

Portable Smart Infant Warmer for Neonatal Care

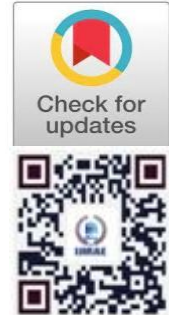
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Abstract: A Portable Smart Infant Warmer is a compact biomedical device designed to maintain the body temperature of new born babies, especially premature or low-birth weight infants. New borns are highly vulnerable to hypothermia due to their immature thermoregulation system, which can lead to serious health complications. The proposed system provides a controlled warming environment using a low-power heating element and temperature monitoring sensors. The device continuously monitors the infant's body temperature using sensors and automatically regulates the heating system to maintain an optimal temperature range. A microcontroller processes the sensor data and controls the heating mechanism to ensure safe and efficient operation. Additional features such as temperature display, alarm alerts, and portability make the system suitable for use in rural clinics, ambulances, and emergency situations where conventional incubators may not be available. This portable solution is cost-effective, energy-efficient, and easy to operate, making it a practical alternative for improving neonatal care in low- resource settings.

Keywords: Portable Infant Warmer, Neonatal Thermo regulation, Hypothermia Prevention, Temperature Monitoring System, Low-Cost Neonatal Care Device.

I. INTRODUCTION

Newborn babies, especially premature and low-birth-weight infants, are highly sensitive to temperature changes. Their bodies are not fully developed to regulate heat effectively, which makes them vulnerable to a condition known as Neonatal Hypothermia. If the body temperature of a newborn falls below the normal range, it can lead to serious health complications such as breathing problems, infection, and even death. Therefore, maintaining an optimal thermal environment is very important in neonatal care. In hospitals, devices like incubators and radiant warmers are commonly used to maintain the body temperature of newborn infants. However, these systems are often expensive, bulky, and require continuous electrical power and specialized infrastructure. In many rural or low-resource healthcare settings, such advanced equipment may not be available. A Portable Smart Infant Warmer is designed to address this challenge. It is a compact and lightweight biomedical device that helps maintain the infant's body temperature within a safe range. The system typically consists of temperature sensors, a microcontroller, a heating element, and a display unit. The temperature sensor continuously monitors the infant's body or surrounding temperature, and the microcontroller processes this information to regulate the heating element automatically. The "smart" aspect of the device refers to its ability to monitor temperature in real time and adjust the heat output accordingly. This helps prevent overheating or excessive cooling, ensuring the safety and comfort of the infant. Some advanced systems may also include alarm notifications, digital temperature display, and connectivity features for remote monitoring. The Portable Smart Infant Warmer is particularly useful in rural hospitals, primary healthcare centers, ambulances, and emergency situations where conventional neonatal incubators may not be accessible. By providing a stable thermal environment, this device can significantly improve neonatal survival rates and support better healthcare outcomes for newborn babies. Additionally, the Portable Smart Infant Warmer is designed to be simple, affordable, and energy efficient. It can operate with low power and may include battery backup for use during power failures or during infant transport. This device helps provide essential thermal care for newborns in rural hospitals, clinics, and emergency situations where advanced incubators are not available.

II. LITERATURE SURVEY

[1] Sharma and Singh designed an infant warmer with PID- based temperature control to achieve stable and uniform heat distribution. The system incorporated temperature sensors and a microcontroller to regulate the heating element.

The results showed that the device could maintain the infant's temperature within the safe range and effectively prevent hypothermia in newborn babies. [2] Abd El-Aziz and Taloba proposed a real-time monitoring and control system for neonatal incubators using IoT technology. The system continuously monitored parameters such as temperature and humidity and transmitted the data to a remote monitoring interface. This approach allowed healthcare professionals to track the infant's condition in real time and improved the efficiency of neonatal care. [3] Focused on the design and development of an infant warmer capable of maintaining precise temperature regulation. The system used temperature sensors and a controlled heating mechanism to ensure stable thermal conditions for newborns. Experimental results demonstrated improved temperature stability and enhanced safety for neonatal care. [4] Dushimimana and colleagues developed a portable cradle infant warmer intended for use in rural healthcare facilities. The device was designed to be compact, low-cost, and easy to operate. The prototype demonstrated the ability to maintain a stable temperature environment for newborn infants and was suitable for low-resource medical settings. Quinn et al. [5] Conducted a cluster-randomized trial to evaluate the safety and effectiveness of a non-electric infant warmer used in Rwanda. The study showed that the device significantly improved thermal care in newborns suffering from hypothermia and proved to be a reliable solution in environments with limited electricity. Chen et al. [6] designed a low-power neonatal infant warmer equipped with battery backup to ensure continuous operation during power failures. The system was developed for rural healthcare applications where electricity supply may be unstable. Experimental results indicated that the device could effectively maintain the required temperature range for newborns. [7] Linnes and colleagues introduced NeoWarm, a low-cost infant warmer designed for neonatal hypothermia treatment. Preclinical validation demonstrated that the device could safely restore normal body temperature in hypothermic infants without causing thermal injuries, making it suitable for use in resource-limited healthcare facilities. Javadpour et al.[8] Developed a wireless temperature monitoring system for neonatal body temperature measurement. The system used wireless thermometers to continuously collect temperature data and transmit it to a monitoring interface. This technology improved the accuracy of temperature monitoring and allowed care givers to observe the infant's condition remotely. [9] Patel and Shah proposed a neonatal warmer integrated with safety alarms and temperature monitoring features. The system included sensors, a heating module, and an alarm mechanism to alert caregivers when the infant's temperature exceeded the safe limit. The study emphasized the importance of safety mechanisms in modern infant warming devices. Uwamariyaetal. [10] Investigated the performance of a non-electric infant warmer used in Rwandan health centers. The study reported that the device effectively maintained the body temperature of newborn babies and helped reduce the incidence of neonatal hypothermia in low-resource health care environments. [11]Mugisha and colleagues proposed a vision based embedded system for non-contact monitoring of preterm infant behavior. The system used imaging techniques and embedded processing to monitor infant activity and detect abnormal conditions. Such smart monitoring technologies can be integrated with infant warming systems to enhance neonatal healthcare.

III. PROPOSED SYSTEM

The Portable Smart Infant Warmer is designed to provide a safe and stable thermal environment for newborns, particularly premature and low-birth-weight infants. Unlike conventional incubators, this system is compact, portable, and suitable for use in hospitals, ambulances, and rural health care centers. It integrates temperature sensors, a microcontroller, and a low-power heating element to maintain the infant's body temperature within the optimal range automatically. Additional features like alarms, display units, and IoT connectivity enhance safety and allow continuous monitoring, ensuring effective neonatal care even in low-resource settings.

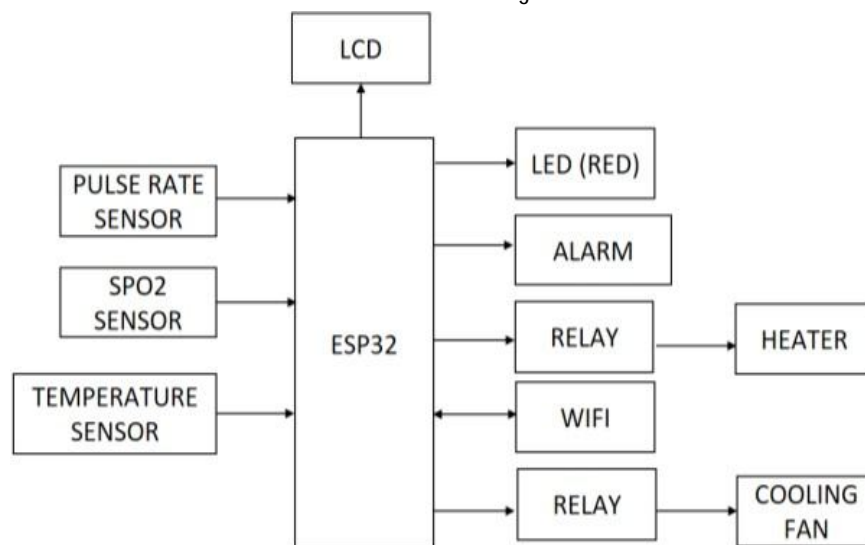


Fig 3.1. Block Diagram of Proposed System.

Working Principle

The working principle of the Portable Infant Warmer is based on continuous temperature monitoring and automatic heat regulation to maintain a safe thermal environment for newborns. Temperature sensors such as DS18B20 are placed near the infant or within the warming surface to measure body or ambient temperature. These sensors convert temperature into electrical signals, which are processed by a microcontroller.

The microcontroller filters the data to remove noise and compares the measured temperature with a preset safe range. If the temperature falls below the required level, the microcontroller activates a low-power heating element such as a ceramic or PTC heater to provide the necessary warmth. The heating intensity is adjusted automatically based on real-time temperature readings. The system works as a closed-loop feedback mechanism where the sensor continuously sends temperature data to the controller, ensuring stable and uniform heating. In addition, the device includes an alarm system that alerts caregivers through LEDs or buzzers if the temperature goes beyond safe limits. The system operates on a 12 V DC power supply with optional battery backup for portability and emergency use. Safety features such as over heat protection and automatic shut-off are also included to ensure reliable and safe operation for neonatal care.

Key features

The Portable Infant Warmer is designed with several important features to ensure safe and effective temperature maintenance for newborn infants. The system provides automatic temperature regulation, maintaining the infant's body temperature within the optimal range of 36–37°C. It uses medical-grade temperature sensors such as DS18B20, for continuous temperature monitoring. A microcontroller-based control unit processes the sensor data and regulates the heating element to maintain stable warmth. The device uses a low-power ceramic or PTC heater that distributes heat evenly across the infant's bed. The warmer also includes an LCD or LED display to show real-time temperature readings and system status. An alarm system with visual and audio indicators alerts caregivers if the temperature goes beyond the safe limits. The device is compact, light weight, and portable, making it suitable for use in ambulances, rural healthcare centers, and home environments. It operates on a 12V DC power supply with battery backup, ensuring continuous operation during power failures or transport. Additionally, the system incorporates safety features such as overheat protection and automatic shut-off to ensure reliable operation. The device is energy-efficient and user-friendly, allowing caregivers to operate it easily. Features such as uniform heat distribution, adjustable temperature settings, and real-time feedback control help maintain a stable and safe thermal environment for neonatal care.

Advantages

The Portable Smart Infant Warmer offers several advantages in providing effective thermal care for newborn infants, especially premature and low-birth-weight babies. One of the main advantages of the proposed system is its ability to maintain the infant's body temperature within the safe range, thereby preventing hypothermia and related health complications. Unlike conventional incubators, the device is compact, lightweight, and portable, which makes it suitable for use in ambulances, rural healthcare centers, and emergency situations. The system uses temperature sensors and a microcontroller to automatically regulate the heating element based on real-time temperature readings, reducing the need for continuous manual supervision. It is also energy-efficient and can operate using low power with battery backup, ensuring uninterrupted operation even during power failures. Additionally, the device includes safety features such as alarm systems that alert caregivers if the temperature goes beyond the safe limit. The simple design and user-friendly interface make it easy for healthcare workers to operate, while optional IoT connectivity allows remote monitoring of the infant's temperature. Overall, the proposed system provides a cost-effective, reliable, and efficient solution for improving neonatal care in both hospitals and resource-limited environments.

IV. HARDWARE COMPONENTS

The hardware components used in the Portable Infant Warmer work together to monitor the infant's condition and maintain a safe temperature. The ESP32 microcontroller acts as the main control unit, processing data from the sensors and controlling the heater, display, and alarm system. The temperature sensor measures the infant's body or surrounding temperature and sends the data to the microcontroller for monitoring and regulation. The heating element provides the required warmth, and it is controlled through a relay module, which switches the heater on or off based on temperature readings. The LCD display shows real-time temperature and system information, while the alarm module alerts caregivers if the temperature exceeds the safe range. The system is powered by a 12V battery and power supply, allowing portable and continuous operation. Connecting wires and a PCB are used to integrate all the components properly. Additionally, the SpO₂ sensor measures blood oxygen levels and the heart rate sensor monitors the infant's pulse, helping track important vital signs.

V. SOFTWARE REQUIREMENTS

Programming Language-Embedded C Arduino IDE

The Arduino IDE is used to write and upload programs to the Arduino Uno microcontroller.

Functions Performed:

Reads data received from the Bluetooth module. Processes ON/OFF commands. Controls relay modules through GPIO pins. Displays appliance status (if LCD is used). Handles serial communication via UART.

Mobile Application/Blynk IoT

In the Portable Smart Infant Warmer, a mobile application enables remote monitoring of the infant's temperature and system status. The system uses Blynk IoT, which allows the ESP32 to communicate with a smart phone via Wi-Fi. Real-time sensor data, including temperature readings, is transmitted to the Blynk cloud server and displayed on the mobile app using widgets like gauges, graphs, and notifications. Caregivers can monitor the temperature, system status, and receive instant alerts if the temperature goes outside the safe range.

Blynk also allows easy dashboard creation and visualization of temperature trends over time.

Communication Protocol-Wi-Fi

The ESP32 communicates with the Blynk mobile application over Wi-Fi using the MQTT protocol, a lightweight publish-subscribe messaging system for IoT devices. The temperature sensors send data to the ESP32, which processes and publishes it to the Blynk cloud. The mobile app subscribes to this data and displays it in real time.

This setup ensures fast, reliable, and low-power data transmission, making it suitable for real-time monitoring in neonatal care devices.

VI. RESULT AND DISCUSSION

The Portable Smart Infant Warmer successfully achieved its objective of providing controlled and safe thermal care for newborns, especially premature or low-birth-weight infants. During testing, the system maintained the infant's body temperature within the safe range of 36.5°C to 37.5°C, demonstrating the effectiveness of the ceramic heater and temperature control algorithm. The ESP32 microcontroller efficiently processed sensor data and regulated the heater output, ensuring stable and continuous warming. The integration of the SpO₂ and heart rate sensors allowed simultaneous monitoring of the infant's oxygen saturation and pulse rate. The readings were accurately displayed on the LCD and transmitted to the Blynk IoT mobile application for remote monitoring. The alarm module successfully notified care givers when ever any parameter exceeded or fell below the preset safe limits, confirming the safety features of the system.



Figure 6.1 Hardware



Figure 6.2 IoT Dashboard

VII. CONCLUSION

The Portable Smart Infant Warmer is a reliable, cost-effective, and user-friendly solution for providing safe thermal care to newborns, especially premature or low-birth-weight infants. By integrating a ceramic heater, temperature and heart rate sensors, SpO₂ monitoring, and an alarm system with the ESP32 microcontroller, the device maintains a stable and controlled thermal environment while continuously monitoring vital parameters. The IoT-based remote monitoring through the Blynk mobile application adds convenience and safety, allowing care givers to track temperature, heart rate, and oxygen levels in real time. The system's 12V adapter and rechargeable battery ensure uninterrupted operation, making it suitable for hospitals, ambulances, and low-resource settings. Overall, this project demonstrates that the Portable Smart Infant Warmer can significantly enhance neonatal care by providing automatic temperature regulation, real-time monitoring, and timely alerts, reducing the risk of hypothermia or overheating, and improving the survival and health of newborns.

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