EEE 4700 (Project and Thesis)

SMART INFANT/BABY INCUBATOR

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Smart Infant/Baby Incubator

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List of Acronyms

NICU	Neonatal Intensive Care Unit
SPO2	Peripheral Oxygen Saturation
ECG	Electrocardiogram
LCD	Liquid Crystal Display
LED	Light Emitting Diode
IoT	Internet of Things

Chapter 1

Introduction

Premature babies are those born before the gestational age of 37 weeks. To alleviate adaptation, preterm babies need to be placed in an environment that resembles the uterus, where the babies can adjust to the conditions outside the womb. Mammals benefit from homeothermy, which maintains the internal temperature constant regardless of what occurs in the external environment. The fundamental structures and the enzymatic activities of premature infants do not proceed through the entire process and thus require meticulous measures of treatment on the part of their immediate environments, i.e., temperature, humidity, light, and even oxygen.

The baby had suffered numerous problems with the regulation of body temperature. The surface area of a toddler is high and has low thermal inertia and weak heat retention powers. The small body size and immobility of newborns do not permit grip onto heat by postural or situational adoptions, or the regulation of the temperature changes which follow thermal needs.

1.1 Basic Functionalities of Smart Infant/Baby Incubator

The device is a protective vessel that has inflexible walls that offer space where an affixed neonate can be placed in a controlled setting where the targeted therapies can be offered. Temperature, relative humidity, and oxygen are kept constant in the treatment by an infant incubator. The incubator must also ensure that the air temperature is 37 °C when doing the treatment. The required relative humidity will depend on the days that the neonate will be in the incubator.

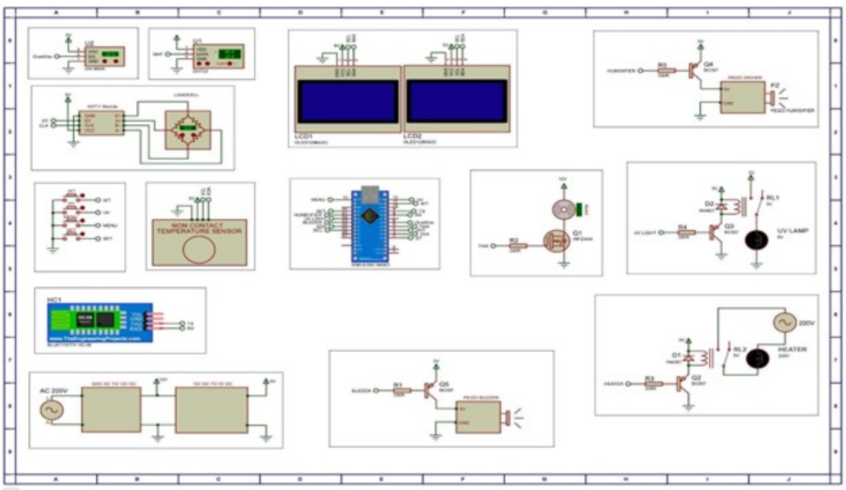

Figure 1.1: Circuit Diagram

1.2 Different Aspects of Infant/Baby Incubator

1.2.1 Monitoring and Regulation

Incorporating sensors into incubators helps medical care professionals to get instant alerts on significant variations in heart rate, breath, and other vital signs. A steady temperature (usually 34-37 °C) and correct humidity are extremely crucial to the survival of the newborns, particularly those with a higher risk.

1.2.2 Technological Integration

Available incubators tend to use the power of IoT to streamline real-time data and notification systems so that they can take additional steps. Projects smart incubators are attempts to deliver these necessary items to communities that require them, and which are scarce, especially in developing countries. To be able to take swift action when required, many modern incubators utilize IoT technology to provide instant data and notifications. Creative innovation has also been done, like the use of smart incubators to attempt to make sure that the necessary lifesaving apparatus is accessible in the constrained resource circumstances (primarily in the developing world).

1.2.3 Safety and Efficiency

The design currently in use is automated, measuring length and weight; thus, the precision and efficiency of patient monitoring are enhanced. humidity Current state-of-the-art control systems aim at the reduction of control errors in temperature and a safe environment for newborns, who are very vulnerable.

1.3 Background and Motivation

The dissertation proposes a design of a cheap incubator, which will be designed to be significantly lower in cost than the commercial designs. Automation by a microcontroller guarantees proper and smart functioning. Digital monitoring is a real-time indicator of temperature and humidity levels. The temperature controller mechanism of the device is automated, and it ensures that it is always warm without the requirement of any manual adjustments. The cooling is turned on via the fan to prevent overheating. The moisture level inside the system is controlled by means that keep the moisture at the same level. Safety alarm system- activated in case of extreme high temperature or humidity. Theoretically, it can expand the IoT, further integration with Wi-Fi/Bluetooth to allow remote monitoring. In the case of a power failure, one of the backup batteries supports an uninterrupted functioning. The design integrates health care technology and embedded system learning ingredients to satisfy the real-life, as well as the learning needs

Chapter 2

Overview of Smart Infant/Baby Incubator

Baby incubators were invented by doctors in the 19th century to ensure that sick premature babies maintain a germ-free environment. Cone, 1981 achieved this. The capability of the backbone technology to track and control gas levels, humidity, and temperature in the atmosphere led to new developments. Medical field innovations involve using cheap incubators based on the Arduino system to check up on the environment, therefore making it possible to use them in developing countries. Even the high-end incubator models currently on the market are fitted with music that replicates the sound of the mother's heartbeat, a feature that not only accelerates infant growth but also helps alleviate the stress of the infant. The incubators used today are automated to control temperature and humidity, which is most effective in the case of medical care for newborns. The functionality of oxygen input devices cannot be disputed since the control of oxygen demand is a prerequisite to the growth of healthy infants.

2.1 Introduction

The ideal shape of an incubator enclosure isolates any external forces that enter it and forms an ideal airtight atmosphere. Keeping a certain thickness of plexiglass cloth, these partitions contain a lot of other items. Ventilation holes are used to regulate the air and humidity, thereby keeping the interior space contained. This incubator is designed in a way that guarantees it a constant temperature, and its internal structure is renovated to guarantee its temperature maintenance. When handling infants, personal protective gear that is modified to suit this purpose is applied.

2.2 Network Architecture

2.2.1 Incubator Design and Core Components

I. Incubator Enclosure

Features hand gloves for safe handling of babies, air renewal vents, and airtight plexiglass panes to regulate humidity and temperature.

II. Light and Humidifier

In order to keep infants comfortable and safe, the system's humidifier uses moisture to avoid dehydration, and adjustable lights are employed for phototherapy for jaundice.

III. Power Supply and Buck Converter

Voltage is accepted using a buck converter and a 12V stable supply, and heating parts are regulated using PWM to ensure precise temperature control.

Figure 2.1: Incubator

2.2.2 Sensory and Monitoring

III. Temperature and Humidity Sensor

This is a reliable digital indication of temperature and humidity and, therefore, indispensable for monitoring incubator environments.

Pulse Monitor

The heart rate sensor works by using a photodiode and an IR sensor to read the pulse of the infant, which is then displayed on an Arduino serial plotter to monitor the pulse in real-time. comfort.

IV. Piezoelectric Buzzer

If the temperature rises above 37°C, the caregiver will be alerted to the risk of overheating.

2.2.3 Control and Communication Systems

V. Bluetooth Communication

The HCO5-Bluetooth Module enables wireless data transfer over distances up to 10 meters with a speed of 3 Mbps for wireless tracking of mobile devices.

Figure 2.2: Sensory and Monitoring

VI. Microcontroller & Relay Module

The AT mega microcontroller analyzes sensor data and controls physical responses. Relay modules are employed to turn on and turn off the fans and other components of the activities by regulating the activities of the incubator.

VII. Push Button Control

Push buttons allow manual control for power parameter adjustments, mode selection, alarm silencing, and enhanced user interactions.

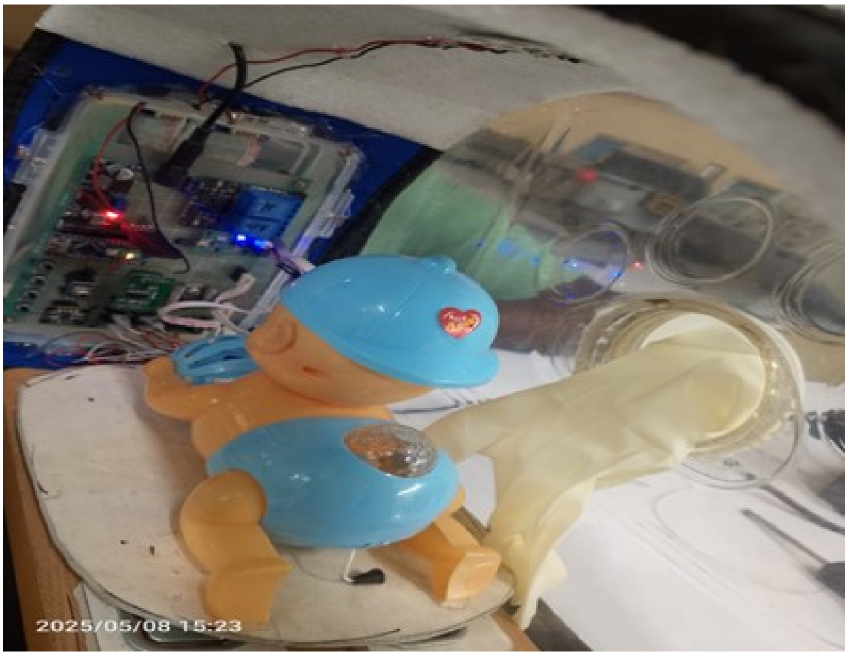

Figure 2.3: Control and Communication Systems

2.2.4 Display and Software Development

VIII. Display Devices

Data that is shown on a 16*2 LCD screen and sent to a mobile application created with MIT App Inventor allows for real-time monitoring.

IX. Arduino IDE Programming

The Arduino IDE is used as a means for programming and sending code to the microcontroller. Moreover, it contains the necessary libraries for supporting sensors, LCDs, and Bluetooth components. The system always monitors the sensor data and sends alerts when required.

X. Mobile App Features

The app displays temperature and humidity with color–code alert, connects via Bluetooth, and notifies the caregiver of abnormal conditions.

Chapter 3

Demonstration of Outcomes

The device, according to the study, is like an incubator, which monitors the environmental requirements of the newborn. Besides, the device controls the humidity and temperature of the room. The device also takes care of the heat of the baby and the humidity of the room the baby is in. It primarily uses application software in its design that takes the data of the sensors with a system of data transfer to read and deliver results but does not store data inside the program. Mobile phone usage contributes to the viewing of medical information by staff and medical personnel, and thus improves the safety of the device.

Chapter 4

Data Analysis and Results

This circuit is also equipped with a buzzer, which is installed with the system, and the temperature is fixed at a limit of 37 degrees Celsius, and once the temperature reaches that point, then the buzzer is turned ON. The whole circuit system is battery-operated. This fan is linked, and this will activate at 36 degrees Celsius. The pulse sensor on the Arduino serial plotter output corresponds to the average heart rate calculated as 70 bpm, as an average value of the heart rate that is in the normal range Kapen et al., 2019. Therefore, based on the above findings, it can be concluded that the system has been designed successfully to meet the purpose.

A buzzer is also installed in this circuit, which is implemented with the system, and the threshold in the temperature is 37 degrees Celsius, beyond which the buzzer becomes activated. The whole system of the circuit is battery-operated. The fan is attached, and it will be programmed to turn on at 36 degrees Celsius.

The deduced average heart rate is 70bpm, which falls in the normal range. Therefore, based on the results above, it can be concluded that the system is designed successfully towards the intended purpose.

Chapter 5

Discussion and Conclusion

A diverse array of requirements has been gathered and developed into a system based on information and research, leading to a cost-effective incubator model that adds extra functionalities such as wireless transmissions of readings, heartbeat monitoring, and the automatic control of temperature and humidity, which not only enhances safety but also the ease of use. It empowers physicians and nurses Veeramani et al., 2024.

Staff to monitor the vital parameters related to the incubator without any complications. These requirements distinguish the Smart Incubator model among the existing models. Its benefits are as follows:

- The components are simple to find in the market, thus they are cost-effective.
- Portable to make it more convenient, particularly during an emergency.
- Real-time and aligned tracking on the LCD and the mobile application.
- Smart, fully automatic, and easy to use.

Is adjustable based on the requirements of the climatic conditions in a specific area, and other parameters such as SpO2, ECG, and others.

To advance the system further, it can be developed by adding solar panels to replace batteries to turn the infant incubator into an eco-friendly device. The system can also include music, and this will positively impact the baby Mukromin et al., 2024.

Moreover, when a baby is warmed by hands, an incubator, or an open care system, the effect of lowering newborn mortality may be minimized. But in the developing world, existing incubators are excessively expensive, unsafe, or inefficient to do this, as argued above. The Smart infant incubator will then target such situations with the view of offering a final solution to be applied in the NICU.

Table 5.1: List of Components

SL	Item Description	Quantity (Qty)
1	Arduino Nano	1
2	2 Channel Relay Module	1
3	OLED Display	2
4	Ultra Mist Maker	1
5	Bluetooth HC-06	1
6	Temp. Sensor (N.C)	1
7	SPO2 Sensor	1
8	Weight Scale Bridge (10 Kg)	4
9	Barometric Sensor	1
10	Heartbeat Sensor	1
11	DHT22 (Temp./Humid) Sensor	1
12	DS18B20 (Body) Temp. Sensor	1
13	Heating Element (Resistive)	1
14	Ventilator Fan	1
15	Circulating Fan	1
16	U.V. Lamp	1
17	Project Enclosure	1
18	Dummy Specimen	1
19	Surgical Globe Set	2
20	Base Block (Wooden)	1
21	Prototype Boards	3
22	DC Power Adapter	1
23	Buck Converter	1
24	Hx711 Voltage Amplifier	1
25	Glue Stick	5
26	Plastic Box for Panel	1
27	Rail Headers 2.5 mm (M+F)	10
28	Wrapping Papers (2 ft)	1
29	Soldering Lead 100 gm	1
30	Membrane Keypad	1
31	Flow Valve	1
32	Wires/Jumpers	1
33	Miscellaneous (Screw, Resistor, Capacitors, Transistors, LED, Buzzer and others)	1

References

Cone, T. E. (1981). The first published report of an incubator for use in the care of the premature infant (1857). *Archives of Pediatrics & Adolescent Medicine*, *135*(7), 658. https://doi.org/10.1001/archpedi.1981.02130310062020

Kapen, P. T., Mohamadou, Y., Momo, F., Jauspin, D. K., & Anero, G. (2019). An energy efficient neonatal incubator: Mathematical modeling and prototyping. *Health and Technology*, *9*(1), 57–63. https://doi.org/10.1007/s12553-018-0253-3

Mukromin, R. I., Setiawan, F., Pradana, D. A., Hyperastuty, A. S., & Mukhammad, Y. (2024). Development of an iot-based temperature and humidity prediction system for baby incubators using solar panels. *Journal of Soft Computing Exploration*, *5*(4), 353–361. https://doi.org/10.52465/joscex.v5i4.497

Veeramani, P., Aravindaguru, I., Saranya, M., Ganesh, M., Dayanand, K., & Indhira, S. (2024). Smart incubatory system for infants monitoring using iot. *2024 3rd International Conference on Automation, Computing and Renewable Systems (ICACRS)*, 467–470. https://doi.org/10.1109/ICACRS62842.2024.10841599