Ensuring IEC 104 Compliance with Existing Hardware Setup

Using ESP32-S3 with a SIM7670G 4G module and an RS485 TTL converter, we need to bridge IEC 104 compliance at the aggregator level without modifying each individual BESS unit. Below is the solution to ensure compliance and handle slow-response units.

1. Key Components in Current Setup

- ESP32-S3
- Handles local data processing for the BESS.
- Connects via WiFi, Bluetooth, or LTE (SIM7670G 4G module).
- SIM7670G (LTE Cat-1)
- Provides remote connectivity for cloud or head unit communication.
- RS485 TTL to Galvanic Isolated Converter
- Ensures safe industrial communication between ESP32 and the BESS.

2. Making This IEC 104 Compliant at the Aggregator Level

Since IEC 104 is not running on each ESP32-S3, the compliance is ensured via the Head IEC 104 Units, which will act as the official IEC 104 communication layer with Energinet.

2.1. Communication Flow for Solution 2

1. ESP32-S3 collects BESS data

- Reads power output, SOC, voltage, frequency, and temperature via RS485 (Modbus RTU).
- Timestamped data is transmitted via MQTT (over LTE) or Modbus TCP to the Local Controller.

2. Local Controllers aggregate data

- Each Local Controller handles ~5,000 BESS units.
- Converts incoming Modbus/MQTT data into structured IEC 104-compatible messages.

3. Head IEC 104 Unit (Aggregator) ensures compliance

- The Head IEC 104 unit aggregates from multiple Local Controllers.
- Maintains time synchronization via NTP/PTP.

- Transmits IEC 104-compliant messages to Energinet's SCADA system.

3. Handling Slow-Responding BESS Units

If one or more ESP32-S3 units fail to respond within Energinet's required time (100-200ms latency for FCR/aFRR), we need a fallback mechanism.

3.1. Strategies to Handle Delayed Responses

✅ Timeout-Based Fallback

- If a BESS unit does not respond within 200ms, the Local Controller marks it as unavailable.
- The Head IEC 104 unit dynamically redistributes the power load to other available BESS units.

✅ Redundant Time Buffering

- ESP32-S3 stores the last known valid state in case of temporary LTE dropout.
- The Local Controller compares incoming data timestamps and ignores outdated values.

✅ Priority-Based Load Redistribution

- If 5% of units fail to respond, the Head IEC 104 unit increases power allocation to available units proportionally.