 2.2 Flowchart of the Infant Oxygen Supply Automatic Monitoring System

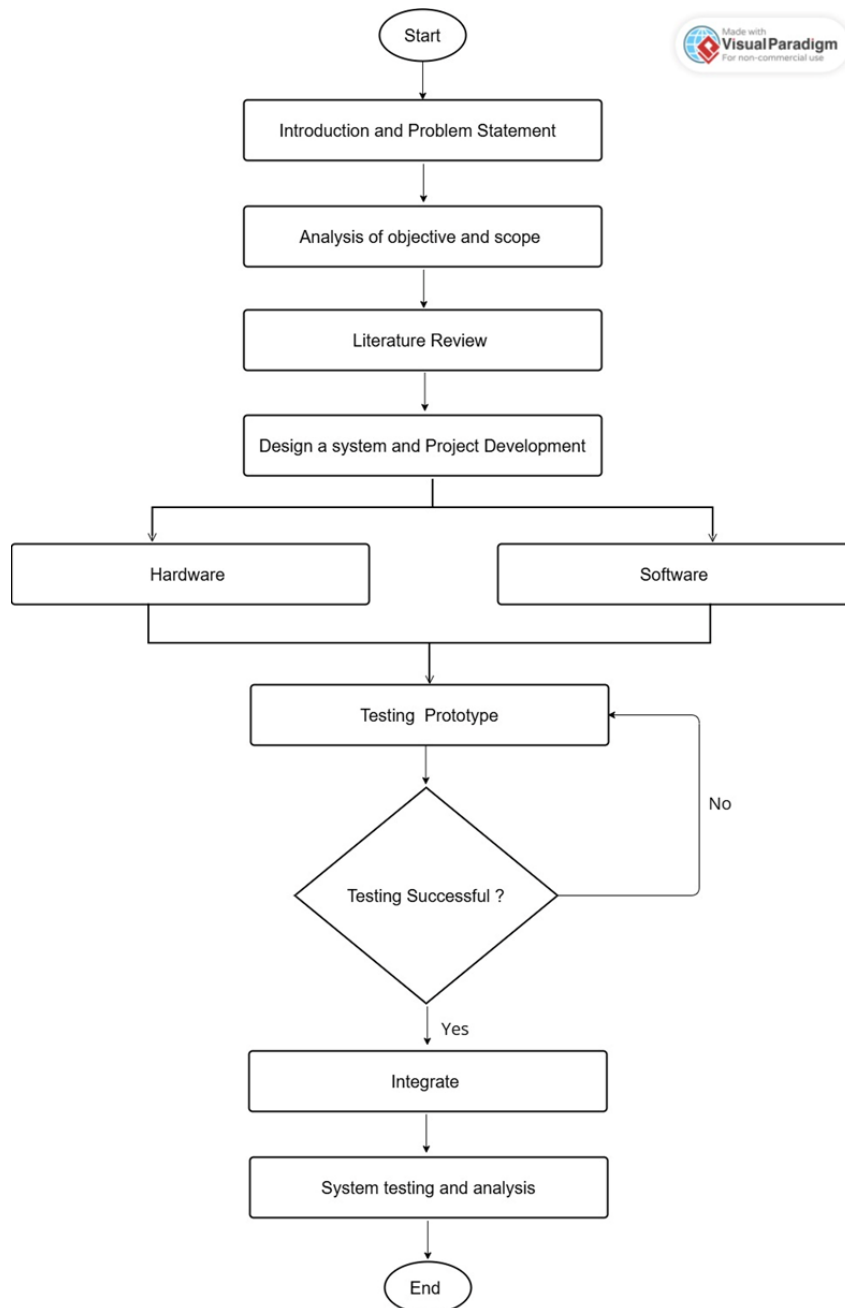
This flowchart illustrates the process flow of an infant Oxygen Supply Automatic Monitoring System. The system begins with system initialization, followed by turning ON the oxygen pump to ensure oxygen is ready for delivery to the infant. Next, the ESP32 module attempts to connect to a Wi-Fi network. If the connection fails, the system will keep looping until a successful connection is established. Once the Wi-Fi connection is made, the system checks if it is connected to the Blynk application, which allows remote monitoring. If it is not connected, it loops back and try again.

When the Blynk is successfully connected, the system proceeds to detect the vibrations, which serves as an indicator of the infant’s breathing. If no vibration is detected, the system triggers a prompt advising to “Seek Doctor” attention. After the vibration is detected or not, the system begins collecting vital signs, which include heart rate, SpO2 and body temperature data. These readings are then normalized to ensure consistency and reliability. Following normalization, the system analyzes the data in real-time to monitor the infant’s condition accurately. If any of the vital signs are identified as abnormal, the system will trigger an alert system, activating a buzzer and LED as a warning signal. These caregivers or hospital staff respond quickly in critical situations. If all vital signs are within the normal range, the system continues monitoring. This structured and automated process ensures safe and efficient oxygen supply monitoring for infants.



**Fig. 2** Flowchart of the Infant Oxygen Supply Automatic Monitoring System

## 2.3 Flowchart of Project Planning



**Fig. 3** Flowchart of Project Planning Infant Oxygen Supply Automatic System

This project planning flowchart as shown in Fig. 3 is a well-structured guide for the development of the Infant Oxygen Supply Automatic Monitoring System, integrating both hardware and software components. The process begins with an introduction and problem statement, which can help to identify the main issues in current infant monitoring systems especially in critical care environments and then followed by an analysis of the project's objective and scope, which outlines specific goals such as the real-time monitoring, alerting for abnormal readings, and ensuring infant safety through automation. The literature review stage comes to providing background information on similar technologies and existing systems. This can help to understand the strength and limitation of inspires innovation in the proposed system. One foundation is established, proceeds with the system design and project development phase. In this stage, components are selected. The ESP32 microcontroller acts as the main of the hardware system, MAX30102 is used for heart rate and SpO2 monitoring, LM35 for temperature sensor and a piezoelectric sensor for detecting movement and respiration patterns. And then, the development is split into two branches is hardware and software. The hardware development involves assembling and wiring the sensors to the ESP32, for the software development is done using Arduino IDE for the

coding, and Blynk as a IoT platform to send real-time data to a smartphone application. If the prototype does not perform as expected the process loop back for improvements. If the testing is successful, the system components are integrated into one working unit, and the safety of the fully integrated system is thoroughly evaluated. This final step ensures the system meets the original goal to automatically monitor an infant's oxygen supply and vital signs, improve the care and early detection of health risk. This flowchart demonstrates a practical and effective planning approach for combining the hardware and software into a reliable healthcare solution.

## 2.4 Circuit Diagram Connection

The circuit diagram connection in Fig. 4 shows the complete hardware connection for the Infant Oxygen Supply Automatic Monitoring System. It includes essential components such as the ESP32 microcontroller, Oxygen Pump, MAX30102 sensor for the heart rate and SpO<sub>2</sub>, LM35 sensor for the body temperature, and Piezoelectric sensor to detect vibration. The LCD display, LED, buzzer and power supply. Each component plays a critical oxygen supply automatically and the ESP32 acts as the central control unit, processing data from the sensors and sending alerts when needed.

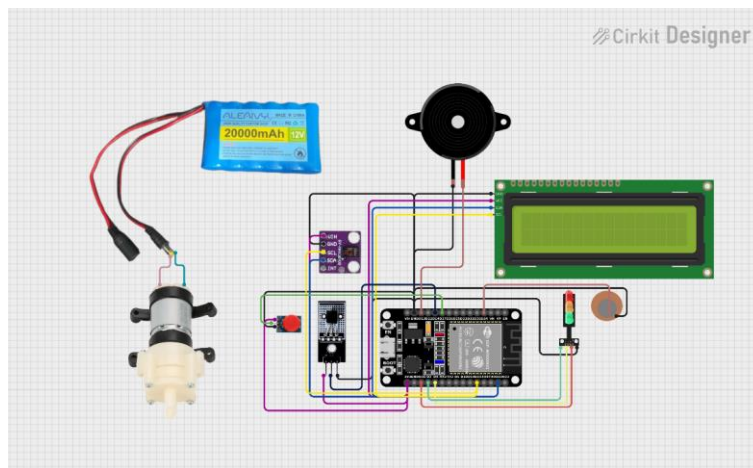


Fig. 4 Circuit diagram for the prototype

## 3. Result and Discussion

This section explains about the project outcomes and discussion the prototype model's testing results. All aspects of the electronic and mechanical components are considered. This chapter concludes with a discussion of the results.

### 3.1 Prototype Design

The prototype of Fig. 5 had been successfully produced. The prototype designs the 3D model presents a detailed design of the overall system enclosure and its structured arrangement. This was conceptualized and developed using SolidWorks, a professional 3D CAD software widely used in modelling and engineering applications for precise design work. This involves the arrangement of several electronic components into a single functional unit that can monitor and respond to the infant's vital signs in real-time. Fig. 5 the system uses a piezoelectric sensor to detect vibrations from the oxygen pump and a MAX30102 sensor to monitor the baby's heart rate and oxygen saturation (SpO<sub>2</sub>) level. These sensors are connected using jumper wires and MAX30102 sensor is use finger sleeve to ensure both comfort and safety. The readings are displayed in the Arduino IDE, while the LCD screen will display the message "Seek Doctor" and a traffic light LED indicator, green for normal, yellow for warning and red for critical conditions. If critical reading is detected, a buzzer is automatically activated to produce a loud alert. Overall, this hardware integration shows great potential for developing an affordable and accessible infant health monitoring solution especially in resource limited areas and making it suitable for use in various settings such as hospitals, clinics or at home.

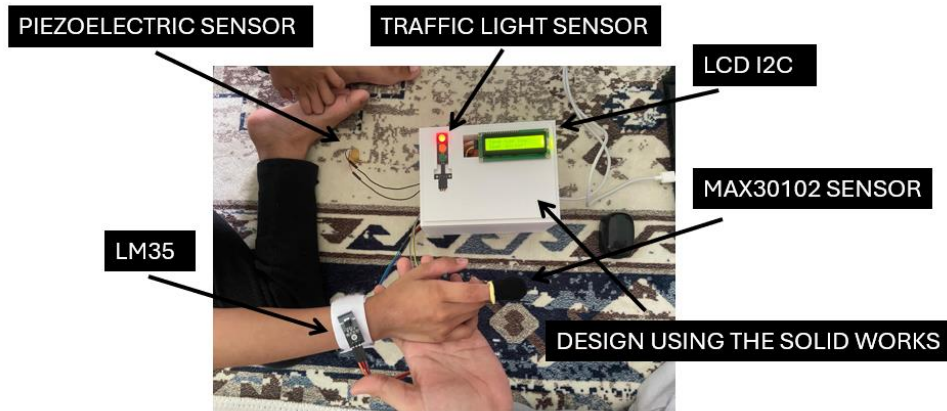


Fig. 5 Prototype of the proposed system

### 3.2 Integration of Hardware and Software Design

This software integration of the Infant Oxygen Supply Automatic Monitoring System utilizes the Blynk IoT platforms, which enables real-time monitoring and remote-control access through smartphones or an online dashboard. As shown in Fig. 6, the Blynk interface is neatly designed and easy to understand. The main dashboard displays real-time readings such as heart rate, oxygen saturation (SpO<sub>2</sub>), and body temperature using gauge widgets and there is a “Health Status” text widget that shows message like “Place Finger” when the sensor fails to detect a reading and when “High and Low” conditions when the sensor give the readings based on conditions, it assisting users in adjusting the sensor placement more effectively. To enhance safety, the system includes a “Vibration Alert” indicator and a control switch. The alert changes to RED if no vibration is detected from the oxygen source and for the ON/OFF switch available on the interface allows users to control the system remotely with ease. Moreover, a graph display is integrated to show the history of heart rate, oxygen saturation (SpO<sub>2</sub>) and body temperature readings over a selected period. This visual record helps users track trends and patterns in the baby’s health condition. Blynk has greatly enhanced the system by it smarter, more accessible, and responsive to real healthcare needs.

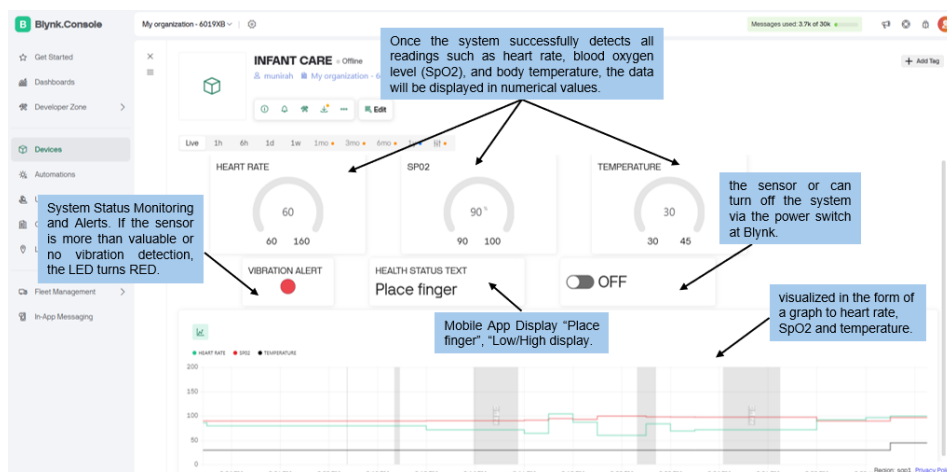
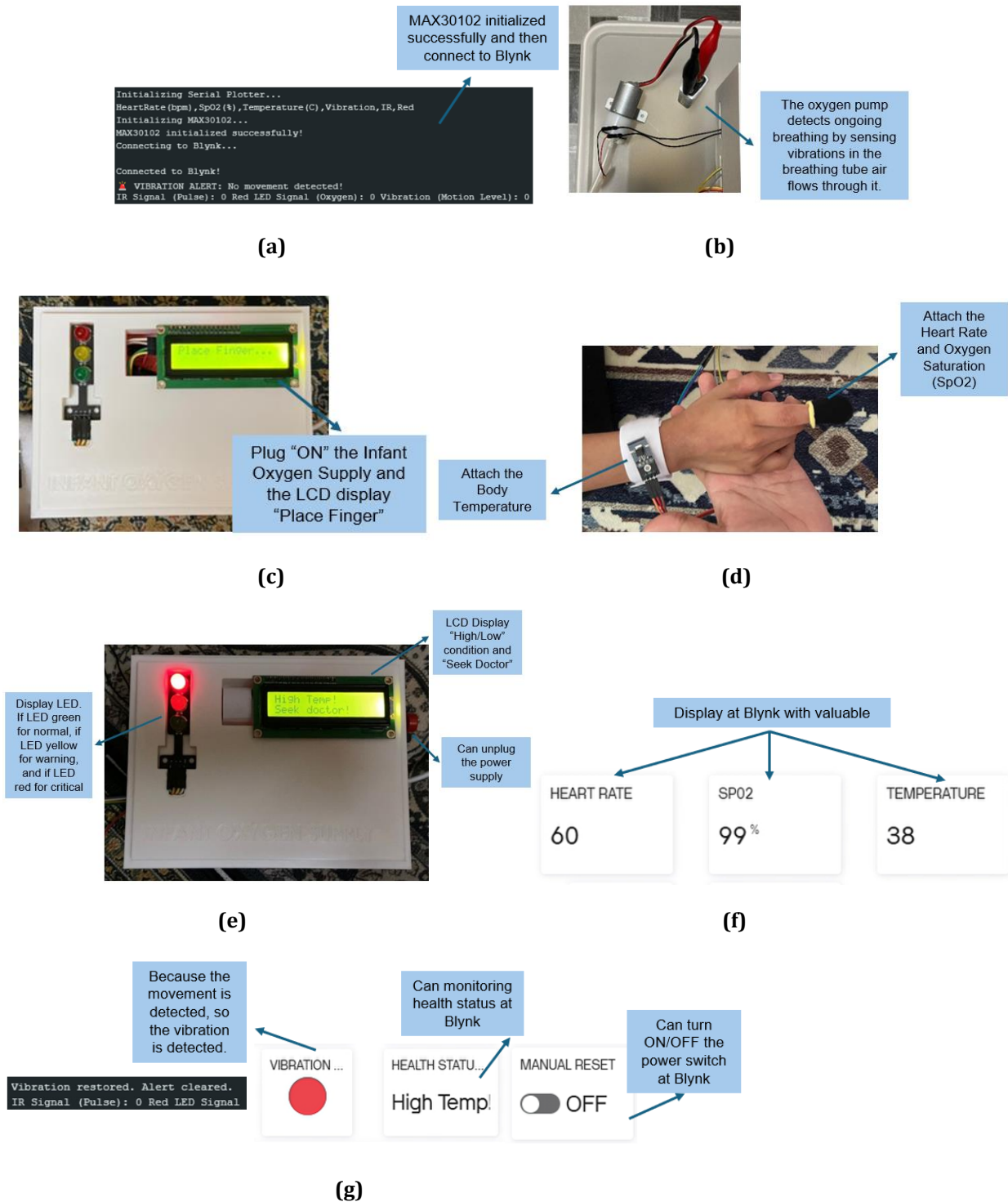


Fig. 6 Blynk interface

Fig. 7 shows the workflow of system startup process where the MAX30102, LM35 and Piezoelectric sensor is successfully initialized and connected to the Blynk platform. The system enables real-time health monitoring and checks for vibration status to determine whether any movement is detected Fig. 7 (a). After detection of oxygen pump, it detects the infant’s breathing through vibrations sensed in the airflow within the oxygen tube. It activates only when airflow vibration is present and indicates ongoing respiration activity (b). The system powered ON and the LCD screen display a message prompting the user to “Initializing .....” and “Place Finger” indicate readings to measure heart rate, oxygen saturation (SpO<sub>2</sub>), and body temperature (c). Thus put the finger at MAX30102, it attaches the heart rate, oxygen saturation (SpO<sub>2</sub>), and body temperature sensor is attached to the wrist and displays at the Arduino IDE (d) and condition where the body temperature rises (38°C) and a red

LED turns on as an alert, and the LCD shows a warning message “High Temp and “Seek Doctor!”. These are variables based on the indicated readings to measure heart rate, oxygen saturation (SpO2), and body temperature. This step ensures accurate detection of vital signs (e). Other than hardware display, using the Blynk app interface on smartphone, displaying essential health parameters such as heart rate is (60bpm), oxygen saturation (SpO2) is (99%), and body temperature is (38°C) (f). Additionally, the app allows users to monitor the health status of view alerts like “High Temp” and then can perform a manual reset and can control the system (g).



**Fig. 7** Workflow of Infant Oxygen Supply Automatic Monitoring System (a) Display successfully connect at Arduino IDE (b) Connection and detection of oxygen pump and piezoelectric sensor (c) Display the “Place Finger” (d) Attach the MAX30102 and LM35 sensor (e) Display the LCD and LED turn ON (f) Display the valuable at Blynk applications (g) Display the detected vibration, health status and switch ON/OFF.

## 4. Conclusion

In conclusion, the Infant Oxygen Supply Automatic Monitoring System has demonstrated its effectiveness and reliability in early tests with infants and three young children. The SpO<sub>2</sub> readings, heart rate, and body temperature values each exhibited only minor errors, all within acceptable clinical ranges. The alert response time ranges between 3 and 5 seconds, indicating that this system is well-suited for real-time use, where every second can be critical to an infant's safety. The combination of LED indicators, and sound buzzer, and mobile notifications via the Blynk creates an integrated alert package that helps the healthcare staff make quick, informed decisions based on trustworthy data. Lastly, this project successfully balances clinical precision with the daily needs of caregivers and infants. Infant Oxygen Supply Automatic Monitoring System prototype has the potential to become an essential tool infant health monitoring and delivering accurate readings in real-time.

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## Conflict of Interest

Authors declare that there is no conflict of interest regarding the publication of the paper.

## Author Contribution

*The authors confirm contribution to the paper as follows: **study conception and design:** Siti Munirah Aziz, Muhammad Mahadi Abdul Jamil; **data collection:** Muhammad Mahadi Abdul Jamil, **analysis and interpretation of results:** Siti Munirah Binti Aziz, Muhammad Mahadi Abdul Jamil; **draft manuscript preparation:** Siti Munirah Aziz, Muhammad Mahadi Abdul Jamil. All authors reviewed the results and approved the final version of the manuscript.*

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