FiltSure Device State — Technical Overview & Current Issues

Device Capabilities

The FiltSure sensor node is designed to collect and transmit a variety of environmental and operational data critical for HVAC monitoring and general sensing applications. The device measures and reports:
- Pressure
- Humidity
- Temperature
- RFID scans
- Wind speed
- Battery level

Data transmission is supported over Wi-Fi when available, with LoRa (RFM96) as a fallback path to ensure resiliency in environments with poor or absent Wi-Fi coverage.

Hardware & Architecture

- Main MCU: ESP32-C6 (primary control, Wi-Fi/LoRa stack)
- Sensors:
  - Bosch BME280 (Pressure/Humidity/Temperature)
  - MFRC522 (RFID)
  - Micro-turbine based wind speed sensor
- Communications:
  - Wi-Fi uplink
  - LoRa (SX1276/77/78/79 family – RFM96) point-to-point link
- Power: USB umbilical for bench testing or 3V D-cell in field tests
- Bus Topology: All peripherals share a single SPI bus with separate chip select (CS) lines.

Datasheets and references:

- LoRa (SX1276–79):

https://cdn-shop.adafruit.com/product-files/3179/sx1276_77_78_79.pdf
- MFRC522 RFID:

 https://www.nxp.com/docs/en/data-sheet/MFRC522.pdf
- Bosch BME280 PHT:

https://www.bosch-sensortec.com/media/boschsensortec/downloads/datasheets/bst-bme280-ds002.pdf
- TI TPS61023 Power Regulator:

 https://www.ti.com/lit/ds/symlink/tps61023.pdf?ts=1756468678481
- Espressif ESP32-C6:

 https://www.espressif.com/sites/default/files/documentation/esp32-c6_datasheet_en.pdf
- ESP32-C6 DevKitM-1:

https://docs.espressif.com/projects/esp-dev-kits/en/latest/esp32c6/esp32-c6-devkitm-1/index.html

Additional project documentation: https://github.com/ExecTio9/FiltSureDev

Current Challenges

1. Multi-Device SPI Bus Conflicts
- Individually, each SPI device (RFID, BME280, LoRa) operates correctly.
- Issue: When multiple peripherals are active simultaneously, communication with the ESP32-C6 becomes unreliable.
- Workaround: Devices have been separated onto multiple boards for independent testing.

2. RFID Instability
- MFRC522 demonstrates inconsistent scanning.
- After some runtime, the module fails entirely, returning blank packets to the server until reset.

3. LoRa Inconsistency
- The RFM96 (SX127x family) initially showed promising results in point-to-point tests.
- However, performance degraded unexpectedly after a few days (with no major environmental changes).
- Symptoms:
  - Packets received only intermittently

- Sessions that previously sustained hundreds of packets now stall after only a handful
- This inconsistency has been the main blocker to stable fallback communications.

4. Power Considerations

- Current prototypes are powered either by USB or a 3V D-cell.
- Early tests suggest the regulator chain is functional, but no deep characterization of power draw vs. stability has been done yet.

5. Software Maturity

- Codebase largely functional (multiple peer reviews by software and EE students).
- Minor updates are required to ensure LoRa compatibility and improve multi-device coordination over SPI.
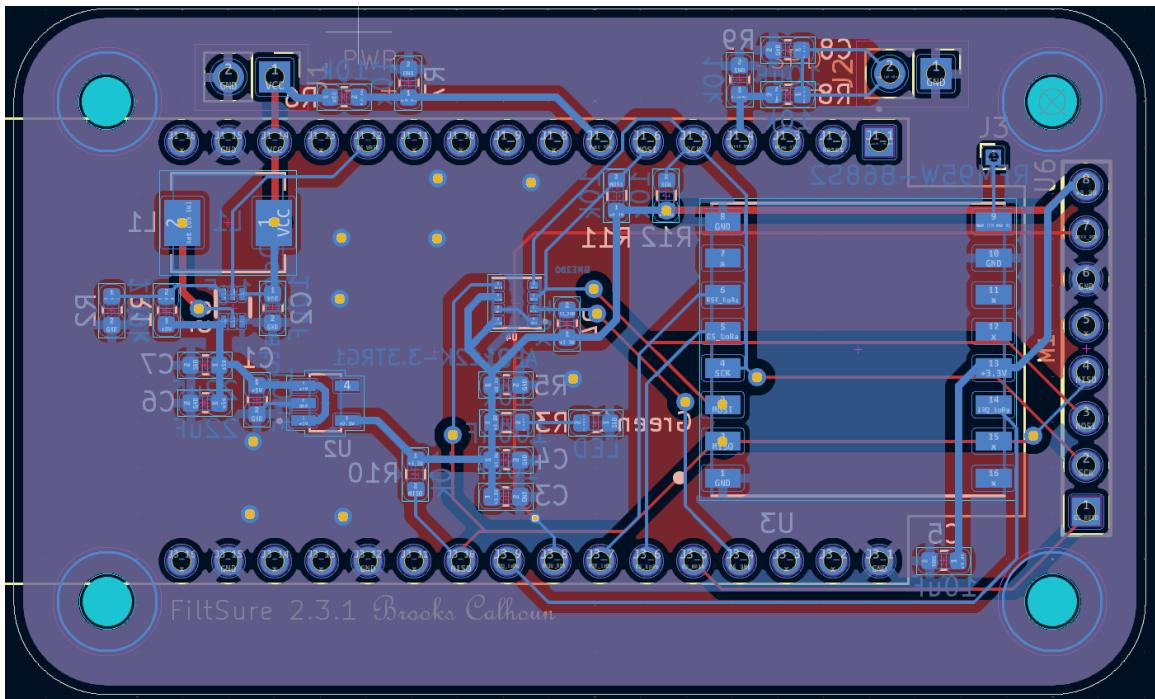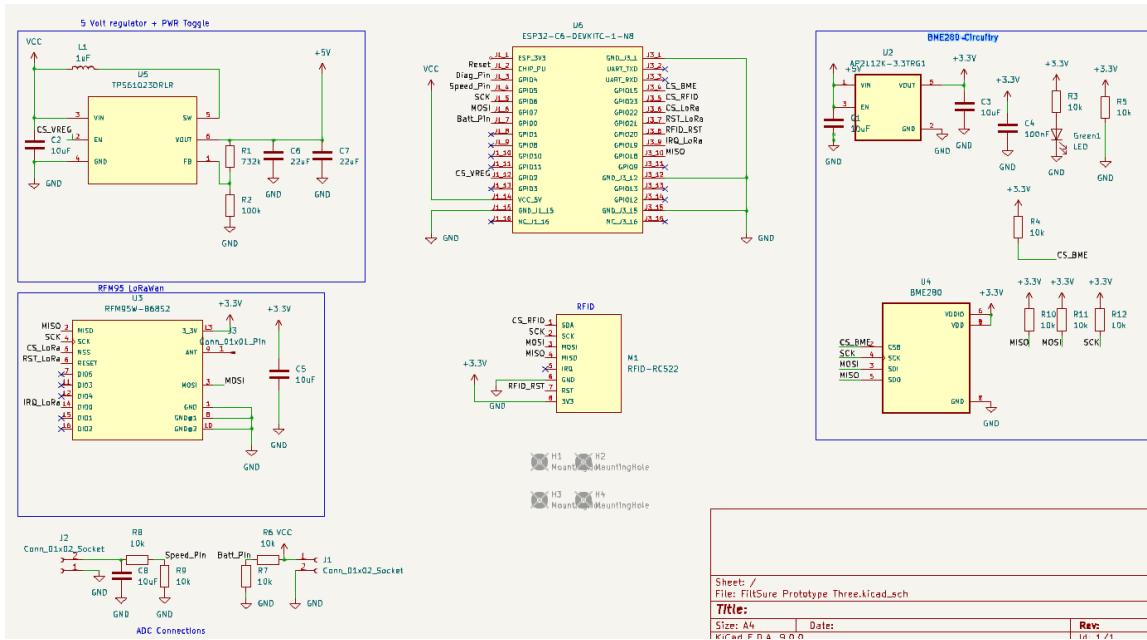
Summary

The FiltSure device is feature-complete in terms of sensing and dual-path communications (Wi-Fi + LoRa).
The main blockers to a stable field deployment are:
1. SPI contention issues with multiple peripherals
2. RFID (MFRC522) instability during extended operation
3. LoRa (RFM96) reliability degradation after initial success

Once these are resolved, the platform will be capable of consistently collecting and transmitting environmental and operational data over redundant communication paths, fulfilling its role as a robust monitoring node.

Past This point are the Datasheets linked in the upper pages