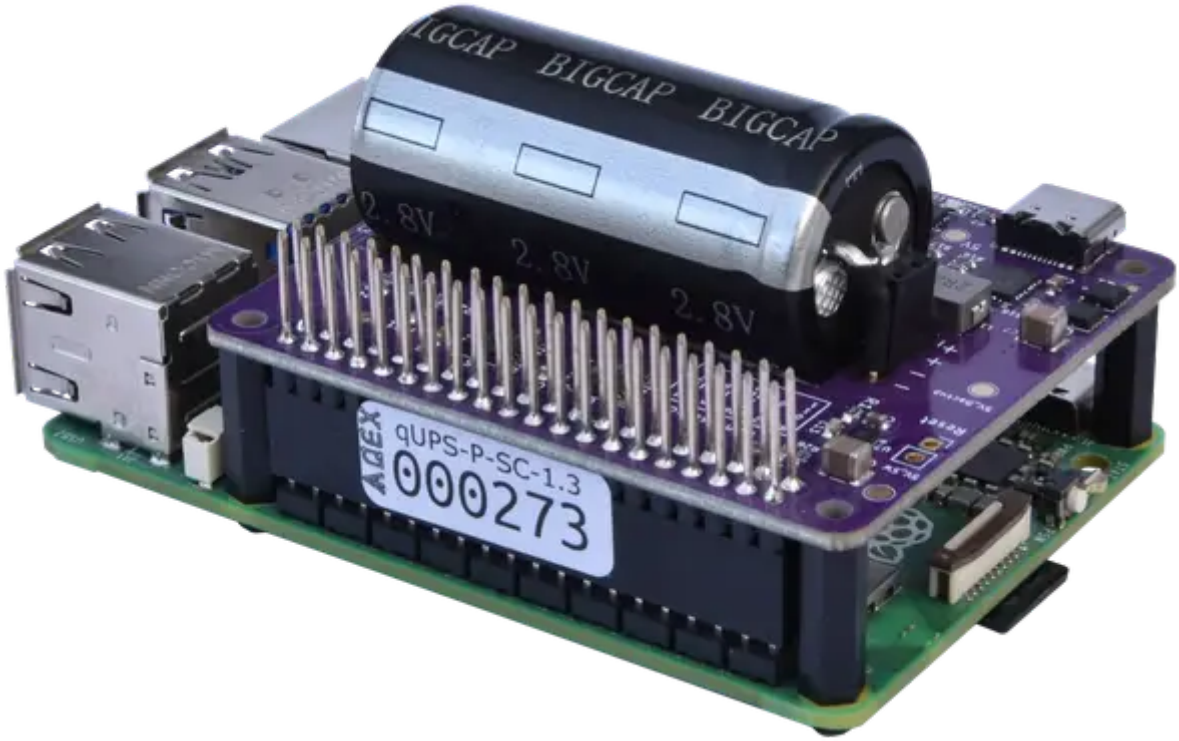
Technical Data Sheet: qUPS-P-SC v1.3

Industrial Ultra-High Capacity Supercapacitor UPS for Raspberry Pi

Official Product Page: https://aqex.eu/qups-p-sc-raspberry-pi-ups-hat-with-supercapacitor.html



1. Product Concept & Strategic Advantages

The **qUPS-P-SC** is a professional-grade, battery-less power protection solution engineered for demanding Raspberry Pi applications. Traditional battery UPSs are a major failure point in industrial environments due to chemical degradation and heat sensitivity—risks that the qUPS-P-SC completely eliminates.

Key Strategic Advantages:

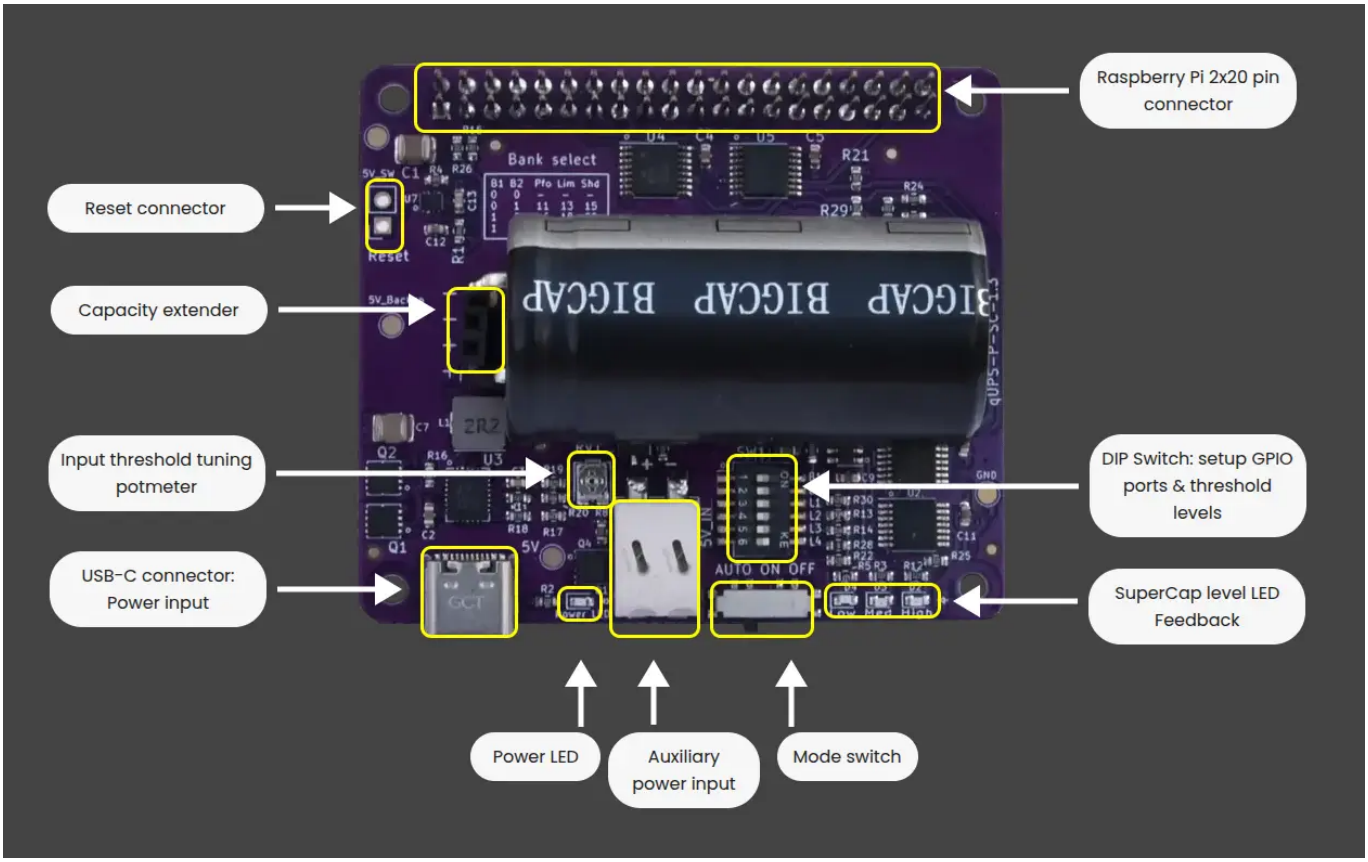
- **Maintenance-Free Supercapacitor Power:** Built with a massive **100F – 120F supercapacitor** offering a >500,000 cycle life and over 10 years of reliable operation.
- **Industrial Thermal Tolerance:** Operating temperature range from **-40°C to +65°C**, ideal for outdoor cabinets, edge nodes, and remote IoT gateways.
- **Open-Source Software Stack:** Powered by our lightweight C/Python `qups-guard` daemon with full source code available on GitHub for easy integration and custom scripting.
- **Home Assistant Integration:** Out-of-the-box support via **Auto-MQTT Discovery & Addon** for real-time telemetry (power loss, low battery) and native automation triggers.
- **Zero-Loss Offline Topology:** Delivers near-zero power loss and heat generation during normal operation, ensuring maximum efficiency.
- **Filesystem Protection:** Ensures data integrity through instant power-loss detection and automated safe shutdown procedures.

2. Comprehensive Technical Specifications

Parameter	Value	Condition / Detailed Notes
Topology	**Offline (Standby)**	**Maximum efficiency during normal operation**
Input Voltage	5.0V – 5.2V	USB-C or Industrial Spring Terminal
Output Voltage	5.2V DC	Precision regulated Step-Up for RPi 4/5
Total Capacitance	**100F – 120F**	High-density EDLC (Supercapacitor) Array
Max Continuous Load	2.5A	Optimized for high-performance RPi models
Operating Temp	**-40°C to +65°C**	**Full Industrial Grade**
Switching Time	100 - 300 µs	Near-instantaneous transition

> **Design Note:** The **Offline topology** ensures almost zero power loss and heat generation during standard operation. A momentary (<1ms) voltage transient occurs during power failure; however, the Raspberry Pi's internal regulation easily filters this, ensuring zero system instability or reboot.

3. qUPS-P-SC User Interfaces and Indicators



4. GPIO Communication & DIP Switch Setup

The qUPS-P-SC features a flexible **GPIO Bank Selection** system via onboard **B1-B2 DIP switches (2)** to prevent hardware conflicts with other HATs or peripherals.

B1 Switch	B2 Switch	Power Good (PFO)	Cap. Low (LIM)	Shutdown (SHD)
OFF	**OFF**	Disabled	Disabled	Disabled
ON	**OFF**	**GPIO 17** (Pin 11)	**GPIO 27** (Pin 13)	**GPIO 22** (Pin 15)
OFF	**ON**	**GPIO 23** (Pin 16)	**GPIO 24** (Pin 18)	**GPIO 25** (Pin 22)
ON	**ON**	**GPIO 5** (Pin 29)	**GPIO 6** (Pin 31)	**GPIO 26** (Pin 37)

- **PFO (Power Fail Out):** HIGH = External Power OK / LOW = Backup Mode active.
- **LIM (Limit):** Signals that the capacitor energy has reached a critical low threshold.
- **SHD (Shutdown):** Command from RPi to UPS. Pull LOW after OS halt to cut output power.

5. Control & Runtime Optimization

Input Level Threshold Adjustment (Potmeter):

Tune the exact voltage point where the UPS triggers the transition from external power to supercapacitor backup. This is critical for:

- **Long Input Cables:** Compensating for voltage drops (IR drop) in industrial wiring.
- **Weak Power Sources:** Preventing premature switching during minor voltage ripples.

Adjustable Detection Thresholds (DIP)

A precision potentiometer allows for **manual calibration of power-fail detection and switching levels**. This empowers engineers to:

- **Maximize Backup Time:** Fine-tune the "empty" threshold to extract every joule of stored energy.
- **Compensate for Voltage Drop:** Adjust for resistive losses in long or thin input cables.
- **Filter Power Noise:** Prevent false triggers during the high-current bursts typical of Raspberry Pi 5.

Visual Diagnostics (LED Group)

LED	Color	Status
External Power	**Green**	Primary 5V power source detected on input.
High	Green	Full charge. System is safe for Boot + Shutdown cycle.
Med	Yellow	Medium charge. Sufficient energy for an emergency OS shutdown.
Low	Red	**Critical energy.** Power-off is imminent.

6. Intelligent Power Management (IPM)

- **Safe-Start Logic:** Prevents the Pi from booting until the energy level reaches the "High" (Green LED) threshold.
- **Anti-Reboot Loop:** Actively prevents "zombie" restart cycles during brownouts or low-energy states.
- **Shutdown Guard:** Ensures the OS halt process completes even if external power returns mid-process, preventing filesystem corruption.

7. Operational Dynamics & Runtime (120F)

Raspberry Pi Model	No Load [s]	50% Load [s]	100% Load [s]
Raspberry Pi 2	168	148	80
Raspberry Pi 3	171	70	41
Raspberry Pi 4	84	44	29
Raspberry Pi 5	**74**	**20**	**8**

**Note: Final runtimes can be significantly extended via user-calibrated threshold settings and software optimization.*

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8. Scalability & Software Support

- **Modular Expansion:** Supports **qUPS-P-EX** extender modules (EX450, EX900, EX1700) via the dedicated capacity interface.
- **Software Support:** Native C++/Python `qups-guard` daemon for background monitoring and automated safe shutdown.
- **Home Assistant Integration:** Seamless out-of-the-box integration via Auto-MQTT Discovery / Custom Addon for real-time power telemetry (PFO, LIM) and native HA automations.
- **Repository:** github.com/aqexhu/qups-guard

HW Version: 1.3 | **Released:** 2024
Manufacturer: AQEX Electronics | aqex.eu