

PROJECT ABSTRACT

MQTT Cold Chain Logger using ESP32

Cold chain temperature logger: ESP32 with DS18B20 probes publishing over MQTT to a live dashboard with 2-8 C excursion alerts and SD-card offline buffering, delivered built-to-order with prototype, firmware, report, PPT and viva kit.

01. Title

MQTT Cold Chain Logger using ESP32

02. Introduction / Background

Vaccines lose potency, and food and blood products spoil, when they drift outside their required temperature window - the WHO-recommended 2-8 C for most vaccines - during storage or transport. The failure is usually invisible: a fridge door left ajar overnight, a delivery van parked in the sun, a power cut nobody logged. Manual twice-daily thermometer checks miss all of it. Continuous electronic logging is the established answer in the pharmaceutical world, but commercial loggers are expensive black boxes that teach a student nothing. This project builds the same capability from open parts: ESP32, digital probes, MQTT telemetry, a live dashboard and offline buffering.

03. Problem Statement

Student IoT projects often stop at 'sensor to serial monitor' and never demonstrate the full telemetry loop: publish, visualize, alert and recover from connectivity loss. Cold chain monitoring is the ideal vehicle because the requirements are real and strict: timestamped readings, a defined safe band, instant excursion alerts, and no unrecorded gaps. This project implements that complete loop on hardware cheap enough for a student bench.

04. Objectives

- Build an ESP32 logger reading two waterproof DS18B20 probes (± 0.5 C per datasheet) over 1-Wire.
- Publish timestamped JSON readings over MQTT (QoS 1) and visualize them on a browser dashboard with the 2-8 C safe band shaded.
- Raise excursion alerts over MQTT the moment either probe leaves the safe window.
- Buffer readings to SD card with NTP timestamps when Wi-Fi drops and bulk-sync on reconnect; use deep sleep between intervals for battery operation; deliver the complete student kit.

05. Proposed Methodology

The ESP32 reads both probes each sampling interval (default 60 s), timestamps via NTP, and publishes a JSON payload (probe ID, temperature, battery voltage) to coldchain/unit01/# with QoS 1. The dashboard subscribes over MQTT WebSockets and plots both series against the safe band. Excursions publish immediately to the alert topic and flag on the dashboard. Without connectivity, readings append to a CSV on the SD card and publish in order on reconnect. Deep sleep between intervals sets the power budget; thresholds, intervals and topics are configurable.

06. System Architecture / Working

Sense: DS18B20 probes on the 1-Wire bus at the monitored points. Publish: ESP32 over Wi-Fi to the MQTT broker (public HiveMQ for demos or local Mosquitto). Visualize: browser dashboard over MQTT WebSockets with live chart, statistics and connection status. Alert: safe-band check per reading with alert-topic publish and dashboard flag. Recover: SD-card CSV buffering with NTP timestamps and ordered backfill on reconnect. A front-panel button forces an immediate reading for live demonstration.

07. Hardware / Software Requirements

- ESP32 DevKit (Wi-Fi, deep-sleep capable)
- 2x DS18B20 waterproof digital temperature probes
- MicroSD card module for offline CSV buffering; Li-ion cell with charging
- PubSubClient MQTT library (QoS 1); Arduino IDE / PlatformIO firmware
- Mosquitto local broker or public HiveMQ broker; NTP for timestamps
- Web dashboard (MQTT over WebSockets, live charting)

08. Expected Outcomes

A working logger that streams dual-probe temperature to a live dashboard, flags 2-8 C excursions with timestamps, and demonstrably loses no readings across a Wi-Fi outage thanks to SD buffering and backfill. Battery life is a design-target calculation from the duty cycle, verified by the buyer on their own cell. The report documents the MQTT topic design, power budget, and the limits: ± 0.5 C sensor accuracy and academic-prototype status, not pharma-validated qualification.

09. Applications

- Vaccine and medicine storage monitoring demos (educational scope)
- Food transport / storage temperature logging demonstrations
- Teaching platform for MQTT, QoS, NTP, deep sleep and offline-first IoT design
- Template for any multi-sensor telemetry logger (humidity, pressure variants as optional customization)

10. Future Scope

- Email/SMS gateway on the alert topic
- GPS tagging for transport-route excursion mapping
- TLS-secured MQTT with client certificates
- Cloud historian (InfluxDB/Grafana) for long-term analytics
- Calibrated probe variant with documented ice-point check procedure