AstroLink 4 Pi

(version 4 - temperature/humidity/dew point/cloud coverage/sky temperature/sky brightness sensors support, voltage/current/energy metering,
Raspberry Pi 4 and 5 support)

astrojolo.com @2023

Rev. 1.4

Main features:

- astroimaging control center based on Raspberry Pi[1] 4 or 5
- dedicated *AstroLink 4 Pi* INDI driver
- focuser motor control for *Robofocus*, *Moonlite*, or generic unipolar or bipolar stepper motor
- up to 1/32 micro-stepping control with 2.0A maximum current and 1.4A maximum continuous hold current
- temperature, humidity, sky temperature/cloud coverage, and sky brightness sensors
- real-time clock embedded
- voltage, current, and energy consumed monitor - must have when powering the setup with a battery
- permanent focuser position – no need to park focuser after the session
- 2 adjustable PWM power outputs to control dew heaters, telescope fans, or custom Peltier coolers. The maximum load is 40W per output
- 2 switchable power outputs to power mount, cameras, or filter wheels. The maximum load is 5A per output
- 1 additional permanent power output
- 1 additional adjustable 3-10V DC output
- XT60 high current input voltage socket

Technical data

- dimensions: 137x83x32mm
- weight: 235g (with Raspberry Pi[1] module installed)
- the maximum current drawn from all outputs: 10A (120W)
- *AstroLink 4 Pi* power consumption: 6W max
- regulated PWM outputs: 50W max
- permanent 12V DC output: 5A max
- switchable 12V DC outputs: 5A max
- focuser stepper motor outputs: RJ12 6 pin, 2.0A max
- adjustable DC output: 2A maximum peak load, 1.5A continuous load
- RJ9 socket for sensors

WARNING!

Do not connect or disconnect the stepper motor when power is on. It may damage the stepper motor controller.

Make sure the stepper hold torque is set to 0% before replacing the stepper motor with a motor of a different type.

Do not cover ventilation slits at the enclosure sides and back.

[1] Raspberry Pi is a trademark of Raspberry Pi Trading

Device overview

System and hardware requirements

AstroLink 4 Pi requires a Raspberry Pi[2] 4 or 5 to be installed. A module with 4GB or 8GB of RAM is recommended. *AstroLink 4 Pi* has been designed to work under the control of the dedicated *AstroLink 4 Pi* INDI driver, which is available at https://github.com/astrojolo/astrolink4pi . **Stellarmate OS** or **Astroberry** system is recommended, however, any working Linux distribution that supports the INDI drivers system will work - for example, **AstroPi 3** was also tested with *AstroLink 4 Pi*. A good quality 32GB or larger card is recommended (Class 10 at least). Most of the Raspberry Pi[2] problems come from a poor-quality power supply or SD card. SD cards as large as 256GB were tested with the device.

PWM outputs

AstroLink 4 Pi has two RCA outputs that provide a PWM (pulse width modulation) regulated signal. Regulations cover the full 0-100% range. These outputs are usually used for powering dew cap heaters. Output can be regulated using controls in the dedicated INDI driver panel. PWM cycle frequency can be set in the INDI driver options in the range 10-1000Hz. The default output value at the connection can be defined.

Switchable 12V DC outputs

The device contains two switchable DC outputs, that may provide a supply voltage for imaging setup components (camera, mount, etc). Output can be switched using controls in the dedicated INDI driver panel. The default output value at the connection can be defined.

Focusing motors control

The focusing motor can be controlled with the *AstroLink 4 Pi* device. The focusing stepper motor can be connected to the 6 pins RJ12 socket. It supports 12V unipolar motors with gearboxes and bipolar motors at any microstepping resolution in a range of full step to 1/32. The focusing motor can be controlled with a dedicated INDI driver panel and via the *INDI* focuser interface. Depending on the *AstroLink 4 Pi* revision, the stepper motor current is adjusted with a potentiometer, or in the INDI control panel. Setting holding power is also possible. For unipolar geared motors it is highly recommended to set holding power to zero, so the motor will not overheat.

Permanent 12V DC output

This output is connected directly to the input 12V XT60 socket. Can be used to provide power to a mini PC or any other device powered with 12V.

Adjustable DC output

Internal switching converter provides regulated voltage in a 3-10V range that can be used to power any peripheral devices (DSLR, USB hub, etc.) Voltage can be adjusted with a 2mm flat screwdriver using a small potentiometer. The actual voltage at the adjustable output is displayed in the INDI driver panel.

Sensors

AstroLink 4 Pi can be connected with temperature, humidity, sky temperature/cloud coverage, and sky brightness sensors. The temperature reading is available in the dedicated INDI driver panel and can be used to perform temperature compensation of the focuser position. Temperature, humidity, sky brightness, and sky temperature values are also available in the INDI Environment tab.

[2] Raspberry Pi is a trademark of Raspberry Pi Trading

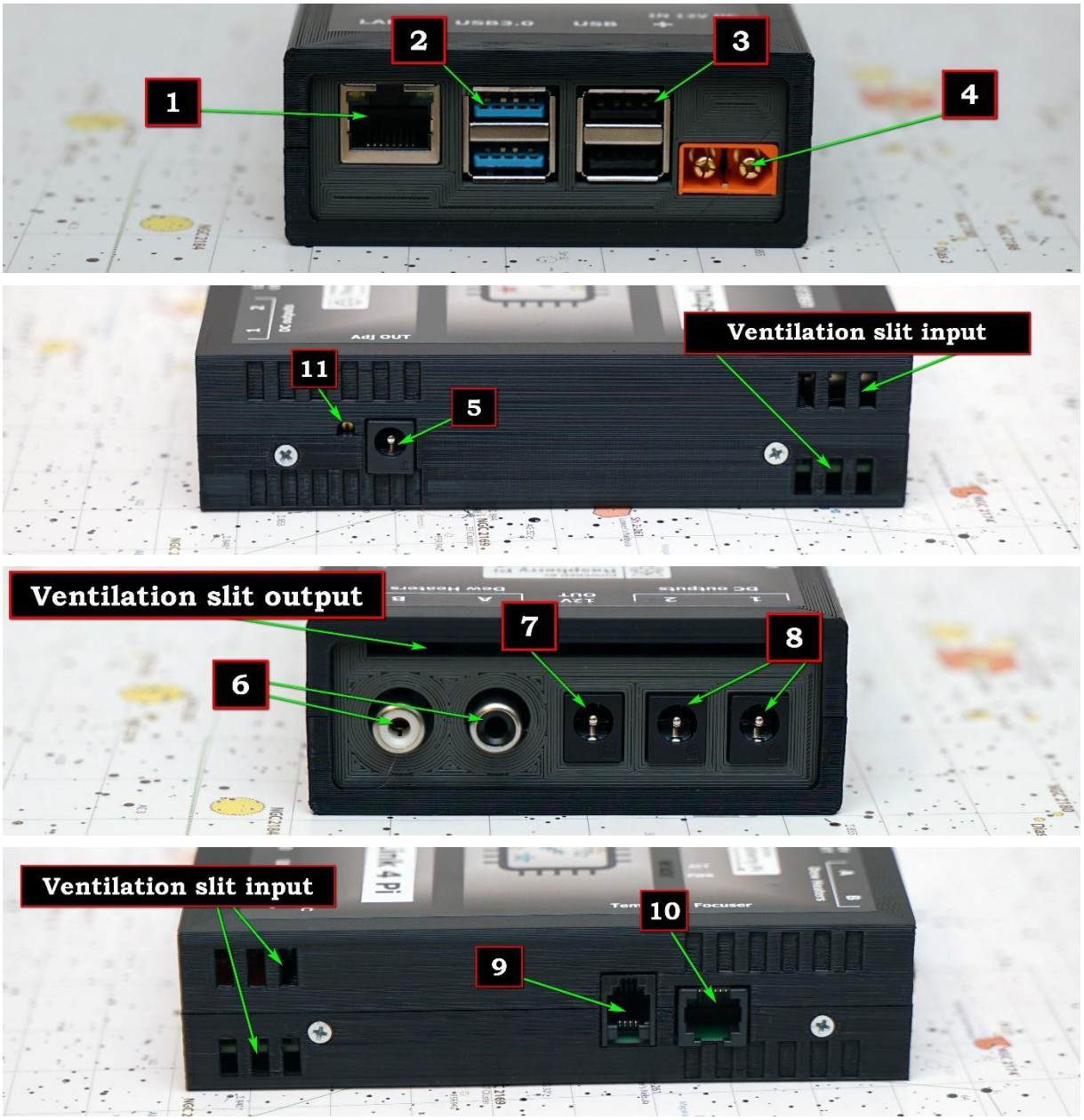
Voltage, current, and energy monitoring

AstroLink 4 Pi device has internal voltage and current sensors. The values from the sensors allow us to read:

- actual input voltage
- actual output voltage on the adjustable voltage output
- actual total current consumption in amperes
- actual total power consumption in watts
- the energy consumed since the power on time - in Ah and Wh

Example travel setup with AstroLink 4 Pi

External view



External views

1. LAN port
2. USB 3.0 ports
3. USB 2.0 ports
4. XT60 power input (12V DC)
5. Regulated DC output (3-10V)
6. Regulated RCA outputs
7. 12V DC output (non-switchable)
8. Switchable 12V outputs
9. Temperature sensor input
10. Focusing motor output
11. Regulated DC output adjustment

Version comparison

Feature	Version 1	Version 2	Version 3	Version 4
FOCUSING MOTOR CURRENT ADJUSTMENT	With potentiometer	In INDI panel		
RTC REAL-TIME CLOCK WITH COIN BATTERY	Not available	Available		
SUPPORTED SENSORS	DS1820 temperature sensor		SHT temperature and humidity sensor MLX sky temperature/cloud coverage sensor	
VOLTAGE, CURRENT AND ENERGY MONITORING	Not available			Available
RASPBERRY PI SUPPORTED	Raspberry Pi 4			Raspberry Pi 4 and 5

RTC battery replacement

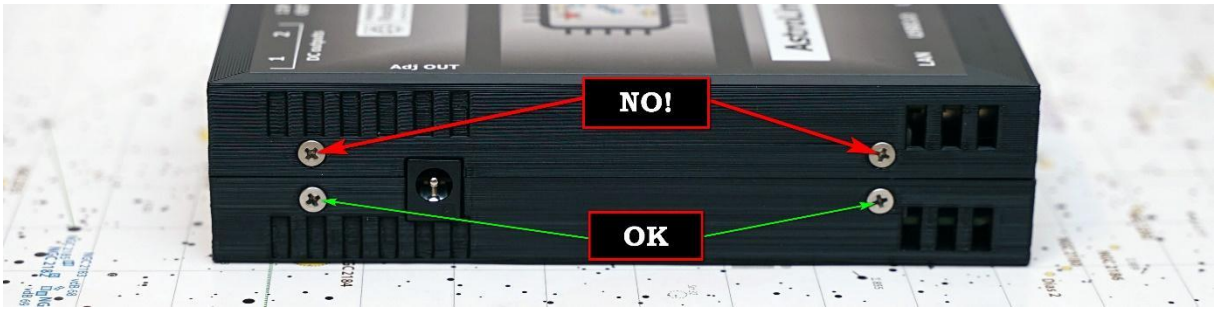
AstroLink 4 Pi revision (version) is displayed in the log window after clicking the Connect button

CR2032 battery that is used to sustain real-time clock should work for several years. If you notice that after switching on the device time is not set properly it may indicate that the battery needs replacement. You need to open the device (see *Hardware Setup* section), remove the Raspberry Pi[3] module and you will see the battery holder. Remove the battery and insert the new one. Make sure the polarity is correct. Refer to the *Software installation* chapter for setting up and synchronizing the time.

[3] Raspberry Pi is a trademark of Raspberry Pi Trading

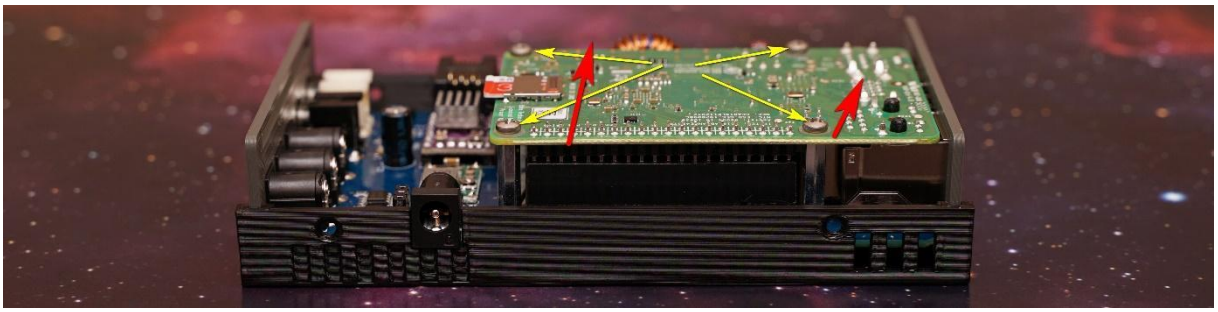
Hardware setup

Raspberry Pi [4] installation



Enclosure screws

Installing the Raspberry Pi[4] module requires opening the *AstroLink 4 Pi* enclosure. You need to unscrew four out of eight screws at the device's sides. Please remove only the bottom screws (there are only the bottom screws in the recent versions of the device). Then remove the enclosure top. After that, you need to unplug the cooling fan.

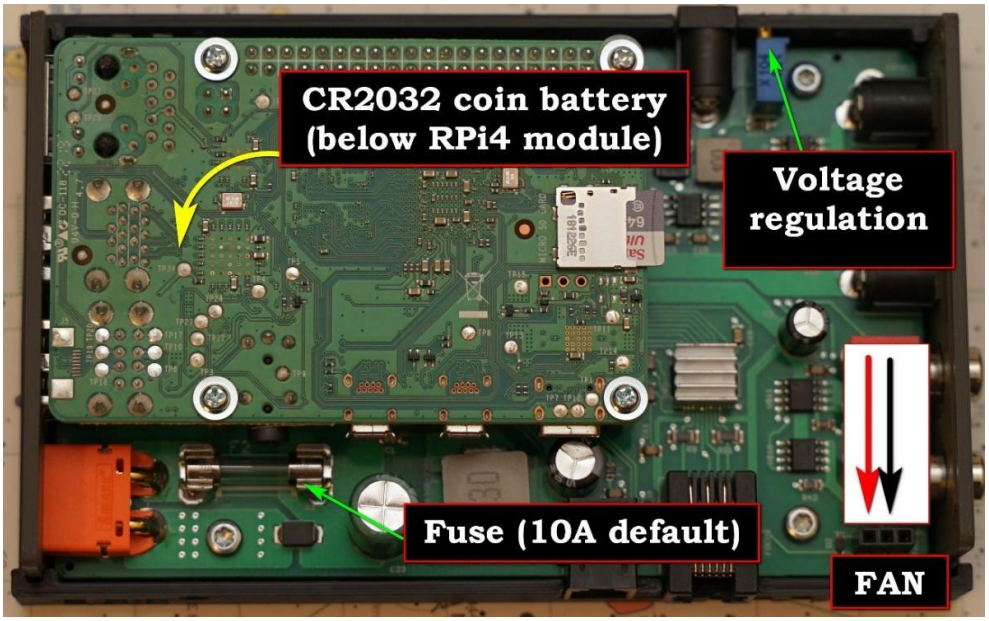


Raspberry Pi module fixing screws

Then remove four screws that fix the Raspberry Pi[4] module and place the module in the device. Watch the proper position of the GPIO socket pins. Put the Raspberry Pi[4] front sockets into the holes in the front device panel and push the pins down to the GPIO socket. Then fix the Raspberry Pi[4] module with four screws, connect the fan, and mount the top part of the enclosure. The last step is to put back four screws at the device's sides.

To unmount the Raspberry Pi[4] module just do all these steps in the reverse order.

[4] Raspberry Pi is a trademark of Raspberry Pi Trading



AstroLink 4 Pi interior

Focusing motor output

The stepper motor current is regulated with an option *Stepper current* in the INDI panel.

The stepper motor socket pinout:

AstroLink 4 Pi focusing motor output

Required connections are listed in the table below.

pin	unipolar	bipolar
1	COMMON	NOT CONNECTED
2	COMMON	NOT CONNECTED
3	COIL A	COIL A
4	COIL A’	COIL A’
5	COIL B	COIL B
6	COIL B’	COIL B’

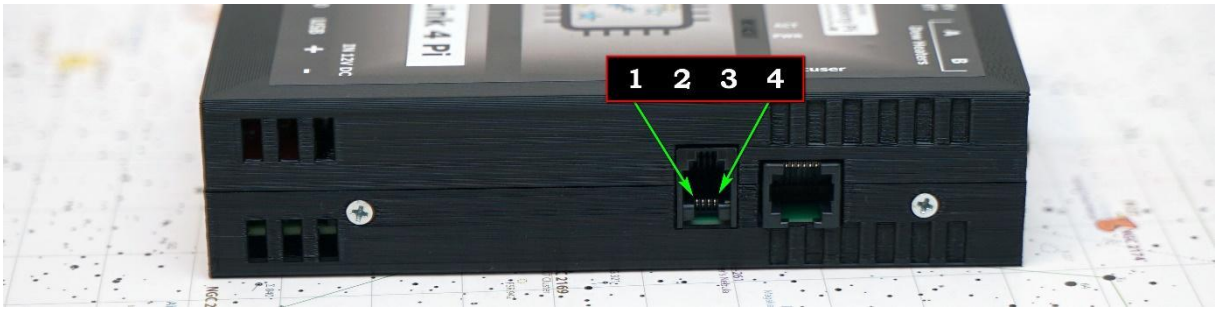
Setting the regulated output voltage

The voltage at the regulated output can be adjusted using a small potentiometer next to the output The regulated output voltage can be set in the range of 3 to 10V. Use a multimeter connected to the regulated voltage output to control the actual voltage value. The actual voltage of the regulated output is also displayed in the INDI driver panel.

Disconnect any device from the regulated voltage output before you start the voltage adjustment operation!

Connecting temperature sensor

AstroLink 4 Pi v.4 supports temperature/humidity and sky temperature/cloud coverage sensors. Sensor socket pinout is presented below. If you want to use more than one sensor, you need to have a sensor signal splitter (sold separately).



AstroLink 4 Pi v4 sensors socket

RJ9 socket	
1	Vcc (3.3V)
2	SCL
3	SDA
4	GND

Software installation

System setup

The recommended software is the *Astroberry* system that can be downloaded at the site https://www.astroberry.io/. *Astroberry* installation procedure is described there in detail. After the first run, you need to update WiFi settings, then connect to the home wireless network and update the system. Do not remove the default astroberry WiFi hotspot, that is used as a failover if it cannot connect to any other configured networks.

After that step, two more actions are required. Open *Raspberry Pi Configuration* and in the *Interfaces* tab enable *I^2C support* – this is required to read data from the temperature sensor. All these actions above are not required when you purchase an *AstroLink 4 Pi* device with the preconfigured system.

StellarMate OS or *AstroPi 3* is the other software that was tested with *AstroLink 4 Pi* device and works well.

INDI driver installation

AstroLink 4 Pi INDI driver is available at the https://github.com/astrojolo/astrolink4pi page. Required installation steps are listed in the README file.

If you have a fresh SD card with an astroberry system, then it is worth updating the system with the command

```
sudo apt update && sudo apt upgrade && sudo apt dist-upgrade
```

Download and install the required libraries before compiling AstroLink 4 Pi driver. See the INDI site for more details. In most cases, it's enough to run:

```
sudo apt install git build-essential cmake libindi-dev
```

Install lgpio library:

```
https://abyz.me.uk/lg/download.html
```

and restart the device. Then you can download and compile the driver:

```
git clone https://github.com/astrojolo/astrolink4pi
cd astrolink4pi
mkdir build && cd build
cmake -DCMAKE_INSTALL_PREFIX=/usr ..
make
```

Or update to the latest version:

```
cd ~/astrolink4pi/build/
git pull
```

```
cmake -DCMAKE_INSTALL_PREFIX=/usr ..
make
```

You can install the drivers by running:

```
sudo make install
```

Real-Time clock enabling

To enable automatic synchronization of the RTC embedded in AstroLink 4 Pi v.4 you need to edit the file

```
sudo nano /etc/rc.local
```

and add the following line before `exit 0` statement at the file end

```
echo ds1307 0x68 > /sys/class/i2c-adapter/i2c-1/new_device
```

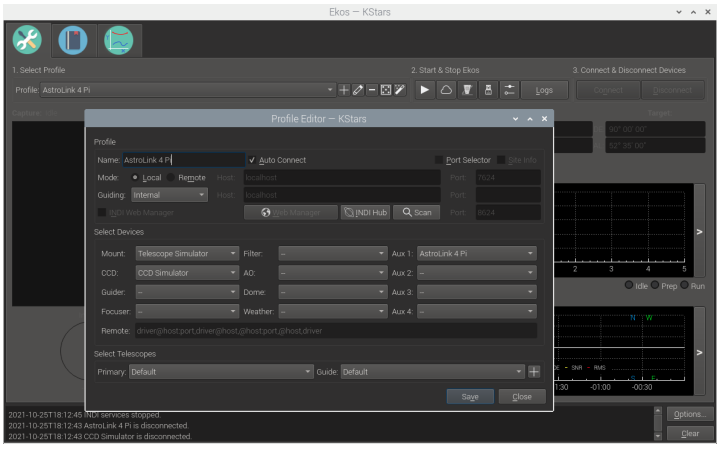
After restart, the astroberry system time will be synchronized with the embedded DS1307 clock.

Driver installation is not required when you purchase an *AstroLink 4 Pi* device with the preconfigured system.

INDI driver configuration

The configuration below will be presented for the Kstars/EKOS system.

The first step is to create a new hardware profile. Click the plus icon next to the profile selector and fill it with all the equipment you have. As one of the *Aux* devices select *AstroLink 4 Pi*. Then click *Save*.

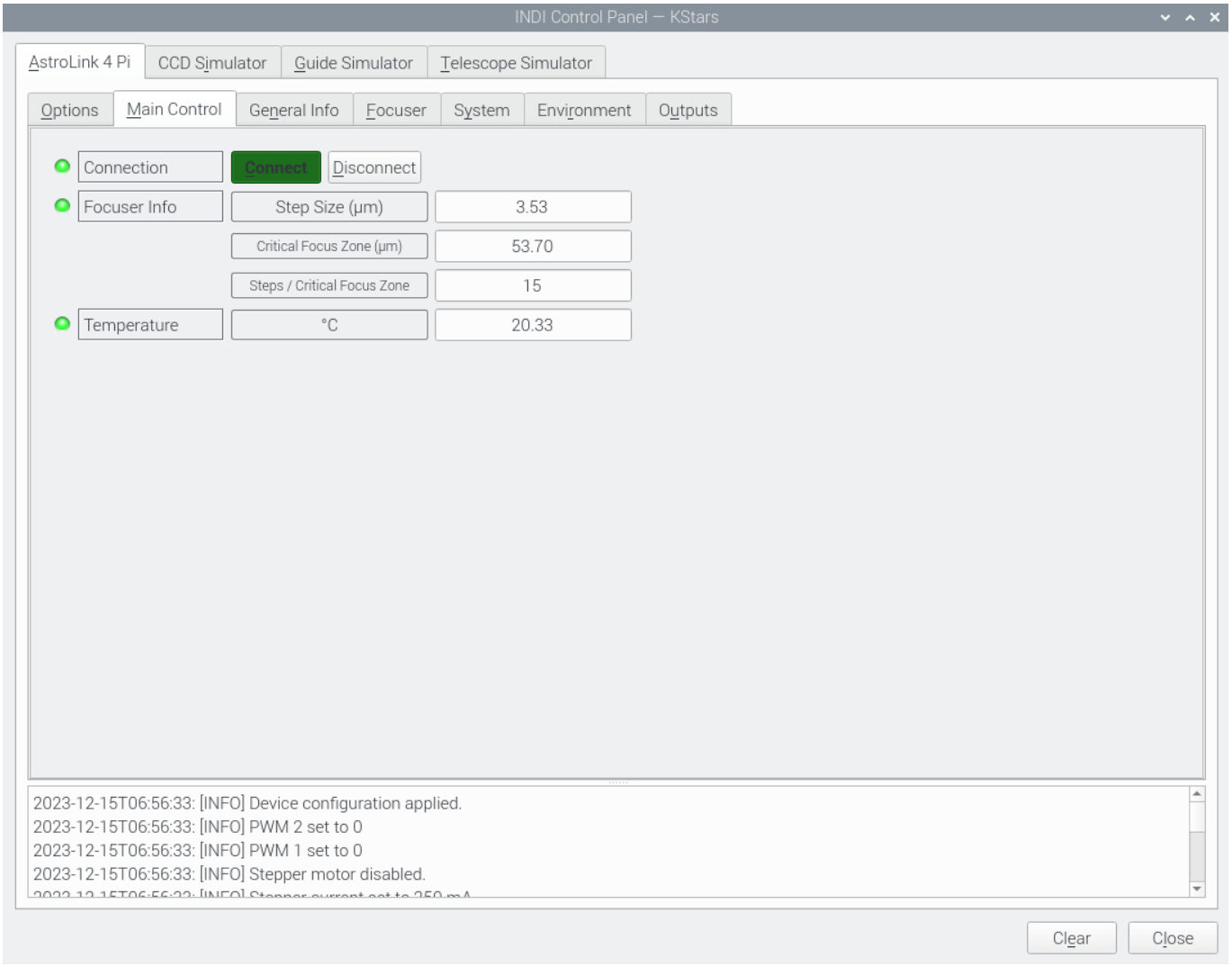


EKOS profile editor

After that, you should be able to start the EKOS with the play button, and the *INDI Control Panel* should be opened. If you close the *INDI Control Panel* by mistake, it can be always opened with the button with the INDI logo.

AstroLink 4 Pi control panel contains several tabs.

Main Control



Main Control

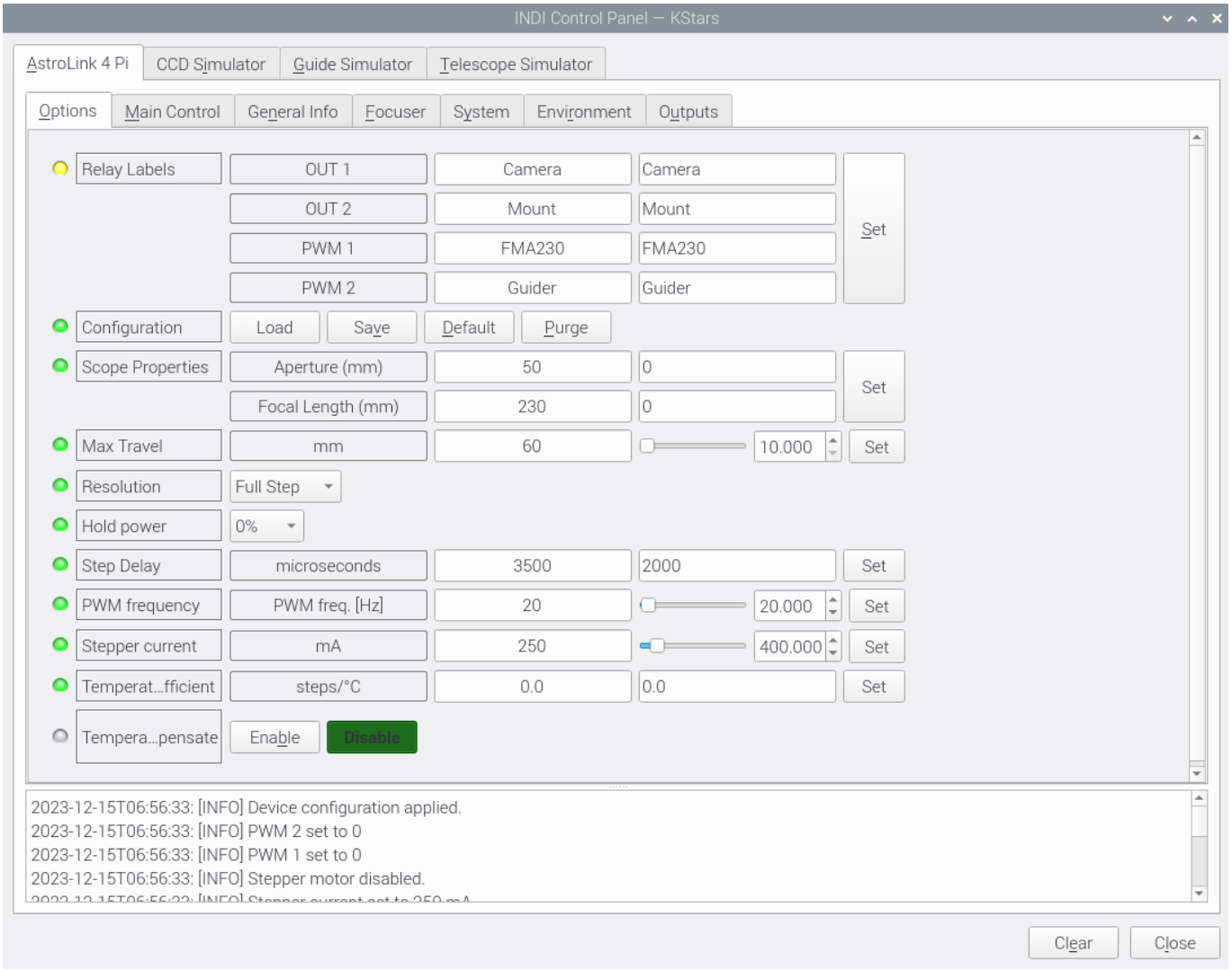
Here you can *Connect* or *Disconnect* from the *AstroLink 4 Pi device* using standard buttons.

Focuser info section contains information about step size and critical focus zone. These values are calculated from focuser parameters and telescope aperture and focal length (Options tab)

If the temperature sensor is connected to the *AstroLink 4 Pi* device, then the *Temperature* section is present and the current temperature is displayed here. When temperature reading is available, also temperature compensation is possible.

The general Info tab contains some basic information about the driver. None of these fields is editable.

Options



Options tab

Configuration – here you can load, save, reset, or purge the INDI driver configuration.

PWM frequency – that is the frequency of the regulated PWM outputs power.

Relay labels – these are names of the outputs, that are shown for convenience in the Output tab.

Step delay – time in milliseconds of each focusing motor step. Should be adjusted to the focusing motor parameters and selected resolution.

Stepper current [mA] – focusing stepper current in milliamperes. Refer to the motor datasheet to set the correct value. For 12V geared unipolar motors set 350 or 400mA here. Stepper current in version 1 of AstroLink 4 Pi must be set with the potentiometer (see *Hardware setup*)

Scope properties – telescope focal length and aperture - this information is used to calculate CFZ information

Max travel – that is the maximum output position of the focuser. This value is used to calculate the step size.

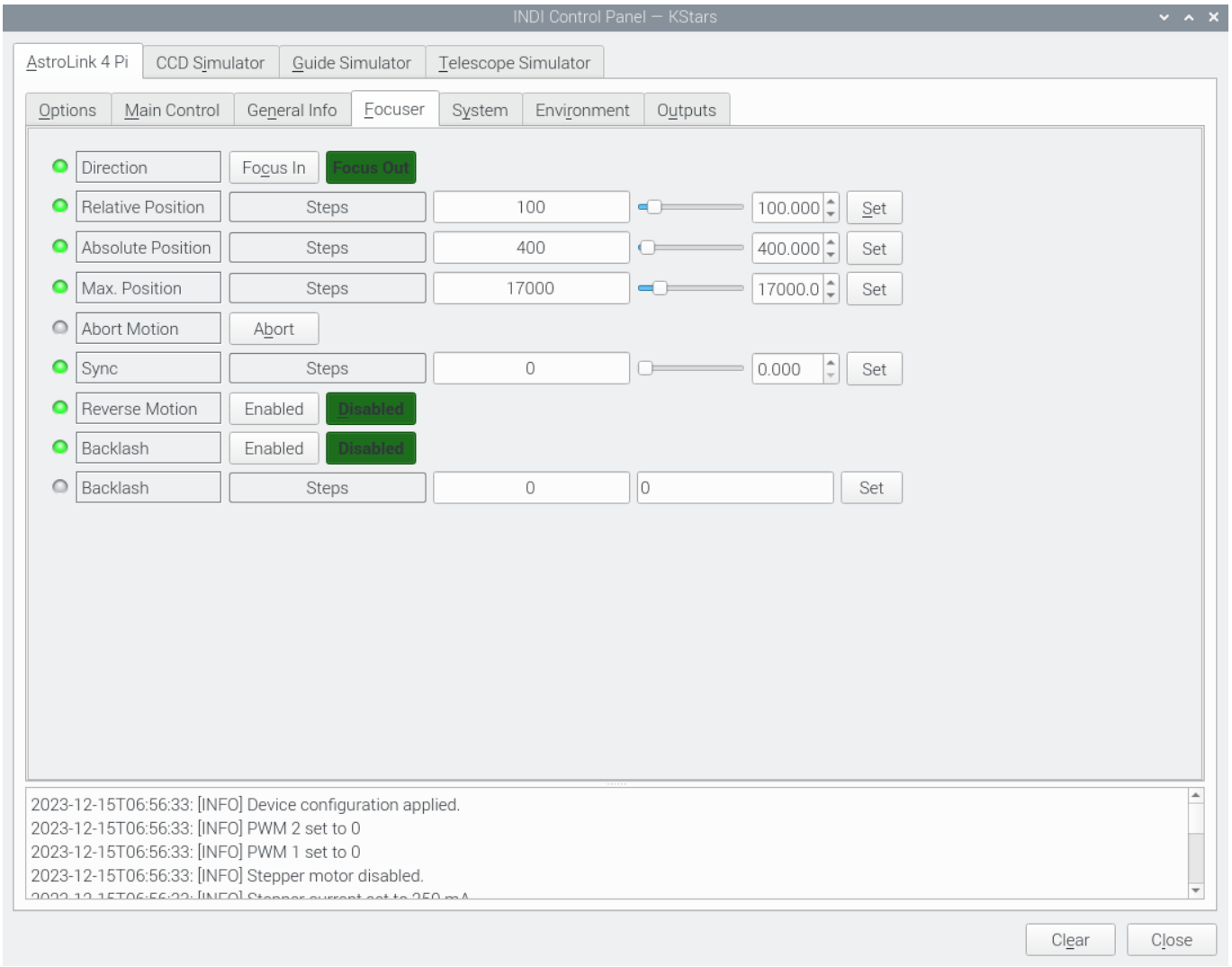
Resolution – here required focusing motor resolution can be selected. For unipolar geared motors 1/1 to 1/8 resolution is recommended. For bipolar motors, without an additional gearbox 1/16 or 1/32 is recommended.

Hold power – here you select the holding power of the focusing motor. For unipolar motors, it should be set to 0 to avoid motor overheating. For bipolar stepper motors should be set to some significant value, so the balance between the motor temperature on idle and holding torque will be preserved. Recommended values are 40-60%.

Temperature coefficient – when the temperature sensor is available, temperature compensation may be performed. The number of steps per one degree of the temperature change should be entered into this field.

Temperature compensate – enable or disable temperature compensation. The temperature compensation cycle is 30 seconds.

Focuser



Focuser tab

Direction – controls the direction of the Relative position move

Relative position – allows moving the focuser by the specific amount of steps

Absolute position – allows moving the focuser to the specific position in steps

Max Position – this is the maximum outward position of the focuser in steps

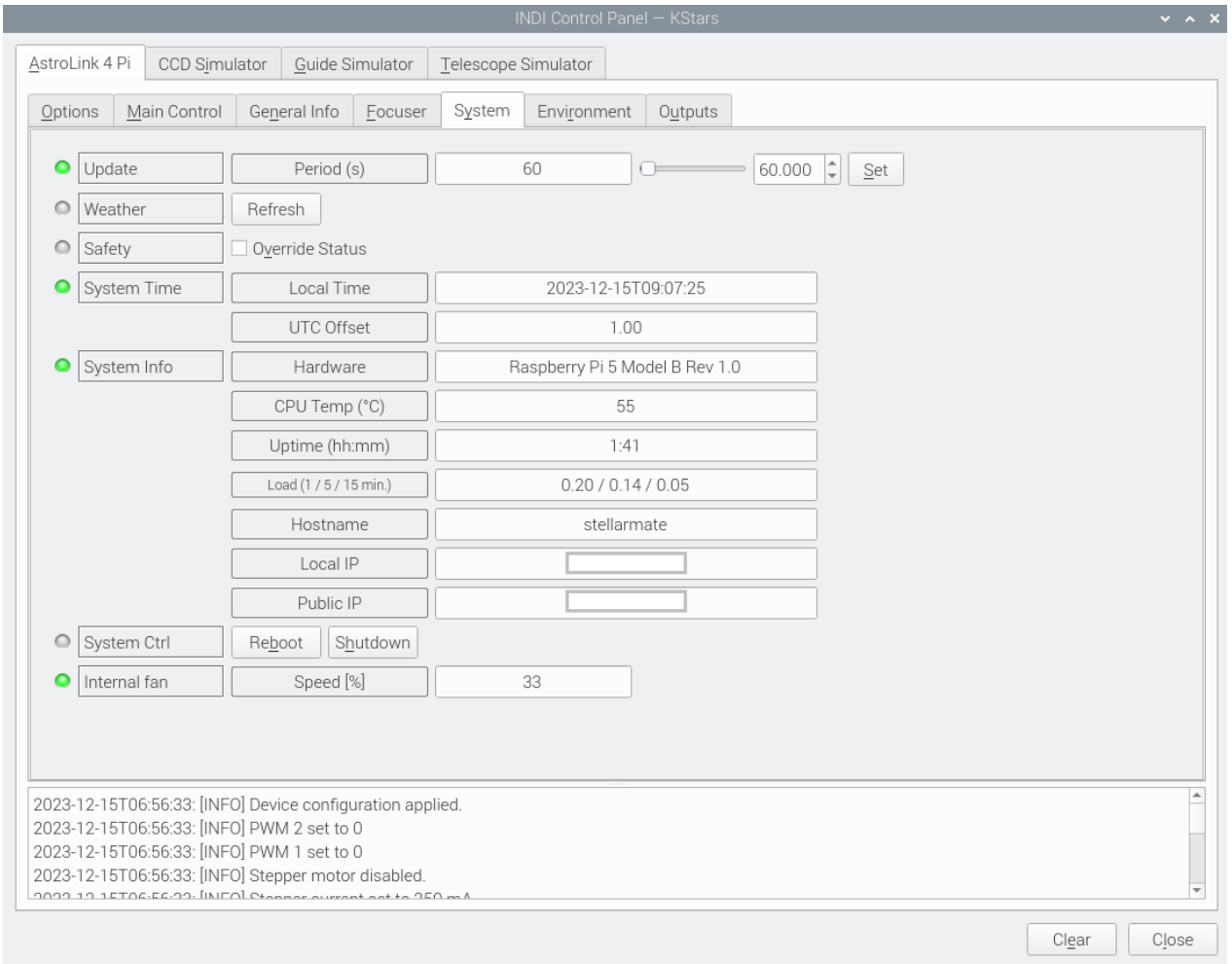
Abort Motion – stop focusing motor movement immediately

Sync - synchronizes current focuser position to the specific amount of steps

Reverse Motion – reverses focuser motion, so In direction becomes Out. This setting depends on your focuser mechanics

Backlash – implements backlash correction

System

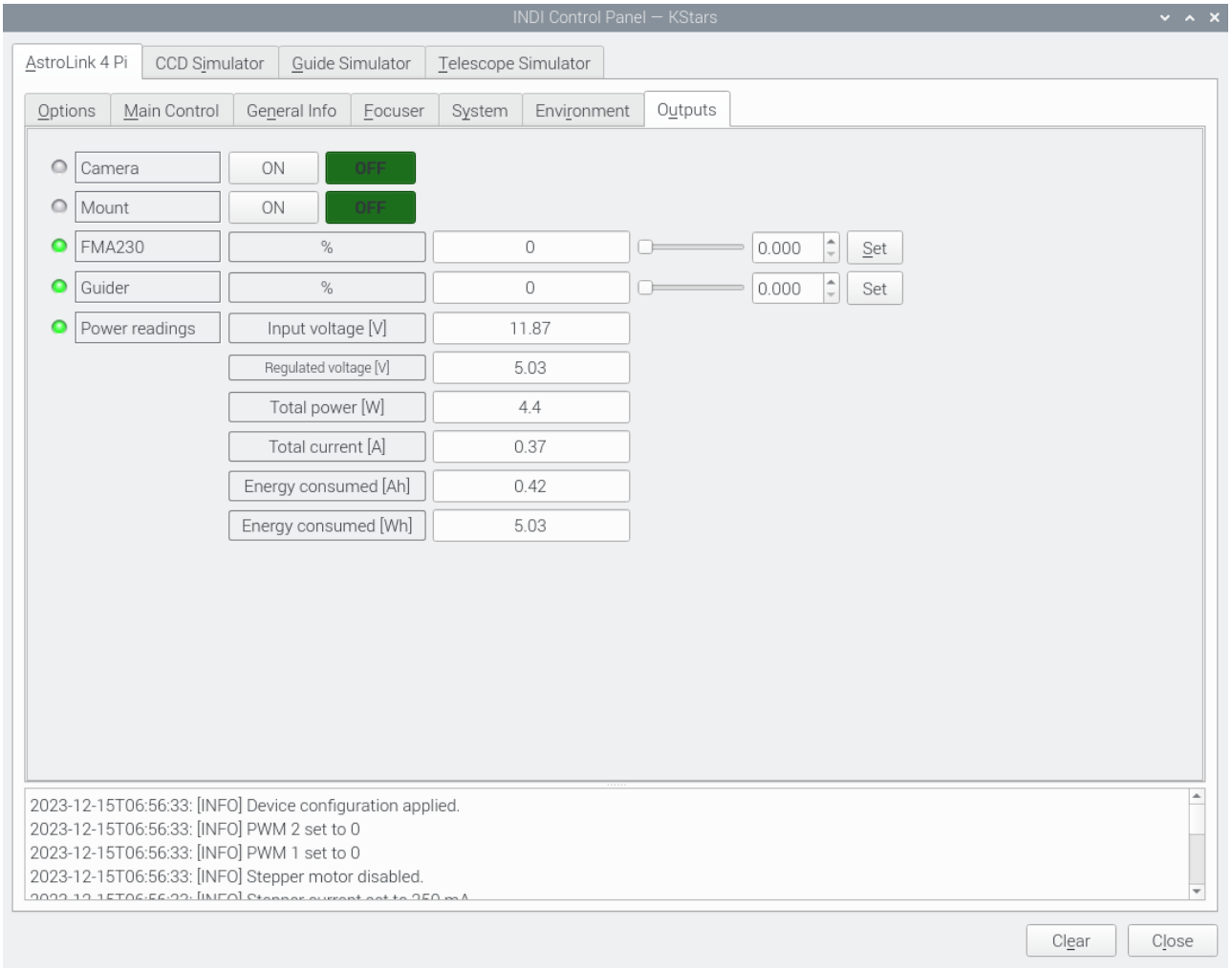


System tab

This tab contains several read-only fields with some information about the system. The *System Ctrl* section allows to reboot or turn off the operating system, but to use these buttons some additional configuration of sudo is required, so these operations are allowed without a password.

The internal fan field displays the current speed of the internal AstroLink 4 Pi fan. This speed depends on the actual CPU temperature.

Outputs



Outputs tab

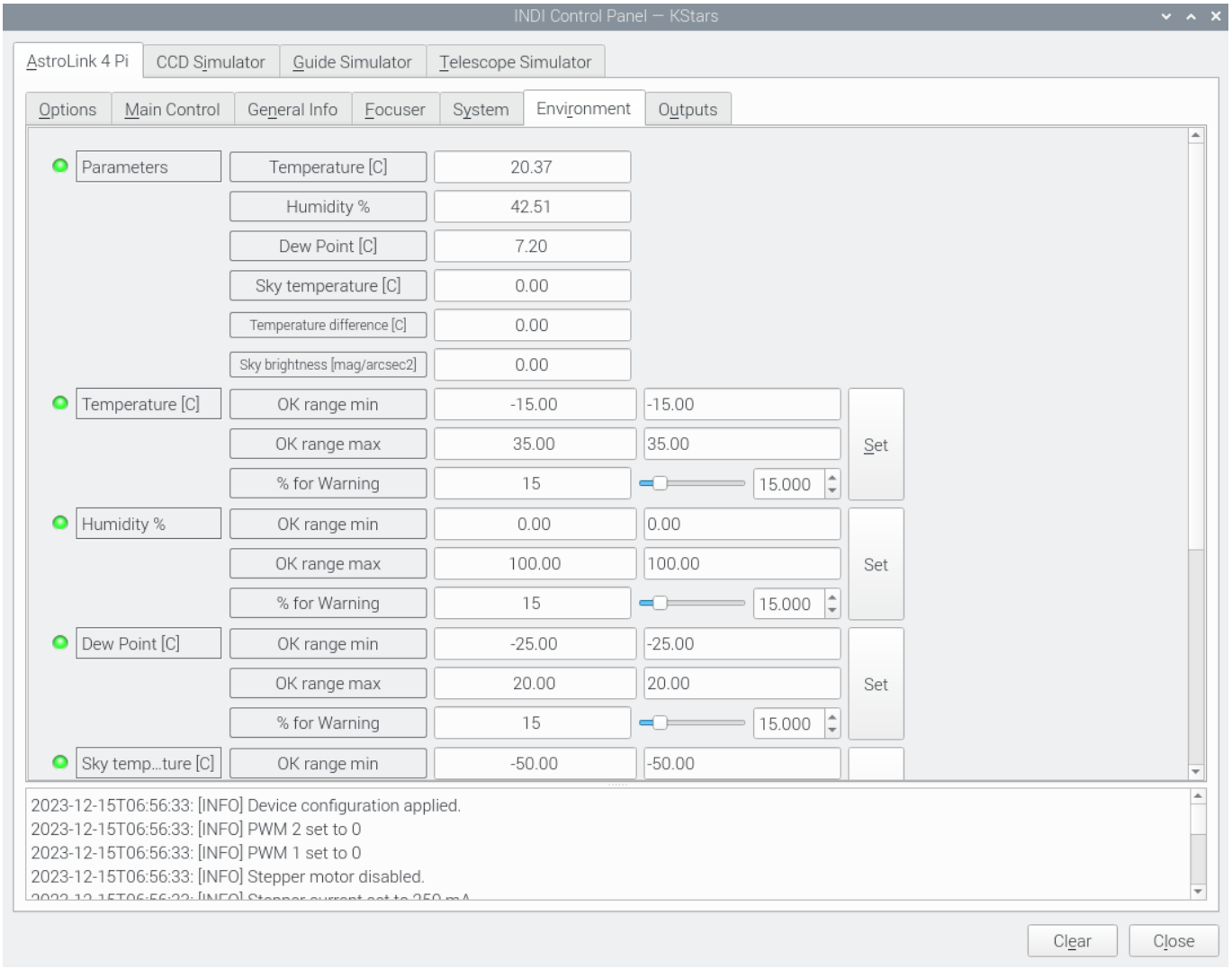
The *Outputs* tab contains controls for operating with external power sockets of the *AstroLink 4 Pi* device. There are three DC 12V outputs in the device. One is permanent, and two are switchable and can be controlled in this panel. There are also two RCA sockets in the *AstroLink 4 Pi* that can be used for powering dew cap heaters. These sockets provide PWM regulation (the frequency can be set in the *Options* tab) in the range of 0 to 100%.

Default values for the outputs can be saved in the *Options* tab. Once saved, these values will be restored on the next connection to the driver.

The *Power readings* section contains measurements from the power sensor inside the *AstroLink 4 Pi* device.

- input voltage measured at the device input
- regulated voltage at regulated output
- total power that the device currently consumes from the battery or power supply
- total current drawn from the battery or power supply
- energy consumed by the device in both Ah and Wh

Environment tab



The *Environment* tab presents data collected from the connected sensors. Currently, temperature/humidity/dewpoint sensor, sky temperature/cloud coverage sensor, and sky brightness sensor are supported.

Temperature compensation

Temperature compensation in *AstroLink 4 Pi* is implemented linearly. So there is only one parameter that describes how temperature affects the focus point. It is not a perfect approach, however, its accuracy is good enough for most amateur setups.

How to determine the temperature compensation coefficient?

The best way is to note the focuser position at different temperatures. When during session temperature changes, the focuser position needs to be adjusted to maintain a sharp focus. When you note these points of temperature and corresponding focuser position, then it is pretty straightforward to calculate the compensation coefficient, i.e. the number of focuser steps required to compensate for one-degree temperature change. This value needs to be entered into the *Temperature coefficient* field in the *Options* tab. When decreasing temperature requires the focuser position to decrease, then the value will be positive.

How to use compensation?

Once you enter the compensation value into the *Temperature coefficient* field, you need also to enable the compensation. Actual compensation is performed once the calculated focuser position correction is larger than half of the critical focus zone. CFZ value is calculated and presented in the *Main control* tab.

AstroLink 4 Pi in the imaging setup

Ground loops

The ground loop in the electrical system occurs when two points that should have the same potential have different voltages. The ground loop in the astroimaging setup may occur when the ground (i.e. minus of power supply voltage) is connected to one receiver with more than one cable path. Here are two example scenarios:

Scenario one

- the newtonian telescope has a mirror cooling fan, and this mirror fan socket is fixed in the metal mirror cell. Its minus is connected to a metal telescope tube
- the imaging camera case is also connected to the power supply minus.

Now, when you power both the fan and camera from the same power supply, then the power supply ground will be connected to the camera with a power supply cable, but also via the fan power socket, then the metal telescope tube, focuser, and camera case.

Scenario two

- an active USB hub is powered from the regulated voltage output from AstroLink
- imaging camera is powered from DC AstroLink output
- the camera is connected to a USB hub with a cable

In this scenario, a negative voltage is supplied to the camera also in two ways. The first one is the main power cable between the camera and AstroLink. The second loop is from 5V output in *AstroLink* to the USB hub and then with the USB cable to the camera.

The ground loop may cause some problems with connections, that are hard to investigate. The best way is to avoid them. Possible solutions for the second scenario are:

- connect the imaging camera to the computer without an additional USB hub
- power camera from a separate supply
- power USB hub from a separate supply
- do not power the USB hub at all - maybe it is not required
- use a USB cable with galvanic isolation

Tips and troubleshooting

I cannot find the device in my network

Make sure it is powered for at least two minutes, so it booted up properly and is connected to the WiFi network.

Use some local area network tool to scan and find the IP address of the Raspberry module (like *Fing* for Android phones).

Make sure you have updated Raspberry Pi[5] module WiFi settings properly. If it cannot connect to the home WiFi network, then it will start as a failover with its WiFi hotspot: SSID *astroberry*, password *astroberry*, IP 10.42.0.1.

If all the above fails, then switch off the home router, so there is no WiFi around, and restart AstroLink 4 Pi. After about two minutes it should be *astroberry* WiFi available, where you can connect.

I have removed the default *astroberry* WiFi hotspot and now cannot connect at all

You need to open the *AstroLink 4 Pi* device and:

- remove the SD card and reflash it with the fresh *astroberry* image. Then you will lose all data and configuration
- remove the Raspberry Pi[5] 4 module from the device, connect the keyboard, mouse, and any screen, power with 5V and 2A power supply, and fix the WiFi configuration

The sensor is connected, but the temperature is not displayed

Make sure that the sensor was connected before switching on the power. Otherwise, it may not be detected and recognized.

[5] Raspberry Pi is a trademark of Raspberry Pi Trading

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