Strato Pi User Guide

January 2017

Revision 009

Board version 2.0

Be sure to always remove the power supply before connecting or disconnecting the Strato Pi board to Raspberry Pi.

In order to meet the relevant CE requirements, Strato Pi must be operated fully enclosed in its DIN-rail case.

Follow all applicable electrical safety standards, guidelines, specifications and regulations for installation, wiring and operations of Strato Pi.

Carefully and fully read this Strato Pi user guide before installation.

Strato Pi is not authorised for use in safety-critical applications where a failure of the product would reasonably be expected to cause personal injury or death. Safety-critical applications include, without limitation, life support devices and systems, equipment or systems for the operation of nuclear facilities and weapons systems. Strato is neither designed nor intended for use in critical military or aerospace applications or environments and for automotive applications or environment. Customer acknowledges and agrees that any such use of Strato Pi is solely at Customer's risk, and that Customer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

Sfera Labs S.r.l. may make changes to specifications and product descriptions at any time, without notice. The product information on the web site or materials is subject to change without notice.

Please download and read the Strato Pi Terms and Conditions document available at:

http://www.sferalabs.cc

Introduction

Strato Pi enhances the Raspberry Pi Model B version 2 and 3 computers with several hardware features to make it suitable for use in professional applications where reliability and service continuity are key requirements.

Strato Pi Base and UPS versions are available as bare boards or fully assembled units including a Raspberry Pi 3 Model B in a standard DIN-rail case.

The information contained in this manual covers all versions, except where explicitly stated otherwise. The bare board is called “Strato Pi board”, while the assembled unit is “Strato Pi server”.

All versions of Strato Pi are compliant with the 2014/35/UE (Low Voltage) and 2014/30/UE (EMC) CE directives and harmonised standards for electromagnetic compatibility (EN61000-6-2:2005), electrical safety (EN60664-1:2007), emission (EN61000-6-3:2007) as well as the RoHS directive for hazardous substances (2011/65/UE).

WiFi and Bluetooth must be disabled on the Raspberry Pi 3 to meet the above CE directives. Also, the Strato Pi serial ports are not compatible with Bluetooth operation.

Features

Strato Pi Base and UPS boards:

- ✓ 9-28Vdc power supply, with surge and reverse polarity protection, and 1.1A resettable fuse
- ✓ up to 3.1A max current to the 5V Raspberry Pi power supply input pins (at 24Vdc)
- ✓ real time clock with on-board lithium back-up battery
- ✓ standard RS-232 and RS-485 interfaces to the Raspberry Pi serial line, with opto-isolator and electrostatic discharge protection
- ✓ on-board buzzer, connected to an I/O pin of the Raspberry Pi board, for acoustic feedback
- ✓ hardware watchdog implemented in the Strato Pi board, fully independent from the Raspberry Pi, controlled via the I/O pins of the Raspberry Pi board
- ✓ on-board LEDs for power supply and serial line activity
- ✓ power supply and serial connections on a screw terminal block
- ✓ compliant with 2014/35/UE (Low Voltage), 2014/30/UE (EMC), EN61000-6-2:2005 (EMC Immunity), EN60664-1:2007 (Electrical safety), EN61000-6-3:2007 (Emission) and 2011/65/UE (RoHS)

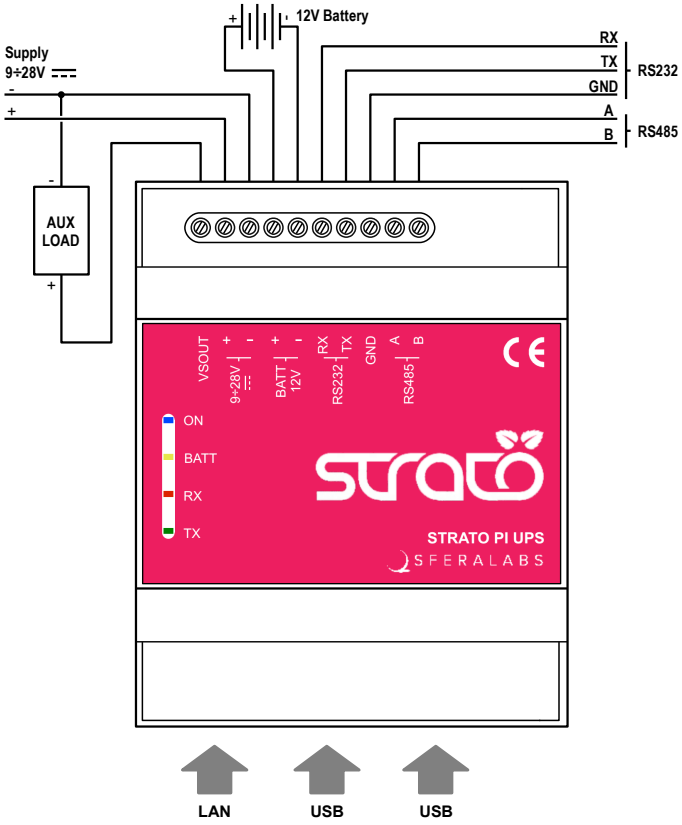
Strato Pi UPS board only:

- ✓ all features of the Strato Pi Base board
- ✓ integrated uninterruptible power supply, with external lead-acid 12V battery
- ✓ 1.1A resettable fuse on battery input
- ✓ auxiliary power supply output voltage, to power external devices with the Strato Pi UPS
- ✓ simple UPS status and control via the I/O pins of the Raspberry Pi board
- ✓ on-board LED for battery operations status

Strato Pi server only:

- ✓ pre-assembled and tested Raspberry Pi 3 Model B with Strato Pi board (base or UPS version) in a standard 4 modules DIN rail case
- ✓ side access to HDMI and 3.5mm jack for audio and composite video
- ✓ access to all USB ports and Ethernet port (opposite to the power and serial terminal block)
- ✓ WiFi and Bluetooth must be disabled on the Raspberry Pi 3 to meet the above CE directives. The Strato Pi serial ports are not compatible with Bluetooth operation.

Usage and connections



STRATO PI UPS CONNECTION DIAGRAM

Hardware Installation

Strato Pi boards

The Strato Pi boards are supplied with all connectors pre-installed. No soldering is required. You should connect Strato Pi to Raspberry Pi aligning the GPIO connector. Use appropriate turrets/spacers to firmly bolt the two boards together, ensuring that no conductive part of one board touches any part of the other board.

Be particularly careful to ensure there is enough clearance between the Ethernet and USB connectors and the bottom of Strato Pi's circuit board.

Strato Pi server

The Strato Pi server comes pre-assembled with a Raspberry Pi 3 Model B board, in a plastic standard DIN-rail case.

There is no need to open the case, unless a change in the RS485 termination resistors is required (see below).

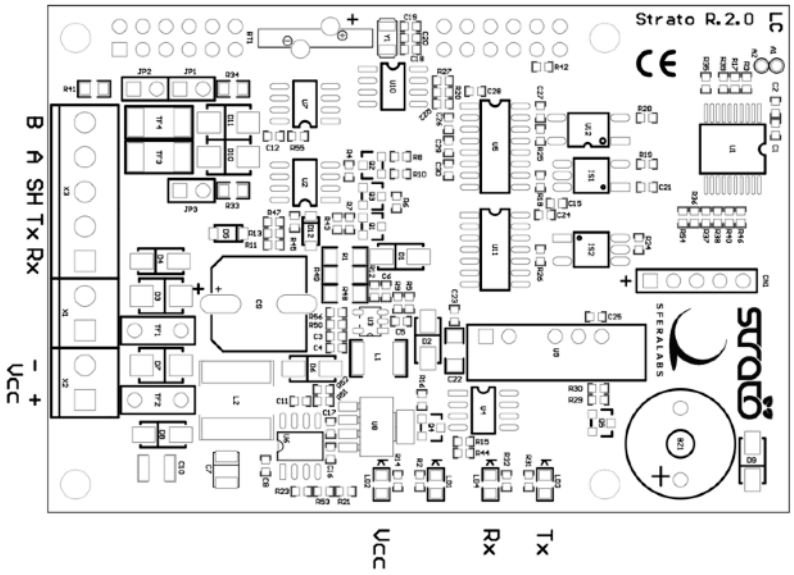
The Micro SD card (not provided) can be inserted through a small opening on the side of the case. Use a small pen or paper clip to gently push the card in its slot.

Terminal block

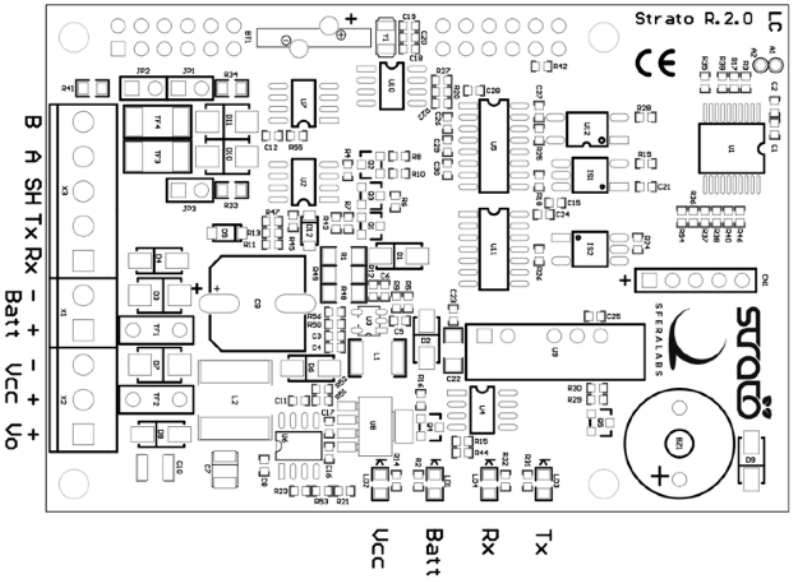
Strato Pi Base has a 9 positions terminal block, used for power and serial connections.

A 10 positions terminal block is used on Strato Pi UPS for power, battery, auxiliary power supply output and serial connections.

The maximum conductor cross section is 1.5 mm^2 (16 AWG), or 0.5 mm^2 when using ferrules (highly recommended). Recommended stripping length is 5 mm. Screw thread is M2. Never exceed 0.25 Nm torque when tightening the screws.



THE STRATO PI BASE CIRCUIT BOARD



THE STRATO PI UPS CIRCUIT BOARD

Power supply

Strato Pi can be powered with DC voltage only:

✓ DC: nominal voltage range 8.1V to 28.0V.

Respect the correct polarity shown in the schematic diagram (+ -). The power supply circuit implements reverse polarity protection using an auto resetting fuse and surge protection up to ±500V/2ohms 1.2/50µs.

A blue on-board LED, also visible through the front panel of the DIN-rail case, is lit when power supply is available.

When a Strato Pi board is used, never connect the Raspberry Pi micro-USB power plug.

The Strato Pi power supply stage is optimised to deliver up to 3A at 5V to the Raspberry Pi. Because Strato Pi has a 1.1A resettable fuse (polyfuse) on the power supply line, the maximum current that its regulator can deliver is also limited by this fuse, and depends on the input voltage. The following table lists the typical measured output current of the power supply stage at different input voltages, and the corresponding input current.

		9V	12V	24V
Iout	**Vout**	**Iin**	**Iin**	**Iin**
0.1	5.02	0.1	0.08	0.05
1.0	4.99	0.69	0.52	0.26
1.3	4.98	0.90	0.68	0.34
1.5	4.97	1.04	0.79	0.39
1.6	4.97	1.14 KO	0.85	0.41
1.8	4.97		0.92	0.46
1.9	4.96		1.01	0.48
2.0	4.96		1.06	0.51
2.2	4.95		1.16 KO	0.56
2.5	4.94			0.63
3.0	4.93			0.78
3.2	4.92			0.83

STRATO PI POWER SUPPLY STAGE TYPICAL IN/OUT VOLTAGE AND CURRENT

A 1.1A resettable fuse is also used to protect the battery input. When Strato Pi works under battery power, the maximum 5V current delivered to the Raspberry Pi should not exceed 2.0A when the battery is fully charged.

Auxiliary power supply output

Strato Pi UPS has an auxiliary power supply output pin, labeled VSOUT, to power external devices.

The aux power supply output is switched between the main power supply voltage, when available, and the battery voltage.

It is not a regulated voltage output and should only be used to power devices that accept a wide range power supply, compatible to both the battery voltage and the power supply voltage you are using.

When the Raspberry Pi is turned off by the Strato Pi UPS controller, the aux power supply output is also switched off.

The maximum current drawn by the loads connected to VSOUT is limited by the current drawn by the Raspberry Pi, the power supply or battery input voltage, and the 1.1A resettable fuses that limit the total amount of input current.

Dedicated GPIO pins

Strato Pi uses some of the Raspberry Pi's GPIO pins. These pins should not be used for other functions.

GPIO pin	Direction	Description
GPIO2/SDA		I²C SDA line for the real time clock
GPIO3/SCL		I²C SCL line for the real time clock
GPIO14/TXD	out	serial TX line
GPIO15/RXD	in	serial RX line
GPIO5	out	cycle high/low for watchdog heartbeat
GPIO6	out	set to high to enable the watchdog
GPIO12	in	high on watchdog timeout
GPIO16	out	set to high to enable the shutdown cycle
GPIO20	out	set to high to sound the buzzer
GPIO26	in	high when on battery power (UPS board only)

Software installation and configuration

Installing the Strato Pi utility

The Strato Pi utility is a simple command-line script to control Strato Pi's buzzer, watchdog and UPS functions.

Run the following commands to download and install the Strato Pi utility:

```
$ cd /usr/local/bin
$ sudo wget http://sferalabs.cc/files/strato/strato
$ sudo chmod 755 strato
```

You can run the Strato Pi utility without arguments to print its options:

```
$ strato
Usage: strato beep on|off|length_millis|length_millis pause_millis repeats
       strato watchdog enable|disable|heartbeat|timeout
       strato shutdown
       strato battery
```

All commands should be run as superuser, so always use sudo to run strato.

Installing the Real Time Clock software

The RTC is based on the Microchip MCP79410 module and is connected to the Raspberry Pi via its I²C serial bus.

Before downloading the installation utility, you should enable I²C and install the "i2c-tools" package.

To enable I²C, run the "raspi-config" configuration utility:

```
$ sudo raspi-config
```

Then go to "Advanced Options", "I2C" and select "yes" to enable the I²C interface, then reboot your Raspberry Pi.

To install the "i2c-tools" package:

```
$ sudo apt-get update
$ sudo apt-get install i2c-tools
```

With these prerequisite installs completed, you should download and run Strato Pi's installation script:

```
$ cd
$ wget http://sferalabs.cc/files/strato/rtc-install
$ chmod 755 rtc-install
$ sudo ./rtc-install
```

If the script completes with no errors, delete the installation script and reboot:

```
$ rm rtc-install
$ sudo reboot
```

Testing the Real Time Clock

Assuming you are connected to the Internet and your Pi was able to reach a public NTP (Network Time Protocol) server, you should see the current date and time using the “date” command:

```
$ date
Thu Dec 10 18:02:32 CET 2015
```

Also check the date and time stored in the hardware clock:

```
$ sudo hwclock -r
Thu 10 Dec 2015 06:03:01 PM CET  -0.546570 seconds
```

If the returned date and time is not correct, or “hwclock” returns an error, use the “-w” option to set the hardware clock to the current time:

```
 $ sudo hwclock -w
```

Then recheck the time stored in the hardware clock to ensure it matches. Linux may have failed to automatically update the hardware clock after the last reboot if its internal registers contained invalid values.

If the RTC still doesn’t work, you should check if the Pi sees the RTC chip on the I²C bus. Run these two commands:

```
$ sudo modprobe -r rtc_ds1307
$ sudo i2cdetect 1
WARNING! This program can confuse your I2C bus, cause data loss and worse!
I will probe file /dev/i2c-1.
I will probe address range 0x03-0x77.
Continue? [Y/n]
     0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f
00:          -- -- -- -- -- -- -- -- -- -- -- -- --
10: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
20: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
30: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
40: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
50: -- -- -- -- -- -- -- 57 -- -- -- -- -- -- -- --
60: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 6f
70: -- -- -- -- -- -- -- —
```

You should see “6f” in the address list. This is the address of the RTC.

If the RTC address is detected, double check your software installation for issues at the Linux modules level.

Run the “lsmod” command to list the loaded modules and check that “i2c_dev” and “i2c_bcm2708” are both listed.

If the RTC address is not detected, the cause could be a hardware problem, on the Strato board or the Raspberry Pi. If you have another Pi or Strato board, try swapping them to isolate the faulty board.

Disabling Bluetooth and WiFi

On Raspberry Pi 3, the main UART is used for Bluetooth, and the TX/RX pins on the GPIO connector are controlled by a limited function Mini UART.

To route the main UART to the RX/TX pins that are connected to the Strato Pi serial ports you should disable Bluetooth. Edit /boot/config.txt and add these lines at the end of the file:

```
# Disable Bluetooth
dtoverlay=pi3-disable-bt
```

You may also run the following command to disable the Bluetooth HCI UART driver:

```
sudo systemctl disable hciuart
```

To disable the WiFi, one convenient solution on Raspbian distributions is to blacklist the WiFi driver. Edit /etc/modprobe.d/raspi-blacklist.conf and add these lines at the end of the file:

```
# Disable WiFi
blacklist brcmfmac
blacklist brcmutil
```

Note that, while Bluetooth must be disabled to ensure proper operation of Strato Pi's serial ports, leaving the WiFi on should not interfere or degrade any of the Strato Pi features.

Strato Pi server has been tested for compliance with the relevant CE directives assuming that both WiFi and Bluetooth are disabled.

Using Strato Pi

Real Time Clock

Strato Pi has a hardware real time clock with a dedicated long-life non-rechargeable back-up battery.

The battery is only used to power the RTC chip when the main or UPS battery power is not available (when the Raspberry Pi is off). Depending on operating conditions it should last more than two years if the Strato Pi board is not powered, and many more years if the Strato Pi board receives external power.

The battery is soldered on the Strato Pi board, but can be easily desoldered for replacement.

Once the RTC modules and configuration files are properly installed, you will simply use the standard Linux date and time commands to control the hardware clock.

Serial port

Strato Pi uses the Raspberry Pi standard UART TX/RX pins on the GPIO connector to implement a standard serial port with support for both RS-232 and RS-485.

Simply connect the RS-232 RX, TX and GND lines to the RS-232 posts of the Strato Pi terminal block, or the RS-485 A, B and GND to the RS-485 posts of the terminal block.

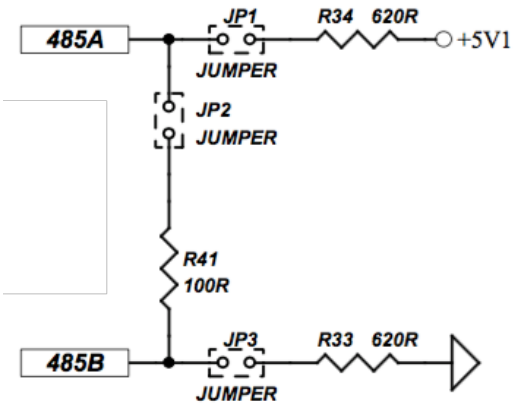
Never connect both RS-232 and RS-485 lines to Strato Pi. Strato implements a single serial port, not two.

Both interfaces are isolated from the Raspberry Pi's serial lines using dedicated opto-couplers, and from the main power supply with a high-efficiency DC-DC converter. This configuration should prevent ground loops between devices connected through the serial lines.

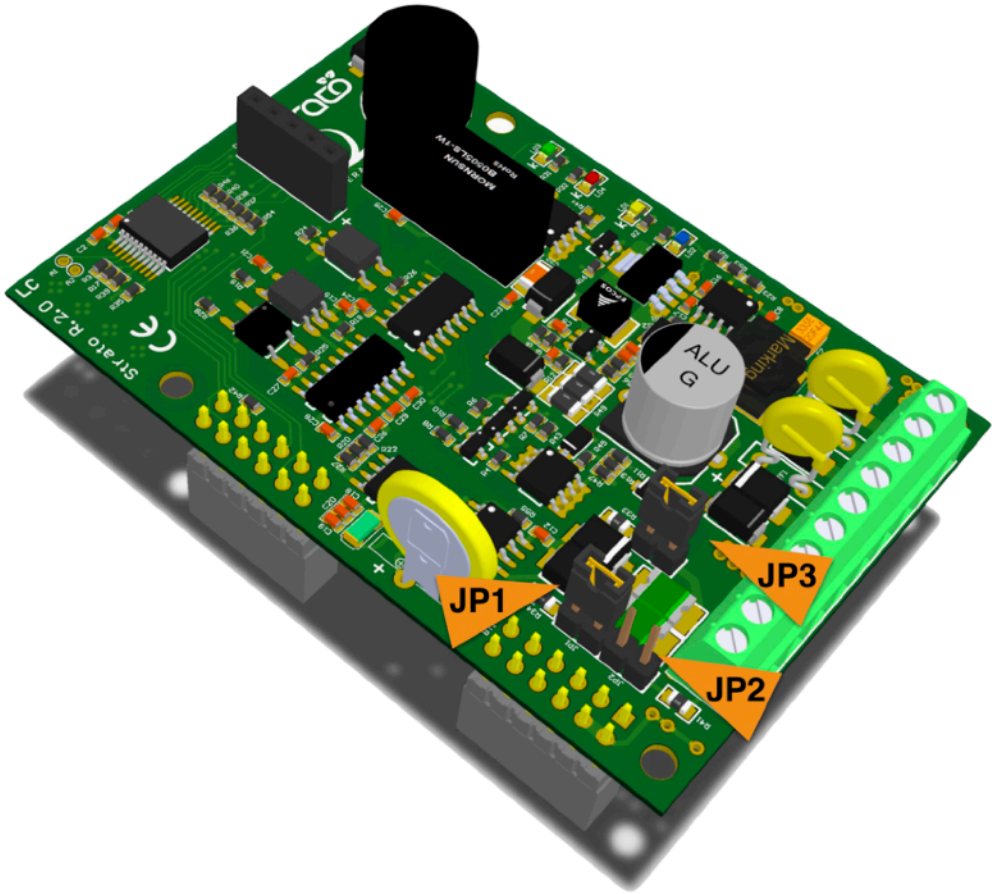
The RS-485 TX/RX switching is implemented automatically in the Strato Pi's micro-controller, based on speed and number of bits detection, and is completely transparent to the software controlling the UART on Raspberry Pi.

The RS-485 line has 620 Ohm pull-up and pull-down resistors on lines A and B. These resistors can be disabled by removing jumpers JP1 and JP3 respectively.

A 100 Ohm termination resistor between A and B can be enabled installing jumper JP2.



RS-485 JUMPERS SCHEMATIC



RS-485 JUMPERS POSITION

Buzzer

Strato Pi has an on-board buzzer that can be controlled using GPIO20. Simply set GPIO20 to high to emit a continuous sound, and back to low to stop. The buzzer is not intended to emit sound indefinitely and could be damaged doing so.

The Strato Pi utility has several commands to control the buzzer.

Buzzer on continuously:

```
$ sudo strato beep on
```

Buzzer off:

```
$ sudo strato beep off
```

Buzzer on for 500 milliseconds:

```
$ sudo strato beep 500
```

Buzzer on for 500 milliseconds, followed by 100 milliseconds pause, repeated three times:

```
$ sudo strato beep 500 100 3
```

UPS

When an external lead-acid rechargeable battery is connected to the Strato Pi UPS board, the Raspberry Pi will remain powered by the Strato Pi board when the main power supply fails, as long as there is enough energy in the battery.

When power is available, the external rechargeable battery is slowly charged with a 30mA current.

Battery operations status is visually notified with an on-board LED and can be checked reading Raspberry Pi's GPIO26 pin.

You can start a delayed power off cycle by rising Raspberry Pi's GPIO16 pin.

When GPIO16 is set to high, Strato Pi will wait 60 seconds and then power off the Pi board for at least 5 seconds.

After being powered off, the Strato Pi board will supply power to the Raspberry Pi when the main power source is restored.

Starting from a power off condition, the Raspberry Pi will not receive power if only the back-up battery is connected to the Strato Pi board.

The Strato Pi utility implements the following commands to monitor and control the UPS.

To print "1" if Strato Pi is operating from the battery, or "0" if main power is present:

```
$ sudo strato battery; echo $?
```

To initiate a delayed power off cycle:

```
$ sudo strato shutdown
```

Hardware watchdog

Strato Pi implements a dedicated hardware watchdog circuit that can be used to perform a full power cycle of the Raspberry Pi.

Being controlled by Raspberry Pi's GPIO pins, it is extremely easy to control watchdog operation using simple custom scripts in your application.

The watchdog is normally disabled. To enable it, set GPIO6 pin to high. While GPIO6 is high, the Strato Pi controller will watch for state changes of the GPIO5 heartbeat pin. You should ensure that GPIO5 flips its state between high and low faster than every 60 seconds.

If the Strato Pi controller doesn't see GPIO5 changing state for more than 60 seconds, it will initiate a shutdown procedure, rising the GPIO12 timeout pin to high, to signal your code that a watchdog timeout has occurred.

If possible, you should immediately initiate a software shutdown on Raspberry Pi, and set the GPIO16 shutdown pin to high. When GPIO16 is set to high or 60 seconds after the timeout, Strato Pi will wait 60 seconds then power cycle the Raspberry Pi.

Note that Strato Pi will power cycle the Raspberry Pi even if GPIO16 is not set high. In this case the power cycles occurs 120 seconds after the heartbeat timeout.

The Strato Pi utility can be used to control the watchdog from your custom scripts.

Enable the watchdog:

```
$ sudo strato watchdog enable
```

Disable the watchdog:

```
$ sudo strato watchdog disable
```

Send the heartbeat:

```
$ sudo strato watchdog heartbeat
```

Print “1” if the watchdog timeout is expired, “0” if not:

```
$ sudo strato watchdog timeout; echo $?
```

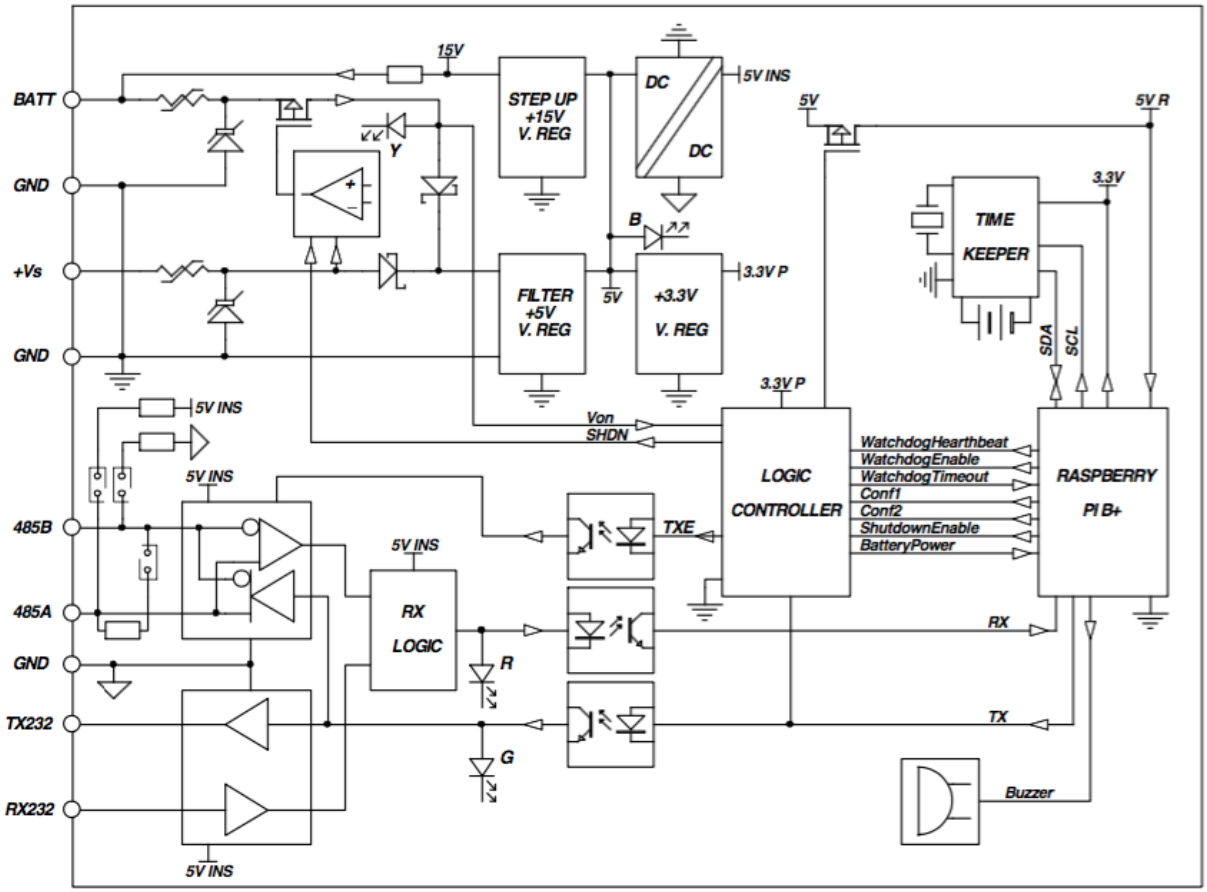
Power cycle

You can start a delayed power off cycle by rising Raspberry Pi’s GPIO16 pin.

When GPIO16 is set to high, Strato Pi will wait 60 seconds and then power off the Pi board for 5 seconds.

The power cycle also affects the VSOUT auxiliary power supply output.

Block diagram



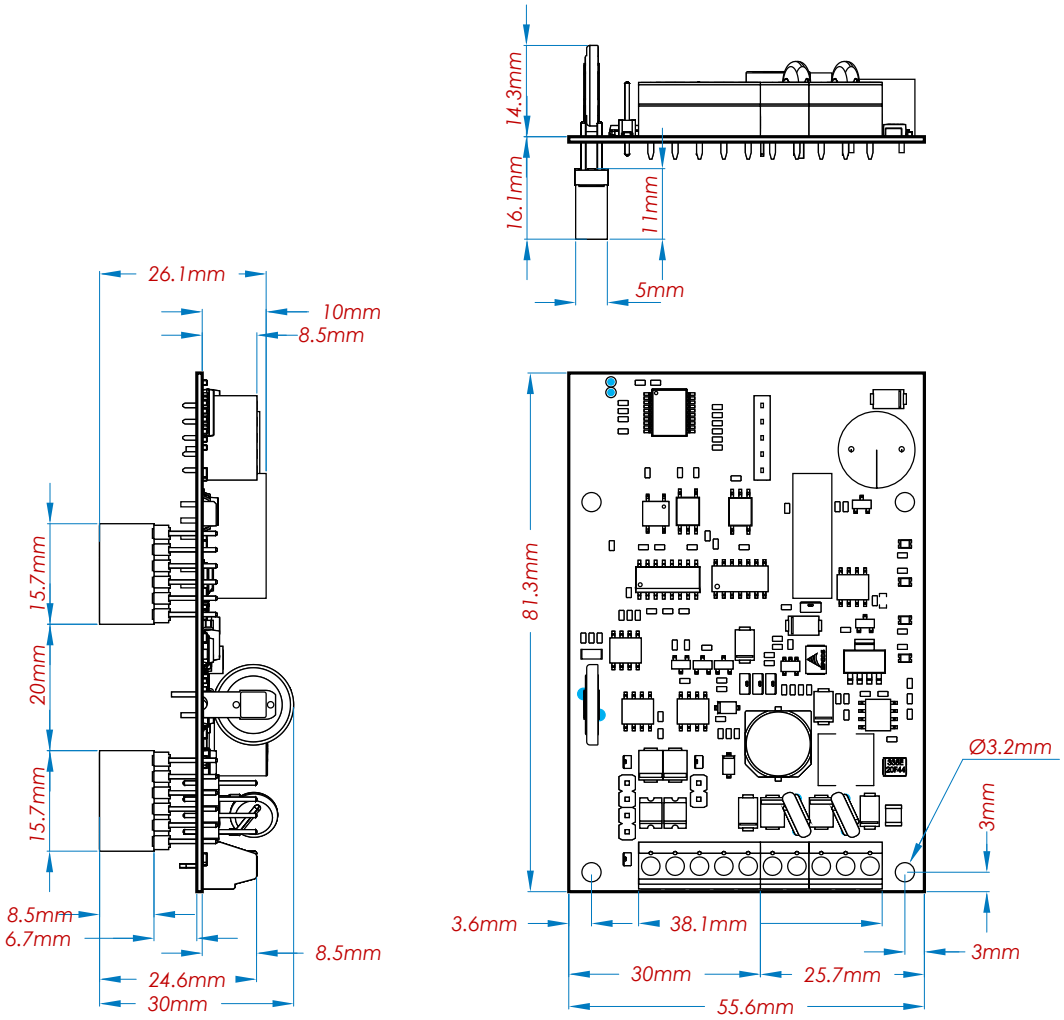
STRATO PI UPS BLOCK DIAGRAM

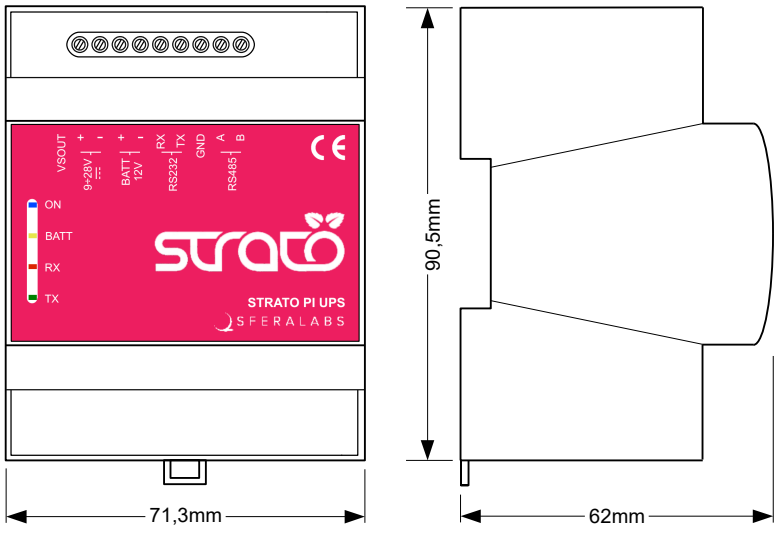
Technical specifications

Power supply	9/28V⎓ (VDC) Reverse polarity protection with 1.1A resettable fuse. Surge protection up to ±500V/2ohms 1.2/50µs
Battery input (UPS version only)	12V lead acid battery (not provided). Suggested capacity: 1.2Ah. Reverse polarity protection with 1.1A resettable fuse. Surge protection up to ±500V/2ohms 1.2/50µs
Battery charge voltage (UPS version only)	15V
Battery charge current (UPS version only)	30mA at 12V battery voltage
Voltage threshold for switching to battery mode (UPS version only)	7.2V, 0.2V hysteresis
Current consumption at VS+=12V⎓ including Raspberry Pi 3 current, with low CPU/GPU load and no USB devices connected	150mA w/o Ethernet and battery 180mA with Ethernet, battery and RS485 Actual current consumption may vary based on working conditions
Current consumption at VS+=24V⎓ including Raspberry Pi 3 current, with low CPU/GPU load and no USB devices connected	85mA w/o Ethernet and battery 100mA with Ethernet, battery and RS485 Actual current consumption may vary based on working conditions
Raspberry platform compatibility	Pi 3 Model B Pi 2 Model B
Serial communication ports	RS-485 Half-Duplex with automatic data direction management RS-232 Full-Duplex
Baud Rates on COMM ports	1200 to 115200
ESD-Protection Voltage on RS-232 TX/RX	±15kV human body model ±8kV contact discharge
ESD-Protection Voltage on RS-485 A/B	±15kV human body model ±8kV contact discharge
Surge protection on RS-485 A/B	Surge protection up to ±500V/2ohms 1.2/50µs; 600W peak pulse power capability at 10/1000µs waveform
Fail safe feature on RS-485	Yes

Real time clock	Internal RTCC circuit with back-up Lithium battery Expected battery life without main power supply: ~3 years Expected battery life with main power supply: >10 years
Housing	standard 4M for DIN rail
Operating temperature	0…+50 °C
Storage temperature	-20…+70 °C
Protection degree	IP20

Dimensions





DIMENSIONS (mm)

Disposal

(Waste Electrical & Electronic Equipment)

(Applicable in the European Union and other European countries with separate collection systems). This marking on the product, accessories or literature indicates that the product should not be disposed of with other household waste at the end of their working life. To prevent possible harm to the environment or human health from uncontrolled waste disposal, please separate these items from other types of waste and recycle them responsibly to promote the sustainable reuse of material resources. Household users should contact either the retailer where they purchased this product, or their local government office, for details of where and how they can take these items for environmentally safe recycling. This product and its electronic accessories should not be mixed with other commercial wastes for disposal.

Strato Pi contains a small non rechargeable manganese dioxide lithium coin battery. This cell battery contain so little lithium that it should not qualify as a reactive hazardous waste. If you need to follow specific disposal procedures for the battery, it can be easily separated from the circuit board by simply cutting its two terminals near the soldering points (paying attention not to pinch or fracture the battery body).

Installation and use restrictions

Standards and regulations

The design and the setting up of electrical systems must be performed according to the relevant standards, guidelines, specifications and regulations of the relevant country. The installation, configuration and programming of the devices must be carried out by trained personnel.

The installation and wiring of connected devices must be performed according to the recommendations of the manufacturers (reported on the specific data sheet of the product) and according to the applicable standards.

All the relevant safety regulations, e.g. accident prevention regulations, law on technical work equipment, must also be observed.

Safety instructions

Protect the unit against moisture, dirt and any kind of damage during transport, storage and operation. Do not operate the unit outside the specified technical data.

Never open the housing. If not otherwise specified, install in closed housing (e.g. distribution cabinet). Earth the unit at the terminals provided, if existing, for this purpose. Do not obstruct cooling of the units. Keep out of the reach of children.

Set-up

For the first installation of the device proceed according to the following procedure:

✓ make sure all power supplies and the external battery are disconnected

- ✓ install and wire the device according to the schematic diagrams on the specific data sheet of the product
- ✓ after completing the previous steps, switch on the power supply and other related circuits.

Standards

This device complies with the essential requirements of the following directives and harmonised standards:

- ✓ 2014/35/UE (Low Voltage)
- ✓ 2014/30/UE (EMC)
- ✓ EN61000-6-2:2005 (EMC Immunity)
- ✓ EN60664-1:2007 (Electrical safety)
- ✓ EN61000-6-3:2007 (Emission)
- ✓ 2011/65/UE (RoHS)

WiFi and Bluetooth must be disabled on the Raspberry Pi 3 to meet the above CE directives.