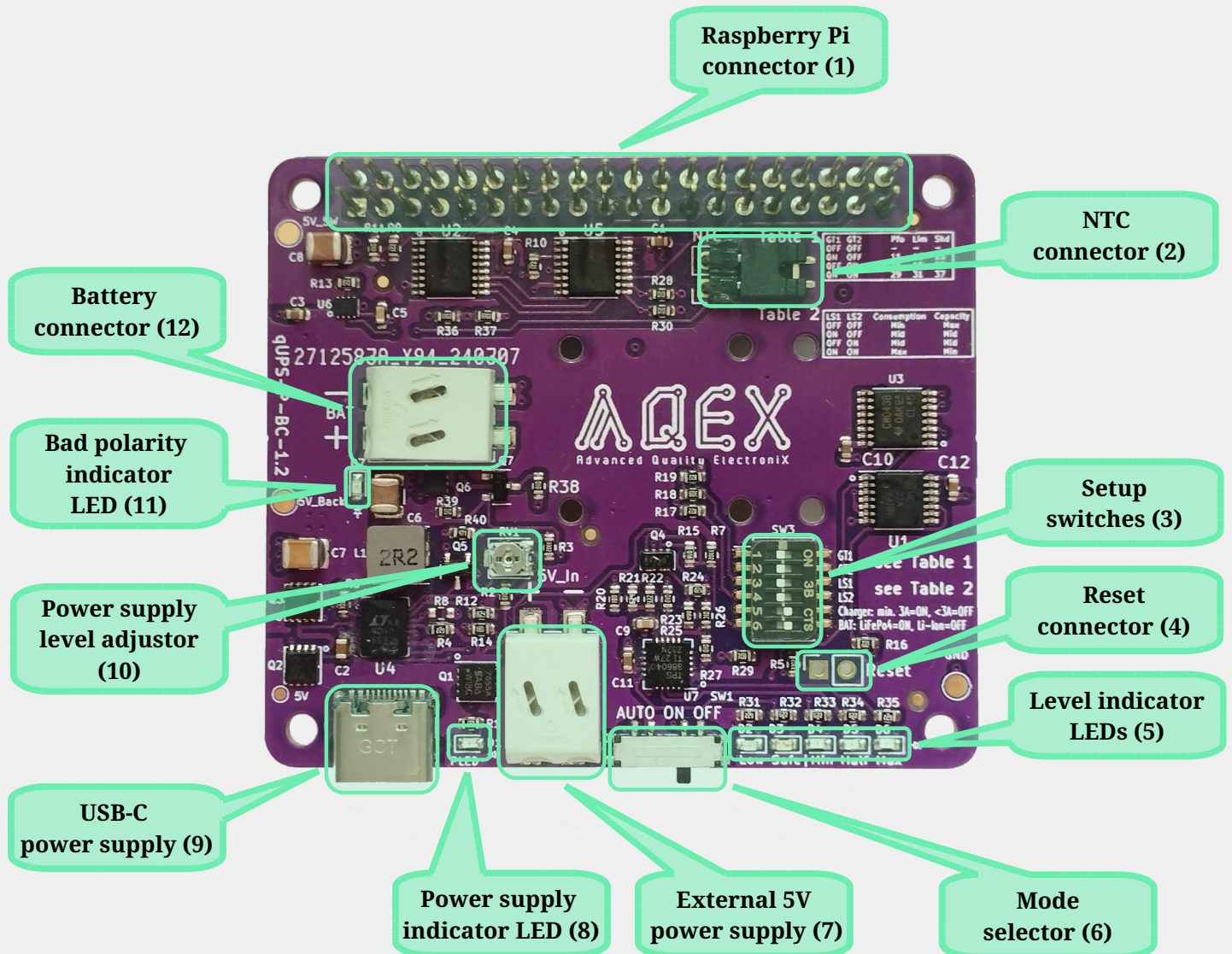


qUPS-P-BC-v1.2

User Manual v1.1
01/10/2024

Please read the instruction manual for safe use and a user experience tailored to your needs.

The qUPS-BC has several connection, setup and feedback points for using it, highlighted in the figure below. For easy identification, the "()" indicates the subsequent reference numbers.



1 Safety regulations

1.1 Personal safety



The qUPS product has an energy storage system that can be energised even when not connected to the mains.

The qUPS-BC has no replaceable parts other than the battery - only the manufacturer or an accredited service centre can carry out repairs and maintenance.

1.2 Product safety



The qUPS product should be protected from too high or too low temperatures, direct sunlight. It should be kept in a dry place for 24 hours before installation.

Conductive liquids, plastic materials may cause short circuiting and permanent product damage, therefore avoid installation in such environments.

The qUPS system should only be powered through the (7) OR (9) connector of the qUPS product.



POWERING THE PROTECTED DEVICE FROM ANOTHER SOURCE IS FORBIDDEN!!

The qUPS must not be operated together with another qUPS product and/or other uninterruptible power supply via connector (1) (40-pin terminal) !

1.3 Precautions

The system operates from 5V, which is low voltage, so it is protected from electric shock in a life-safety sense. In case of short circuits caused by foreign matter, the contacts may heat up and cause injury!

2 Introduction

Thank you for choosing AQEX smart qUPS-P-BC to protect your electronic device!

The qUPS family has been carefully and thoroughly designed to provide the most efficient way to ensure smooth operation in a wide range of conditions, to meet a wide range of user requirements.

The qUPS family is designed for uninterruptible operation of Raspberry Pi compatible microcomputers. It can also protect any device requiring 5V DC with a maximum power consumption of 2.5 A. Hereafter, we will refer to the connected product collectively as "Protected Device".

The qUPS-P-BC is the battery version of the qUPS family. It has the advantage of longer operating time without power supply. It uses 1 pc Li-ion, Li-Po or LiFePo4 battery for energy storage. The uninterrupted operating time determined by the battery capacity and the current consumption of the protected device.

Raspberry Pi model	No load [min]	50% load [min]	100% load [min]
2	530	365	280
3	450	250	220
4	312	190	144
5	265	168	160

Table 1: Expected operating time [minutes] in case of 4000mA LiFePO4 battery

For extremely long operating time requirements, the qUPS-P-BC can be used with any LiFePo4 (LFP) or Li-ion battery. Rectangular (prismatic) shaped batteries have a significantly higher energy capacity (>300Ah exists) than standard sized cylindrical batteries. The battery must be individually fixed.



Pay attention to compatibility! The current draw can be up to 4-5A, which the battery must be capable of.



A higher capacity naturally also means longer charging times! At a 2A charging current, a 100Ah battery will be fully charged in about 50 hours. The maximum operating time can be expected, if the battery is fully loaded.

2.1 Optimal circumstances of use

Thanks to the high capacity of the battery connected to the qUPS, the product can be used in places where several hours of power outage or power surges can compromise reliable operation. With a sufficiently large battery capacity, several days of operation are guaranteed.

The qUPS family is suitable for microcomputers, single board computers, microcontrollers and any 5V DC powered devices:

- for protection against power failure
- for overvoltage protection
- to achieve safe disconnection
- to ensure tasks and communication before disconnection
- for safe restart after a power failure

2.2 Non optimal circumstances of use

It is not suitable for protecting high-power computers due to the device's maximum current drain of 2.5A. Other products are better suited for higher current needs.

3 Commissioning

The qUPS product is ready for use immediately after preparation and unpacking. For computers using a Raspberry PI compatible 40 pin header, the connection is plug-and-play based, while in other cases the two pin +/- connection can be used.



The product is configured to use LiFePo4 battery by default. If you are using Li-Ion or Li-PO batteries, please make sure that they are set correctly. Details are in [section 3.3.1.1.4](#).

3.1 Power supply

The qUPS requires a 5V DC, min. 2A (min. 3A recommended) power supply. The output should be either a pair of unplugged cables (7) or a cable with a USB-C connector (9).

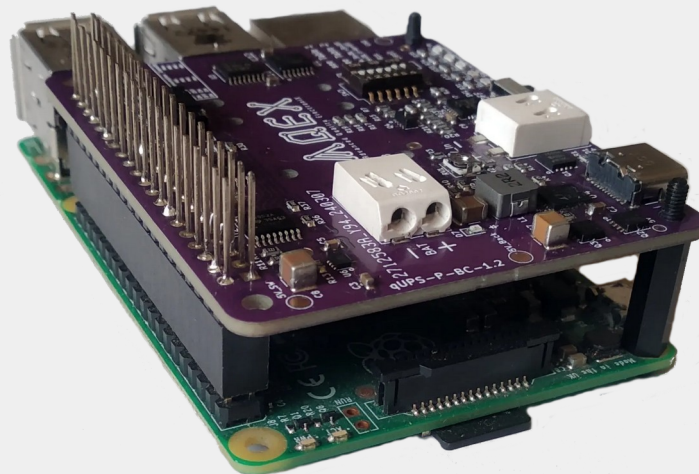
See Appendix for a list of tested power supplies and Troubleshooting.

3.2 Connctions

The protected device can be connected to the qUPS product in different ways.

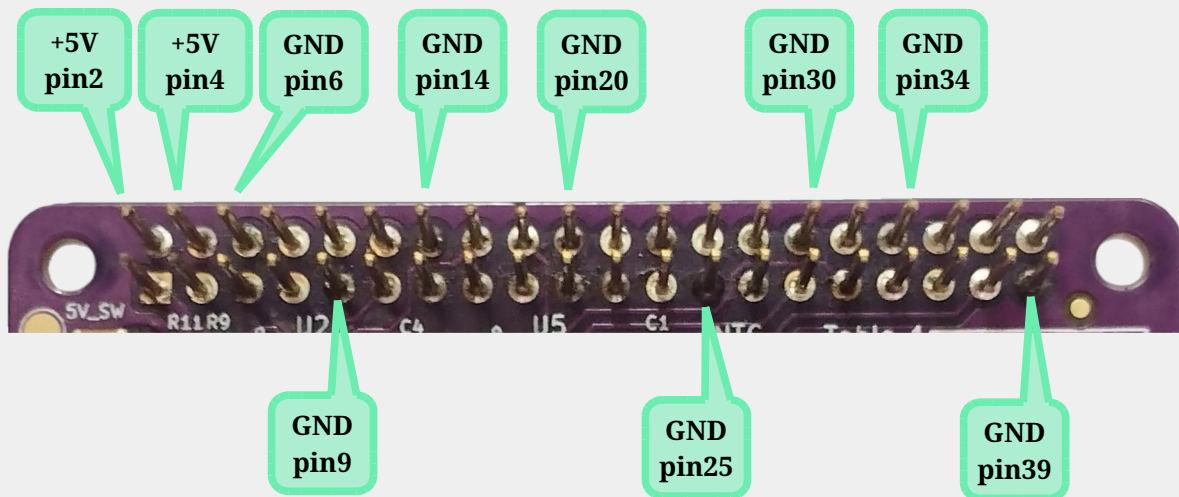
3.2.1 Single board computers (SBC)

If the SBC is equipped with a Raspberry PI compatible 40 pin header, the qUPS product is suitable for HAT connection. Simply plug the qUPS product's (1) socket onto the computer's pin header as shown in the picture below.



3.2.2 Other devices

Any device that operates from 5 V DC can be connected to the qUPS product using the appropriate contacts on the 40-pin header (1).



3.2.3 Powering the unit

The qUPS should be powered via connector (7) OR (9).

Connector (7) is polarity protected. The presence of power is indicated by LED (8).

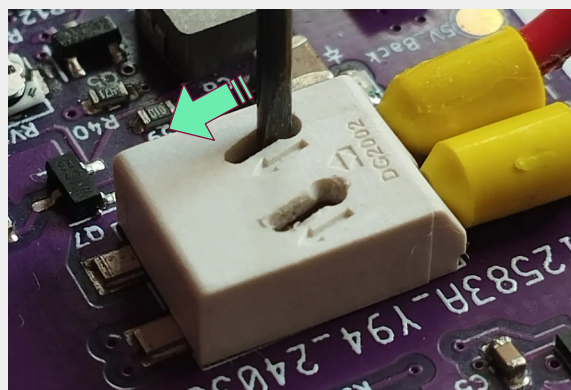
! The two power connector MUST NOT be fed from 2 separate sources!

3.2.4 Battery

The battery has to be connected to the qUPS via the (12) connector.

Pay attention to the polarity! The system is protected against reverse polarity connection, in which case LED (11) indicates the fault.

To remove the cable, pull the spring-loaded locking pin with a small screwdriver via the small window at the top of the connector.



3.2.5 Temperature sensing

Battery life is significantly reduced if they are charged at temperatures that are too high or too low. The critical lower and upper temperatures depend on the technology, typically 0°C to +40°C for Li-Ion/LiPo and -20°C to +60°C for LiFePo4.

The qUPS is capable of stopping the charge if the battery temperature is not within the required limits. A temperature sensor (NTC) is optionally available for the product and must be connected to connector (2). The connector is polarity independent.



The product can also be operated without temperature detection, in which case the (2) terminal must be short-circuited.

3.2.6 GPIO pins

All GPIO pins of the protected device connected via the 40 pin row (1) can be accessed on the top side of the qUPS. All but the 3 GPIO pins selected on [connector \(3\)](#) are free to be used for any other purpose.

3.2.7 Reset

The Reset connector (4) has the function of momentary power interruption. It is possible to solder in a cable, push button, standard 2.54 mm pin header or switch. If a short circuit occurs between the two contacts, the qUPS product will cut the power and the operation of the protected device will be stopped for the duration of the short circuit (reset function).

The contact is polarity independent.



Voltage control is not allowed, only contact („short-circuit” or „open-circuit”) can be used.

3.3 Setup

3.3.1 Hardware setup

3.3.1.1 6 circuit „Setup switch” (3) – DIP switch

The qUPS-P-BC product has a 6-circuit two-position switch, which controls 4 system parameters:

- Communication pin assignment (GT1 and GT2). Details in [section 3.3.1.1.1](#).
- Level adjustment (LS1 and LS2). Details in [section 3.3.1.1.2](#).
- Charge current (Charge): 1A or 2A. Details in [section 3.3.1.1.3](#).
- Battery technology (BAT): Li-Ion or LiFePo4. Details in [section 3.3.1.1.4](#).

3.3.1.1.1 Communication pins

The qUPS product uses three GPIO pins to exchange information with the computer in a flexible and configurable way. If there is no need for communication, the GPIO legs can be freed for further use - in this case the operation of the GPIO pins is completely transparent and not affected by the qUPS product.

The state of the GT1 and GT2 switches determines the pin allocation for communication with the protected device as shown in the table below:

DIP switch setup	GPIO pin on connector (1)		
GT1-GT2	Power Good (pfo)	Capacitor low voltage level (lim)	Shutdown (shd)
OFF-OFF	-	-	-
ON-OFF	11	13	15
OFF-ON	16	18	22
ON-ON	29	31	37

Table 2.

Pin functions:

- pfo: „power good”

When the voltage on the pin is high (logic 1, TRUE), the protected device is powered from the mains, and when it is low (logic 0, FALSE), the qUPS product does not receive power from the mains, so it uses the energy stored in the battery to power the protected device.

- lim: „limit”, battery charge state is above the limit

If the voltage on the pin is high (logic 1, TRUE), the energy stored in the battery is above the level set by switches LS1 and LS2. If the voltage level on the leg is low (logic 0, FALSE), the energy stored by the qUPS product has reached a critical level and a safe shutdown process should be initiated if required.

- shd: „shutdown”, protected device is operational

Indication to the qUPS product that the protected device is in operation. Its purpose is to ensure that the device restarts correctly after software shutdown, when power is restored and the energy storage has reached the correct charge level.

- The protected device indicates to the qUPS that it is operational by pulling up the "shd" pin (logic 1, TRUE). Loss of external power and the energy storage falling below critical level may result in software shutdown of the protected device. In this case, the pin will be set to a low voltage level (logic 0, FALSE). This will signal to the qUPS product that the protected device must be restarted in any case when external power is restored. If the energy storage is below the low charge level, the system will first recharge it to high charge level and then power on the protected device.

3.3.1.1.2 Detection level finetuning

The LS1 and LS2 switches adjust the detection levels to the battery capacity and the power consumption of the protected device. If the level is too high, the waiting time from the start of charging to the start of the device will be unnecessarily long or the full capacity can't be used. If the level is too low, there won't be enough time to start the protected device and then to disconnect it stably.

Switching voltage levels from low to high:

- LS1 – OFF LS2 - OFF
- LS1 – OFF LS2 – ON
- LS1 – ON LS2 – OFF
- LS1 – ON LS2 - ON

Raspberry type	LS1	LS2
Pi2	OFF	OFF
Pi3	OFF	OFF
Pi4	OFF	OFF
Pi5	OFF	ON

Table 3: Suggested setup in case of 4000mA LiFePo4 battery

3.3.1.1.3 Charge current

Use the switch to change the charging current of the battery: 1A (OFF) or 2A (ON).

If the power supply is not able to supply the combined load of 2A charge current and the current drawn by the protected device, set the switch to OFF. If even at 1A is not sufficient, replace the power supply.



The external power supply may be able to operate the Raspberry without the qUPS, but not through the qUPS. The reason can be that the power supply does not have enough power to meet the increased current demand caused by the battery charging.



It is recommended to avoid a lower quality power supply. When used, current consumption below the indicated maximum load may cause voltage stability problems. If the voltage drops below the level tolerated by the protected device, shutdown or unstable operation will occur.

3.3.1.1.4 Battery technology (BAT)

The qUPS is suitable for use with both Li-Ion/LiPo and LiFePo4 batteries.

For wider temperature ranges and more charging options, we recommend using LiFePo4 batteries. If you buy the qUPS together with the battery, we will also include it with the product.



As the voltage levels of the different chemistries are different (Li-Ion/LiPo 3V - 4.2V, LiFePo4 2.5V - 3.6V), the exact setting of the switch is extremely important to protect the battery!

3.3.1.2 Potentiometer (10) for adjusting the threshold of the input voltage

The reason for this adjustability is to enable the device to operate optimally with different power supply type and any protected device pair.

The threshold voltage of the external power supply can be adjusted by the potentiometer (10). Below this voltage level, the qUPS product switches to uninterruptible mode and above it to external power supply.



If the level is set too high, the device will switch between modes unnecessarily, and in extreme cases it may switch permanently.



If the level is set too low, the device will not switch to uninterruptible mode in a timely manner and the Raspberry may shut down. The Raspberry model 5 is particularly sensitive to power supply voltage.

3.3.1.3 Mode switch (6)

The mode switch has three positions, which are indicated on the panel.

- „OFF” mode

The qUPS product will remove power from the protected device (regardless of the presence of an external power source and the power level of the energy storage device).

- „ON” mode

The qUPS product shall provide power to the protected device if an external power source is available or if there is sufficient power in the energy storage device.



If the charge level of the energy storage device is low and the external power supply is cut off, the protected device will not be able to perform a guaranteed regular load/unload cycle.

- „AUTO” (automatic) mode

The system shall guarantee the execution of a regular boot/shutdown cycle regardless of the loss of external power supply.

3.3.2 Software settings

The qUPS is able to share information with the protected device about the power supply and its own status. This allows the protected device to safely perform the necessary steps for saving and exit before the battery is completely discharged.

The exact details of the power-off and power-on function can be set in software.

The feedback pins in [chapter 3.3.1.1.1](#) are intended to provide information to the device and to perform adjustments on the qUPS product.

4 Usage

4.1 Battery assembly

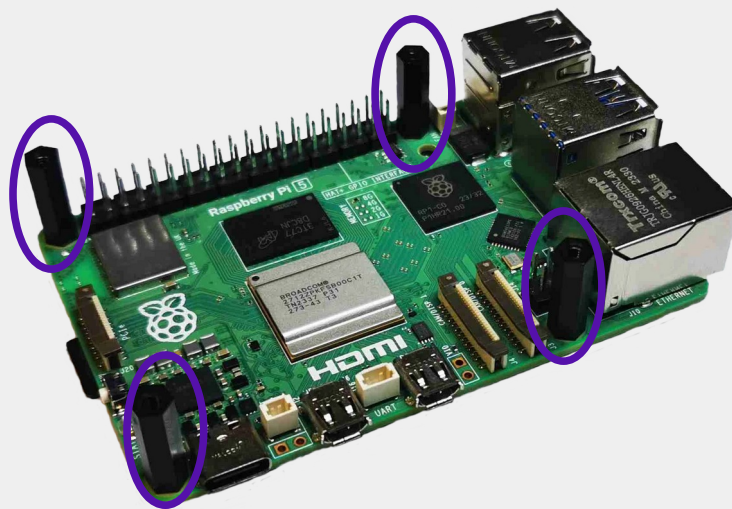
The qUPS-P-BS is supplied without battery. It is also possible to purchase the battery tested by AQEX and fitted with the optimal cable. In this case, correct operation is guaranteed. The package also includes the battery holder and the corresponding screws.

If you use your own battery, you can purchase the battery holder and the necessary screws.

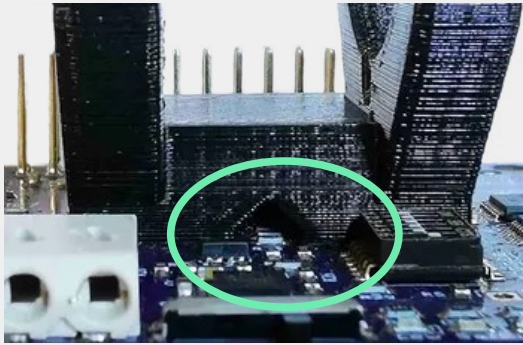
The battery holder can also be produced with your own 3D printer. Anyone can download the 3D design of the holder in STL format from <https://github.com/aqexhu/qups-guard> and use it freely. In this case you will also need 6 1.7x6mm screws for assembly.

Whether you connect your own battery or the optional battery offered by AQEX, please follow the assembly sequence suggested below:

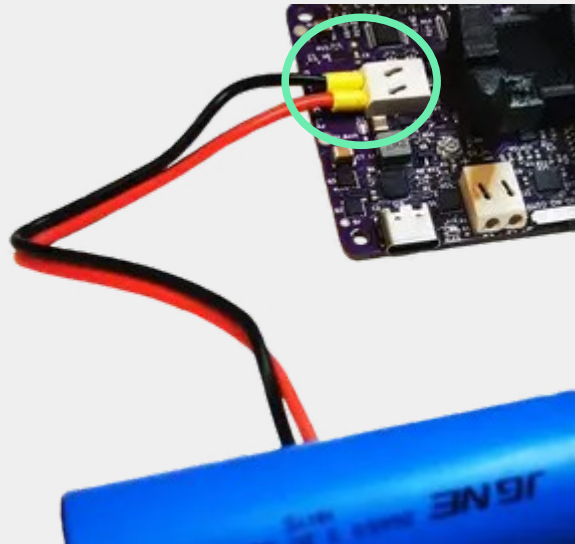
- 1, Set the mode selector switch (6) to "OFF". The protected device is then guaranteed not to be power.
- 2, Screw the 4 spacers included in the qUPS package onto the Raspberry. The package also contains the necessary screws.



3, Screw the battery holder with 4 screws. The holder is placed on the component side of the qUPS panel. Please make sure that the hole on the bottom of the battery holder is above the small parts on the panel. The screws should be screwed in from the bottom of the panel, as appropriate.



4, Plug the battery cables into the qUPS (12) connector. Make sure the polarity is correct.



5, Insert the battery into the battery holder so that the cables are positioned at the bottom of the holder in the recess.



6, Clamp down the battery with the 2 clamping half-rings of the holder. First hook the hooked side of the half-ring into the holder, then unscrew the other side.



7, Fit the qUPS onto the Raspberry as shown in section 3.2.1 and secure with M2.5 screws.

8, The qUPS is ready for operation, you can switch the mode selector switch (6) to "ON" or "AUTO".

4.2 Battery disassembly

The disassembly of the qUPS is done in reverse order of the assembly.



Also before disassembly, remember to set the mode selector switch (6) to "OFF".

4.3 Operation

If properly connected, the system will work under normal conditions with default settings.

The qUPS product will start charging the energy storage after the power supply is connected.



In AUTO mode, the protected device will only be powered when the battery is sufficiently charged. This can take up to minutes depending on the power supply and the qUPS product settings.



In ON mode, the protected device is immediately powered up and starts. If the power supply is interrupted before the battery reaches a critical power level, the protected device can't be safely shut down.

4.4 Switch between mains and battery power

The qUPS product detects the loss of external power supply or a voltage drop below the level set by [potentiometer \(10\)](#). In this case it automatically switches to battery power. When the external power supply is restored, it will switch back and recharge the energy consumed from the battery.



The transition from the mains to battery states will of course take time, but the duration is very short (100-300 μ s.). At this point the output voltage may drop below the operating threshold voltage of the protected device. In case of Raspberry, this state may be detected by the operating system and a "Under-voltage detected! (0x00050005)" alarm may be sent to the user. Due to the short duration of this transient state, it does not cause any downtime or malfunctioning of the Raspberry.

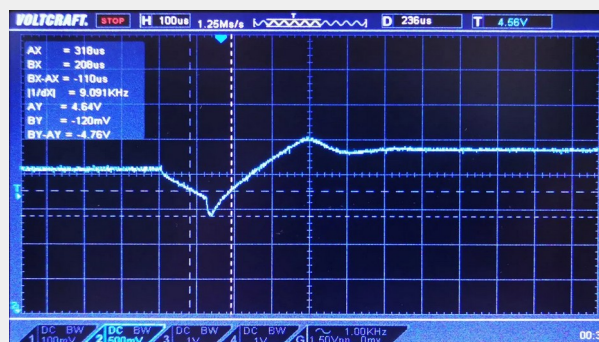


Figure 1: Raspberry Pi 5 at 50% load

No alarm in the event of a switch back to mains power.

4.5 *Intelligent functions*

In addition to providing power to the protected device, the qUPS product can also provide information about the power status and the charge level of the energy storage.

The operation of the qUPS can be influenced by the settings of the protected device.

With this information, the protected device can intelligently and safely prepare for possible power failures that will inevitably occur when the power supply is interrupted. The qUPS provides sufficient time to inform the protected device, which can perform critical pre-shutdown tasks and shutdown safely. This prevents property damage, information security risks and other undesired events.

4.5.1 Event handling

The operating system or program running on the protected device can be prepared to detect in real time the information communicated by the qUPS product and perform various tasks in this context.

Two types of status indications are continuously displayed on the qUPS product:

- presence of external power supply - pfo
- energy storage battery charge level - lim

Via the presetted GPIO pins, the service or program running on the device detects the changes and provides the possibility to trigger pre-set mechanisms.

For more information and utilities written in C and Python, see the <https://github.com/aqexhu/qups-guard> page.

4.6 Level indicator

The battery charge is indicated by the LED group numbered (5).

The five different coloured LEDs indicate the following battery power levels:

1. Low (red): low level, the device can be switched off at any time.



If the device is in "AUTO" mode and the corresponding SHD pin is at low level, this level will disconnect the power from the protected device when reached.

2. Safe (yellow): there is sufficient time for a safe shutdown.

3. Min (green): There is sufficient time for one start-up and one shutdown - in "AUTO" mode the protected device will start.

4. Half (green): The power level is half.

5. Max (green): Fully charged.



The lights indicate the existence of the above charge levels, not a percentage. These levels are not proportional at all.

5 Appendix

5.1 List of supported power adapters

- RaspberryPi official power adapter [5V@2.4A](#)
- RaspberryPi 5 official power adapter 5V@5A
- Goobay 43651 5V@2.1A

5.2 Troubleshooting

Symptom	Cause of error	Solution
Battery is not charging	The temperature of the battery is outside the safety range (in case of NTC)	The battery temperature must be brought within the limit
Battery is not charging	In the absence of NTC, connector (2) is not short-circuited	Short-circuit connector (2)
Raspberry won't start despite having an external power supply	Power supply is insufficient for the combined power requirements of Raspberry and battery charging	Turn the CHARGE pin on switch (3) to OFF
If an external power supply is present, the "External power LED" (8) is not lit	External power supply problem	Replace the power supply
Raspberry will not start if the "Min" LED is on	Mode switch (6) is on OFF state	Mode switch (6) must be set to ON or AUTO