Solar-Powered Infant Incubator for Rural and Emergency Use

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SDGs

Abstract

This project presents a low-cost, solar-powered infant incubator designed for rural and off-grid areas. Using an Arduino Nano and a 7.4V Lithium battery system, the device maintains a stable temperature of 37C to prevent neonatal hypothermia. The system includes gas and motion sensors for enhanced safety and a Bluetooth module for remote monitoring. Results show that the prototype is reliable, portable, and provides a life-saving solution for clinics with unstable electricity.

Methods & Design

The methodology of this project is based on a structured engineering design process aimed at creating a reliable, standalone medical micro-environment for neonates in off-grid areas. The development phase began with the selection of the Arduino Nano as the central processing unit, chosen for its efficiency in managing multiple sensors and actuators simultaneously. A key technical feature of the design is the power management system, which utilizes a solar panel to harvest energy and store it in a 7.4V Lithium-ion battery bank consisting of two 3.7V cells. This power source is regulated by a BMS (Battery Management System) to ensure safety and is specifically used to drive a heater and a circulation fan via a relay module to maintain a stable 37°C internal temperature.

For comprehensive environmental monitoring, the prototype integrates a DHT11 sensor for thermodynamic tracking, a gas sensor for air quality assessment, and a PIR sensor for motion detection. The system provides a sophisticated user interface through a 20x4 LCD screen that acts as a real-time data dashboard. To enhance user control, two manual buttons are included to toggle the buzzer alarm and the PIR motion system independently during maintenance or feeding. Finally, the integration of an HC-06 Bluetooth module ensures that all collected parameters are transmitted wirelessly to a mobile application, providing a modern, secure, and autonomous solution for neonatal care in low-resource and emergency settings.

Results

The experimental tests confirmed that the incubator maintains a steady temperature of 37C with a small error margin of -+ 0.5 C. The LCD successfully displayed real-time alerts such as 'Air is Cold' and 'Humidity is Dry' when environmental changes occurred. Furthermore, the HC-06 Bluetooth module transmitted all sensor data to the mobile application without lag, and the BMS protected the batteries during the solar charging process.

Discussion

The results prove that solar energy is a dependable power source for neonatal care in remote regions. The integration of gas and PIR sensors provides a higher level of safety compared to traditional incubators. This 'frugal innovation' approach shows that using affordable components like Arduino can produce medical-grade results, making life-saving technology accessible and portable for emergency use.

References

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