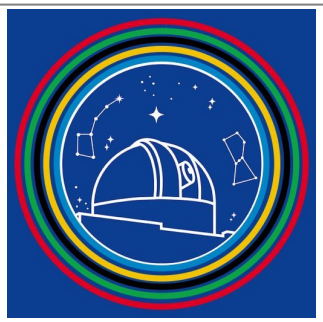
AstrAlim Specification
Revision 0.1-94

DGE
FRIDAY, DECEMBER 29, 2023



AstrAlim

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Revision History

Revision	Date	Contributor	Comments
0.1-09	12/11/2023	DenisG	Initial Revision
0.1-23	13/11/2023	DenisG, ArnaudV	Work on power supply and other sections.

1. Introduction

1.1. Document Management

This Libre Office document resides at the following URL: https://hsanchezii.wordpress.com

This document's status is: *Work-in-progress*.

1.2. Acronyms

GPIO	General Purpose Input/Output
USB	Universal Serial Bus
NafaBox	Nomad Astronomie For All

1.3. General context :

The purpose of NafaBox-Hardware, which was born at the end of 2018, is to be able to offer to everyone plug-in electronic cards for a Raspberry Pi (or a card with a compatible 40-pin connector) dedicated to amateur astronomers.

The NafaBox-Hardware is designed in order to offer the capacity to drive a complete set of telescope hardware with minimal cabling, and in the context of Nomadism, where the power supply is a 12V batterie.

The NafaBox is there to provide for a device hub. Limiting cabling for the telescope devices.
The NafaBox provides for a CPU enabling to leave the telescope operating alone during the night with minimal power consumption.
The NafaBox provides for power management.

Device to take into account :

1. Mount (12V alimentation, EQMOD (USB) Interface.
2. Main cooled camera (12V alimentation, USB3 interface)
3. Guide Camera (USB3 interface)
4. Heat strips for drew management.
5. Focuser step motor.
6. Temperature sensors. (e.g. DS18B20)
7. Humidity pressure and temperature sensor (E.g.: I2c BME280 or DHT22)
8. GPS sensor for easy positioning and time management.
9. RTC clock.

The NafaBox-Hardware is meant to be used with Indi interface library.
The NafaBox-Hardware is meant to be used with a Raspberry pi computer which provides for the Software interface to the user PC.

Target software to be run on the NafaBox set are : Kstars, VNC, specifics, …

The NafaBox is currently made of a Rapsberry PI4 with 4 stacked hats.

1.4. User requirements :

With regards to the NafaBox original the requirements are :
The Astralim board is designed to offer as many functions as the original 4 board while maintaining software compatibility.
If possible, it aims to leverage the stacking principle to introduce additional functions in the future while preserving the initial stacking concept.

1.4.1. Context of usage :

The solution shall provide the electronic and power distribution to enable astrophotogaphy.
The solution shall be usable in mobility, as well as on fixed location.
The solution shall be usable remotely.
The Astralim must connect to a rpi4 or rpi5 via via a standard hat 40 connector
The Astralim must accept a 12v 10a input line on a 2.1mm connector
The Astralim must output a 12v line for the mount
The Astralim must output a 12v line for the cooled camera with a 2,1 connector
The Astralim must output up to two 12v lines for the dew heaters on RCA connectors
The Astralim must output to a 12v output for the focuser on a 2.1mm connector
The 2 RCA/dew heaters must be PWM controlled

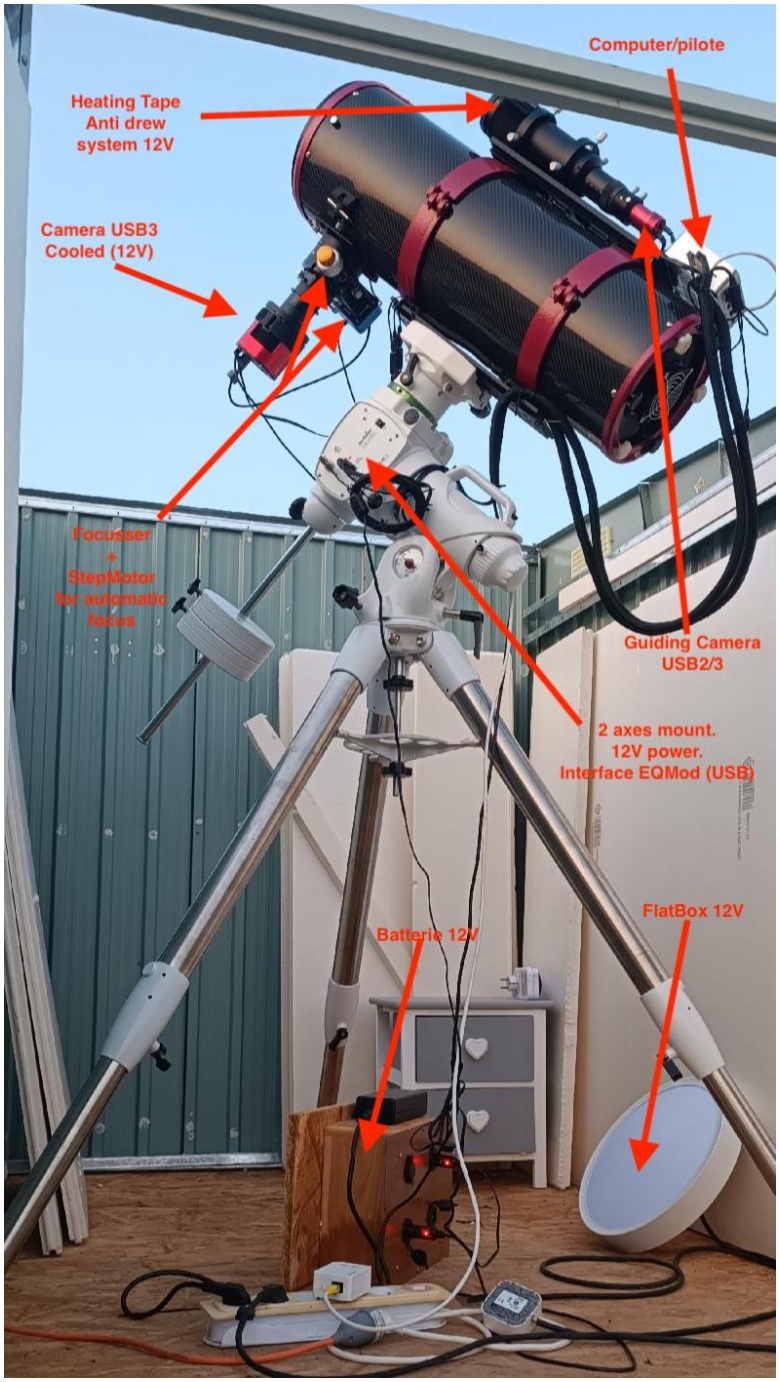


Figure 1: Typical astro setup

1.4.2. Computation capacity and user interface :

The solution shall provide the computational power needed to prepare and run autonomously the night of Astrophotography.
The solution shall enable the user to take of it's laptop from the telescope setup while the telescope is continuing operations.

1.4.3. Time and positioning :

The solution shall include a saved clock in order for the computer for correct skymap working.

The solution shall include a GPS for correct earth positioning.
The solution shall include a GPS for a precise time synchronization (lower than ms). This will enable occultation measurements (Step below special Camera setup).

1.4.4. Anti drew system:

The interfaces shall enable the computation of the drew point, in order to enable the temperature control of the telescope optics with drew heaters.

The calculation of the drew point could be given by Magnus-Tetens[1] formula, or similar formula. The calculation needed measurement of the temperature, humidity, and optionally the pressure.

1.4.5. Licensing :

The solution shall enable open source software solutions.

1.4.6. Power management and mobility :

In mobility, the power needed is a battery. As a consequence the solution shall be usable with a quite standard power solution. (12V battery pack).

In mobility we shall be able to monitor power consumption of the different devices.
We shall be able to cut the power of unneeded devices.
In particular during mission preparation, only a small set of devices shall be powered on.

When power from the electrical grid is available, it shall be possible to supply 12V through an external switched-mode power supply. (Compatibility aspect)

1.4.7. Setup to be managed :

The setup includes :

1. A main cooled astronomic camera (USB3 and 12V cooling standard interfaces).
2. A guiding camera.
3. Drew heaters.

1.5. Open discussion – Not to be included

1.5.1. Open discussion :

1.5.2. Not to be included

After being investigated, the usage of the RPI for the study of asteroid occultation, seems to be rather difficult to attain. Anyhow, the RPI will have it's RTC synchronized with the GPS Time, Further tests will be conducted to refine the potential usage of the solution for asteroids observations. A software solution will be preferred.

[1] https://fr.wikipedia.org/wiki/Point_de_ros%C3%A9e

2. List of requirements

2.1. Context and hypothesis :

2.1.1. Needs for 5V power and constraints :

2.1.1.1. Power consumption of equipment connected to raspberry :

- **RPI4** USB output :
  - All of the models with 4 USB ports have a maximum USB port output of 1.2A for all 4 ports combined, with no per-port limits (meaning, all 1.2A is available on a single port if no others are in use).
- **RPI5** USB Output :
  - **When using a standard 5V, 3A** (15W) USB-C power adapter with Raspberry Pi 5, by default we must limit downstream USB current to **600mA** to ensure that we have sufficient margin to support these workloads. **This is lower than the 1.2A** limit on Raspberry Pi 4
- USB 3 : 900 mA
- Camera : Mainly USB3 type B with no specific characteristics => 900mA. (Wikipedia)
  - Main Camera :
    - ASI533-MC : Camera Power consumption: 650mA at 5V
  - Guide: idem ASI553.
- EQMod interface : Negligibl.
- Memory :
  - PI5 Case : Nvme 1To power consumption : 1A

2.1.1.2. Power consumption of equipment connected to raspberry :

- RPI5 : RPI : Stress test : 12W (5V 2,4A)
- RPI4 : 400% CPU load (stress --cpu 4) 1280 mA (6.4 W)

2.1.1.2.1. Total :

- RPI4 : Min 5V, 3A.
  - (650mA * 2 Camera) maximisé par 1,2A pour la some des USB + 1280 mA (stress test) = 2480mA
  - Soit 12,4W
  - On a surestimé les camera
- RPI5 : Min 5V, 4.7A.
  - (650mA * 2 Camera) + 1A pour Nvme + Stress 2,4A
  - Total : 4700mA
  - Soit 23,5W

2.1.2. Needs for 12V power and constraints :

2.1.2.1. Mount power consumption :

Example of mount power consumption :

- *EQ8 : 12V 4.6A*
- HEQ6 : 12V 2A
- ZWO AM3 : 12V 1.7A
- ZWO AM5 : 12V 1.5A
- CQ350 : 12V 3A

Capacity to cut power enable to provide for a remote reset of the mount in case of bug of the goto part of the mount.

2.1.2.2. Camera Cooler :

- ARES-C Pro : 12V 2,5A
- ASI533-MC : 12V at 3A Max
- ASI2400MC : Cooling : 12V@3A DC

2.1.2.3. Heat Strip:

```
12V 0.2W /cm = 12V 0,02A
60mm guide scope => 0,7A
200mm Main mirror : 2,4A
```

2.1.2.4. Total:

Taking out EQ8 which is not movable : 12V 9A.

2.1.2.5. Using RPI GPIO for power input unlocking limitation :

Official documentation : Powering Raspberry Pi 5
PI4 :Physical/Board pin 2
RPI EEPROM : Github

Need to add to *boot*config.txt : “usb_max_current_enable=1”

2.2. General Requirements :

REQ1 : The board shall take power from a 12V DC source.

REQ2 : The board shall be protected by a re-settable fuse 10A

REQ3 : The board shall be protected against polarity inversion of the power source.

REQ5 : The board shall contain a Raspberry hat 40pin gpio connector.

REQ6 : The board shall connect the ground to all GPIO ground pins.

2.3. Price Targets :

REQ18 : The price of the board shall not be greater than 150€.

2.4. Raspberry compatibility :

REQ9 : The board shall be compatible with Raspberry PI4.

REQ11 : The board shall be compatible with Raspberry PI5.

The compatibility implies compliance with the Hat raspberry specifications, In particular having a boot eeprom, even if the Raspberry concept is not compatible with having multiple hats stacked on the same board.
References for this eeprom are here :

- ADD-ON BOARDS AND HATs (Rasberry requirements)
  - B+ HAT ID EEPROM FORMAT SPECIFICATION
- Exploration de l'EEPROM HAT du Raspberry Pi (Partie ½)
- Exploration de l'EEPROM HAT du Raspberry Pi (Partie 2/2)
- Raspberry Pi HAT identity EEPROMs, a simple guide

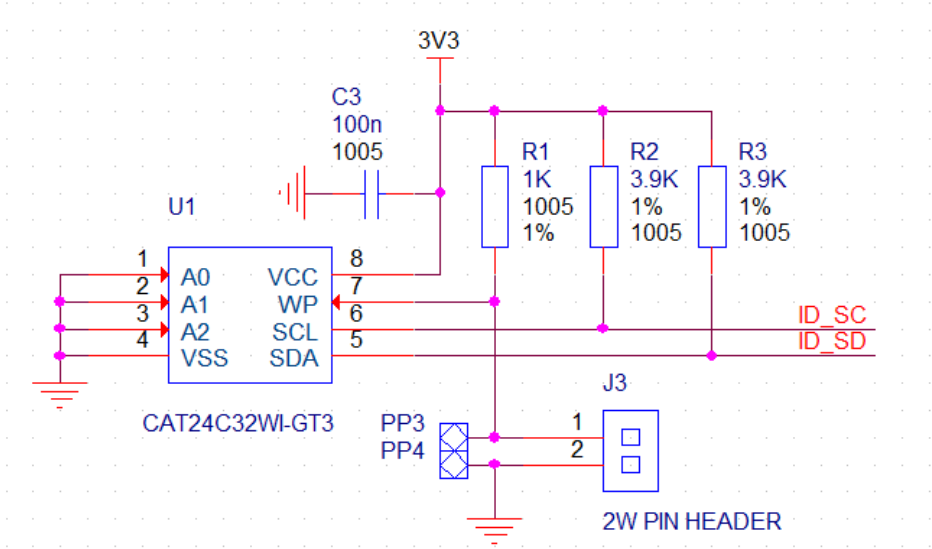


Figure 2: Wirering for the eeprom

2.4.1.1. 5V Outputs:

Rational for the following requirements : See analysis section 2.1.1..

REQ10 : The board shall provide the capacity to provide the 5V to the raspberry via the GPIO.

REQ10.4 : The board shall conform to HAT raspberry requirements about power from the GPIO. (back power from Raspberry power source).

Below two schematics extracted from the Raspberry documentation for hats.

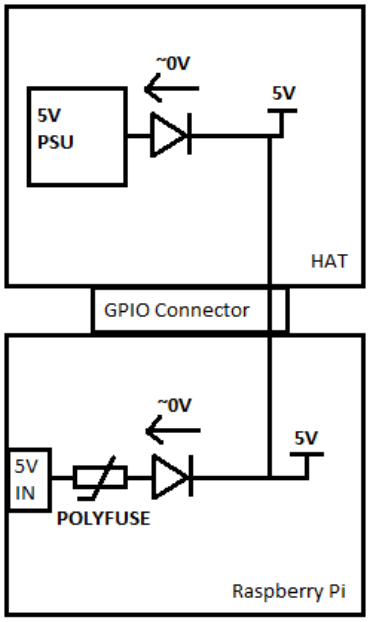


Figure 3: Backpower protection principle

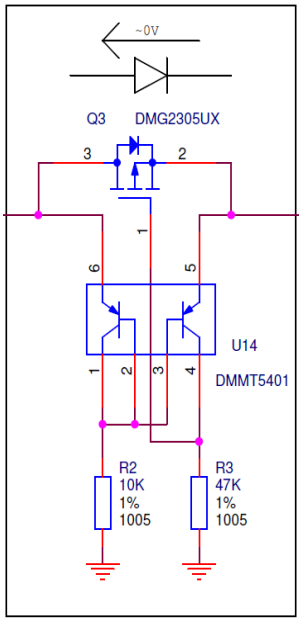


Figure 4: Backpower protection example for the raspberry

REQ10.1 : Hyp 1 : via all the GPIO pins controlled by a dip switch.

Rational : the PI5 raspberry limits the current to 500mA to it's USB outputs, and may provide for limited operations if the power is not provided by the USB-C connector.

REQ10.2 : Hyp 2 : via all the USB-C raspberry connector.

Rational : In this hypothesis an external connector is needed (E.g. : LinkAdaptor).

REQ10.3 : Hyp 3 : The power is provided through the GPIO, with 5A capacity.
The /boot/config.txt contains usb_max_current_enable=1 as expressed in section 2.1.2.5. should enable appropriate USB power output for the cameras.

REQ7 : The board shall include a DC-DC step down circuit that will provide 5V 5A (25W) power from 12V input power. (see REQ10.1, REQ10.2 and REQ10.3)
E.g.: DC-DC TRACOPOWER, THL 25

2.5. 12V Outputs :

Need :

- Termal regulation of camera.
- 2 heat strips for Guide, primary, and secondary
- Power for mount.

REQ12 : A measurement of out power shall be provided for each output.

REQ13 :The board shall provide a controllable 12V 3A outputs for external device interfacing. (Mount)

REQ21 : The board shall provide a controllable 12V 3A outputs for external device interfacing. (Cooler)

REQ14 : The board shall provide two PWM-controllable 12V 3A outputs for interfacing with heater strips.

2.6. 9V Outputs :

REQ8 :The board shall include a DC-DC step down circuit that will provide 9V 3A power.

2.7. Focuser :

Rational for the following requirements : The indi driver astroberry-diy driver for kstars provides for an appropriate interface..

REQ15 : Provide either DRV8834 and A4988 stepper controllers.

REQ16 : Interface STEP, DIR, MS1, MS2, MS3 shall be connected to the GPIO.

REQ24 : The Focuser component shall be inserted as a removable component too enable change of the component in case of bad usage of the driven motor.

2.8. GPS :

Pps signal ?

REQ25GPS : A module GPS shall be included with a SMA connector to enable external antenna.
e.g.: NEO-6M (Amazon) or NEO-6M (AliExpress)

2.9. Physical format and stacking constraints :

REQ4 **:** The board format shall be a Raspberry Hat format.

REQ17 : The board high shall be a multiple of 11mm high for GPIO connector compatibility. (To be reworded).

2.10. Drew environmental sensors :

REQ22 : Temperature sensor that can be external to the board enclosure.
E.g.: 1wire connector for DS18B20

REQ23 : humidity, pressure and temperature sensor.
E.g.: BME280.

2.11. Thermal aspect :

TBD

2.12. Compatibility with other NAFABox boards :

REQ19 : The Astralim shall be compatible with other NafaBox Hardware if the functionality is not completely replaced.

REQ20 : The Astralim shall be compatible with other NafaBox hardware if addition of the original Nafa Board does add functionality to the complete set.

3. Implementation strategie

3.1. Connectors:

3.1.1. 12V

3.1.2. USB

3.1.3. 9V

3.1.4. GPS

3.1.5. Focuser

3.1.6. Raspberry hat compatbility

3.2. Price management:

The following table gives a price evaluation:

REQ		Prix TTC €
GPS NEO-6M Mini		

3.3. Requirement compliance (Traceability and rational) :

Requirement Number	Rational for implementation or rejection	Implemented (Yes/no)

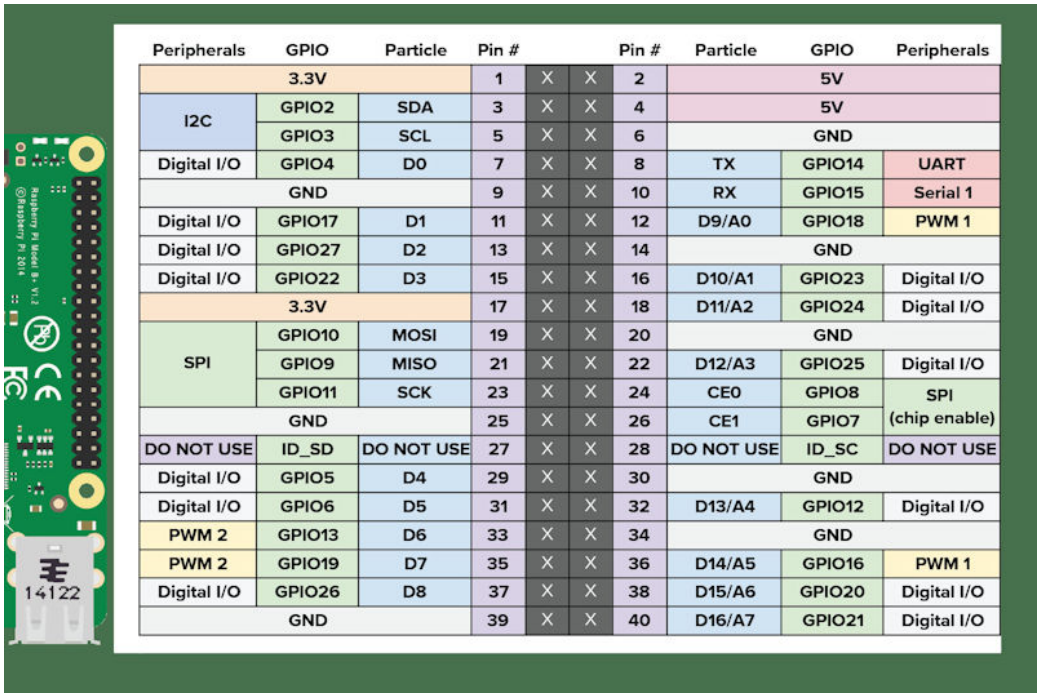
Requirement Number	Rational for implementation or rejection	Implemented (Yes/no)

3.4. Compatibility with other NafaBox board folowup.

In the view of the preliminary conception the Astralim provides for all functions of the NafaRes, and NafaAlim board.
=> compatibility is not needed save for the Software aspect.

Pin	Fct			NAFA Base	NAFA Relay	AstrAlim	
1	3.3V						
2	5V						
3	GPIO 2	I2C SDA		RTC		PowerSensor1,2,3,4 Pwm Out 3, Pwm Out 4	
4	5V						
5	GPIO 3	I2C SCL		RTC		PowerSensor1,2,3,4 Pwm Out 3, Pwm Out 4	
6	GND						
7	GPIO 4					1 Wire	
8	UART TX					Gps (tx/rx)	
9	GND						
10	UART RX					Gps (tx-rx)	
11	GPIO 17				Relay1		
12	GPIO 18		PWM0		Relay2	Relay_GPIO18_PWM0	
13	GPIO 27				Focus Dir		
14	GND						
15	GPIO 22				Relay3		
16	GPIO 23				Relay4		
17	3.3V						
18	GPIO 24				Focus RST		
19	GPIO 10	SPI0 MOSI					
20	GND						
21	GPIO 9	SPI0 MISO				GPS PPS	

22	GPIO 25				Focus Step		
23	GPIO 11	SPI0 SCLK					
24	GPIO 8	SPI0 CS0					
25	GND						
26	GPIO 7	SPI0 CS1					
27	GPIO 0	EEPROM I2C SD				EEPROM I2C SD (ID-SD)	
28	GPIO 1	EEPROM I2C SC				EEPROM I2C SC (ID_SC)	
29	GPIO 5						
30	GND						
31	GPIO 6						
32	GPIO 12		PWM0	FAN			
33	GPIO 13		PWM1			Relay_GPIO18_PWM0	
34	GND						
35	GPIO 19	SPI1 MISO	PWM1				
36	GPIO 16	SPI1 CS0					
37	GPIO 26						
38	GPIO20	SPI1 MOSI					
39	GND						
40	GPIO 21	SPI1 SCLK					



Peripherals	GPIO	Particle	Pin #			Pin #	Particle	GPIO	Peripherals
3.3V			1	X	X	2	5V		
I2C	GPIO2	SDA	3	X	X	4	5V		
	GPIO3	SCL	5	X	X	6	GND		
Digital I/O	GPIO4	D0	7	X	X	8	TX	GPIO14	UART
GND			9	X	X	10	RX	GPIO15	Serial 1
Digital I/O	GPIO17	D1	11	X	X	12	D9/A0	GPIO18	PWM 1
Digital I/O	GPIO27	D2	13	X	X	14	GND		
Digital I/O	GPIO22	D3	15	X	X	16	D10/A1	GPIO23	Digital I/O
3.3V			17	X	X	18	D11/A2	GPIO24	Digital I/O
SPI	GPIO10	MOSI	19	X	X	20	GND		
	GPIO9	MISO	21	X	X	22	D12/A3	GPIO25	Digital I/O
	GPIO11	SCK	23	X	X	24	CE0	GPIO8	SPI (chip enable)
GND			25	X	X	26	CE1	GPIO7	
DO NOT USE	ID_SD	DO NOT USE	27	X	X	28	DO NOT USE	ID_SC	DO NOT USE
Digital I/O	GPIO5	D4	29	X	X	30	GND		
Digital I/O	GPIO6	D5	31	X	X	32	D13/A4	GPIO12	Digital I/O
PWM 2	GPIO13	D6	33	X	X	34	GND		
PWM 2	GPIO19	D7	35	X	X	36	D14/A5	GPIO16	PWM 1
Digital I/O	GPIO26	D8	37	X	X	38	D15/A6	GPIO20	Digital I/O
GND			39	X	X	40	D16/A7	GPIO21	Digital I/O

Figure 5: Header du raspberry

3.5. Technical aspects and conception elements :

3.5.1. I2C

3.5.1.1. I2C address :

I2C Adress		A0	A1	A2	Function	Component	Board
0x69[2]	0110 1001[3]				RTC	DS3231MZ	NafaBase
0x41	0100 0001	3.3V	Gnd		Measure Out 1	INA219AIDR	Astralim
0x44	0100 0100	Gnd	3.3V		Measure Out 2	INA219AIDR	Astralim
0x49	0100 1001	3.3V	SDA		Measure Out 3	INA219AIDR	Astralim
0x4D	0100 1101	3.3V	SCL		Measure Out 4	INA219AIDR	Astralim
0x28	0101 0000	Gnd	Gnd	Gnd	Pwm Out 3 [4] (Set duty / Shut Down /recall / Read pwm duty)	DS1050Z-005	Astralim
0x2A	0101 0100	Gnd	3.3V	Gnd	Pwm Out 3 [5] (Set duty / Shut Down /recall / Read pwm duty)	DS1050Z-005	Astralim

[2]May be set at first time setup.
[3]May be set at first time setup.
[4]In shutdown mode output will be high impedance. With regards to the Astralim design which has a pull own resistor, this mode will shut off the output consistently.
[5]In shutdown mode output will be high impedance. With regards to the Astralim design which has a pull own resistor, this mode will shut off the output consistently.

Note: No compatibility aspect on the eeprom I2C hat.

3.5.1.2. I2C Hardware:

On pin GPIO2 and 3 it is not necessary to have pull up resistors.
https://pinout.xyz/pinout/i2c

3.5.2. 1Wire :

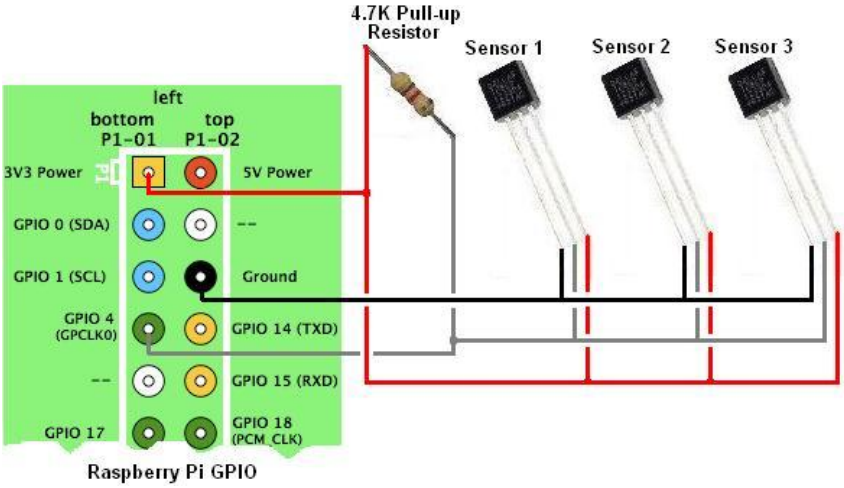


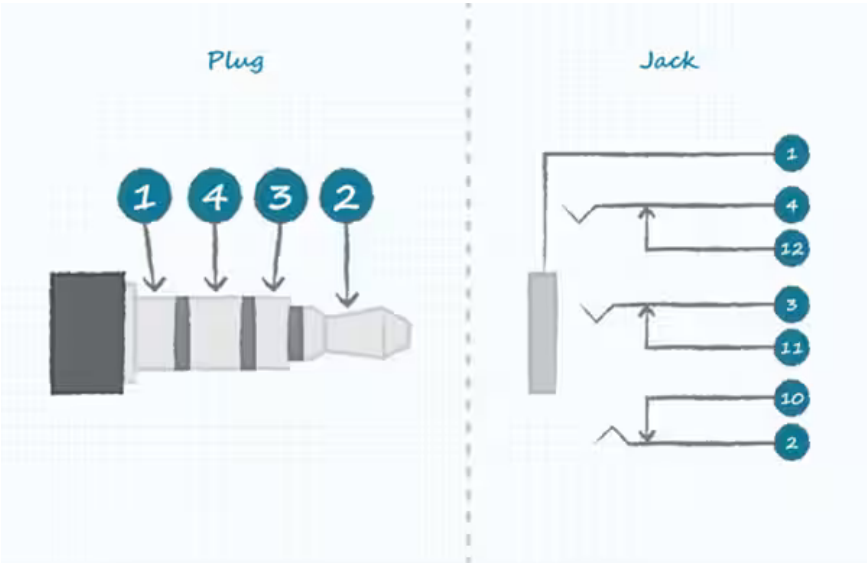
Figure 6: Branchement multiples capteurs 1wire

Source : https://doc.ycharbi.fr/index.php/Utiliser_un_DS18B20_%28capteur_de_temp%C3%A9rature%29

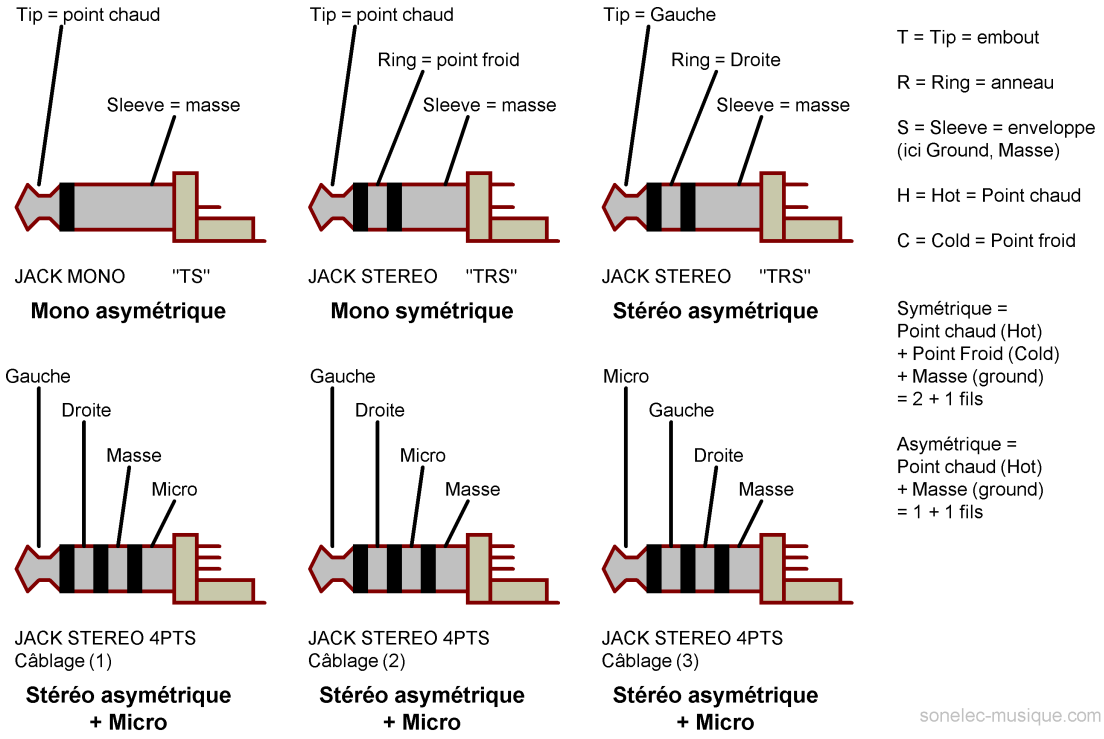
3.5.3. Jack audio connector for 1 wire and I2C :

3.5.3.1. Audio Standards analysis

https://www.digikey.fr/fr/articles/a-deep-dive-into-audio-jack-switches-and-configurations



and :
https://www.sonelec-musique.com/connectique_connecteurs_bf.html



This implies for audio connectors, that:
1,3,4, 12,11 may be associated to GND.
2,10 is always separated.

To avoid GND/3.3V output to be short circuit, we shall have 1 as Gnd and 2 as 3.3V.

3.5.3.2. Impact with PJ-35372

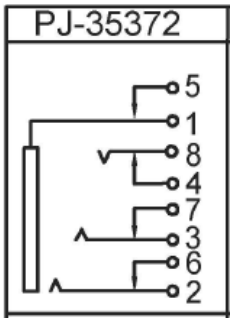


Figure 7: Audio Jack connector PJ-35372

3.5.3.2.1. 1 Wire :

1/5 is Gnd.
8/4 is 3.3V (Because this avoid short circuit between 3.3V and Gnd if inserting a mono jack by error)
7/3 is 1 wire (Because this enable to work with mono jack for 1 wire.
6/2 is Gnd to comply with jack without mic.

3.5.3.2.2. I2C :

1/5 is Gnd.
8/4 is 3.3V (Because this avoid short circuit between 3.3V and Gnd if inserting a mono jack by error)
7/3 is SCA
6/2 is SCL.

4. To check:

4.1. Mode économie d'énergie :

Check that PI with power input via header pins is not in low power consumption leading to lower performance.

4.2. Mosfet :

https://www.google.com/search?q=montage%20interrupteur%20mosfet%2012vdc%20pilot%C3%A9%203.3V&tbm=isch&tbs=rimg:CcaCpHvidmBIYaLSqXthpDARsgINEAA6BAgAEABVB8kvP8ACANgCAOACAA&client=firefox-b-e&hl=fr&sa=X&ved=0CBwQuIIBahcKEwiwg6exx4-DAxUAAAAAHQAAAAAQBw&biw=1920&bih=1087&dpr=1#imgrc=bv90Wmwv9amCIM&imgdii=wzFKX9I9LqF08M

https://zestedesavoir.com/forums/sujet/13122/controle-de-moteur-avec-p-mosfet/

4.3. PWM :

- On PI5 that the two PWM outputs are available. + Fréquence.
  - If so = Bord is limited to PI5, and/ or the Nafa Base out for the fan is lined.
  -
- Circuit de pilotage.
- Existe t il un module pilotage pwm.

Sys pwm

https://github.com/jdimpson/syspwm

Documentation : https://github.com/dotnet/iot/blob/main/Documentation/raspi-pwm.md

https://rpi-lgpio.readthedocs.io/en/release-0.4/api.html#RPi.GPIO.setup

PWM à essayer :

https://github.com/jdimpson/syspwm/blob/master/README.md

!!!!!!!!

Sur PI5 Les pines mises en oeuvres sont GPIO18 (PIN12) et GPIO13(PIN33)

Impossible de mettre en oeuvre les 2 autres pins à ce jour 25/12/2023

4.4. GPIO std compatible PI5:

Module rpi.gpio semble obsolète et ne marche plus, et ne fonctionne pas sur PI5.

La lib gpiod utilisant les capacités kernel (/proc ou /sys) semble être la bonne solution.

!!!!!!!!!!!!!!!

sudo apt install gpiod python3-libgpiod

https://github.com/brgl/libgpiod/blob/master/bindings/python/examples/gpiofind.py

stellarmate@stellarmatePI5:~ $ gpioinfo

gpiochip0 - 32 lines:

line 0: "-" unused input active-high

```
        line   1: "2712_BOOT_CS_N" "spi10 CS0" output active-low [used]
        line   2: "2712_BOOT_MISO" unused input active-high
        line   3: "2712_BOOT_MOSI" unused input active-high
        line   4: "2712_BOOT_SCLK" unused input active-high
        line   5:          "-"      unused   input  active-high
        line   6:          "-"      unused   input  active-high
        line   7:          "-"      unused   input  active-high
        line   8:          "-"      unused   input  active-high
        line   9:          "-"      unused   input  active-high
        line  10:          "-"      unused   input  active-high
        line  11:          "-"      unused   input  active-high
        line  12:          "-"      unused   input  active-high
        line  13:          "-"      unused   input  active-high
        line  14:   "PCIE_SDA"      unused   input  active-high
        line  15:   "PCIE_SCL"      unused   input  active-high
        line  16:          "-"      unused   input  active-high
        line  17:          "-"      unused   input  active-high
        line  18:          "-"      unused   input  active-high
        line  19:          "-"      unused   input  active-high
        line  20:   "PWR_GPIO" "pwr_button"   input   active-low [used]
        line  21: "2712_G21_FS" unused input active-high
        line  22:          "-"      unused   input  active-high
        line  23:          "-"      unused   input  active-high
        line  24:    "BT_RTS"       unused   input  active-high
        line  25:    "BT_CTS"       unused   input  active-high
        line  26:    "BT_TXD"       unused   input  active-high
        line  27:    "BT_RXD"       unused   input  active-high
        line  28:     "WL_ON"  "wl_on_reg"  output  active-high [used]
        line  29:     "BT_ON"   "shutdown"  output  active-high [used]
        line  30: "WIFI_SDIO_CLK" unused input active-high
        line  31: "WIFI_SDIO_CMD" unused input active-high
gpiochip1 - 4 lines:
        line   0: "WIFI_SDIO_D0" unused input active-high
```

line 1: "WIFI_SDIO_D1" unused input active-high

line 2: "WIFI_SDIO_D2" unused input active-high

line 3: "WIFI_SDIO_D3" unused input active-high

gpiochip2 - 17 lines:

line 0: "RP1_SDA" unused input active-high

line 1: "RP1_SCL" unused input active-high

line 2: "RP1_RUN" "RP1 RUN pin" output active-high [used]

line 3: "SD_IOVDD_SEL" "vdd-sd-io" output active-high [used]

line 4: "SD_PWR_ON" "sd_vcc_reg" output active-high [used]

line 5: "SD_CDET_N" unused input active-high

line 6: "SD_FLG_N" unused input active-high

line 7: "-" unused input active-high

line 8: "2712_WAKE" unused input active-high

line 9: "2712_STAT_LED" "ACT" output active-low [used]

line 10: "-" unused input active-high

line 11: "-" unused input active-high

line 12: "PMIC_INT" unused input active-high

line 13: "UART_TX_FS" unused input active-high

line 14: "UART_RX_FS" unused input active-high

line 15: "-" unused input active-high

line 16: "-" unused input active-high

gpiochip3 - 6 lines:

line 0: "HDMI0_SCL" unused input active-high

line 1: "HDMI0_SDA" unused input active-high

line 2: "HDMI1_SCL" unused input active-high

line 3: "HDMI1_SDA" unused input active-high

line 4: "PMIC_SCL" unused input active-high

line 5: "PMIC_SDA" unused input active-high

gpiochip4 - 54 lines:

line 0: "ID_SD" unused input active-high

line 1: "ID_SC" unused input active-high

line 2: "PIN3" unused input active-high

line 3: "PIN5" unused input active-high

```
line  4:      "PIN7"  "onewire@0"  output  active-high [used open-drain]
line  5:     "PIN29"      unused   input  active-high
line  6:     "PIN31"      unused   input  active-high
line  7:     "PIN26"      unused   input  active-high
line  8:     "PIN24"      unused   input  active-high
line  9:     "PIN21"      unused   input  active-high
line 10:     "PIN19"      unused   input  active-high
line 11:     "PIN23"      unused   input  active-high
line 12:     "PIN32"      unused   input  active-high
line 13:     "PIN33"      unused   input  active-high
line 14:      "PIN8"      unused   input  active-high
line 15:     "PIN10"      unused   input  active-high
line 16:     "PIN36"      unused   input  active-high
line 17:     "PIN11"      unused   input  active-high
line 18:     "PIN12"      unused   input  active-high
line 19:     "PIN35"      unused   input  active-high
line 20:     "PIN38"      unused   input  active-high
line 21:     "PIN40"      unused   input  active-high
line 22:     "PIN15"      unused   input  active-high
line 23:     "PIN16"      unused   input  active-high
line 24:     "PIN18"      unused   input  active-high
line 25:     "PIN22"      unused   input  active-high
line 26:     "PIN37"      unused   input  active-high
line 27:     "PIN13"      unused   input  active-high
line 28: "PCIE_RP1_WAKE" unused input active-high
line 29:  "FAN_TACH"      unused   input  active-high
line 30:  "HOST_SDA"      unused   input  active-high
line 31:  "HOST_SCL"      unused   input  active-high
line 32:  "ETH_RST_N"  "phy-reset"  output   active-low [used]
line 33:        "-"       unused   input  active-high
line 34: "CD0_IO0_MICCLK" "cam0_reg" output active-high [used]
line 35: "CD0_IO0_MICDAT0" unused input active-high
line 36: "RP1_PCIE_CLKREQ_N" unused input active-high
```

line 37: "-" unused input active-high

line 38: "CD0_SDA" unused input active-high

line 39: "CD0_SCL" unused input active-high

line 40: "CD1_SDA" unused input active-high

line 41: "CD1_SCL" unused input active-high

line 42: "USB_VBUS_EN" unused output active-high

line 43: "USB_OC_N" unused input active-high

line 44: "RP1_STAT_LED" "PWR" output active-low [used]

line 45: "FAN_PWM" unused output active-high

line 46: "CD1_IO0_MICCLK" "cam1_reg" output active-high [used]

line 47: "2712_WAKE" unused input active-high

line 48: "CD1_IO1_MICDAT1" unused input active-high

line 49: "EN_MAX_USB_CUR" unused output active-high

line 50: "-" unused input active-high

line 51: "-" unused input active-high

line 52: "-" unused input active-high

line 53: "-" unused input active-high

stellarmate@stellarmatePI5:~ $ dpkg -L gpiod

4.5. Mesure de tension/courant

- Le composant INA (Mesure des tensions / Ampère de sortie) aussi. Ceci provoque un écart de disons 10% sur la mesure qui n'était pas très acceptable pour les cartes de satellites auquel il a participé. Pour notre cas d'usage ce n'est pas trop important. => mesure à faire. à l'oscilo pour voir.

4.6. Autre

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- Est-ce que le transistor suffit pour le pwm à 5KHz DS1050Z-005
- La fréquence trop élevée du PWM peut être un Pb pour le mosfet (expérience de Seb) => attention + mesure de sortie.
- MU Nafa Bx : Les entrées sont d’un coté les sorties de l’autre.
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Appendices