ESP32-S3 AMOLED Sensor Dashboard

Multi-Sensor IoT Platform with 1.91" AMOLED Display & Web Bluetooth Integration

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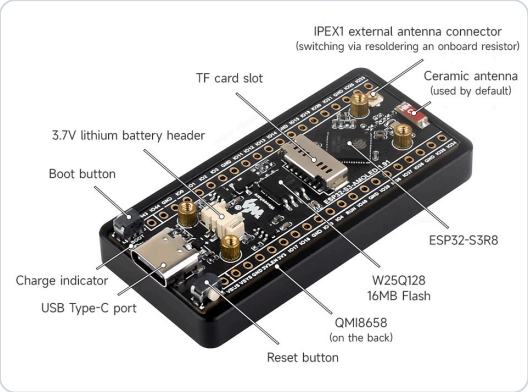
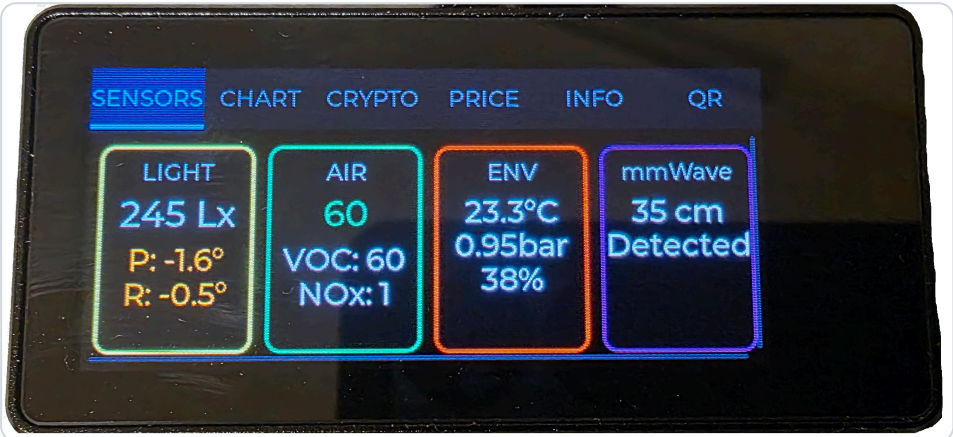
A **professional IoT sensor platform** built on the **ESP32-S3** (Xtensa dual-core @ 240 MHz) with **8 MB PSRAM**, featuring a stunning **1.91" AMOLED display (536×240)** running **LVGL 8.3**. This system integrates **7 environmental sensors**, **mmWave radar presence detection**, **BLE Long Range (Coded PHY S=8)**, and a **responsive web dashboard** accessible via WiFi. The platform demonstrates real-time multi-sensor fusion, adaptive brightness control, cryptocurrency tracking, and professional UI/UX design patterns for embedded systems.

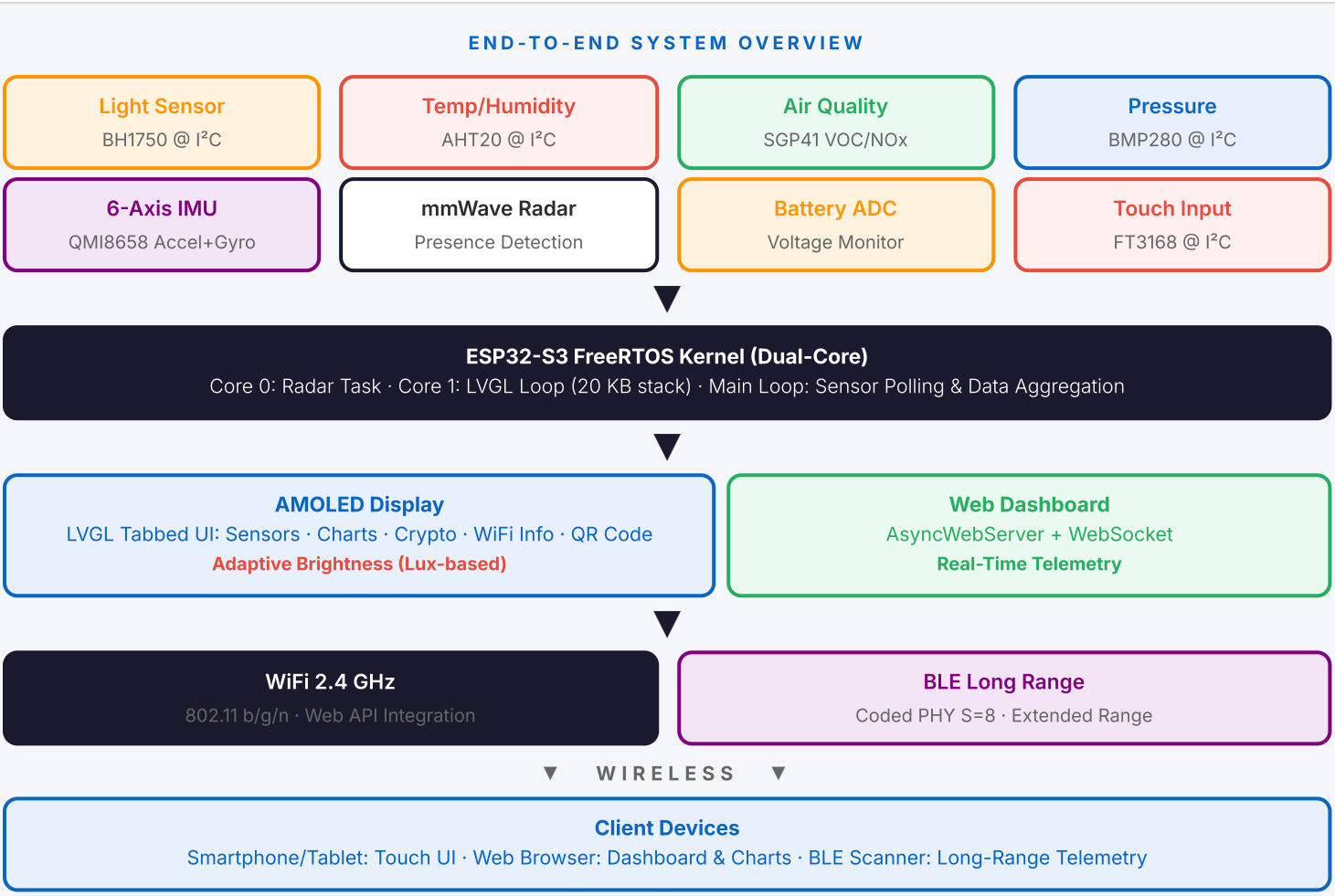




TECHNOLOGY STACK

LAYER	TECHNOLOGY
MCU / SoC	ESP32-S3: Xtensa dual-core LX7 @ 240 MHz, 8 MB PSRAM, 16 MB Flash
RTOS	FreeRTOS (preemptive multitasking, dual-core task pinning)
Display	1.91" AMOLED 536×240 (RM67162 controller, QSPI interface)
UI Framework	LVGL 8.3.9 (hardware-accelerated graphics, tabbed interface)
Connectivity	WiFi 802.11 b/g/n, BLE 5.0 LE Coded PHY (Long Range), Web Bluetooth API
Sensors	BH1750 (light), AHT20 (temp/humidity), BMP280 (pressure), SGP41 (VOC/NOx), QMI8658 (6-axis IMU), mmWave radar (presence)
Web Server	ESPAsyncWebServer with real-time telemetry streaming
Power	LiPo battery with ADC monitoring, adaptive display brightness
Data Integration	Live cryptocurrency prices (API Ninjas), Bitcoin chart visualization

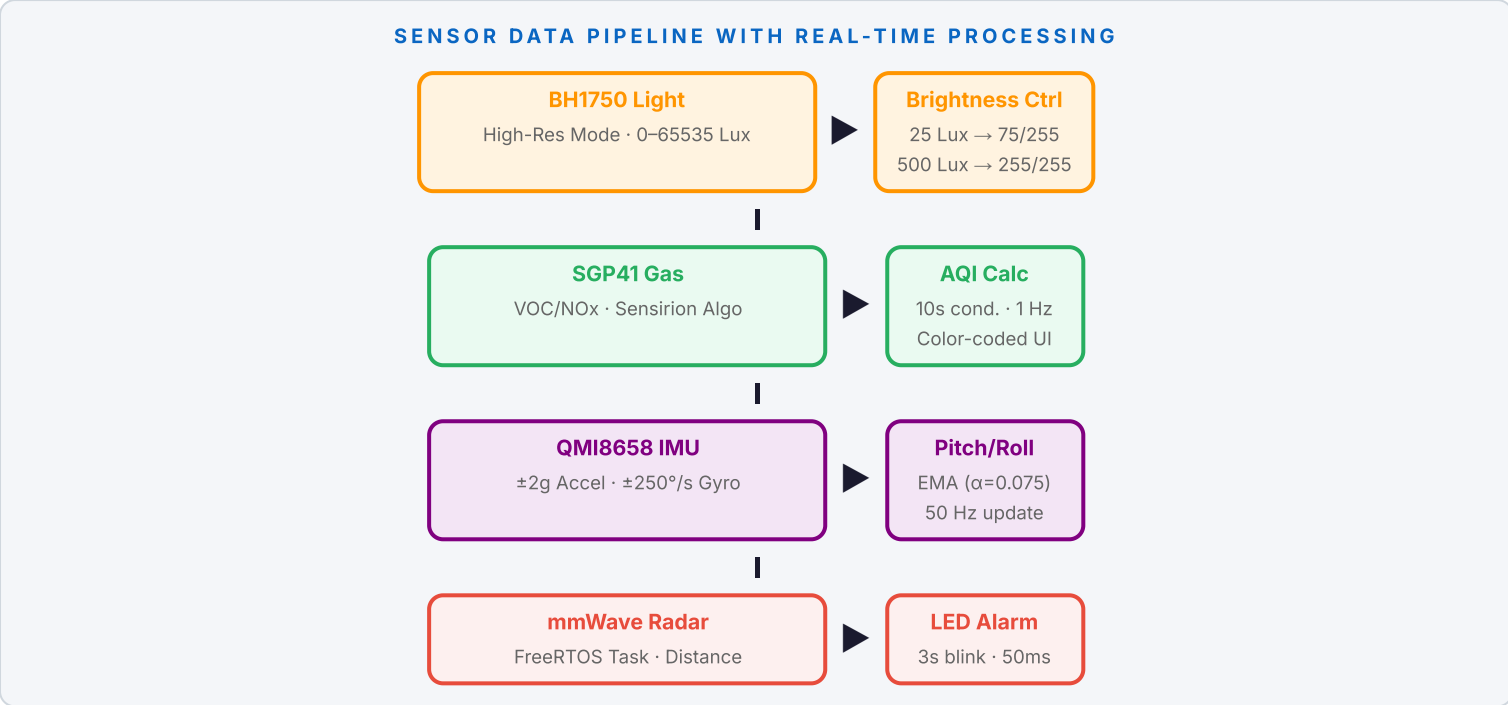
SYSTEM ARCHITECTURE



SENSOR INTEGRATION & DATA PROCESSING

Multi-Sensor Fusion Architecture

Seven sensors provide comprehensive environmental monitoring with intelligent data processing:



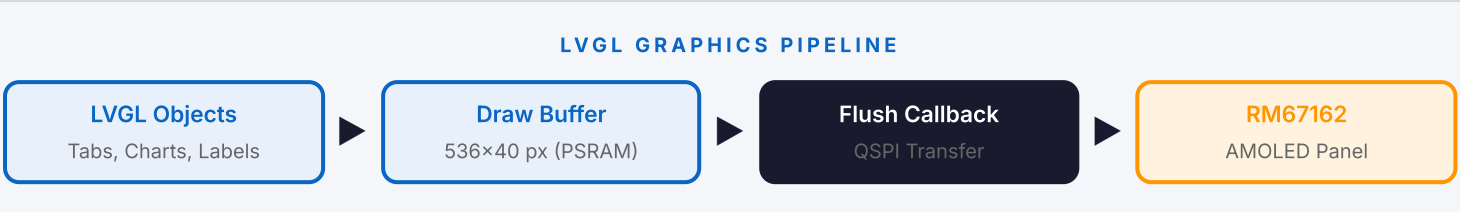
Sensor Specifications

SENSOR	MEASUREMENT	RANGE / ACCURACY	RATE
BH1750	Light	0–65535 Lux / ±20%	Cont.
AHT20	Temp	-40 to +85°C / ±0.3°C	On-dem.
AHT20	Humidity	0–100% RH / ±2%	On-dem.
BMP280	Pressure	300–1100 hPa / ±1 hPa	On-dem.
SGP41	VOC	0–500 / Sensirion	1 Hz
SGP41	NOx	0–500 / Sensirion	1 Hz
QMI8658	Accel	±2g / 16-bit	50 Hz
QMI8658	Gyro	±250°/s / 16-bit	50 Hz
mmWave	Presence	0–500 cm / ±5 cm	Cont.

DISPLAY & USER INTERFACE

AMOLED Display System

The 1.91" AMOLED panel (RM67162 controller) delivers vibrant colors and deep blacks with hardware-accelerated rendering via LVGL:



Tabbed Interface Design

TAB	CONTENT	UPDATE FREQUENCY
SENSORS	4 cards: Light/Gyro, Air Quality (VOC/NOx), Environment (Temp/Pressure/Humidity), mmWave Radar	Real-time
CHART	Rolling sensor charts: Light (50 pts), Temperature/Pressure/Humidity (50 pts, 3 series)	Continuous
CRYPTO	Bitcoin price chart with 6 timeframes (1h, 24h, 7d, 1m, 1y, 5y), tap to cycle	60s / on-demand
PRICE	Live BTC prices in USD, EUR, CHF (API Ninjas integration)	60s
INFO	WiFi status (SSID, RSSI, speed, channel), BLE status (Coded PHY), battery, uptime	1s
QR	Dynamic QR code for web dashboard access (auto-generated from IP address)	On IP change

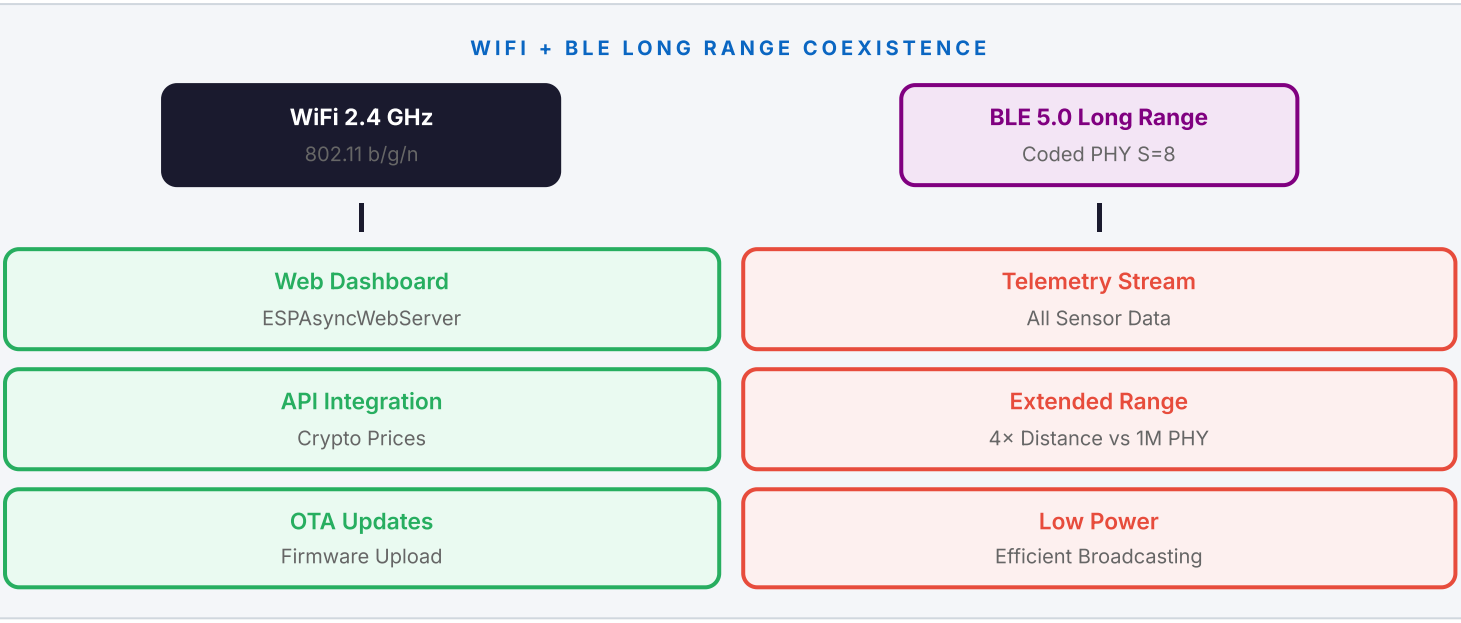
Adaptive Brightness Control

Lux-based automatic dimming with hysteresis prevents display flicker and reduces power consumption:

- **< 25 Lux:** Brightness = 75/255 (dim indoor)
- **25–500 Lux:** Linear scaling 75 → 255
- **> 500 Lux:** Maximum brightness (255/255)
- **Hysteresis:** ±5 brightness units to prevent oscillation
- **Update Rate:** 500 ms throttle

WIRELESS COMMUNICATION

Dual-Radio Architecture



BLE Long Range Telemetry

Bluetooth 5.0 Coded PHY (S=8) provides extended range for remote monitoring applications:

PARAMETER	VALUE
PHY Mode	LE Coded PHY S=8 (125 kbps effective)
Range Extension	~4× compared to 1M PHY (theoretical 400m+ outdoor)
Telemetry Data	Gyro (X/Y/Z), Pitch, Roll, Light, AQI, Temp, Humidity, Pressure, Radar Distance, Battery %
Update Rate	Continuous (main loop, ~1 Hz effective)
Library	NimBLE-Arduino 1.4.1

Web Dashboard Features

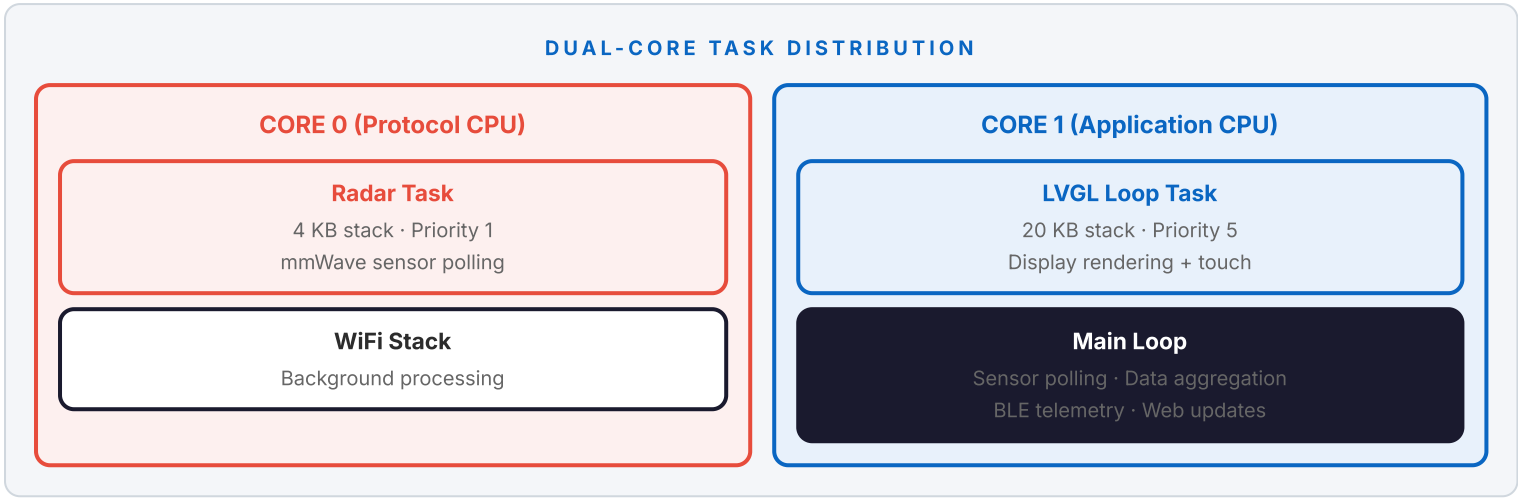
- **Real-Time Telemetry:** All sensor values streamed via WebSocket (1s update)
- **WiFi Diagnostics:** RSSI percentage, download/upload speed, frequency, channel
- **Battery Monitoring:** Voltage (ADC), percentage estimation (3.2–3.7V range)
- **QR Code Access:** Scan from display to open dashboard instantly
- **Responsive Design:** Mobile-optimized layout





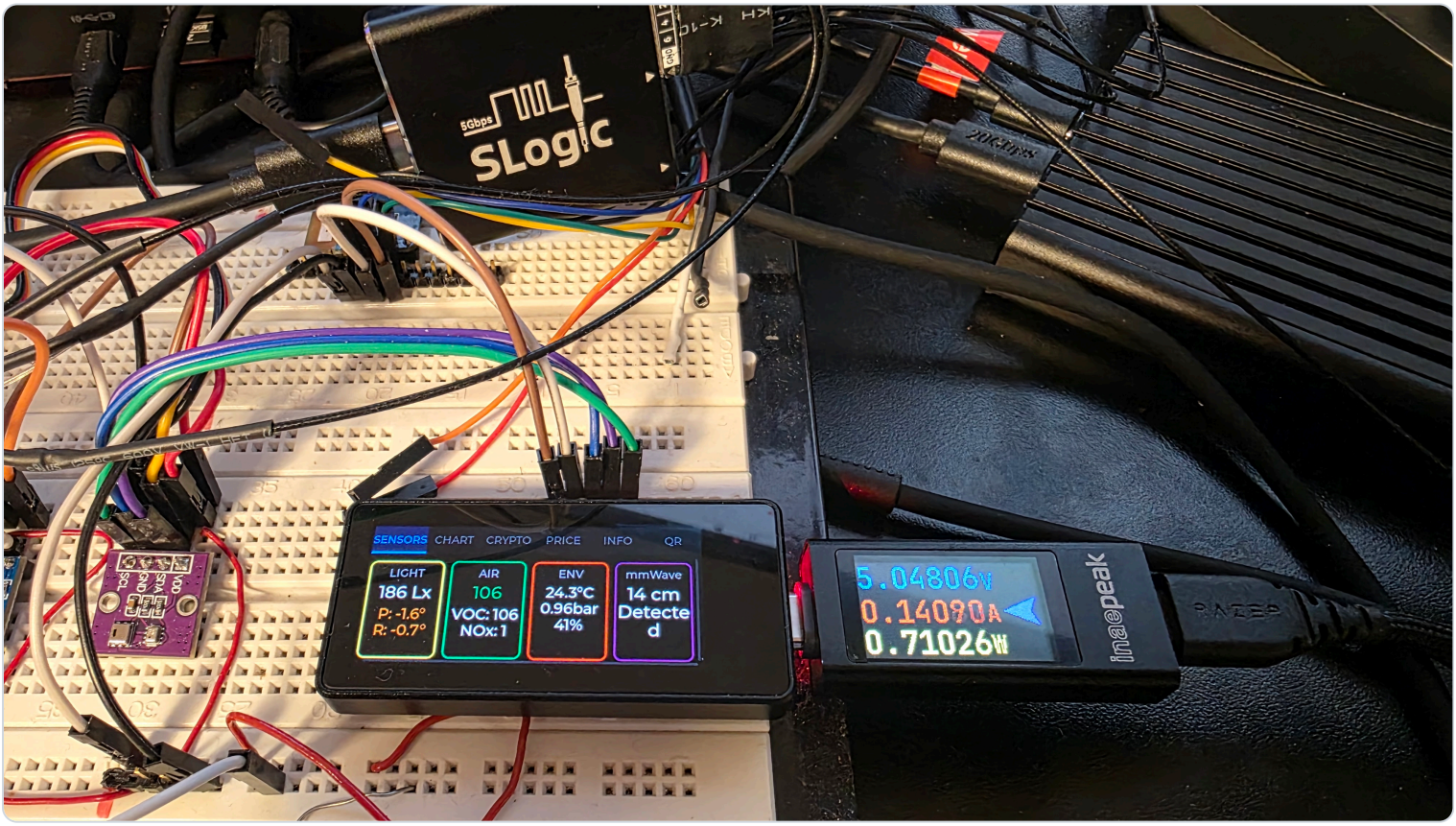
REAL-TIME OPERATING SYSTEM

FreeRTOS Task Architecture



Synchronization & Thread Safety

- **I²C Mutex:** FreeRTOS semaphore protects shared I²C bus (QMI8658 access from multiple contexts)
- **Task Pinning:** LVGL on Core 1 (high priority), Radar on Core 0 (isolated)
- **Non-Blocking Design:** Main loop uses 1 ms delay, no busy-wait patterns
- **Brownout Protection:** Disabled via register write to prevent false resets during WiFi TX bursts



KEY ENGINEERING HIGHLIGHTS

1 Professional AMOLED UI
Stunning 536×240 display with LVGL framework: tabbed navigation, real-time charts, touch input, adaptive brightness.

2 7-Sensor Fusion
Comprehensive environmental monitoring: light, temp, humidity, pressure, air quality (VOC/NOx), IMU, mmWave radar.

3 BLE Long Range
Coded PHY S=8 extends range 4× for remote telemetry: all sensor data streamed continuously to BLE clients.

4 Dual-Core RTOS
FreeRTOS task pinning: LVGL on Core 1 (20 KB stack), Radar on Core 0, I²C mutex for thread-safe sensor access.

5 Web Dashboard
AsyncWebServer with real-time telemetry streaming, WiFi diagnostics, battery monitoring, QR code access.

6 Crypto Integration
Live Bitcoin prices (USD/EUR/CHF) via API Ninjas, interactive chart with 6 timeframes, tap-to-cycle UI.

7 Smart Presence Detection
mmWave radar (S3KM1110) with dedicated task: distance measurement, person detection, LED alarm feedback.

8 Production Patterns
PSRAM allocation, brownout protection, I²C mutex, EMA filtering, hysteresis-based brightness, graceful WiFi reconnect.

ESP32-S3 · FreeRTOS · AMOLED 536×240 · LVGL 8.3 · BLE Long Range · WiFi 2.4 GHz · 7 Sensors · Web Bluetooth · mmWave Radar · AsyncWebServer

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Built with ESP32-S3 · LVGL · FreeRTOS · Arduino Framework · April 2026