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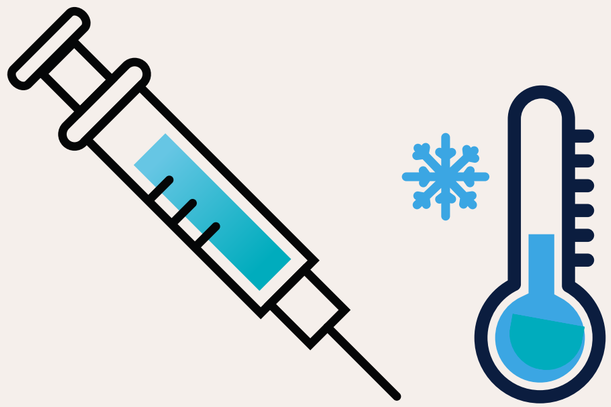

REAL-TIME VACCINE TEMPERATURE MONITORING SYSTEM

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Table of contents

1 Background & Problem

2 Need statement

3 Existing and Proposed Solution

4 Initial Concept Selection

5 Selected Components

6 System Design (Block Diagram)

7 Enclosure

8 Circuit Diagram

9 Software Logic

10 Prototype &Results

11 Budget Analysis

12 Conclusion & Future Improvements

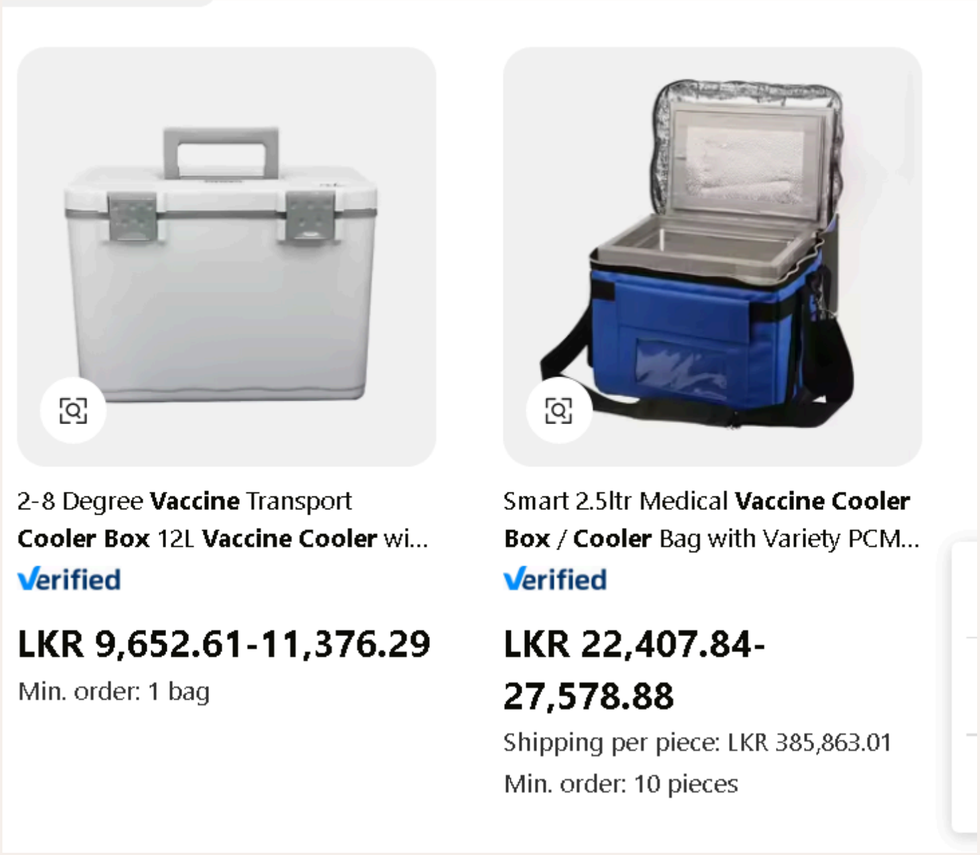
Background of the Problem

- Vaccines must be stored between 2–8°C to remain safe and effective.
- Temperature excursions during transport often go undetected, especially in rural outreach.
- Existing cold-chain solutions are either expensive, heavy, or lacking real-time monitoring.
- Our aim is to design a portable, affordable, and actively cooled vaccine box with continuous temperature monitoring.

Need Statement

A way to maintain safe temperature conditions for temperature-sensitive vaccines during transport for healthcare workers in rural and low-resource settings to improve the reliability of vaccine delivery.

Existing Solution



Limitations Across Existing Solutions

- **High cost** and **complexity** for rural healthcare setups.
- Limited real-time visibility and alarm systems.
- Often don’t integrate easily with manual ice pack replacement workflow.

Our Solution

Real-Time Vaccine Temperature Monitoring System

Intelligent Control

Automated temperature regulation for optimal preservation.

Portable Design

Compact and easy to transport for last-mile delivery.

Continuous Monitoring

Real-time data and alerts to prevent excursions.

Low-Cost Implementation

Accessible technology to support wider distribution efforts.

Features

Continuously monitors vaccine temperature in real time.

Displays current temperature and indicates safe range.

Buzzer alerts hospital staff if temperature goes outside the safe range.

Manual ice pack replacement and reset by healthcare workers ensures safe storage.

Simple, affordable, and easy-to-use for rural and low-resource settings.

Initial Concept Selection

- **Passive Insulated Carrier:**

Enhanced thermal insulation without electronics or alerts.

- **Digital Thermistor-Based Monitor:**

Simple digital sensing with manual alert capability.

- **Mobile-App-Connected Monitor:**

Temperature monitoring paired with Bluetooth/Wi-Fi communication.

- **Hybrid System (Digital + Wireless + Light Active Cooling):**

Combined sensing, wireless alerts, and optional active cooling features.

Evaluation Criteria:
Feasibility • Cost • Usability • Power Requirements • Suitability for Low-Resource Settings

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Outcome:
The hybrid digital-monitoring approach provided the strongest balance between practicality, affordability, and essential functionality for rural vaccine transport

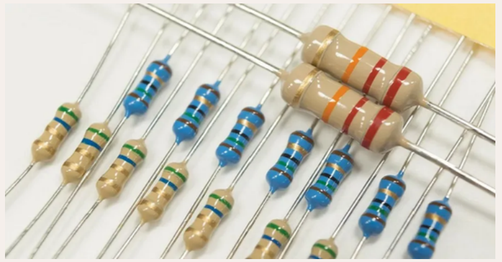
Methodology

Selected Components

DS18B20 Waterproof Digital Temperature Sensor Probe

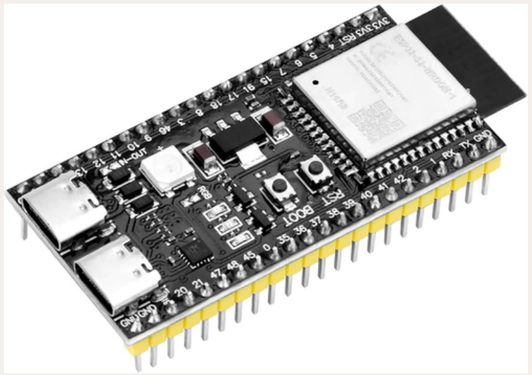
Active Buzzer

OLED Display Module



4.7K ohm and 330 ohm resistors

NodeMCU ESP8266



ESP32 S3

LED

4X4 Numeric Keypad Module

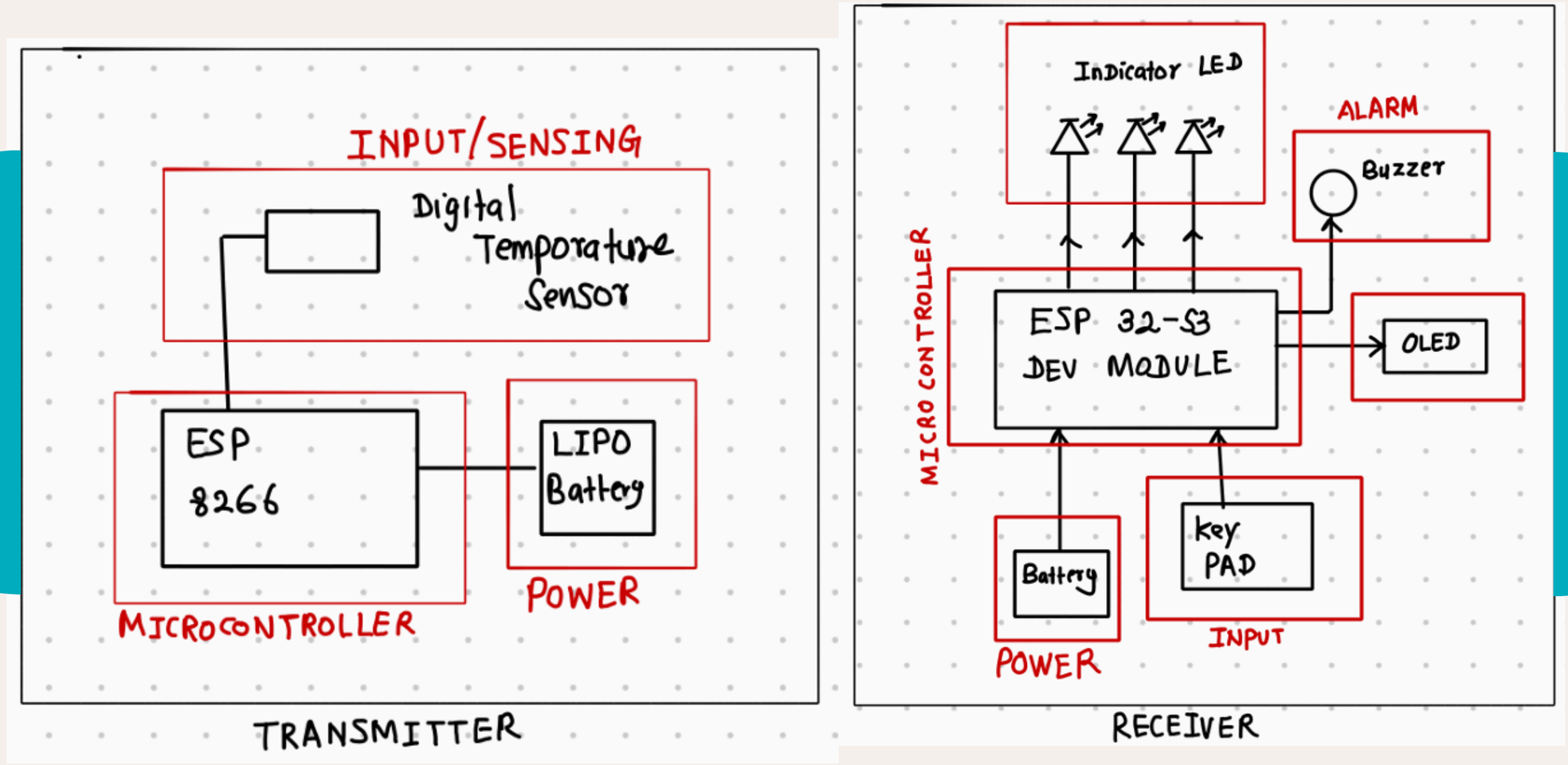
Selected Components

3.7V 500mAh Lipo Battery

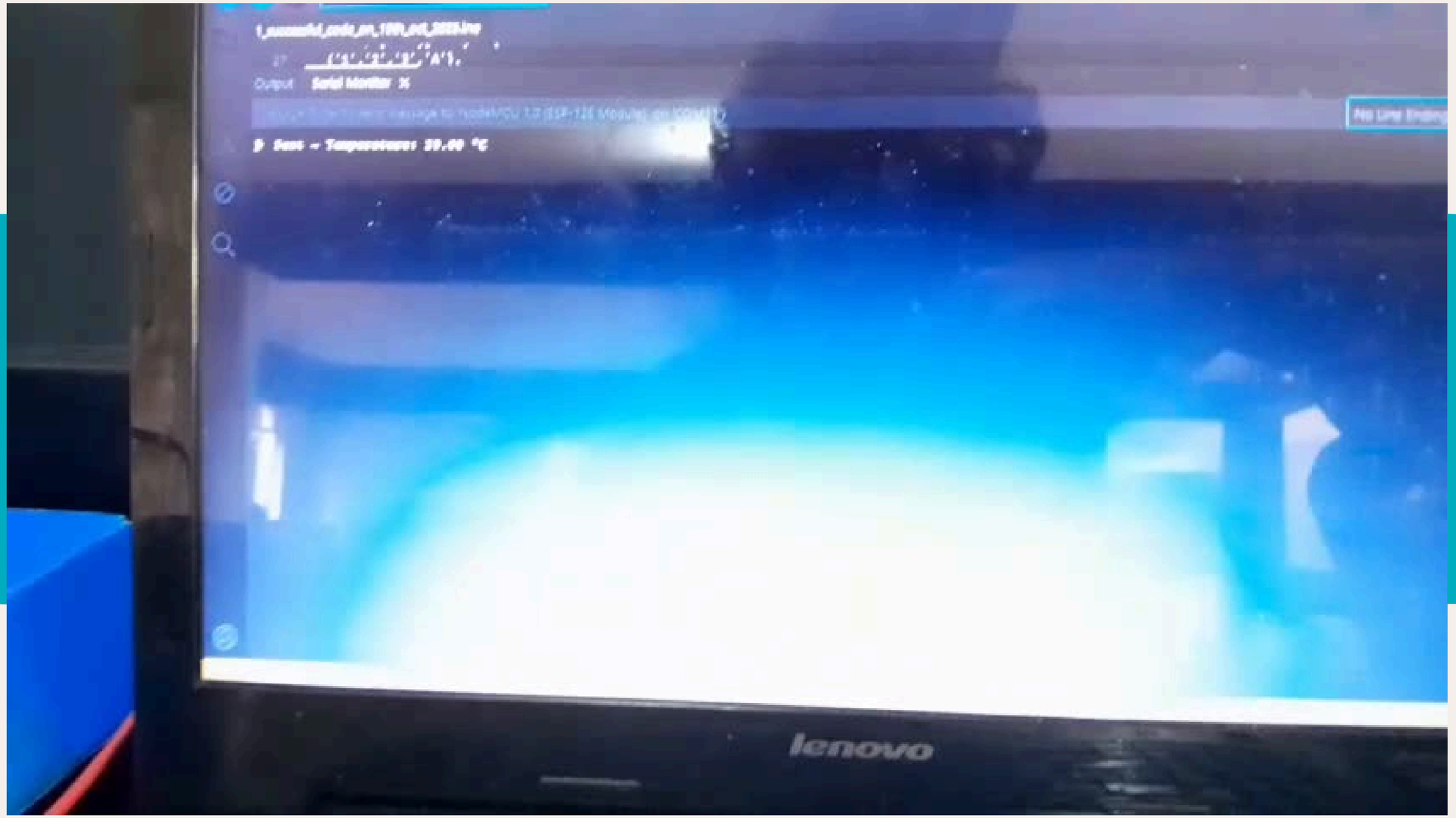
3.7V 1000mA 18650 Li-ion Rechargeable Battery

LM2596S 3-40V to 1.5-35V 4A DC to DC Adjustable Step-Down Buck Module

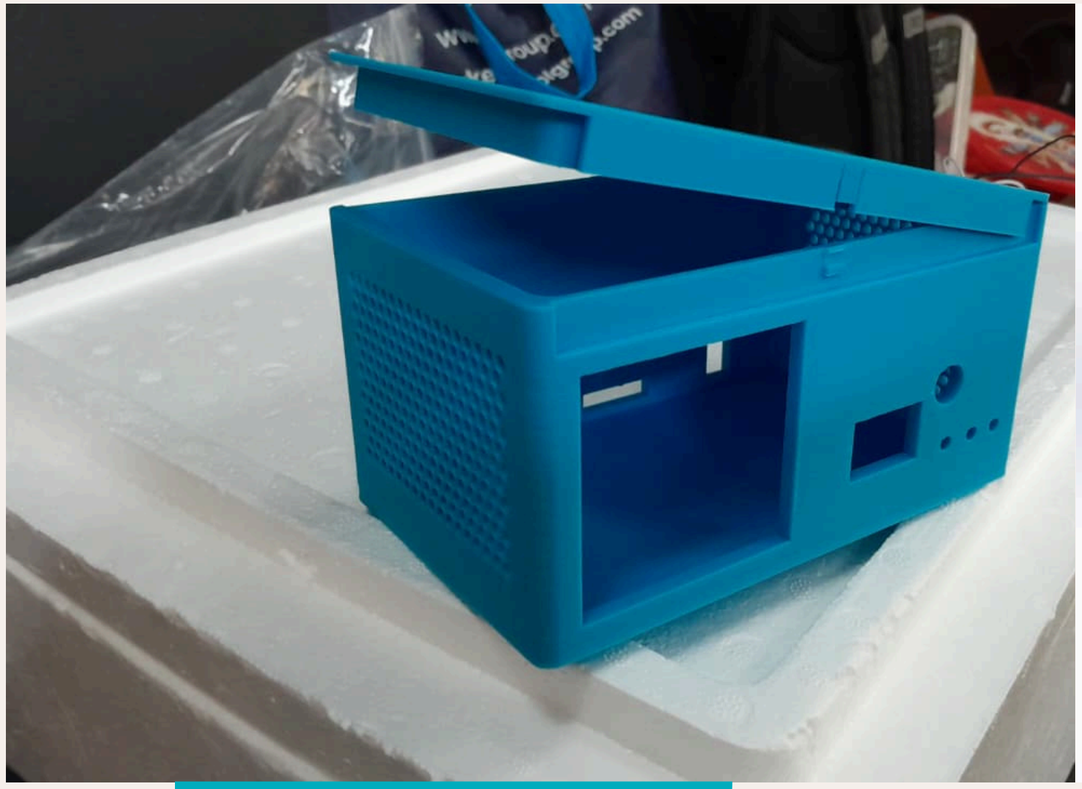
System Design (Block Diagram)

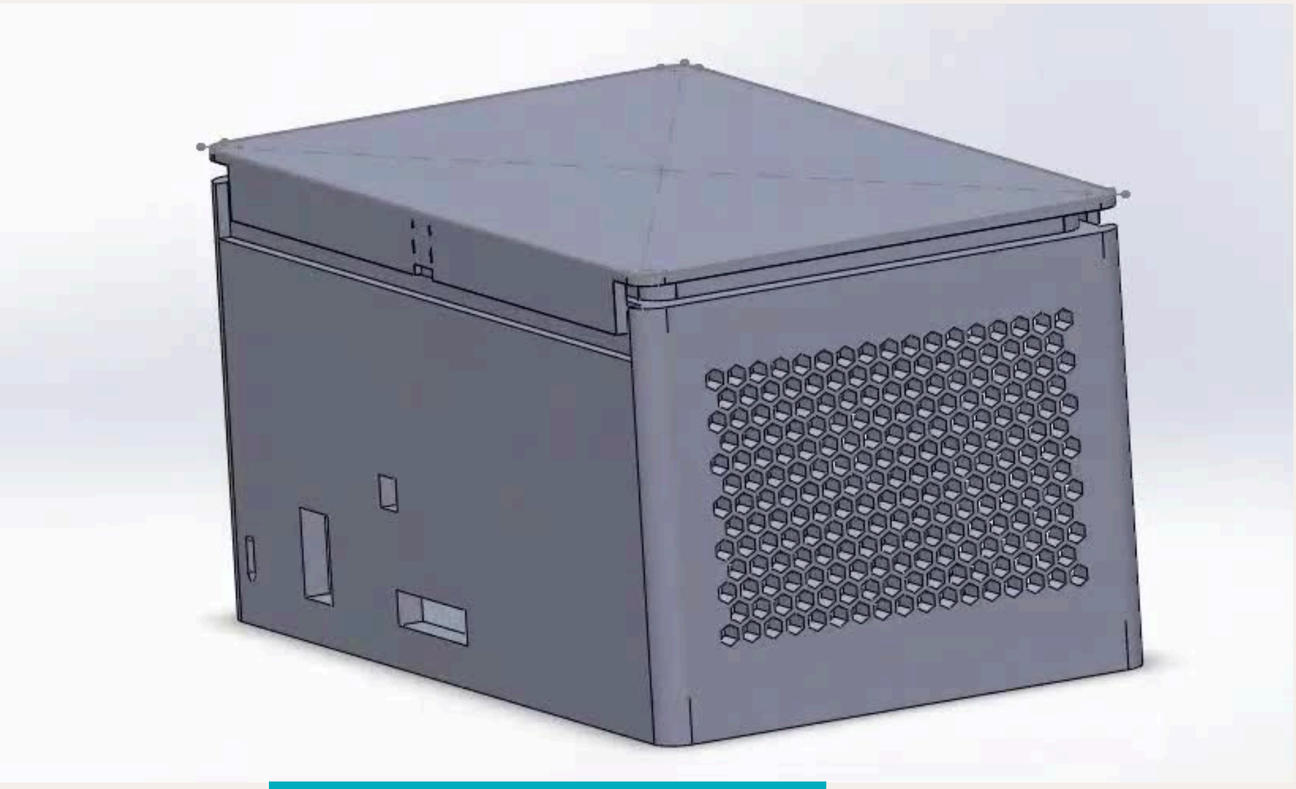


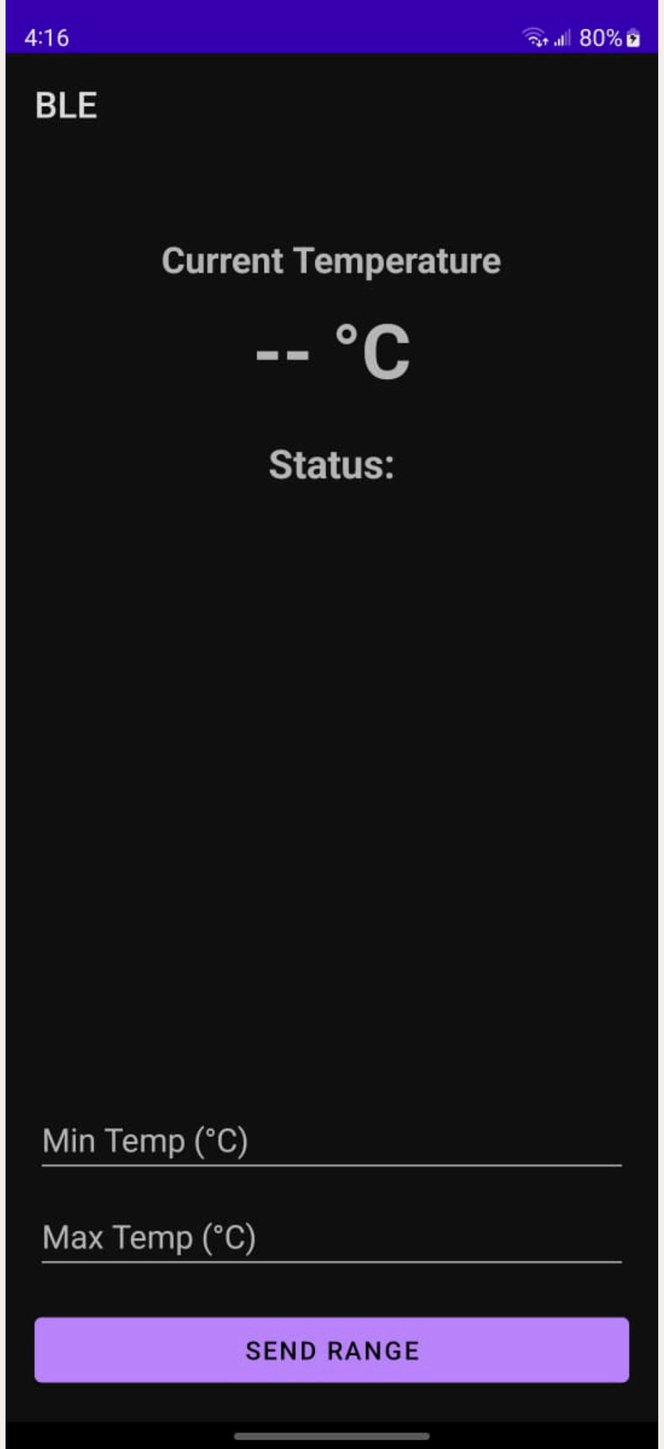
Simulation Results



Enclosure

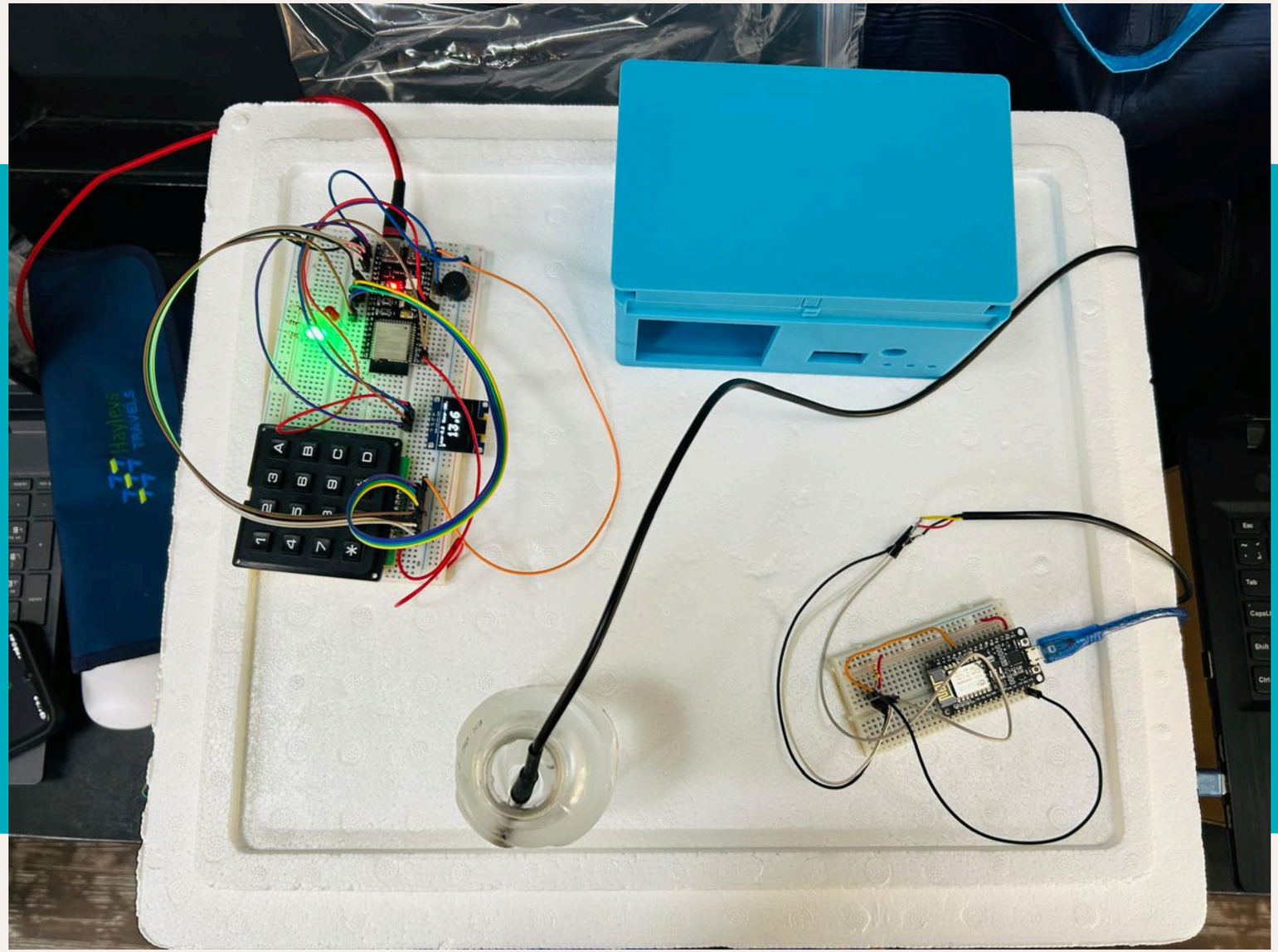




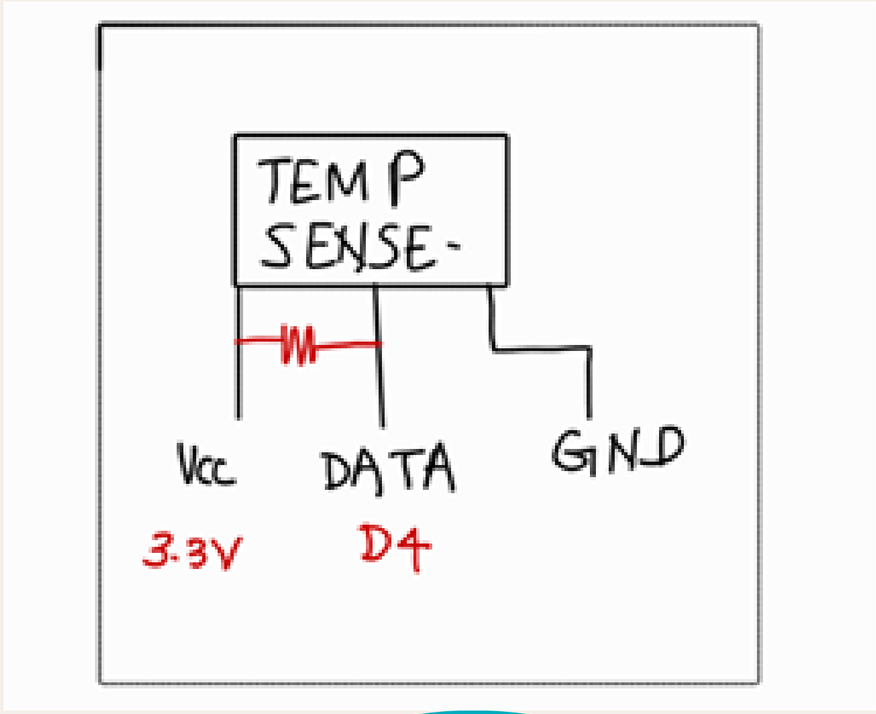

4:16
80%
BLE
Current Temperature
-- °C
Status:
Min Temp (°C)
Max Temp (°C)
SEND RANGE

APP UI

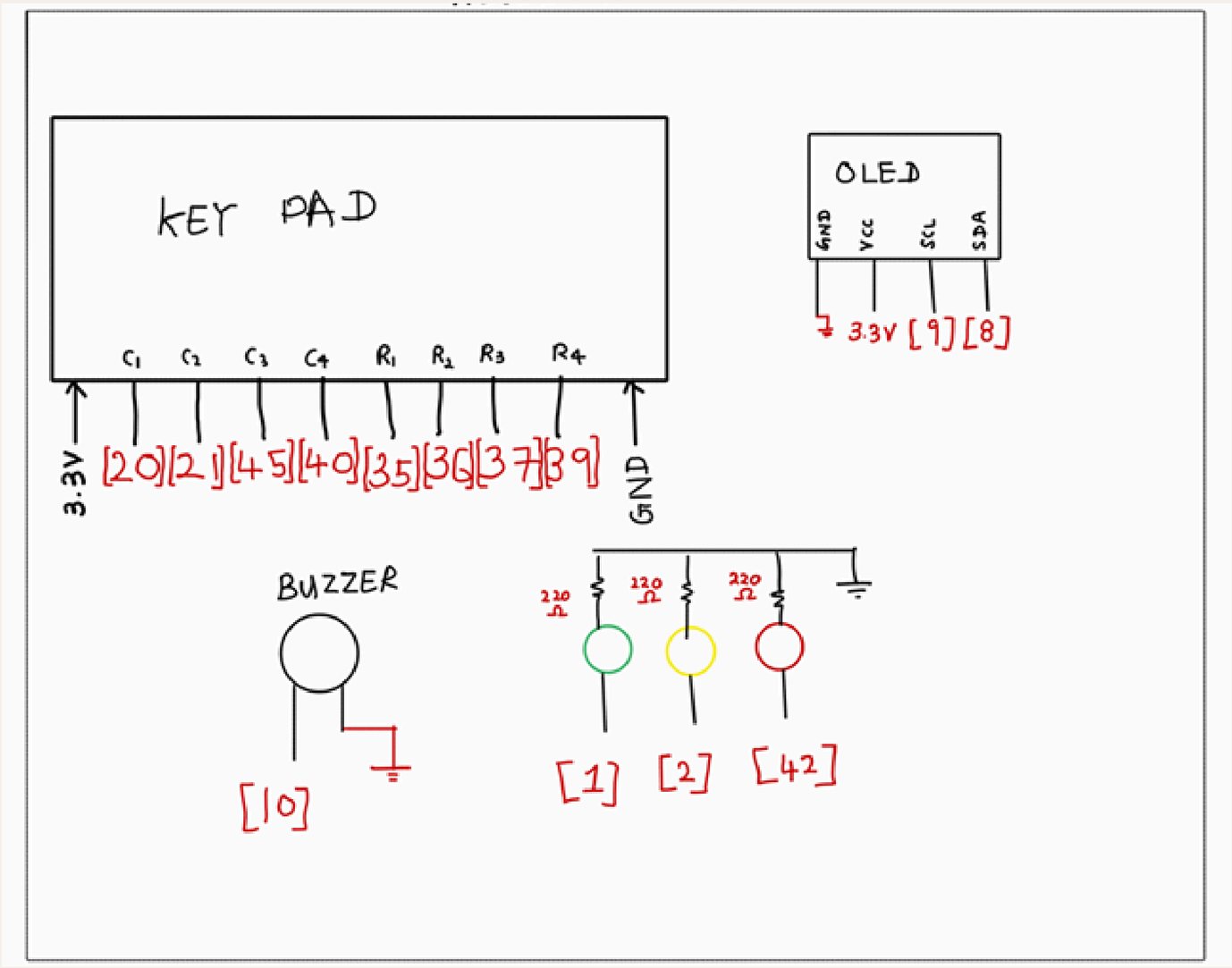
Circuit Diagram



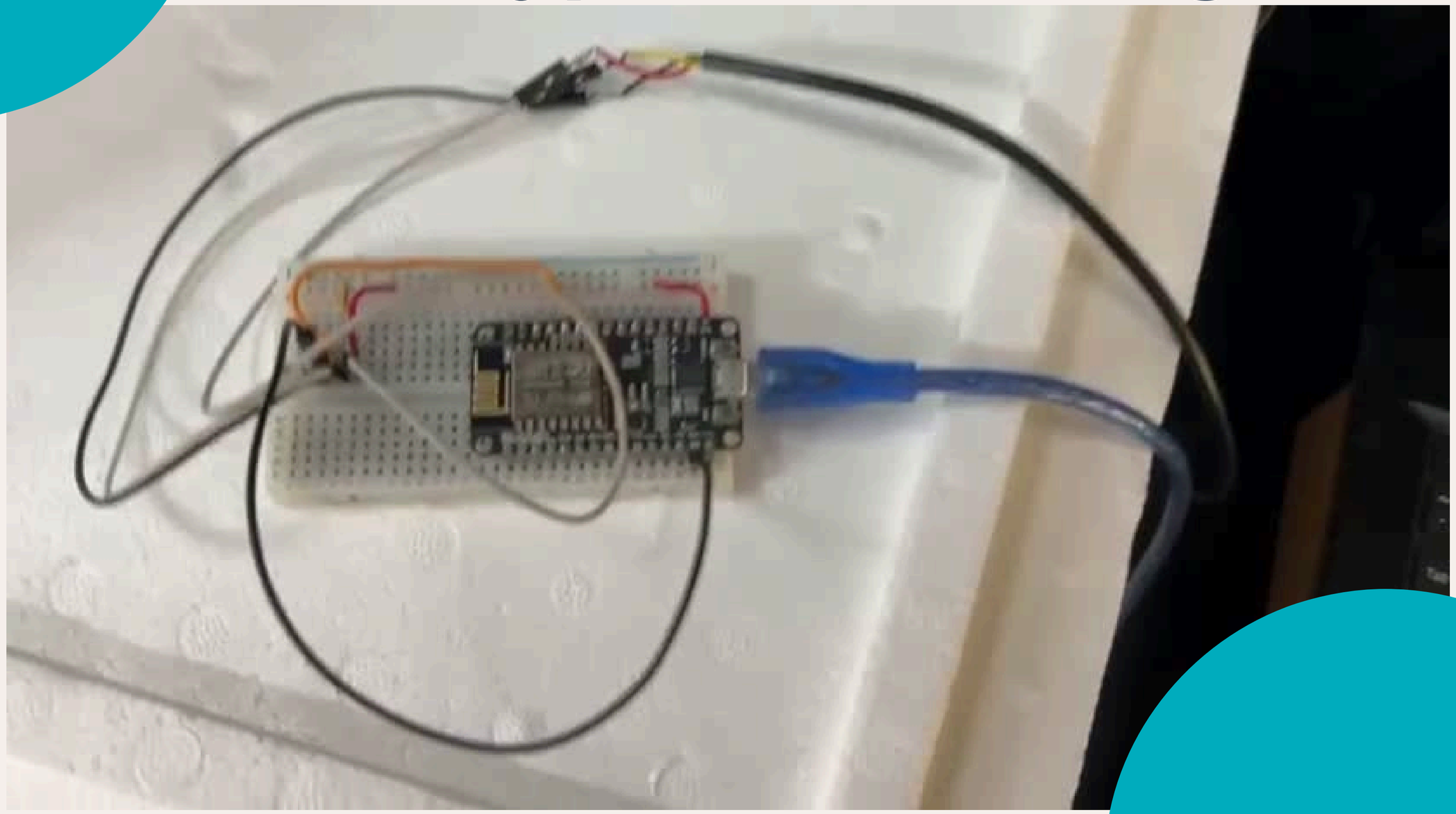
Transmitter



Receiver



Prototype and Testing



Test Results

Test	Method	Result	Status
Sensor stability	10 readings	Stable	✔
Communication	Serial/WiFi	Working	✔
App UI	Basic flow	Partially working	△

Regularoty Pathways

- **Device Classification:**
  - **Falls under low-risk monitoring devices since it only measures and alerts on temperature without altering the product.**
- **FDA Classification (U.S.):**
  - **Likely Class I (low-risk) as a temperature monitoring device.**
  - **Many Class I devices are 510(k)-exempt, but still require proper labelling and quality standards.**
- **EU MDR Classification:**
  - **Expected to fall under Class I (Non-Sterile, Non-Measuring) since it only displays temperature and gives alerts.**
- **Sri Lanka NMRA Context:**
  - **Considered a low-risk medical accessory used in the cold chain.**
  - **Basic registration + compliance with ISO safety standards.**
- **Key Requirements:**
  - **Electrical safety (IEC 60601 basics if classified as a medical accessory)**
  - **Accurate temperature measurement validation**
  - **Clear user instructions and warnings**
  - **Proper device labelling and documentation**

Budget

Component	Price
ESP8266 NodeMCU (Transmission Unit)	700
ESP32 S3 (Reciever Unit)	1850
DS18B20 Waterproof Temperature Sensor	240
OLED Display (0.96'')	540
Buzzer	50
LEDs (x3)	30
Buck Converter	150
Wires + Connectors	355
Vero Board	120
Rigifoam Box	3000
LiPo Battery (3.7V 500mAh)	600
Li-ion Battery (3.7V 1000mAh)	170
Switch	10
4x4 keypad	680
Total	**8,495**

Future Improvements

- Add a Peltier-based active cooling module for automatic temperature regulation.
- Improve insulation to extend passive cooling time.
- Enhance the mobile app with data logging and cloud sync.
- Integrate solar charging for remote field use.
- Use multiple sensors for better internal temperature accuracy.
- Include automated fault detection for sensors and communication modules.

Conclusion

Our system delivers a practical and dependable way to monitor vaccine temperature in real time during transport, giving healthcare workers clear visibility and instant alerts whenever the temperature moves outside the safe range. By keeping the design simple, affordable, and easy to use, it suits rural and low-resource settings where advanced cooling solutions aren’t feasible. With wireless communication, configurable thresholds, and a clear display, the device ensures timely manual action to protect vaccine potency and maintain the integrity of the cold chain.

Q&A Session?

References

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THANK YOU!