



IoT-Based Blanket Warmer with Emergency Features (Alarm and Auto-Shutdown) and Android Display Integration

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ABSTRACT

Hypothermia is a medical condition in which the body's temperature regulation mechanism struggles to maintain normal temperature under cold exposure, characterized by a core body temperature below 35°C. This condition disrupts the function of the nervous system and other vital organs, potentially leading to severe complications such as cardiac and respiratory failure or even death if untreated. Leveraging advancements in technology, this study presents the development of a blanket warmer equipped with emergency features such as an alarm and auto-shutdown, along with an Android-based monitoring system. The device is designed to assist nurses or users by displaying real-time body temperature and providing alerts during overheating incidents via a buzzer and Android notifications, enabling immediate intervention to turn off the device. The blanket warmer employs a DS18B20 temperature sensor to measure the heated air from a dry heater and a skin sensor connected to an Arduino microcontroller for monitoring and controlling patient body temperature and heat energy distribution. The device integrates with Android using the Blynk application for user-friendly operation. Testing results indicate that the tool achieves a body temperature reading accuracy of 99.64% and a blanket temperature accuracy of 99.22%.

KEYWORD Blanket Warmer, temperature, DS18B20 sensor, Heater, Blynk, Android

I. INTRODUCTION

Hypothermia is a condition in which the body's mechanisms for the temperature regulation system have difficulty coping with cold temperature pressure. Hypothermia can also be defined as the temperature inside the body below 35 °C [1]. When the body temperature drops, the nervous system, and other organs cannot work normally. If left untreated, hypothermia can lead to heart and respiratory failure and even death.

To prevent and treat hypothermia, one common method is the application of a blanket warmer, a device designed to restore the body temperature to a normal range of 36–37°C [1]. The use of blanket warmers allows medical professionals to monitor and regulate the patient's body temperature effectively, reducing the risk of complications associated with hypothermia. A blanket warmer is typically an air-compressed blanket engineered to provide consistent warmth during hypothermic conditions [2].

A blanket warmer is a special air-compressed blanket designed to provide warmth when experiencing

hypothermia.[3]. Along with the development of the times, technological advances and security are inevitable to facilitate human work. The device or work industry is one of the technological sectors whose advancement supports human activities. The application of the device can be used to control or see all activities carried out by humans. One of the additional devices used by people today is Android devices. On this Android device, it can be controlled and monitor activities needed by humans with a connection that has been determined by the user.

Technological advancements have increasingly supported the development of medical devices, enhancing their functionality and safety. In particular, the integration of Internet of Things (IoT) technology and Android devices has revolutionized medical monitoring and control systems. Android devices enable users to monitor and manage various activities, including medical interventions, through seamless connectivity. This technological support simplifies processes for medical professionals, improving patient safety and device usability.

The existence of technology support through Android devices is expected to make it easier for nurses/users to

maintain safety in the patient's devices and body temperature. So that the patient's body temperature when recovering can be easily controlled.

Amrul Hanifah, in 2020 made a *blanket warmer* with *monitoring* to make it easier for users to monitor body temperature in patients[1]. However, in this study, the author will improve security by adding an overheating alarm to the device, a notification on the nurse's headphones developed in an Android-based application, and can also turn off the device remotely. The author observed that in the study no one has used *the emergency* feature (Alarm and Stop) and the display on Android based on the Internet of Things (IoT).

II. RESEARCH METHODS

A. RESEARCH DESIGN

The blanket warmer is a specially designed device that provides controlled warmth to patients experiencing hypothermia [7]. Hypothermia is a medical condition where the core body temperature drops below 35°C due to prolonged exposure to cold environments, impairing the nervous system and vital organ functions, which can potentially lead to severe complications or even death.

This study focuses on the development of an IoT-based blanket warmer equipped with emergency features, including an alarm and auto-shutdown, as well as a real-time monitoring display via an Android application. The device integrates multiple sensors and components to ensure accuracy and safety in temperature regulation.

The research design involves the following stages:

1. **System Development:** The device is developed using an Arduino Uno microcontroller as the core, integrating temperature sensors (DS18B20) to measure the heated air and a skin sensor for monitoring the patient's body temperature.
2. **Emergency Features:** The system includes a buzzer and auto-shutdown mechanism to provide immediate alerts and control during overheating conditions.
3. **IoT Integration:** The ESP32 Wi-Fi module is used to connect the device to the Blynk application on Android for remote monitoring and control.
4. **Power Supply:** The device utilizes both AC and DC power supplies to ensure the stable operation of components like the solid-state relay, blower, and heater.

The research aims to evaluate the accuracy and reliability of the blanket warmer in maintaining safe and consistent temperatures, with a focus on usability for medical practitioners. Testing and measurements include evaluating the accuracy of temperature regulation, skin sensor readings, and the functionality of the emergency features and IoT-based Android display.

B. CONCEPTUAL FRAMEWORK

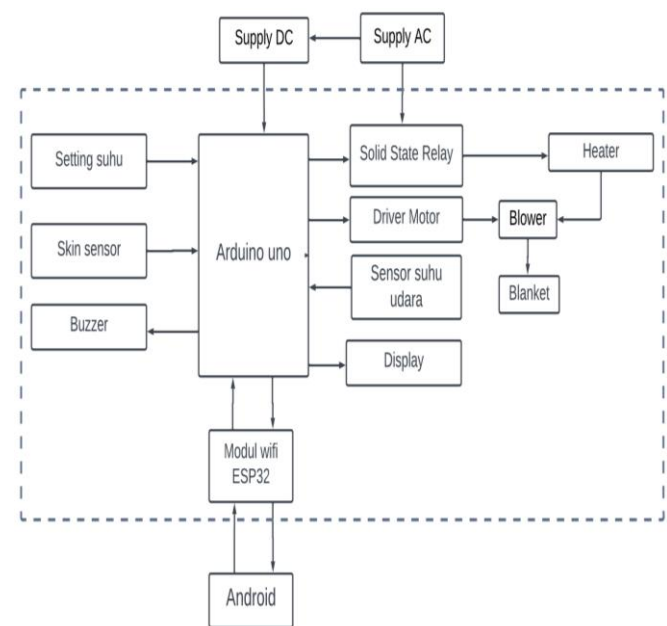


FIGURE 1. Conceptual Framework. The diagram block of the IoT-based Blanket Warmer system illustrates the main components and their connections. The system integrates an Arduino Uno microcontroller, skin and air temperature sensors, solid-state relay, heater, blower, display, and buzzer for emergency features. The device is connected to an Android application via the ESP32 Wi-Fi module for monitoring and control, powered by both AC and DC supplies.

From Fig, 1 the stage can be explained as follows:

1. **Arduino Uno**, serves as the main control block that regulates the work of the tool to match the set one. This block is the brain of the tool's performance so that it can work properly.
2. The **ESP32 module**, functions as a link between the device and the Android device via a wifi network.
3. **Android devices**, such as smartphones *for monitoring* the body temperature of surgical patients so that it makes it easier *for users* to monitor the patient's body temperature.
4. **Power Supply**, as a voltage source block for components in the tool. This voltage source will support the performance of the appliance during use.
5. **Temperature setting**, to set *the* temperature value required by the patient. The values of the settings are 35 °C, 38 °C, and 41 °C.
6. **Temperature sensor**, the sensor used is a DS18DB20 sensor. This sensor will read the captured temperature and then turn it into a digital number which is then displayed on the *display*.
7. **Heater**, this heating element is a heat-producing component needed by *the blanket*.
8. **Buzzer**, is an alarm component that will be a marker in the event of a low body temperature or high body temperature.
9. **Relay driver**, to regulate the power used by the *heater* so that *the setting* temperature can be reached.

10. *A blower/fan*, is a fan that works to circulate hot air from the appliance to the *blanket*.

C. DATA COLLECTION TECHNIQUES AND RESEARCH INSTRUMENT

After the blanket warmer was designed according to the specifications, the next process involved testing to validate its functionality and accuracy. The testing aimed to ensure that the deviation in temperature measurements did not exceed $\pm 1^\circ\text{C}$, ensuring the tool's reliability and compliance with performance standards. The data collection process included the following steps:

1. Temperature Testing on Blankets

Temperature measurements were taken using a digital thermometer to validate the blanket's ability to maintain consistent heat distribution.

2. Readability Testing on Android

Testing was conducted to evaluate the accuracy and responsiveness of the temperature readings displayed on the Android application connected to the device.

Data Collection Procedure:

- Temperature readings were taken every 15 minutes using a digital thermometer, with a total of six measurements for each temperature setting.
- Simultaneously, temperature readings were monitored and recorded from the Android application.
- A 15-minute pause was implemented between measurements to allow the blanket to return to a stable temperature, ensuring accurate readings.

This iterative process ensured that the system's accuracy, stability, and real-time monitoring capabilities were thoroughly evaluated under controlled conditions.

Research Instruments:

To conduct the testing and data analysis, the following tools were utilized:

1. Toolset: Used for assembling, calibrating, and maintaining the blanket warmer system during testing.
2. Digital Thermometer: A precision instrument used for measuring the blanket's temperature and validating the system's accuracy against the Android application readings.

To further enhance the validity of the results, the blanket warmer was tested under various temperature settings and environmental conditions. This included simulating potential scenarios where the device may be used in clinical settings. The use of a reliable digital thermometer and systematic intervals ensured consistent data collection, while the Android application's integration with the device enabled seamless monitoring and control.

These methods and instruments provided a robust framework for evaluating the blanket warmer's performance, ensuring that it meets the desired standards for safety and effectiveness in treating hypothermia.

D. DATA ANALYSIS TECHNIQUES AND METHODS OF DATA PRESENTATION

Data Analysis Technique

The data collected from the testing process were analyzed using statistical formulas to evaluate the tool's accuracy,

error, and performance consistency. The following techniques were used:

1. Average Value

The average value was calculated to determine the central tendency of the measurement data:

$$\bar{x} = \frac{1}{n} \sum_{i=1}^n x_i \tag{1}$$

Where,

\bar{x} = average value of the measurement

x_i = random value of ,.....,i measurement data x_1, x_2

n = amount of data retrieved

2. Error Value

The error value was calculated to assess the deviation between the measured average and the standard value or setpoint:

$$\text{Error} = - \text{uut } x \tag{2}$$

Where,

x = average value of the measurement

Uut = standard value/setting value

3. Error Percentage value

The percentage error was calculated to evaluate the relative deviation between the measured values and the setpoint:

$$\% \text{Error} = x \ 100\% \tag{3}$$

Where,

Error = error

Setting = Regulated value

4. Accuracy percentage value

The percentage accuracy was calculated to determine how closely the tool's measurements aligned with the standard value:

$$\% \text{Accuracy} = 100\% - \% \text{Error} \tag{4}$$

The analyzed data were presented using tables and graphs to facilitate a clear and comprehensive understanding of the results. The key aspects of the data presentation include:

1. Tabular Data

- Average values, error values, error percentages, and accuracy percentages were compiled into tables for easy comparison across different temperature settings and testing scenarios.

2. Graphical Representation

- Line charts were used to display the trends in temperature stability over time.

- Bar graphs were employed to compare accuracy and error percentages across different settings.

3. Descriptive Summary

- A concise summary of the findings was provided, highlighting the tool's overall performance, reliability, and consistency.

- The error analysis was conducted for both the blanket temperature and the Android application's readings to ensure the system's comprehensive evaluation.
 - The graphical presentation of the results aimed to emphasize the relationship between temperature stability and the functionality of the IoT-based features, such as real-time monitoring and emergency notifications.

III. RESULT AND DISCUSSION

In this section, the results of the measurements taken from the blanket warmer tool are presented to determine whether the tool meets the specifications and expectations. The data obtained have been processed and analyzed to ensure accuracy and stability. The analysis focuses on the blanket temperature measurements and skin sensor readings under different temperature settings. These results are crucial in evaluating the performance and reliability of the device.

1. Blanket Temperature Measurement Data on the Tool Display

This section presents the measurement data of the blanket temperature taken from the tool's display. The measurements were conducted at three different temperature settings: 35°C, 38°C, and 41°C. Each temperature setting was measured six times at 15-minute intervals to evaluate the tool's accuracy and stability.

TABLE 1. BLANKET TEMPERATURE MEASUREMENT DATA

No	Setting °C	Measurement °C					
		1	2	3	4	5	6
1	35	34,5	35,1	34,9	35,4	34,7	34,9
2	38	37,5	38,2	38,2	38,2	37,2	38,0
3	41	40,6	40,8	40,6	41,1	40,8	41,1

The data from Table 1, indicate that the blanket warmer maintained temperatures close to the setpoints with minimal deviations, demonstrating stable performance. The average temperature measurements for each setting were calculated, and the error percentage was within acceptable limits.

2. Skin Sensor Measurement Data

This section presents the measurement data from the skin sensor used to monitor the patient's body temperature. The measurements on Table 2 were taken at multiple temperature settings, with six readings for each setting.

TABLE 2. SKIN SENSOR MEASUREMENT DATA FOR 38°C SETTING

No	Setting °C	Measurement °C					
		1	2	3	4	5	6
1	38 °C	37,8	38,3	37,4	37,8	37,8	38,1

TABLE 3. SKIN SENSOR MEASUREMENT DATA ACROSS ALL SETTINGS

No	Setting °C	Measurement °C					
		1	2	3	4	5	6
1	35	35	35,6	35	35,1	35,6	35,5
2	38	38	38,3	38,6	38	37,9	38
3	41	40,9	40,8	40,9	41	41,6	41,6

Table 3 show the the skin sensor readings show consistency across multiple measurements, with deviations remaining minimal. These results indicate that the skin sensor accurately monitors body temperature and aligns closely with the temperature settings.

IV. CONCLUSION

The IoT-based Blanket Warmer equipped with emergency features (alarm and auto-shutdown) and an Android display has been successfully designed and developed according to the planned specifications. Testing and measurements demonstrate that the blanket warmer operates effectively, with temperature regulation achieving an accuracy of 99.22%, the skin sensor showing an accuracy of 99.64%, and the temperature readings on the Android application reaching 99.5% accuracy. Additionally, the emergency features, including the alarm and auto-shutdown, function reliably, providing effective alerts and automatic responses during overheating conditions. These results indicate that the device is well-suited for enhancing patient safety and comfort in medical applications.

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