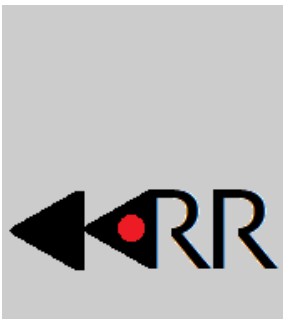

RED REACTOR V1.7

Cambridge, UK

This manual is in draft status and is subject to change

User Manual

THEREDREACTOR.COM

RED REACTOR

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2022

Table of Contents

Chapter

1

Welcome!

Thank you for purchasing a Red Reactor! Please take a moment to read this manual and we hope you will enjoy using the features of your Red Reactor for many years to come. If you have any questions or feature suggestions, please feel free to contact us through our website.

This manual has separate chapters for each of the major functions of your Red Reactor, and, in case of any problems, a trouble shouting guide. Please make sure you read the warnings presented in this document.

Feature Highlights

- Software interface for real-time reading of:
  - Actual battery voltage in software to ensure safe shutdown
  - Battery Current and determine when charger connected/charging
- Supports high currents for the Raspberry Pi and peripherals
- Separates battery from the load for optimum charging cycles
- Supports a Hard Reset function using the same ON/OFF button
- Use standard 5v USB interface for charging
- Seamless transition when external power removed
- Supports a momentary external ON/OFF button
- Extremely low stand-by current (<100uA)
- Can operate with 1 or 2 standard 18650 batteries
- Connects underneath a Raspberry Pi, keeping the 40pin header free

The design is aimed at maximising battery life, and provide hardware battery protection mechanisms.

Detailed technical data is provided at the end of this manual.

Important Information

When using 2 batteries, you must ensure that they are identical parts and both in identical state of charge. If they are not identically charged, you should first fully charge them individually. Though protected by a re-settable fuse, mixing battery brands and charge state may lead to excessive dissipation between the batteries, incorrect charge cycles and premature battery failure, which may present a fire hazard.

Always replace your batteries if you suspect any kind of malfunction.

Only insert batteries when the external power supply is OFF.

☞ **Power Supply**

Please ensure that you only use an external power supply that can provide enough current for your project and the charging current required. Otherwise, you may experience under-voltage warnings on your device, potentially leading to operational failures. Note that some USB cables incur a significant voltage drop and may therefore deliver less power than expected. This product is not designed to operate from mobile phone chargers or battery power banks.

Please note that incorrect use of the Red Reactor may lead to damage of attached devices, and exceeding the capabilities of the Red Reactor may damage the Red Reactor.

Introduction

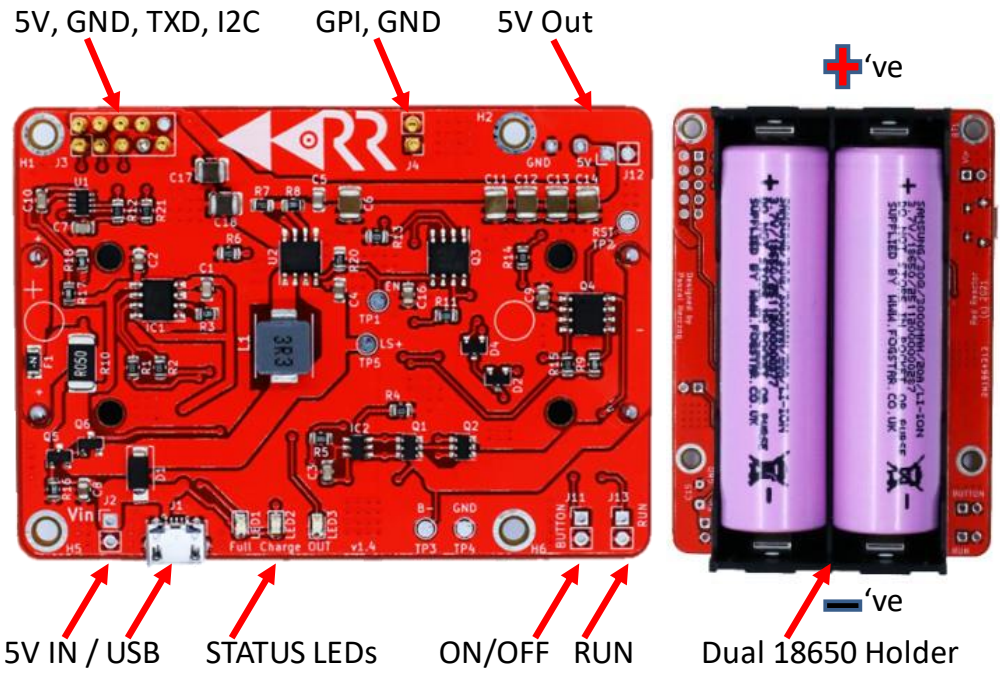
☞ **Important**

The Red Reactor is designed solely for use with 18650 rechargeable batteries, with a maximum voltage of 4.2v. When using protected cells, which are slightly longer, you may need to adjust the battery spring terminals and place a ribbon underneath for safe removal from the battery holder.

The Red Reactor uses internal circuitry that protects the battery from being drained when first inserted. Normally, the board will exit this protected state after a few seconds, but due to component tolerances and battery charge level it may remain in its protected state.

In that case, it must be powered by an external power supply before the output can be turned ON. If the batteries are below the board's under-voltage threshold, they will not be enabled until the charging process has reached the under-voltage release threshold.

It is recommended that you fully charge the batteries before operating without external supply to maximise battery life.



ENSURE CORRECT BATTERY ORIENTATION

You MUST ensure that the batteries are oriented correctly in the battery holder. Failure to do so may result in damage to the board, and could cause severe battery damage.

One or Two Batteries

The board can operate with either 1 or 2 batteries. When only using 1 battery, it is recommended to use the battery slot nearest the 5v/I2C/GND header port (shown top of the picture below), which includes a resettable fuse.

Single BATTERY Use Case

☞ **Important**

For high current applications it is recommended to use 2 batteries, reducing the peak current draw from each and significantly increasing battery life. When using a single battery, the resettable fuse may trigger if drawing more than 3 Amps.

Battery Choice

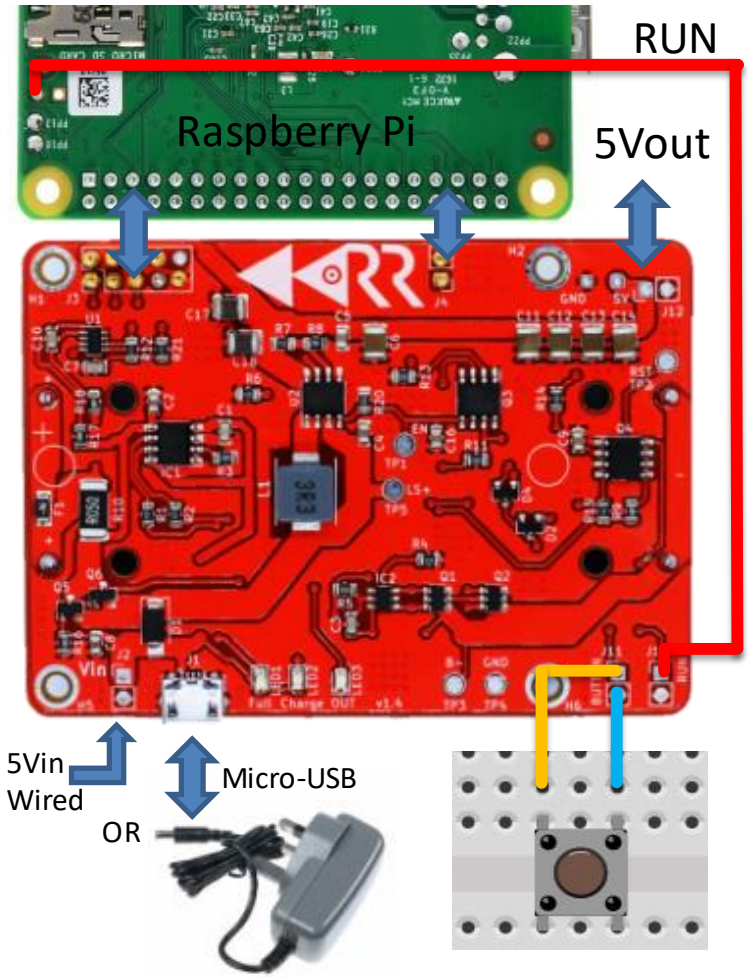
It is strongly recommended that you use batteries from a reputable supplier.

The maximum charge current is set to 1 Amp, and therefore you must use 18650 batteries that are of greater capacity than 1000mAh.

Most 18650 batteries can deliver more than 2 Amps, but beware that current consumption rises as the battery voltage drops, to maintain the same power delivery. For example, if you require 3 Amps at 5 Volts, you will be drawing over 5 Amps from a battery at 2.9 Volts. Using 2 batteries in the Red Reactor will significantly extend their battery life and increase the total power you can draw from the battery (which can be significantly less than the stated capacity under high loads).

By design, the maximum capacity of authentic 18650 batteries does not exceed around 3500mAh – batteries that claim higher capacity should be treated with caution!

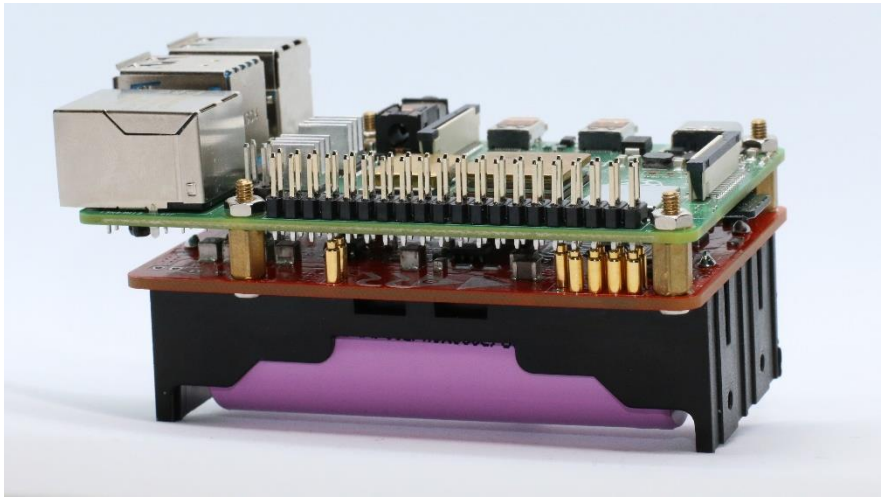
Connections



TYPICAL CONNECTIONS

The Red Reactor has been tested with a Raspberry Pi Model Zero, Model 3A+, Model 3B+ and Model 4 (2GB), for direct connection using the 40-pin header. For other types of CPU board, use the interface information in this guide to provide an appropriate connection.

Before attaching the Red Reactor, please ensure the Raspberry Pi UART is enabled as per section 4, "Raspberry Pi Configuration"



ATTACHING THE RED REACTOR

Do not insert batteries or attach external power until you have verified all connections between the Red Reactor and the Raspberry Pi are correct and secure

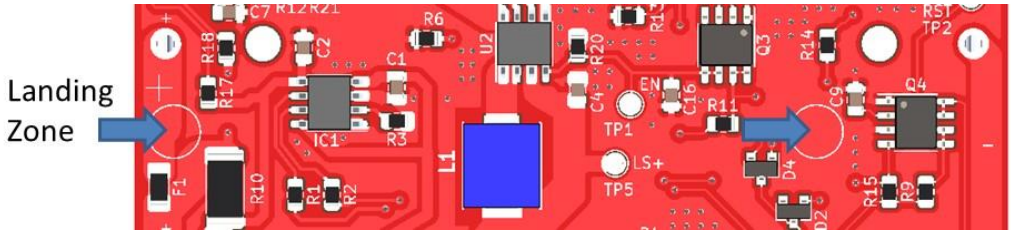
When mounting the Red Reactor as shown above, please ensure that the pogo-pins are mated correctly with the underside of the Raspberry Pi 40pin header before securing the stand-offs. It is recommended to loosely tighten all stand-offs, check the pogo-pin alignment and then push the Raspberry Pi down before fully tightening the stand-offs.

Further information on Assembly

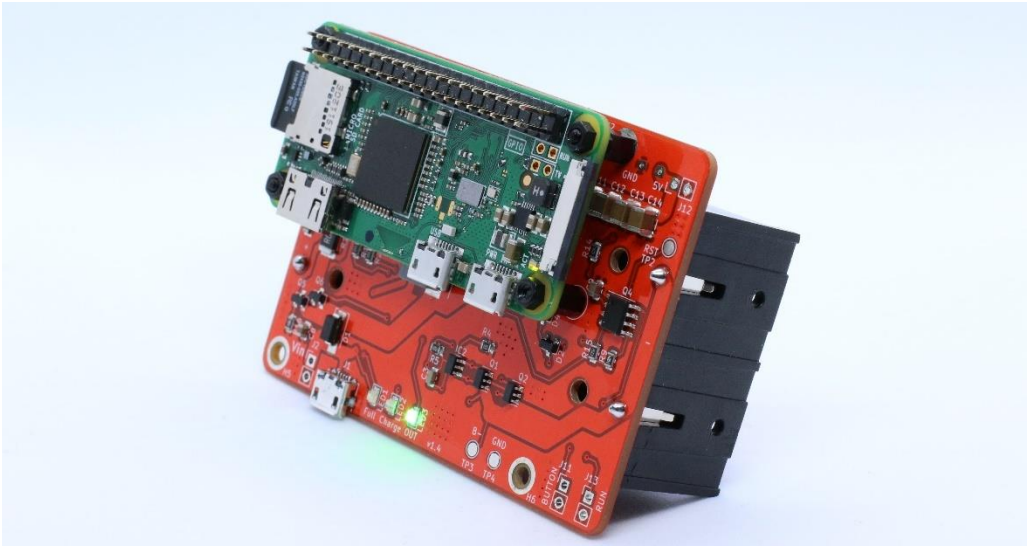
The YouTube video at https://www.youtube.com/watch?v=NvDd5q-TUnc shows how to assemble the Red Reactor with your Raspberry Pi.

Assembly with a Pi Zero

Because of the Pi Zero's narrow form-factor, the 2 mounting holes nearest its USB connectors cannot be screwed into the Red Reactor. Instead, the stand-offs for these 2 locations fit onto the landing zones on the Red Reactor to provide mechanical stability in addition to the 2 stand-offs either side of the 40-pin header location.



The assembly is shown in the picture below:



To attach the Raspberry Pi Zero, please follow these steps:

- Attach 2 nuts and stand-offs provided to the Pi Zero mounting holes nearest its USB ports (with the nut on the Pi Zero top side to hold the stand-off)
- Attach 2 further nuts and stand-offs to the Pi Zero, again, with the nuts on the top side of the Pi Zero
- Place the Pi Zero carefully on top of the Red Reactor, aligning the pogo-pins
    - The front stand-offs sit directly on the Red Reactor landing zones
- Insert the 2 screws for the header side stand-offs, gently squeeze the boards together to re-check alignment and tighten the screws
- Confirm correct mounting before applying power

Important for First Use

The Red Reactor requires the Raspberry Pi to be configured correctly to maintain the power supply after pressing the ON button. The required configurations are documented in the chapter Raspberry Pi Configuration.

☞ **Important**

On first use, if you have not already configured the Raspberry Pi, then you will need to maintain the power supply by keeping the ON pin grounded (i.e., by connecting the 2 ON Button pins together) until you have applied the configurations and shutdown the Raspberry Pi. Alternatively, you could apply the required configurations to the Pi **before** connecting the Red Reactor, as they do not interfere with normal Pi operation.

Turning ON

If using the Raspberry Pi TXD header signal to maintain power, a simple momentary button can be used to turn the supply ON. With a Raspberry Pi Zero, Model 3A+, 3B+ and Model 4, the ON button input must be pulled to ground for typically less than 2 seconds to enable the Raspberry Pi to assert TXD and maintain the ON state.

The Red Reactor maintains the ON state for around 4 seconds after releasing the ON button, and after the TXD signal is de-asserted. This enables the Red Reactor to support the reboot sequence, during which the TXD signal is briefly de-asserted.

Any subsequent grounding of the ON button input can trigger a software interrupt which may be used to interpret a short, medium or long press and take action, such as issuing a shutdown command. The Raspberry Pi will then automatically de-assert the TXD signal which will turn off the power supply around 4 seconds after shutdown.

If the ON button input is pulled to ground for approximately 7 seconds, it will pull the RUN signal to ground. If this is wired to the RUN port of a Raspberry Pi, it can be used to force a hard reset in case your software has become non-responsive to the ON button interrupt.

Once the Raspberry Pi has been reset, it will restart by releasing the ON button.

If the Raspberry Pi TXD signal is not used to maintain power, it is necessary to use a latched-ON switch. Note that in this case it will not be possible to receive button press software interrupts and you should only de-assert the ON switch when it is safe to do so.

When using a latched-ON switch., the RUN signal will be pulled low after 7 seconds, and so should not be used as a hard reset signal.

☞ **Important**

External power should be provided **EITHER** through the Micro-USB port, **OR** by directly wiring to the VIN/GND port of the Red Reactor. Do not connect to both inputs simultaneously, and do not draw power from the VIN port or USB connector.

DO NOT Connect power to the Raspberry Pi's USB power input when the Red Reactor is attached

When the Red Reactor is connected to external power, you must use a power supply that meets the power demands of your design, accounting for any additional charging current. For high current applications (>2.5 Amps total) it is required to solder directly to the Vin power input ports.

A regulated 5V Output is available for use with ancillary devices. This output is supported by 600uF (± 20%) ceramic capacitance to smooth the output. Nevertheless, if attached devices create significant current peaks you may observe brief under-voltage warnings from the Raspberry Pi. In this case, additional capacitance (e.g., Electrolytic) may be added via the mounting holes provided. Be aware of any height constraints when mounting underneath a Raspberry Pi.

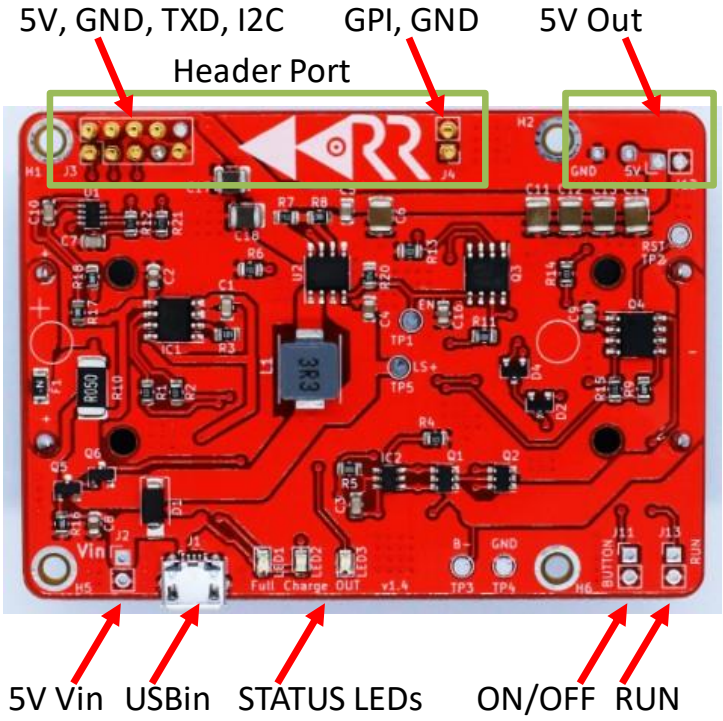
Please note that because of the high output capacitance and low stand-by power drain, the output voltage may take some time to fully dissipate when the Red Reactor is turned off, and should be handled with care during this time.

Chapter

2

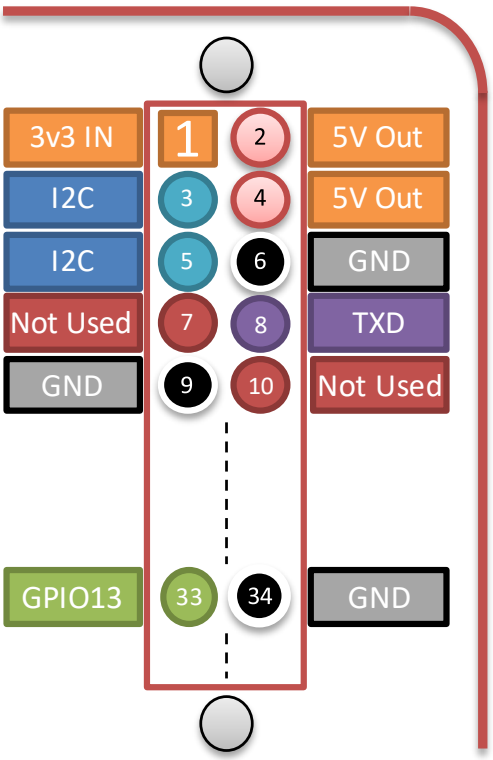
Interfaces

The Red Reactor can be mounted directly underneath a Raspberry Pi, or wired via header pins.



RED REACTOR INTERFACES

Header Port



RED REACTOR HEADER PORT

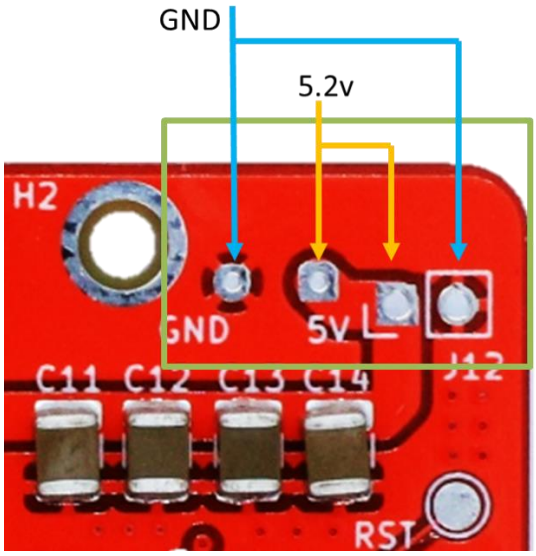
This port provides the following interfaces:

- 3v3 IN – input from Raspberry Pi for I2C I/F
- I2C – Software I/F for Battery Monitoring
- 5V OUT – Powers Raspberry Pi
- TXD – Raspberry Pi output maintaining ON state when HIGH
- GPIO13 – Raspberry Pi input, Falling Edge for ON button press

The 5V output is set to provide 5.2v, equivalent to the typical output of a standard Raspberry Pi USB power supply.

Ancillary Port

The Ancillary Port may be used to power additional devices. This output is shared with the Raspberry Pi 5V Out, and automatically enabled/disabled at the same time.

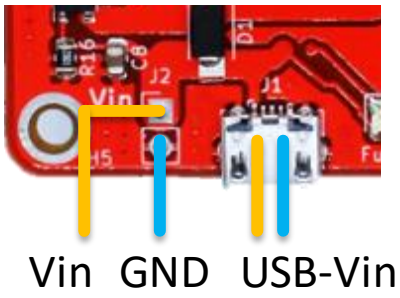


RED REACTOR ANCILLARY PORT

The 5V Ancillary Port is set to provide 5.2v. Internal protection limits the total current to 6 Amps from the battery. If this is exceeded, the load is disconnected from the battery and the Red Reactor is turned OFF. The battery is reconnected by connecting an external power supply. It is possible to use the through-holes of this port as a mounting point for additional capacitance (e.g., by using an electrolytic capacitor).

If the Red Reactor is connected to a powered charger, the output current is limited by the voltage regulator to approximately 5.6 amps. Note that board temperature may impact these limits. Devices drawing significant current may generate peaks triggering a shutdown.

Vin Port



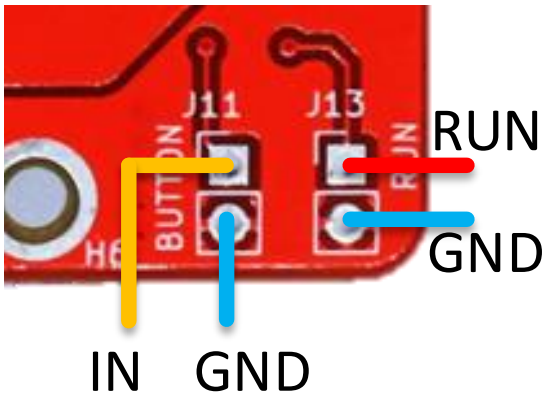
RED REACTOR VIN PORT

You must only connect to either the USB-Vin port, or wire directly to Vin and GND.

Input voltage must be 5v +/- 5%. The USB-Vin connector meets the USB2.0 requirement.

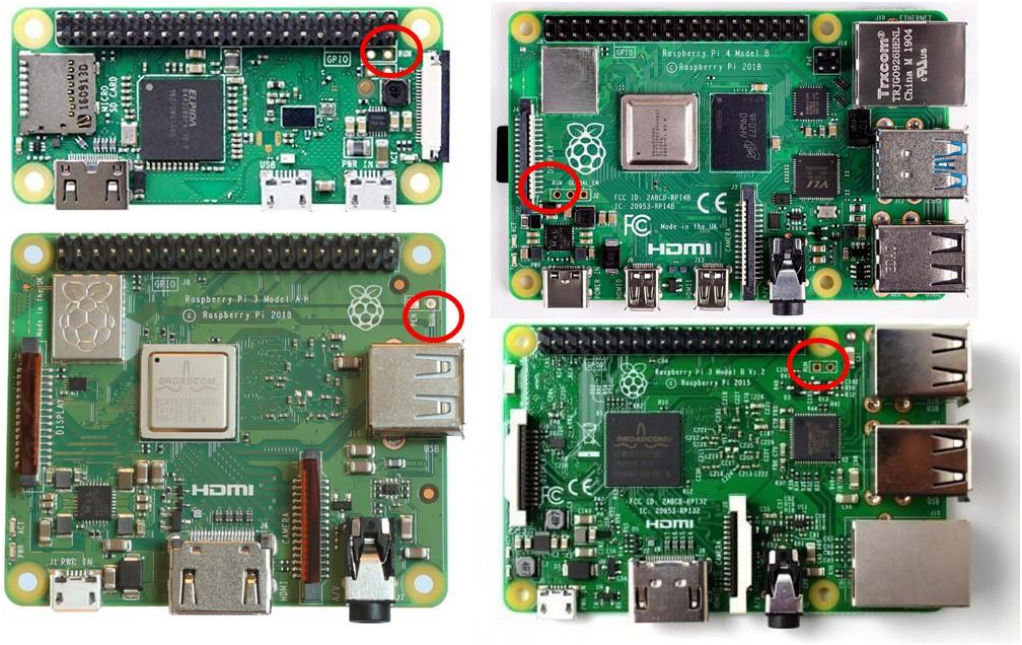
BUTTON and RUN Ports

The Button Port enables connection of an external ON/OFF button, by simply momentarily connecting the IN port to GND.



RED REACTOR BUTTON AND RUN PORTS

The RUN input can be wired to the Raspberry PI's RUN signal, and will be pulled to GND when the Button port IN signal is pulled to GND for approximately 7 seconds. Subsequently, the output power will go OFF approximately 4 seconds after the IN signal is disconnected from GND. The GND port on the RUN header is not required for normal use.



RUN PORT LOCATIONS ON RASPBERRY PI

Status LEDs

LED	Colour	Meaning
Charging	RED	ON whilst battery is charging FLASHING if NO batteries fitted
FULL	GREEN	ON when charging is complete or battery fault detected
ON	GREEN	ON when 5v Output is enabled

If external power is removed, only the ON LED will light whilst active.

I2C - Battery Monitoring

The Red Reactor uses a INA219 Voltage and Current Measurement IC. It is configured to measure across a highly accurate 0.05 Ohm resistor on the battery +ve supply. It is accessed via the I2C interface. It requires the 3v3 I2C supply from the Raspberry Pi to operate.

Reading Current

When the battery is charging, ampere readings will show negative numbers (e.g., -900 mA). When charging is complete, with external power active, the readings will show <5mA positive numbers. This can be used to identify that charging is complete.

The charging current will vary depending on the state of the battery. The limit is set at approximately 1000mA, and is shared if 2 batteries are fitted.

When operating directly from the battery, readings will show positive numbers. Note that the ampere readings are measured at the battery voltage when calculating power. Therefore, for steady state operation, you would see an increase in current as the battery voltage slowly decreases.

Reading Voltage

This provides an accurate battery voltage reading. Note that when drawing power from the battery, instantaneous current demands may mean the numbers can vary over a short time, and you may wish to average the readings when using the results to determine operating state changes, such as forcing a shutdown in software.

Battery Fuse

When using 2 batteries, they are connected in parallel. A 6A resettable fuse prevents a large discharge of current from one battery to the other in case of battery failure. If this has triggered, you should replace both batteries. The fuse is automatically reset when its temperature drops.

Chapter

3

Battery Management

Battery Charging

The Red Reactor uses a Battery Management IC for charging. The maximum charge current is set to 1 Amp to maximise battery life. When using a single battery, its capacity must be at least 1000mAh.

Thermal feedback within the IC regulates the charge current to limit the die temperature during high power operation or high ambient temperature.

The charging cycle is switched from constant current to constant voltage as necessary. It is terminated at a battery voltage of 4.2v +/- 1.5%.

When the battery voltage drops to 4.05v the charge cycle starts again.

☞ **Important**

You should ensure that the batteries are above 0^0C when charging for maximum safety. The battery temperature is not monitored by the Red Reactor.

Battery Protection

The Red Reactor uses a Battery Protection IC to provide Over-charge, Over-discharge and Over-Current protection.

It has the following performance characteristics:

Metric	Min	Typical	Max
Over-Charge Detection Voltage	4.25v	4.3v	4.35v
Over-Charge Release Voltage	4.05v	4.10v	4.15v
Over-Discharge Detection Voltage	2.30	2.40	2.50
Over-Discharge Release Voltage	2.9	3.00	3.10

BATTERY PROTECTION THRESHOLDS

Over-Charge Protection

The charging voltage is controlled by the Battery Management IC. As an added protection, if the Battery Management IC charging voltage exceeds the over-charge detection voltage, the battery voltage is reduced by the protection IC. When the over-charge voltage drops below the over-charge detection voltage, the battery charging voltage is restored.

Whilst the Red Reactor is connected to external power, the output can remain active.

Over-Discharge Protection

If the system software does not take action at the recommended minimum voltage level for your battery, the battery will be disconnected from the load when the battery voltage reaches the Over-Discharge Detection Voltage.

Battery operation is restored when a powered charger is connected and the battery voltage reaches the Over-Discharge Release Voltage.

☞ **Important**

It is highly recommended to use software to shutdown your system at or before reaching the battery specified minimum voltage to maximise battery life.

Over-Current Protection

The over-current protection is set to 6 Amps measured over 20ms. If the Over-Current Protection is triggered, the battery is disconnected from the load.

Battery operation is restored when a powered charger is connected.

Note that when only using 1 battery, the top battery slot is protected by a resettable fuse. This is specified not to trigger below 3 Amps, and designed to trip at 6 Amps (measured at 20^0C, these numbers may reduce at higher temperatures). Therefore, this fuse may trigger first depending on the current profile. This will also disconnect the load from the battery, but the connection is automatically restored when the fuse temperature is reduced.

Please note that some external devices may draw a significant in-rush current when switched on, and could trigger the over-current protection mechanisms depending on total current drawn.

You must ensure that you choose batteries that are specified to deliver the amount of current that your system requires, otherwise this may lead to premature battery failure. Prolonged high current usage, particularly at lower voltages will significantly shorten battery life.

Operating without Batteries

It is possible to operate the Red Reactor without batteries. In this case, the red CHARGING LED will flash rapidly whilst the green FULL LED will remain ON, indicating a Battery Fault condition.

Please note that in this case, the voltage readings on the I2C interface will show varying values around 4.65v as a result of the Battery Fault condition.

Please note that the Battery Fuse and the over-current output protection of the Battery Protection IC are ***NOT Operational*** in this case. The current limiter of the Vout voltage regulator remains operational.

☞ **Important**

Do not insert batteries whilst the Red Reactor has external power.

Chapter

4

Raspberry Pi Configuration

The Raspberry Pi should be configured to assert the TXD signal immediately upon booting, which is typically within a few seconds from applying power.

Step 1 – Enable the TXD and I2C ports

The following must be applied before connecting to the Red Reactor:

- Enable the UART, either via
  - The command line, use
    - **`sudo raspi-config`**
      - ⇨ Select **`3 – Interface Options`**
      - ⇨ Select **`P6 – Serial Port`**
      - ⇨ Select **`NO for Login-shell over serial`**
      - ⇨ Select **`YES to Enable Serial Port`**
      - ⇨ Select **`OK to Confirm the settings`**
      - ⇨ **`Repeat for P5 to enable the I2C Port`**
      - ⇨ Select **`FINISH to exit`**
  - **OR**, use the Raspberry Pi Configuration menu in the Desktop Graphical User Interface (GUI)
    - From the Applications Menu (start) icon:
      - ⇨ Select **`Preferences`**
      - ⇨ Select **`Raspberry Pi Configuration`**
      - ⇨ Select **`Interfaces`**
      - ⇨ Select **`Enabled for the Serial Port`**
      - ⇨ Select **`Disabled for the Serial Console`**
      - ⇨ Select **`Enabled for the I2C`**
      - ⇨ Select **`OK to confirm`**

Step 2 – Verify the Boot Command File

You can verify this setting by confirming that the `/boot/cmdline.txt` file contains the `CONSOLE=TTY1` entry. From the command line, use:

- ⇨ **`cat /boot/cmdline.txt`**
- ⇨ **This should include the following text (all lower case):**

```
console=tty1
```

An example line is shown here, with spaces either side of the above command:

```
dwc_otg.lpm_enable=0 console=tty1 root=/dev/ …
```

Step 3 – Modify the /boot/config.txt File

Use the following command line to open the `/boot/config.txt` file in an editor, after opening a command shell:

- **`sudo nano /boot/config.txt`**

With this file, scroll down to the `[all]` section:

- Ensure the TXD output is asserted by the UART function:
  - Verify that the `/boot/config.txt` file contains:

    ```
    [all]
    enable_uart=1
    ```

- Control the TXD output on shutdown
  - Add the following in the same `[all]` section – **all on one line and no spaces**:

    ```
    dtoverlay=gpio-poweroff,gpiopin=14,
    active_low=1,timeout_ms=5000
    ```

  - *Please note that a copy/paste of the above text may insert a space before 'active_low' – if so, please ensure to delete it*

- Verify that the I2C port is enabled
  - Verify that the `/boot/config.txt` file contains:

    ```
    [all]
    dtparam=i2c_arm=on
    ```

To manually edit the `/boot/config.txt` or `/boot/cmdline.txt` file, you must do so as super-user (e.g., `sudo nano /boot/config.txt`)

To exit the editor and save the changes, press CTRL and X, then Y to confirm saving.

A reboot will be required for the changes to take effect.

The ON button maintains power for a few seconds after being released, however, power may be turned OFF if it is released before TXD is asserted. On device shutdown, power is maintained for a few seconds after TXD is de-asserted, allowing the device to restart when using the 'reboot' command.

Verify I2C operation

This can only be done once the Red Reactor is attached to the Raspberry Pi, and the batteries have been enabled by supplying external power.

Test access to the INA219 Battery Measurement IC on the I2C interface from the command line using:

```
i2cdetect -y 1
```

This should show the following result:

```
     0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f
00:          -- -- -- -- -- -- -- -- -- -- -- -- --
10: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
20: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
30: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
40: 40 -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
50: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
60: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
70: -- -- -- -- -- -- -- --
```

The entry at address 0x40 is the INA219 IC. If you do not see this response, please ensure that the I2C interface is enabled via the raspi-config or GUI Desktop utilities.

☞ **Important**

If you have another I2C device attached that occupies address 0x40, you must change the address of that device to avoid conflict. You cannot change the address of the Red Reactor.

Software Battery Management

It is recommended that software monitors the state of the battery at regular intervals. To maximise battery life, it is important to use the voltage readings to determine when the system should shut down, instead of operating until the Red Reactor forces the power off. This also helps protect the memory card from corruption.

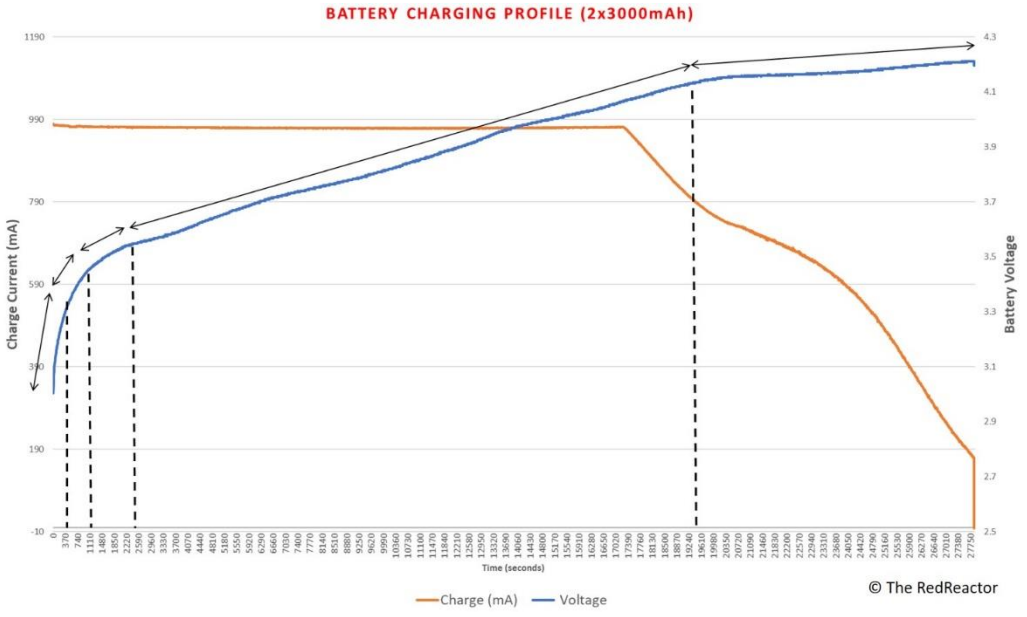
☞ **Important**

It is recommended to set the minimum voltage at around 2.8 to 3v. Voltage readings will vary depending on instantaneous power demands, so you may wish to monitor both a short-term average and an absolute minimum threshold. Note that at lower voltages, the battery has to supply more current for the same power demand.

When operating in colder ambient temperatures both peak power and low operating voltages are more damaging to battery life.

Due to the nature of batteries, the charging times may vary.

Note that whilst the batteries are charging, the voltage readings are as set by the Battery Management IC battery charging profile. Therefore, this will read approximately 4.2v before the batteries are fully charged. By monitoring the current flow you can determine when the end of the charging cycle has been reached.



BATTERY CHARGING PROFILE (ABSOLUTES MAY VARY)

The graph shows the different stages of the charging profile, starting from deep discharge through to fully charged using constant current and constant voltage phases. When using different battery capacities, the voltages at which these transitions occur remains the same, but duration of each phase will change.

Detecting Button Press

You can configure your Raspberry Pi software to detect the button press via the GPIO input port GPO13 (pin header number 33). It will present a falling edge and can be used with software debouncing and timers to distinguish between a short and long press.

See the Python application software examples in the next chapter and on our website.

Do not configure GPIO13 as an output, since it will be pulled to GND by the Red Reactor.

Using the OS to detect the button press for safe shutdown

If you do not wish to manage the Button in your own software, it can be configured to enable the Operating System to detect a long button press and automatically trigger a safe shutdown. This may be useful for example when running 3rd party OS images and software that controls all normal operations of your system.

☞ **Important**

Note that when using this configuration, you cannot use your own software (with, e.g. the Python GPIO library) to enable edge detection on the same GPIO pin. However, you can simply wire the GPO13 pin to another available GPIO input pin so that you can detect button presses in software on the new pin, whilst the OS takes care of shutdown on a longer button press on GPIO13.

Use the following command line to open the `/boot/config.txt` file in an editor, after opening a command shell:

- **`sudo nano /boot/config.txt`**

With this file, scroll down to the `[all]` section:

- Add the following in the same `[all]` section – **all on one line and no spaces**:

```
dtoverlay=gpio-shutdown,gpio_pin=13,debounce=3000
```

To exit the editor and save the changes, press CTRL and X, then Y to confirm saving.

A reboot will be required for the changes to take effect.

The debounce value of 3000 configures a 3 second wait before triggering. It is recommended to make this at least a few seconds to avoid accidental triggering.

Chapter

5

Application Software

We have created a number of software applications that you can use to manage the Red Reactor, and as example code should you wish to incorporate these functions into your own application development.

At the time of writing, the following applications are available (please check our GitHub sites for regular updates):

- Example code for detecting ON button presses (e.g., short, medium, long)
- Example code for monitoring Battery Voltage, Current, Battery Charge and whether a charger is connected / not connected, including automatic shutdown
- A Pi Battery Widget that creates a battery icon in your GUI desktop status bar, with battery status and battery life information, including battery low warning and automatic system shutdown warning
- A Flask based Python Web Application for Remote Monitoring of your system, with graphs showing voltage, current and device temperature, and full control over the monitoring process including remote reboot and shutdown functions

To run these applications you will need to install several supporting libraries, as detailed in our GitHub repositories, which you can find at:

- GitHub – RedReactor
  - This also contains this manual, and the Remote Monitoring Software
- GitHub – Pi-Battery-Widget
  - Includes an installation script

Our website (https://www.theredreactor.com) also contains news articles describing further details of these applications.

☞ **Important**

These applications have been fully tested on the Buster and Bullseye (32-bit) OS versions for the Raspberry Pi products**. Nevertheless, you should always ensure that the software is functioning as intended before using them in your system.**

Example Software

Example Python routines are available via our GitHub site.

Please ensure you have installed the required python libraries and enabled the I2C interface.

The SHUNT_OHMS value is set to the Red Reactor resistor value used to measure voltage and current. Set MAX_EXPECTED_AMPS to your target (e.g., 5.5, do not exceed 6.0)

The INA219 library will automatically scale the measurement resolution, but see our GitHub site for more information.

```
# Import libraries
from ina219 import INA219  # This controls the battery monitoring IC
from ina219 import DeviceRangeError  # Handle reading errors

# Constants
I2C_ADDRESS = 0x40       # RED REACTOR I2C address
SHUNT_OHMS = 0.05        # RED REACTOR Measurement Shunt (defined in Ohms)
MAX_EXPECTED_AMPS = 5.5  # Set Current Measurement Range
```

This shows how to access the readings (for simplicity without error handling, please see our example code for full details)

```
# Verify that RED REACTOR is attached (on I2C bus 1), else abort
red_reactor = INA219(SHUNT_OHMS, MAX_EXPECTED_AMPS, busnum=1)
red_reactor.configure(red_reactor.RANGE_16V)

voltage = red_reactor.voltage()  # In Volts
current = red_reactor.current()  # In mA
```

To detect the GPI button press in Python, the following library and configurations can be used:

```
from gpiozero import Button as GPIOButton  # Used to access pin state
import time

# Constants
# Monitors GPI Button; GPIO-13 is the ON button pin on the 40-pin header
gpio_button = 13
```

```
def pwr_button_pressed():
    # Triggered by GPIO interrupt
    while pwr_btn.is_active:
        time.sleep(1)


pwr_btn = GPIOButton(gpio_button, bounce_time=0.2)
pwr_btn.when_activated = pwr_button_pressed
```

Additional Interfacing Examples

The Red Reactor YouTube channel has a number of videos to show how you can extend the capabilities of the Red Reactor for your projects:

- Using an RTC to Power ON
  - This shows you how you can add an RTC that enables you to completely power down your system, reducing stand-by current to a few micro-amps, until the RTC alarm triggers the ON button to restart everything. A second alarm could be used to trigger a timed power down too!
  - The RTC module interfaces via the I2C and ON button ports
  - Example use cases include battery based remote monitoring, and timed availability of application servers (e.g., between 8am and midnight)
- Enabling External Power Auto-ON
  - This shows how you can use a simple circuit to trigger the ON button when external power is restored, whilst giving you the option to continue on batteries or power down when external power has failed.
  - This interfaces directly to the ON button port (alongside your normal ON button)
  - Example use cases include server based systems whose power drain limits available battery life, or where external systems cannot continue without external power, such as 3D printers
- Hard Reset Feature
  - This short and simple video shows you how to use the ON button system reset feature to force your Pi to restart – handy if your software gets stuck and is not responding to normal inputs!
  - Simply wire the RUN port to your Pi
  - Example use cases include where you have encased the whole system making battery access more difficult, since this avoids having to remove the batteries to force a shutdown when the system has got stuck!

Please visit our YouTube channel and our website for additional examples and information. We'd love to hear from you about your projects and ideas for new features!

Appendix

A

Possible issues and solutions

As with any product, unfortunately there may the times when you experience issues with your Red Reactor. If the problem persists after following these guidelines, please contact us at https://www.theredreactor.com/ for support.

This chapter covers some fault-finding guides.

Issue	Possible Cause	Action
No output power after first inserting batteries	The Red Reactor may have entered the battery protection state	Normally this is cleared after a few seconds, but it cannot exit protection state whilst the ON button is pressed. Enabling external power will also exit protection state.
Charging LED Flashing	No batteries, Faulty batteries or inserted incorrectly	Check battery fit and condition
Power Output does not stay ON	Power Output not held by TXD signal	Ensure the TXD signal is correctly asserted (check the config.txt file). If not available, use a latched ON switch
Under-voltage lightning symbol on Raspberry Pi	External Power Supply not able to provide sufficient current to power device and charge battery	Ensure adequate external power supply. Consider wiring directly to Vin input port. Note, some USB devices such as USB Hubs can draw significant current when first plugged in, triggering the lightning symbol. This is normal and should clear immediately.

Issue	Possible Cause	Action
Under-voltage lightning symbol on Raspberry Pi	Very high peak current draw from attached ancillary device	Power separately or consider adding additional smoothing capacitance on the 5V Out port
Battery is not charging	Insufficient Vin/USB voltage	5v Required
Battery is not charging	Internal IC temperatures triggered charging stop	After some time the charging process will automatically resume. Check air ventilation.
Battery is not charging	Battery fault	Replace both batteries

Safety Notices

- Handle with care to avoid electrostatic discharge damaging the circuitry; do not touch the electronic components
    - Some components may retain a voltage for some time after disconnecting external / battery power due to the ultra-low stand-by power consumption and capacitors in the system
- Ensure adequate air ventilation particularly when charging the battery
- Do not expose this product to heat from any source; it is designed to operate at normal room temperatures
- Do not expose this product to water or moisture
- Take care when handling this product to avoid sudden shocks or physical damage
- Do not place near strong magnetic sources
- Do not use sharp / metal objects on the PCB
- If not using the Red Reactor for an extended period it is safest to remove and store the batteries in a protected case. Charge them to around 3.7v before removal for maximum battery life.
- Regularly inspect the batteries for signs of damage, and replace them when necessary. The Red Reactor cannot protect your design from drawing more current than that specified for the battery, if this is less than 6 Amps.
- Ensure the Red Reactor power input is OFF when inserting batteries
- Do not use for safety critical applications

Acknowledgements

Aspects of this design were inspired by the TinyUPS design hosted on EasyEDA.