

Technical Data Sheet: Stubborn Balance Zero v1.0

Ultra-Durable Maintenance-Free Hybrid Supercapacitor UPS HAT for Raspberry Pi Zero

Official Product Page: <https://www.aqex.eu/stubborn-balance-zero-raspberry-pi-zero-ups-hat-hybrid-supercap.html>



1. Product Concept & Strategic Advantages

The **Stubborn Balance Zero** is a specialized uninterruptible power supply designed for the **Raspberry Pi Zero** family. Unlike traditional battery-based systems, it utilizes **Hybrid Supercapacitor (HSC)** technology to provide a maintenance-free, high-endurance power backup solution for industrial and remote IoT applications.

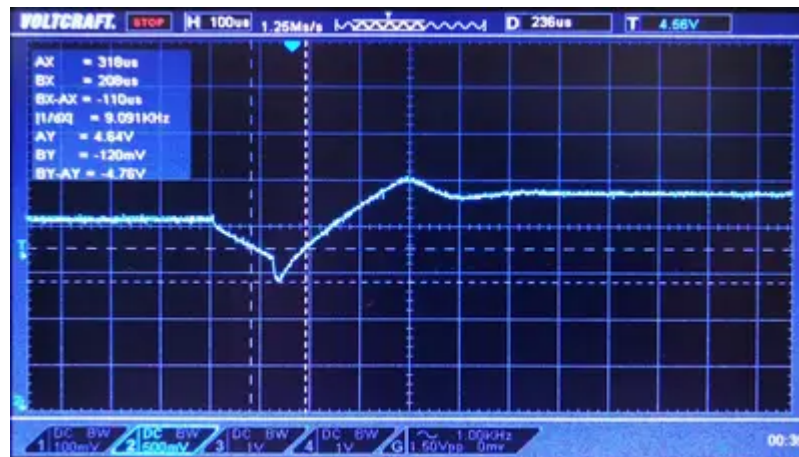
Strategic advantages:

- **Extended Runtime:** Offers significantly higher energy density and longer backup power duration compared to standard supercapacitors.
- **Extreme Longevity:** The HSC technology supports up to 50,000 charge cycles, outlasting traditional Li-ion batteries.
- **Maintenance-Free:** No chemical aging typical of batteries; ideal for hard-to-reach deployments.
- **Superior Temperature Stability:** Operates reliably in environments where standard batteries would fail.
- **Compact Form Factor:** Designed specifically to match the Raspberry Pi Zero's footprint.
- **Zero Maintenance:** No periodic battery replacements required during the typical lifecycle of the equipment.

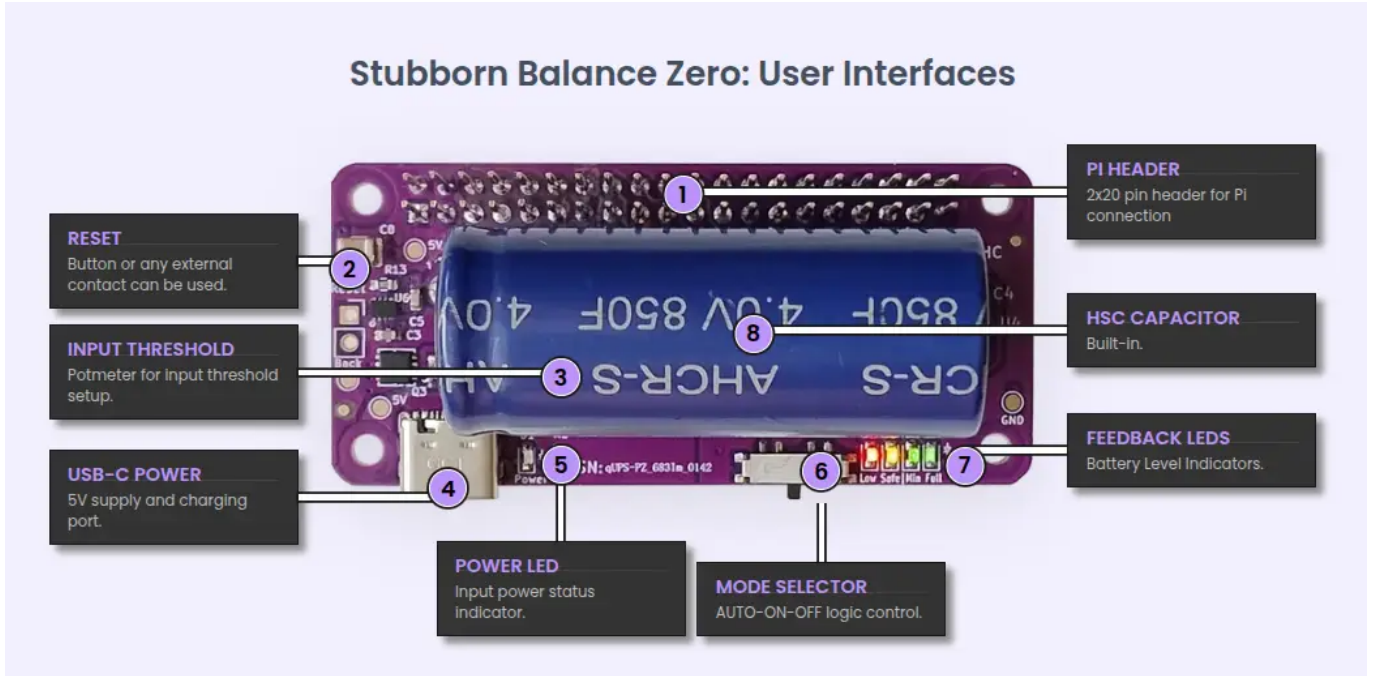
2. Comprehensive Technical Specifications

Parameter	Value	Condition / Detailed Notes
Input Voltage (USB-C)	5.0V – 5.2V	Minimum 2A - 3A recommended
Output Voltage	5.0V DC	Regulated for Raspberry Pi Zero
Storage Technology	Hybrid Supercapacitor	High energy density with long cycle life
Max Continuous Load	3.5A	Enhanced current delivery for RPi Zero 2WH + Peripherals
Cycle Life	~50,000 Cycles	Industrial grade durability
GPIO Interface	40-pin Header	Pass-through design for stacking
Switchover Time	100 – 300 μ s	No-reboot guaranteed 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. Stubborn Balance Zero User Interfaces and Indicators



4. Power Management & Protection

Feature	Specification
Logic Control	Hardware-level voltage monitoring
Safety	Protected against over-discharge and input voltage fluctuations
Input Tuning	Potentiometer for input threshold calibration
Restart Logic	Automatic recovery after power restoration in AUTO mode

5. User Interfaces & Configuration

5.1 Mode Selection (Switch 4)

- **OFF:** Complete power cut.
- **ON:** Immediate power-up when power (internal or external) is available.
- **AUTO:** Intelligent start-up logic; only boots the Pi when the battery reaches the "Min" energy level.

5.2 GPIO Communication

The system utilizes a 3-pin GPIO interface for OS-level integration. The following pins are used on the 40-pin Raspberry Pi header:

- **PFO (Power Fail): GPIO 17 (Pin 11)** — Signals external power loss (HIGH = OK / LOW = Backup Mode).
- **LIM (Limit): GPIO 27 (Pin 13)** — Signals that the battery has reached the critical low threshold.
- **SHD (Shutdown): GPIO 22 (Pin 15)** — Handshake signal. The UPS cuts power after the OS pulls this pin LOW (or the daemon signals a halt).

6. Visual Diagnostics (LED Indicators)

LED	Color	Status / Meaning
External Power	Green	Primary 5V power source detected.
Full	Green	Battery fully charged (>3.9V).
Min	Green	Sufficient energy for a safe boot-shutdown cycle.
Safe	Yellow	Sufficient energy for a safe shutdown cycle.
Low	Red	Critical level. Immediate shutdown required.

7. Intelligent Power Management (IPM)

- **Safe-Start Logic:** Prevents "brown-out" loops by ensuring the Pi only starts when the battery can support the peak current of the boot process.
- **Shutdown Guard:** Monitors the Pi's state and ensures power is only cut after the operating system has safely unmounted the filesystem.
- **Input Threshold Tuning:** Onboard potentiometer allows adjustment for voltage drops caused by long input cables.

8. Estimated Runtimes with Raspberry Pi Zero2 WH

HSC Capacity	No Load	100% Load
450F	46 min	13 min
850F	90 min	22 min
1100F	105 min	28 min

9. Software Support

- **qups-guard:** Native **open-source** daemon for automated monitoring and safe shutdown.
- **Compatibility:** Fully compatible with Raspberry Pi OS (Debian-based).
- **Repository:** github.com/aqexhu/qups-guard

HW Version: 1.0 | **Released:** 2025 **Manufacturer:** AQEX Electronics | aqex.eu