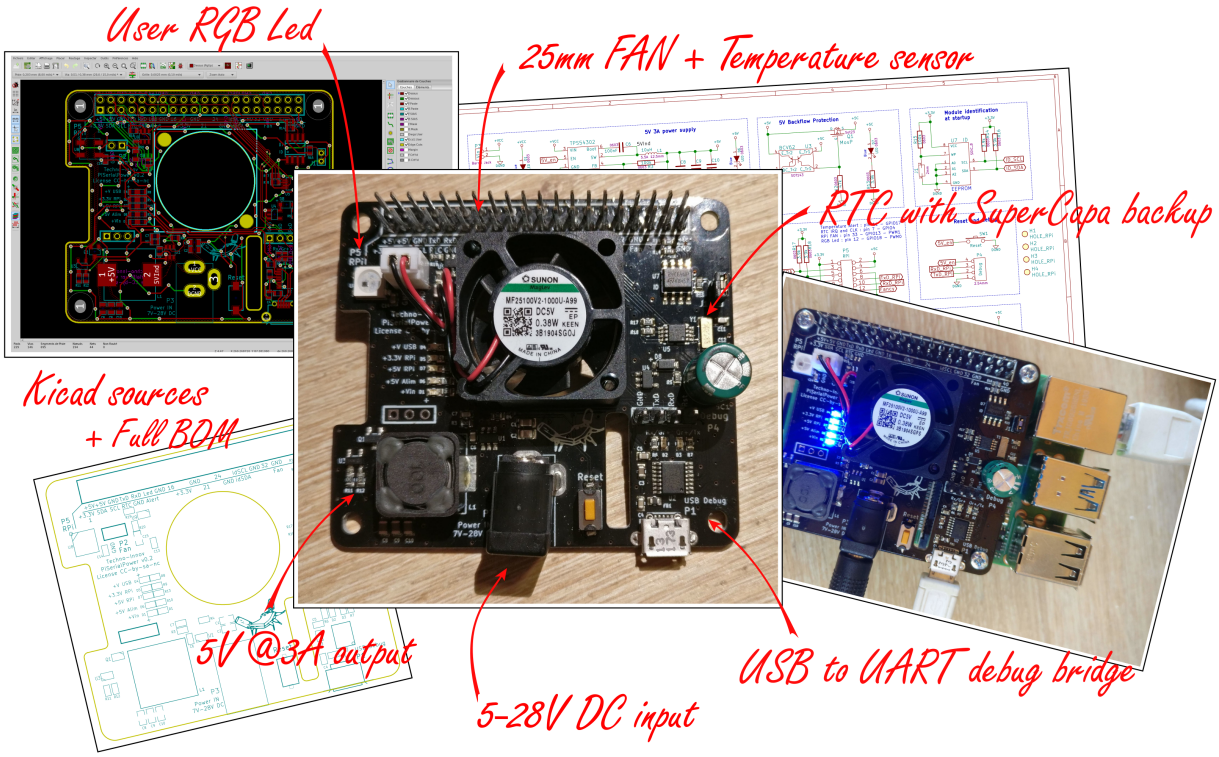
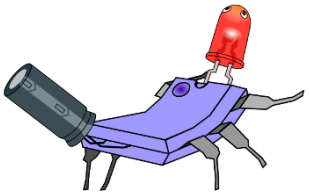


Raspberry Pi Serial and Power Hat
System Reference Manual

PiSerialPower_SRM for Board v0.2
September, 04 2020 - Doc rev 0.2c
Author: Nathaël Pajani



Contents

1 Introduction

You are reading the **System Reference Manual** for the PiSerialPower RPi Hat.

The PiSerialPower RPi Hat is an electronics development and prototyping adapter board for Raspberry PI SBC's [1].
The PiSerialPower RPi Hat has a 5-28V DC to 5V@A3 power stage with a common barel Jack connector, a Small but powerfull FAN, an USB-UART interface to provide easy access to the Linux console, and also provides a RTC with Super-Capa power backup, a temperature sensor, a RGB led, and a reset button.

The Board uses the form factor specified by the RPI designers, leaving access to both camera connectors to the whole expansion connector (though some signals are used to interface with the board's components) and to the four mounting screw-holes.
It also includes a factory programmed (but user accessible) Eeprom for automatic board detection and configuration by the Linux system.

The PiSerialPower RPi Hat is designed for users interested in embedded ARM development using free, libre and open source softwares only.
Every information about the design is available and all components documentations are freely accessible. You can download the source files for the PiSerialPower RPi Hat and modify them using KiCad [2] EDA (GPL) according to the license terms found in the license section.
You can create and produce your own PiSerialPower RPi Hat or a modified version (but not sell them).

In this document the PiSerialPower RPi Hat will also be referred to as **the HAT**.

2 Licenses

2.1 Documentation license

The present document is under Creative Commons CC BY-SA-NC 4.0 [3] License.
It is written in LaTeX and the PDF version is generated using pdflatex.

2.2 Hardware license

The PiSerialPower RPi Hat hardware and schematics are under Creative Commons CC BY-SA-NC 4.0 [4] License.
You can produce your own original or modified version of the PiSerialPower RPi Hat, and use it however you like, but not sell them, even without profit.

2.3 Software license

All the software examples created for the PiSerialPower RPi Hat are under GPLv3 License.

1. https://www.raspberrypi.org/
2. http://www.kicad-pcb.org/display/KICAD/
3. https://creativecommons.org/licenses/by-nc-sa/4.0/legalcode
4. https://creativecommons.org/licenses/by-nc-sa/4.0/legalcode

3 Hardware

3.1 Dimensions

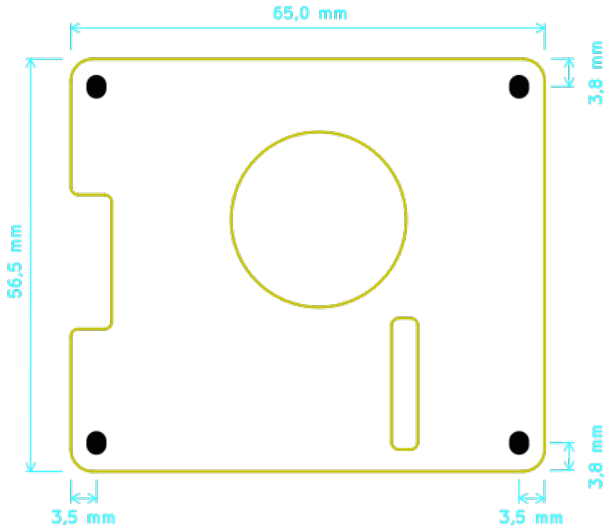


Fig 1 – Board

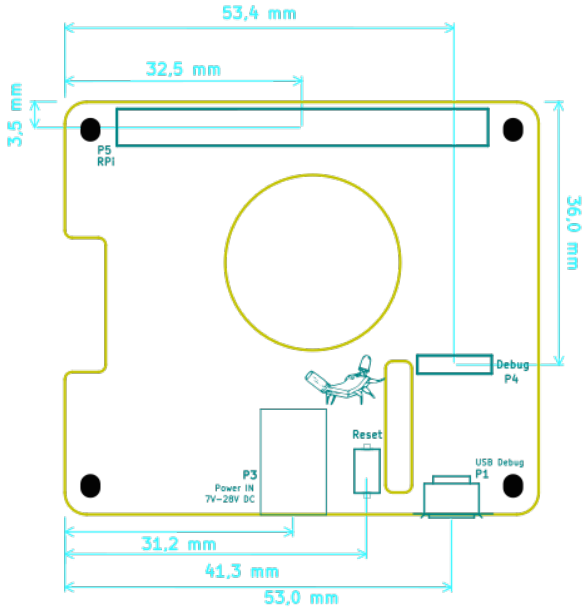


Fig 2 – Connectors

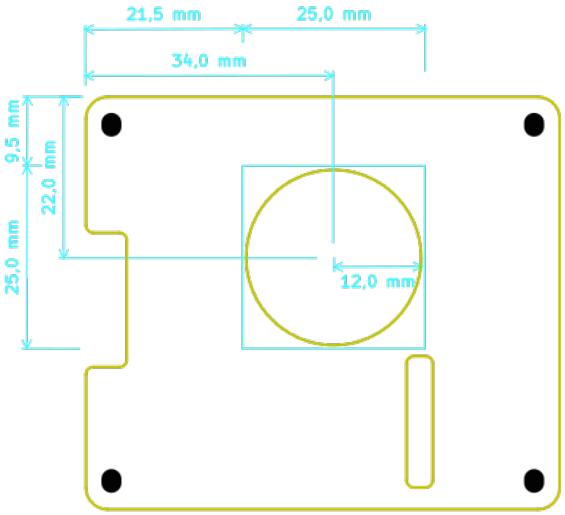


Fig 3 – FAN

Figures 1, 2 and 3 give the different dimensions and the positions of the main elements (FAN, connectors, reset button and user led) of the PiSerialPower RPi Hat.

3.2 Connectors

The HAT has one USB connector numbered P1, a DC barel Jack connector numbered P3, and two 2.54mm pitch headers numbered P4 and P5. Refer to figure 4 for connectors position and to table 1 for a short description. Detailed description of the signals found on each connector pin follow.

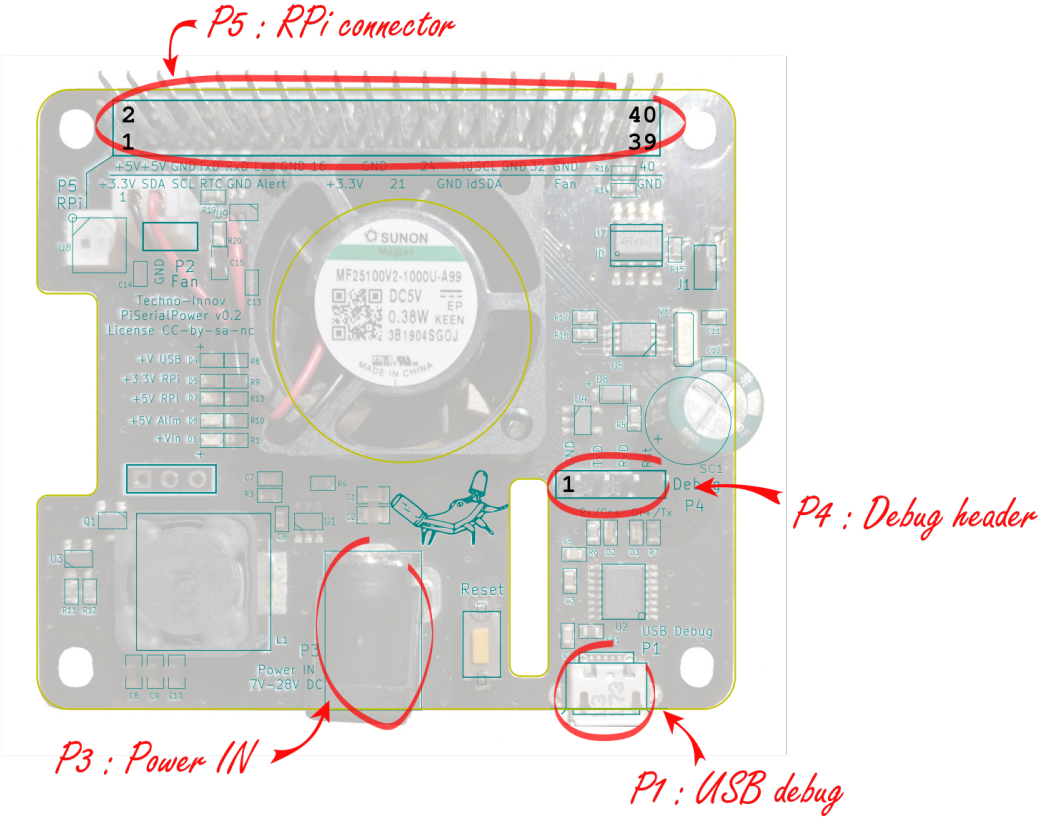


Fig 4 – Module Connectors

Name	Description
P1	USB microB female connector.
P3	DC barrel jack. +Vin and ground input.
P4	4 pins, 2.54mm pitch header. Provides Debug UART and Reset.
P5	40 pins, 2.54mm pitch header. Provides access to RPI expansion header.

TABLE 1 – Module Connectors Description

3.2.1 P1 Connector

P1 is a female USB microB port.
Refer to the Universal Serial Bus (USB) [5] page on Wikipedia for pinout and more information on the USB bus and connectors.

5. http://fr.wikipedia.org/wiki/Universal_Serial_Bus

3.2.2 P3 Connector

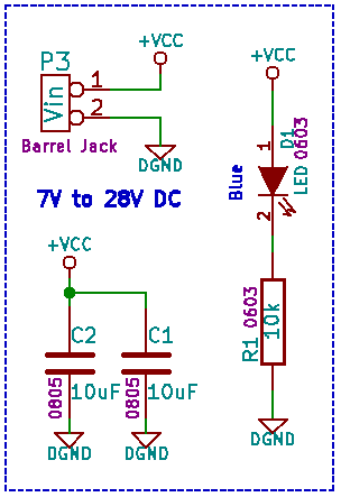


Fig 5 – P3 Connector

Pin #	Description	RPi pin
1	+Vin : External unregulated input, +5V to +28V	-
2	GND : Ground	GND pins 6, 9, 14, 20, 25, 30, 34 and 39

TABLE 2 – P3 Connector Pinout

P3 connector is a standard 2.1mm barrel jack.
+Vin is on the central tip, and GND on the outer sleeve.
Insersion detection is not used.
P3 connector provides access to +Vin and Ground for the onboard step-down regulator. The input ranges from 5V to 28V. This lets you power the board using a large variety of power sources.

3.2.3 P4 Connector

P4 connector is a standard 2.54mm (0.1 inch) pitch header, with 1 row of 4 pins.
P4 connector provides access to Debug UART and Reset.

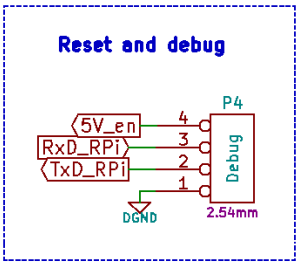


Fig 6 – P4 Connector

Pin #	Description	RPi signal	RPi Pin
1	GND : Ground	GND	pins 6, 9, 14, 20, 25, 30, 34 and 39
2	RPi TxD	UART0 Tx	pin 8
3	RPi RxD	UART0 Rx	pin 10
4	5V enable (Reset)	-	-

TABLE 3 – P4 Connector Pinout

Note : P4 connector allows direct access to the debug UART and to the power enable pin without powering the USB-to-UART bridge. This option has been added to allow external access and control of clusters of Raspberry Pi boards through a single UART concentrator with aditionnal GPIO to control the DC/DC enable pin.

3.2.4 P5 Connector

P5 connector is a standard 2.54mm (0.1 inch) pitch header, with 2 row of 20 pins.
P5 connector provides access to the Raspberry PI expansion header.

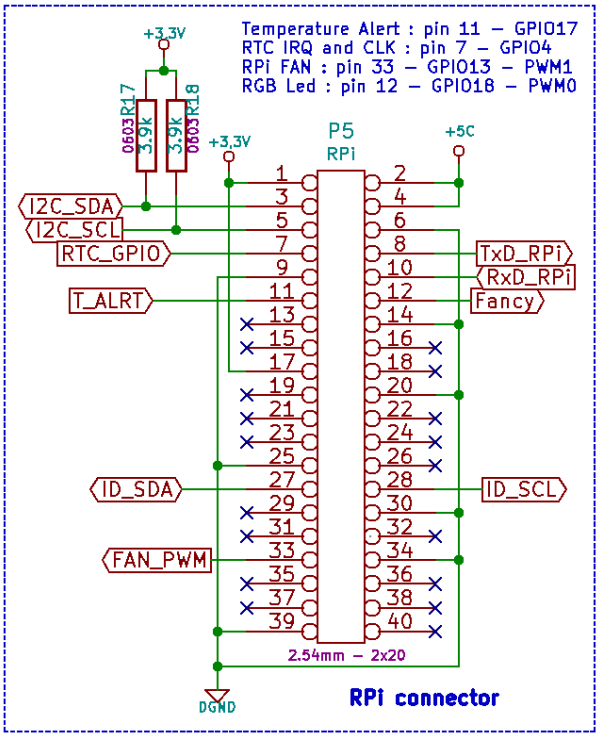


Fig 7 – P5 Connector

Pin #	Description	RPi signal
1	+3.3V from RPi	+3.3V
2	+5V to RPi	+5V
3	SDA : Bidirectional Serial Data for I²C bus 1	I2C1 SDA
4	+5V to RPi	+5V
5	SCL : Clock for I²C bus 1	I2C1 SCL
6	GND : Ground	GND
7	RTC GPIO	GPIO 4
8	RPi TxD	UART0 Tx
9	GND : Ground	GND
10	RPi RxD	UART0 Rx
11	Temp sensor GPIO	GPIO 17
12	RGB Led	GPIO 18 - PWM0
13	-	
14	GND : Ground	GND
15	-	
16	-	
17	+3.3V from RPi	+3.3V
18	-	
19	-	
20	GND : Ground	GND
21 to 24	-	
25	GND : Ground	GND
26	-	
27	SDA : Bidirectional Serial Data for I²C bus 0 (EEPROM)	I2C0 SDA
28	SCL : Clock for I²C bus 0 (EEPROM)	I2C0 SCL
29	-	
30	GND : Ground	GND
31	-	
32	-	
33	Fan PWM	GPIO 13 - PWM1
34	GND : Ground	GND
35 to 38	-	
39	GND : Ground	GND
40	-	

TABLE 4 – P5 Connector Pinout

4 Electronics

The PiSerialPower RPi Hat has been created using KiCad [6] EDA software suite for the creation of the schematics and printed circuit boards.

See page 16 in the annexes for the full schematics. The sources for the schematics are available for download from the Pi Serial Power HAT [7] on Techno-Innov.fr.

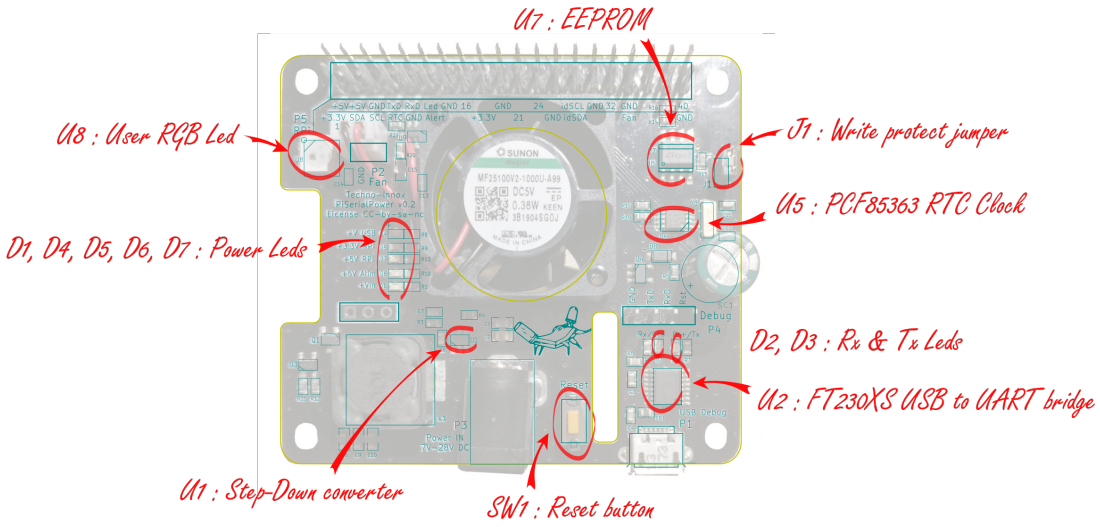


Fig 8 – HAT Main Components

Name	Description
U1	TI TPS54302 DC-DC step-down converter.
U2	FTDI FT230XS USB to UART bridge.
U5	NXP PCF85363 RTC Clock
U6	TI TMP101 I²C temperature sensor.
U7	ST M24C64 8KB EEPROM
U8	WS2812B user RGB led.
D1	Input power Presence.
D2	Green led : FTDI Rx activity.
D3	Orange led : FTDI Tx activity.
D4	USB FTDI Power OK.
D5	+3.3V Power from RPi.
D6	+5V to RPi.
D7	+5V from RPi.
SW1	Reset button.
J1	EEPROM write protection jumper (remove for write protection)

Table 5 – HAT Main Components Description

6. http://www.kicad-pcb.org/display/KICAD/
7. http://www.techno-innov.fr/PiSerialPower/

4.1 USB to UART bridge

In order to ease the development process on Raspberry Pi the HAT provides an USB to UART bridge.
This bridge is made by a FTDI FT230XS chip, which is well supported on most operating systems so there is usually no configuration required to use it as a serial line on the host development system. It provides a 3.3V regulated voltage for the UART interface but does not power the HAT or the Raspberry Pi.

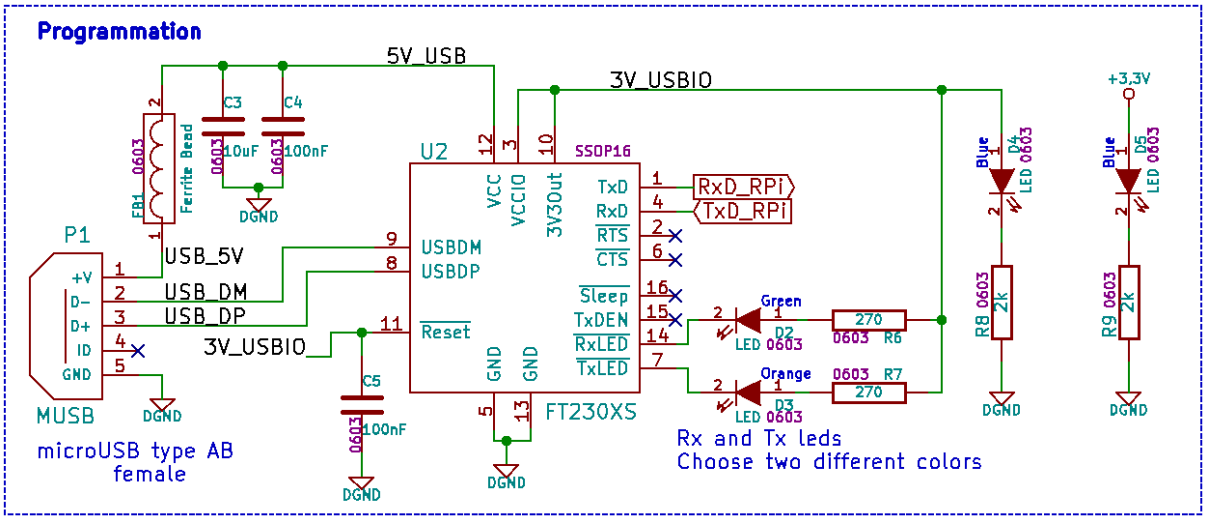


Fig 9 – USB to UART bridge

The FTDI chip controls two "activity" leds for Rx (D2, the green one) and Tx (D3, orange one) data over the serial link.

The USB to UART bridge is connected to UART0 (pins 8 and 10) on the RPi connector. On most variants of the RPi boards this interface must be activated manually in the device tree or in the bootloader configuration on the first partition of the SD card. Refer to the Raspberry Pi User Manual and online documentation and other ressources for more information on how to activate this interface.

4.2 I²C

The PiSerialPower RPi Hat uses both I²C busses from the RPi connector.
Bus 0 holds the required EEPROM for HAT identification and configuration, at address 0x50.
Bus 1 holds the TMP101 temperature sensor at address 0x4A and the PCF85363 RTC clock at address 0x51.

4.2.1 I²C Addresses

I²C Component	7 bits I²C address	I²C Address + R / W bit
TMP101 Temperature sensor	0x4A	0x94 / 0x95
PCF85363 RTC Clock	0x51	0xA2 / 0xA3
24C64 EEPROM	0x50	0xA0 / 0xA1

Table 6 – I²C Addresses

Table 6 shows all the possible I²C Addresses for the components used on the HAT.

4.2.2 RTC Clock

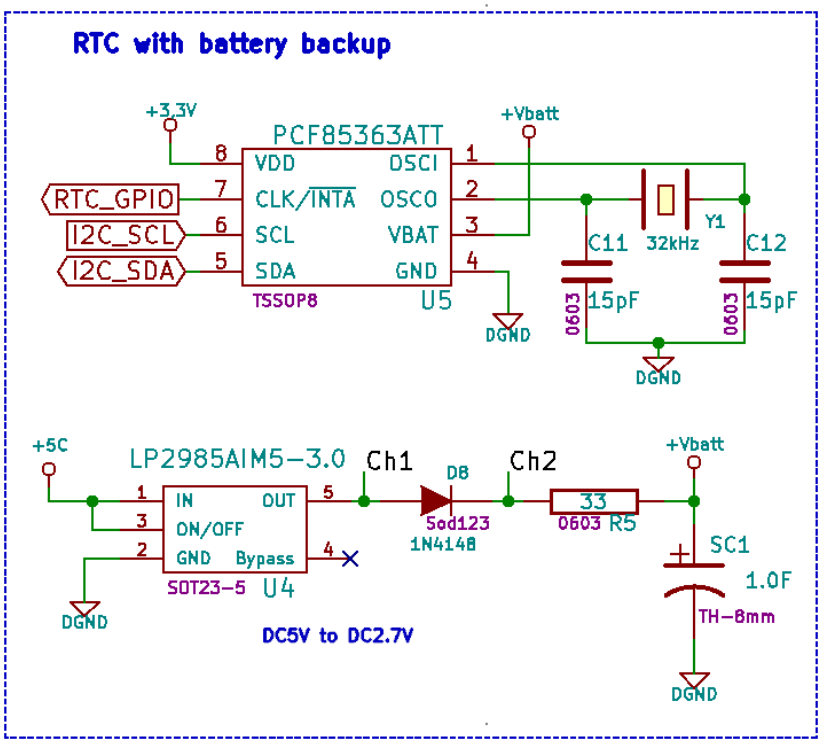


Fig 10 – RTC Clock

The PiSerialPower RPi Hat includes a PCF85363 RTC with super-capacitor power backup.
The use of a Super-capacitor for power backup lowers the environmental footprint and remove the need to replace (and dispose of) the battery at the expense of a shorter time retention, which is between one and two months, but should be enough for most applications.

The Linux kernel has support for the PCF85363 RTC in the rtc-pcf85363 module.
After loading the rtc-pcf85363 module in the kernel, you must add the RTC to the list of devices on the I²C bus 1 :
`echo pcf85363 0x51 > /sys/bus/i2c/devices/i2c-1/new_device`
This is not necessary if the device tree is loaded from the EEPROM.
You can the access the RTC from `/dev/rtc0` or with the `hwclock` command (from the `util-linux` package on Debian based GNU/Linux distributions.

4.2.3 Temperature sensor

The HAT has a TMP101 temperature sensor (from Texas Instrument) on the I²C bus 1 (address 0x94 / 0x95).

This temperature sensor has an "alert" function available through a dedicated pin. This pin is routed to pin 11 of the RPI connector (GPIO0_17) which allows the temperature sensor to send an event to the Raspberry Pi.

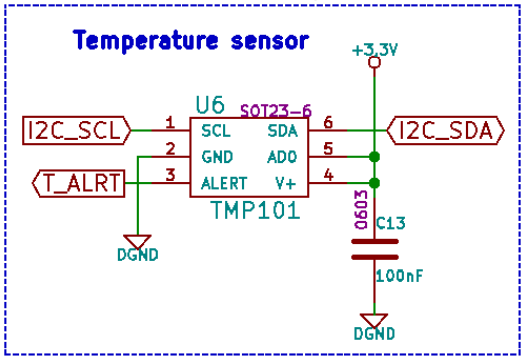


Fig 11 – Temperature sensor

Refer to the Raspberry Pi User Manual for more information on how to use this signal, and to the TMP101 documentation for more information on the temperature alert signal.

The Linux kernel has support for the TMP101 temperature sensor in the lm75 module.
Once the lm75 module is loaded in the kernel, you must add the TMP101 sensor to the list of devices on the I²C bus 1 :

```
echo tmp101 0x4a > /sys/bus/i2c/devices/i2c-1/new_device
```

This is not necessary if the device tree is loaded from the EEPROM.
You can then read the temperature using the "`sensors`" command, which is provided by the `lm-sensors` package on Debian based GNU/Linux distributions.

4.2.4 EEPROM

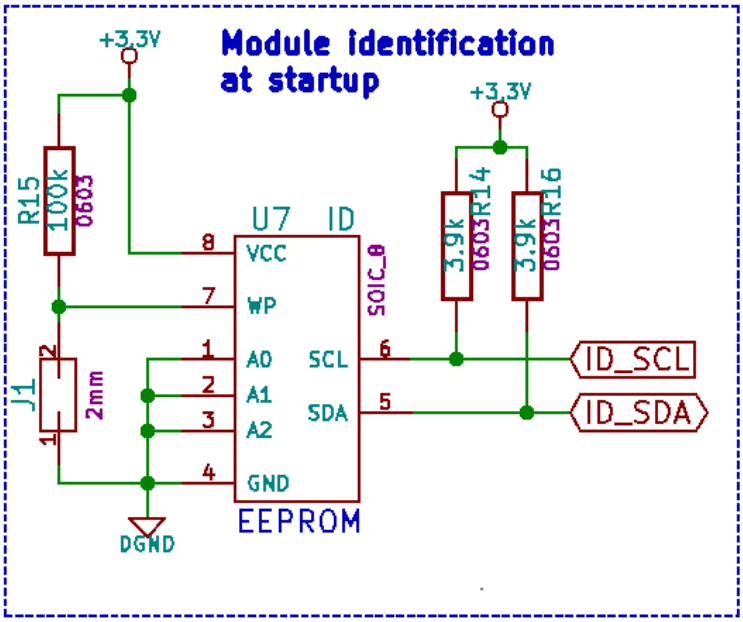


Fig 12 – EEPROM

In order to respect the Pi HAT design requirements the PiSerialPower RPi Hat has a 24C64 (8Kbyte) EEPROM

on I²C bus 0 at I²C address 0x50 (7bits).
This EEPROM holds identification data and the HAT device tree blob which is loaded by the Linux kernel to enable the components (RTC and temperature sensor) found on the HAT.
This EEPROM has a write protection pin which must be left floating or driven low to allow write operation. The control of the state of this write protection pin is made by the J1 jumper. When the jumper is present, the pin is driven low and the user can write to the EEPROM. Removing the jumper disables write operations.

4.3 Reset Button

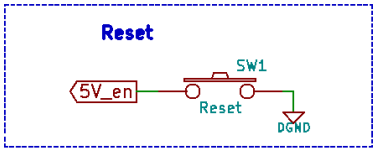


Fig 13 – Reset button

The module has a reset button, connected directly to the enable pin of the step down regulator.
Pressing the button removes power from this power source, which will immediately shut down the Raspberry Pi if it has no other power source, or do nothing if the RPi is also powered from its type C USB connector or any other way.

4.4 FAN

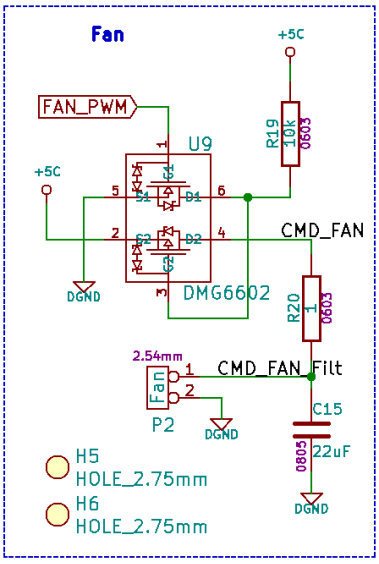


Fig 14 – Cooling Fan

The module has a 25mm cooling FAN controlled by pin 33 of the RPI connector (GPIO_13 - PWM1).
This pin is PWM capable, which allows you to control the FAN speed, though the fan used has an internal controller which prevents direct control using PWM, so we added a simple charge pump to modulate the fan voltage, which has the effect of modifying the FAN speed.

Refer to the Raspberry Pi User Manual and online documentation and other resources for more information on how to control the PWM output.

4.5 User RGB Led

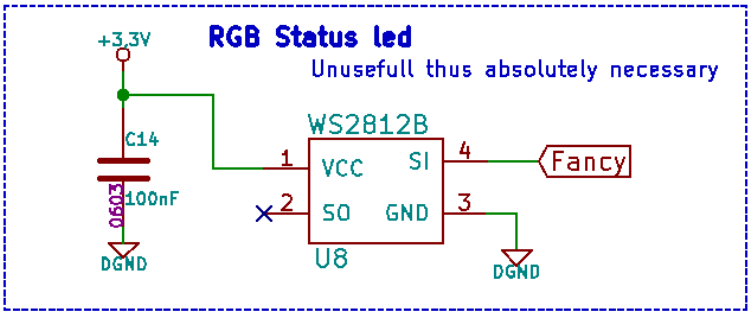


Fig 15 – User RGB Led

The module has one WS2812B RGB Led connected to pin 12 of the RPI connector (GPIO_18 - PWM0). This Led is available for the user.
Refer to the Raspberry Pi User Manual and online documentation and other resources for more information on how to control this WS2812B RGB Led.

5 Software

We noticed that software information evolves way too quickly to be included in such a documentation.

You will find all relevant information on our public wiki : http://wiki.techno-innov.fr/index.php/Products/PiSerialPower [8]

6 Board revisions history

6.1 v0.1

This board revision has not been sold to public.
First prototype version, produced on customer request.

6.2 v0.2

Actual version sold as of writting of this documentation.
Fixes v01 mistakes and adds PWM for the FAN and a RGB led.

8. http://wiki.techno-innov.fr/index.php/Products/PiSerialPower

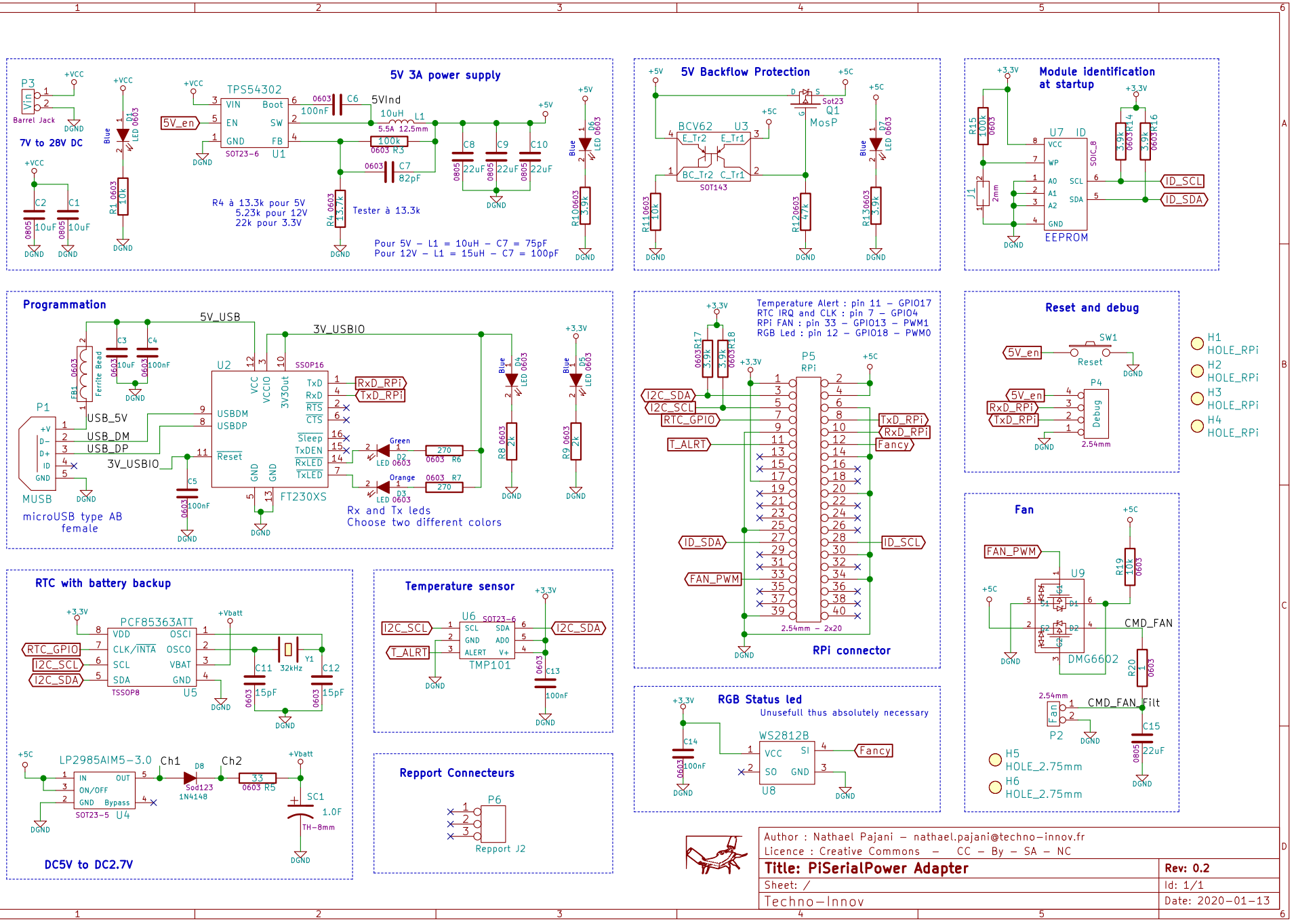
7 Annexes

7.1 Schematics

The board schematics and PCB layout have been created using KiCad [9] EDA software suite. You can download the sources on the Wiki HAT page [10] on Techno-Innov.fr.

(See on next pages)

9. http://www.kicad-pcb.org/display/KICAD/
10. http://wiki.techno-innov.fr/index.php/Products/PiSerialPower



Author : Nathael Pajani – nathael.pajani@techno-innov.fr
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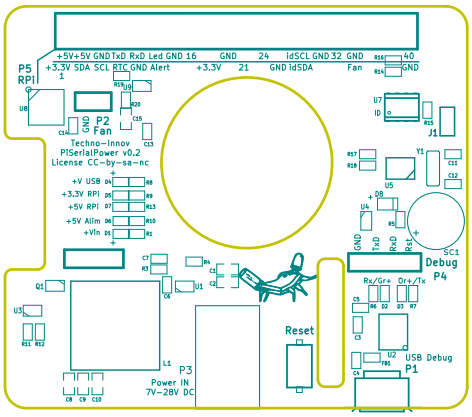
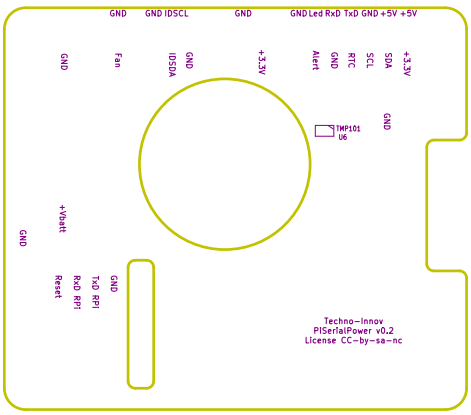
Title: PiSerialPower Adapter	**Rev: 0.2**
Sheet: /	Id: 1/1
Techno-Innov	Date: 2020-01-13

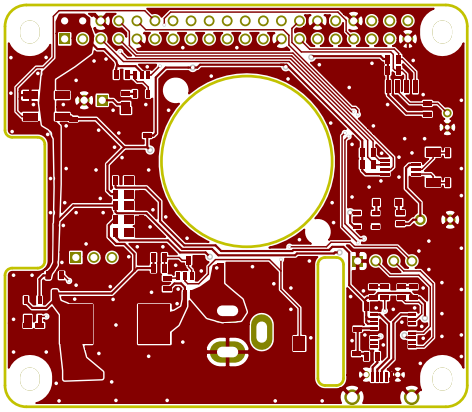
Top silk screen



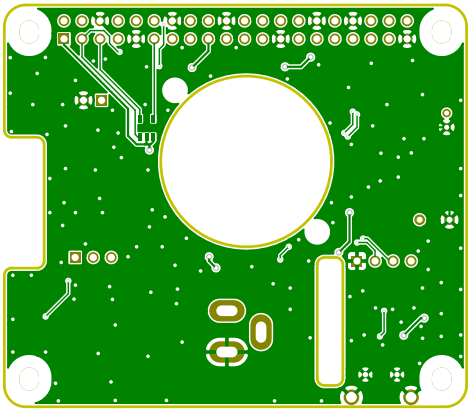
Bottom silk screen



Top copper layer



Bottom copper layer



Author : Nathael Pajani – nathael.pajani@techno-innov.fr Licence : Creative Commons – CC – By – SA – NC **Techno-Innov**		
Sheet: File: PiSerialPower.kicad_pcb		
Title: PiSerialPower Adapter		
Size: A4	Date: 2020-01-07	**Rev: 0.2**
KiCad E.D.A. kicad 5.1.5+dfsg1-2+b1		Id: 1/1

7.2 BOM

Part Description	Ref	Module	Nb	Vendor	Vendor ref	Farnell
Power IN						
Barrel Jack DC, Femelle, 5 A, 2 mm	P3	TH	1	Wurth Electronik	694106301002	2472149
DC/DC Converter 7V to 28V Vin, 5V 3A Out	U1	SOT23-6	1	Texas Instrument	TPS54302DDCT	3007332
Capacitor 10uF 0805 25V 20%	C1, C2	0805	2	MURATA	GRM188R61A106ME69I	2456110
Capacitor 22uF 0805	C8, C9, C10	0805	3	Murata	GRM21BR61E226ME44I	1907510
Decoupling capacitors 0,1uF 0603 50V 10%	C6	0603	1	MULTICOM	MC0603B104K500CT	1759122
Resistor 100k Ohms	R3	0603	1	MULTICOM	MC 0.063W 0603 1% 100K	9330402
Resistor 13,7k Ohms	R4	0603	1	MULTICOM	MCWR06X1372FTL	2694716
Feedback capacitor 82pF	C7	0603	1	MULTICOM	MC0603N820J500CT	1759065
Self 10uH 5,5A shielded	L1	12,5mm	1	Bourns	SRR1260-100M	2212501
Resistor 3,9k Ohms – Leds	R10, R13	0603	2	MULTICOM	MCWR06X3901FTL	2447363
Resistor 10k Ohms – Leds	R1	0603	1	MULTICOM	MCWR06X1002FTL	2447230
Blue leds	D1, D6, D7	0603	3	VISHAY	VLMB1300-GS08	2251459
Mosfet P 4,3A 0,042 Ohms	Q1	SOT23	1	Infineon	IRLML2244TRPBF	2468051
Double PNP, 30 V	U3	SOT143B	1	Nexperia	BCV62B,215	1081261
Resistor 10k Ohms – NPN1	R11	0603	1	MULTICOM	MCWR06X1002FTL	2447230
Resistor 47k Ohms – NPN2	R12	0603	1	MULTICOM	MCWR06X4702FTL	2447376
Prog USB						
Resistor 270 Ohms – RX & Tx Leds	R6, R7	0603	2	MULTICOM	MC 0.063W 0603 1% 270R	9330917
Decoupling capacitors 0,1uF 0603 50V 10%	C4, C5	0603	2	MULTICOM	MC0603B104K500CT	1759122
Capacitor 10uF 0603 6,3V 20%	C3	0603	1	MURATA	GRM188R61A106ME69I	2456110
Ferrite 100MHz 600 Ohms	FB1	0603	1	TDK	MMZ1608R601A	1669700
Orange led – Tx	D3	0603	1	VISHAY	VLMO1300-GS08	2251473
Green led – Rx	D2	0603	1	VISHAY	VLMG1300-GS08	2251461
FT230XS FTDI USB to UART	U2	16SSOP	1	FTDI	FT230XS	2081321
Micro-USB type A-B – bottom	P1	CMS	1	MOLEX	47589-0001	1568023
Resistor 2k Ohms – Leds	R8, R9	0603	2	MULTICOM	MCWR06X2001FTL	2447319
Blue leds	D4, D5	0603	2	VISHAY	VLMB1300-GS08	2251459
Rpi connector						
2x20 Extended Tail Socket	-	TH	1	-	-	REF-182684-02

TABLE 7 – BOM by functional block

Part Description	Ref	Module	Nb	Vendor	Vendor ref	Farnell
RTC						
PCF85363 RTC I²C 64Bytes SRAM	U5	TSSOP-8	1	NXP	PCF85363ATT/AJ	2775939
Resistor 3,9k Ohms – I²C Pull-up	R17, R18	0603	2	MULTICOM	MCWR06X3901FTL	2447363
Xtal CMS ABS10 32,768KHz	Y1	ABS10	1	ABRACON	ABS10-32.768KHZ-7-T	2101351
Capacitor 15pF 0603 NPO 50V 5%	C11, C12	0603	2	MULTICOM	MC0603N150J500CT	1759055
LDO 3,0V	U4	SOT23-5	1	Texas Instruments	LP2985AIM5-3.0/NOPB	1469133
Diode 1N4148	D8	SOD-123	1	DIODES Inc	1N4148W-7-F,	1776392
Super capacitor 1F, 2,7V	SC1	TH-8mm	1	BUSSMANN	HV0810-2R7105-R	2148482
Resistor 33 Ohms – curent limit	R5	0603	1	MULTICOM	MCWR06X33R0FTL	2447344
Temp sensor						
TMP101NA I²C Temperature sensor	U6	SOT23-6	1	Texas Instruments	TMP101NA/3K	3009062
Decoupling capacitors 0,1uF 0603 50V 10%	C13	0603	1	MULTICOM	MC0603B104K500CT	1759122
Startup ID						
EEPROM 24c64 – 8K x 8bits	U7	SOIC8	1	STMICRO	M24C64-WMN6P	9882685
Resistor 3,9k Ohms – I²C Pull-up	R14, R16	0603	2	MULTICOM	MCWR06X3901FTL	2447363
Pull-Up resistors 100k Ohms	R15	0603	1	MULTICOM	MC 0.063W 0603 1% 100K	9330402
2mm header – 2 pins	J1	2mm	1	Fisher Elektronik	SLY1.085.50G	9729135
2mm jumper	-	-	1	HARWIN	M22-1900005	510932
Reset and Debug						
CMS Switch	SW1	CMS	1	MULTICOM	DTSM-32S-B	9471898
WS2812B RGB Led	U8	CMS	1	—	WS2812B	
Decoupling capacitors 0,1uF 0603 50V 10%	C14	0603	1	MULTICOM	MC0603B104K500CT	1759122
2,54mm Header – 4 pins	P4	2,54mm	4	Sullins Connector Solutions	CONN HEADER .100" SNGL STR 40POS	S1012EC-40-ND
Ventilateur						
Mos N+P 30V 3,3A	U9	SOT23-6	1	DIODES Inc	DMG6602SVT	2061522
Pull-Up resistors 10k Ohms	R19	0603	1	MULTICOM	MCWR06X1002FTL	2447230
Resistor 1 Ohms – filter	R20	0603	1	MULTICOM	MCWR06W1R00FTL	2447289
Capacitor 22uF – filter	C15	0805	1	Murata	GRM21BR61E226ME44	1907510
Axial Fan – 5VDC - 25x25x10mm	-	-	1	SUNON	MC25101V1-000U-A99	MC25101V1-A99
Fan PH connector	-	-	1	JST	PHR-2	3616186
Crimp terminal	-	-	2	JST	SPH-002T-P0.5S	1671245
Screws N4 0,25 PRST60 Z100	-	-	2	TR Fastenings	N4 0.250 PRST60 Z100	9491856
Fan connector – 2mm	P2	TH	1	JST	B2B-PH-K-S(LF)(SN)	9491856

TABLE 8 – BOM by functional block (continued)

Note : Components used on Board may change for functionnally equivalent references without prior notice

7.3 Document revision History

Version	Date	Author	Information
0.2a	March, 27 2020	Nathaël Pajani	Initial revision
0.2b	April, 01 2020	Nathaël Pajani	Fixed BOM
0.2c	September, 04 2020	Nathaël Pajani	Typo fixes

7.4 Disclaimer

The PiSerialPower RPi Hat is provided "as is" without warranty of any kind, either expressed or implied, including, but not limited to, the implied warranties of merchantability and fitness for a particular purpose. The entire risk as to the quality and performance of the PiSerialPower RPi Hat is with you. Should the PiSerialPower RPi Hat prove defective, you assume the cost of all necessary servicing, repair or correction.