

RoX

The Reflectance Box, a hyperspectral instrument for
unattended observation of surface reflectance.

Manual for Installation and Operation

Content:

Description and Dimension

Overview and Operation

Permanent Installation

Raw Data

Post Processing

Serial Interface

Appendix

Dust and Bird Protection

RoX DESCRIPTION AND DIMENSIONS

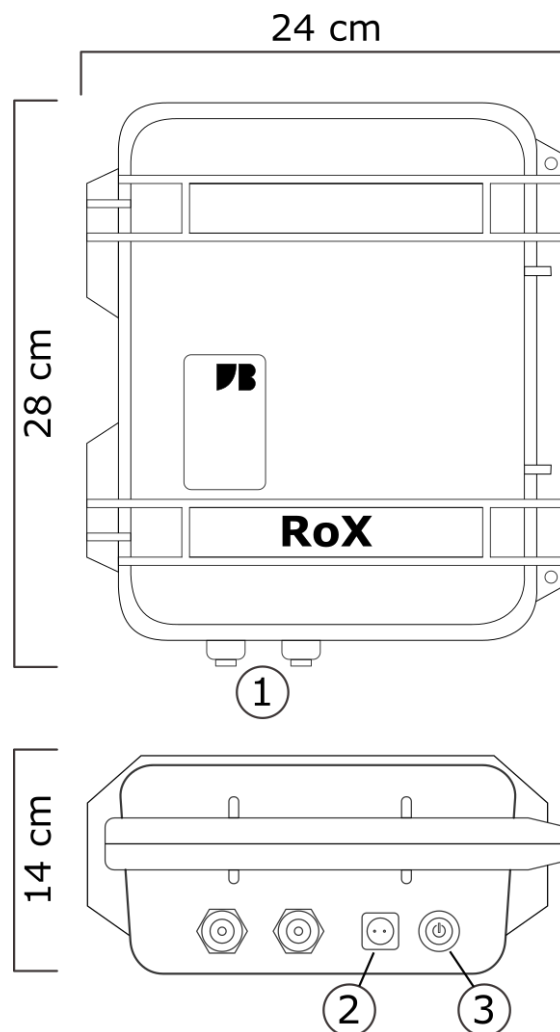
Last Update: 2020-10-26 RoX Firmware: 2.22a

Included Items

1. RoX Spectroscopy System
2. AC/DC Wall Converter 60 W
3. Spare Cosine Receptor
4. 32 Gb SD card (2 times)
5. Micro USB Cable
6. Power Plug (unassembled)
7. Flight Case for shipping

Dimensions

Figure 1 The RoX rugged case is based on the waterproof 1200 Pelicase®. The dimensions are the extents of the case. Note that the fibers (1) should not be removed and thus increase the dimensions for shipment. At the front panel, the main power socket (2) is next to the On/Off Button (3).



RoX DESCRIPTION AND DIMENSIONS

Last Update: 2020-10-26 RoX Firmware: 2.22a

Table 1 Parameters and features of the RoX as an automatic spectroscopy system for unsupervised operation

Operational Performance	Parameter Description
Automatic Acquisition	Fully autonomus measurement mode for unattended data acquisition
Manual Acquisition	User triggered measurement mode
Signal Optimization	Automatic adaption to varying light conditions
Dark Current Measurement	Accurate dark current determination for each measurement
Fast Measurements	5 seconds under bright sunshine 20 seconds in overcast conditions
Various Metadata	Internal Temperature, Internal Humidity, GPS Position, GPS Time
Data Storage	SD card up to 32 gb (5 Years of measurements)
Power Supply	12V DC (10-14 V acceptable)
Power Consumption	15 Watt
Sleep Mode	User defined active and power saving time
Interface	RS-232 via cable

Table 2 Optical Parameters of the internal spectrometer

Optical Performance	Value	Description
Spectral Range	~ 400 - 950 nm	Covering the visible to near-infrared
Spectral Samling Interval (SSI)	~ 0.65 nm	1024 Pixels
Spectral Resolution	~ 1.5 nm	Full Width at half Maximum (FWHM)
Signal to Noise Ration (SNR)	~ 250	
Dynamic Range	16 Bit	
Field Of View (FOV)	~ 180° Upwards; ~ 20° Downwards	Dual field of view optical path

RoX PERMANENT INSTALLATION

Last Update: 2020-10-26 RoX Firmware: 2.22a

The field of view

Prior to setup the RoX over a canopy, considerations about the homogeneity inside the field of view are essential. A low vegetation type (e.g. grass) with a homogenous pattern yields useful data from low observation heights. Larger, more coarse vegetation (eg. corn or shrubs) or even forest will require a larger field of view, thus a higher observation position. The opening angle of the downward looking fibre is 23° which leads to recommendations given in Fig 1. Further, consider that the 3D canopy architecture or rows of managed vegetation (e.g. vineyards) can have a significant effect on the diurnal pattern of the retrieved reflectance signal. The tower itself should be placed north of the field of view to eliminate shadows of the structure inside the observed vegetation. A nadir setup reduce these effects and generates measurements comparable to airborne, satellite and other instruments.

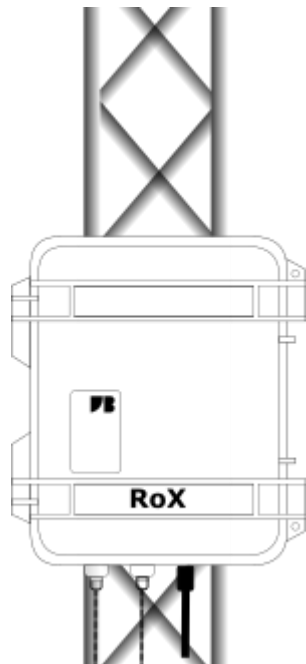


Figure 2 RoX installed at tower radiation and rain. Fibre ports and power sockets are facing downwards.

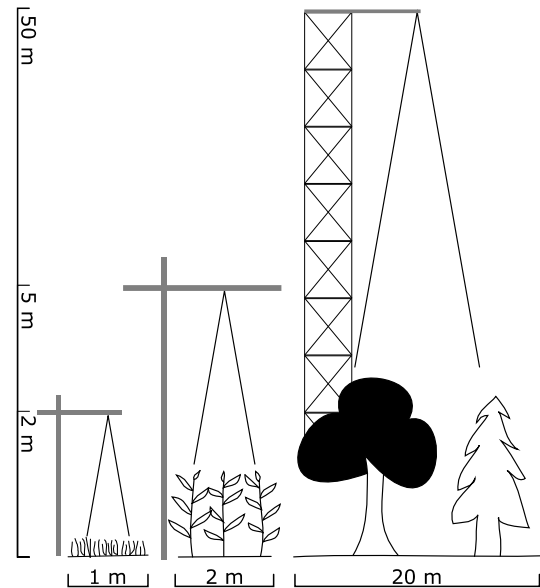


Figure 1 Typical tower setups for grass, corn and forest with reasonable size estimations based on working setups. Drawing not to scale.

Tower type and setup

The necessary height of the installation drives the tower type. Towers up to a size of 5 m are available in relatively easy to deploy forms and can be erected within a day (Contact JB for tower types). Larger structures may already be available at the research site or require bigger efforts in construction. The RoX usually has a fiber length of 7 m (longer fibers are an option). If the instrument should remain accessible close to the ground the overall height of the tower is limited to about 5 m. On a bigger tower, the instrument may be attached to the tower directly at an elevated position. The weight of the instrument (3 kg) and additional cables, optics and accessories should be well within the limitations of the support under all environmental conditions (e.g. wind or snow). To attach the RoX directly to a tower, mounting screws are available at the back of the instrument.

RoX PERMANENT INSTALLATION

Last Update: 2020-10-26 RoX Firmware: 2.22a

Install the RoX with fiber ports and power plug facing downwards to prevent direct exposure to rain. Lead the downward looking fibres above the vegetation of interest and level the optics nadir. Lead the upward looking fibres with the cosine receptors to the very top of the tower and guarantee that the observed hemisphere is completely free from obstacles. Level the cosines. Using a bird and dust protection system is recommended to keep the sensitive upward looking optics functioning for long periods. Do not bend the optical fibres below a radius of 8 cm. The RoX has a durable weather-proof casing and can withstand extreme environmental conditions. However it is recommended to shield the instrument from direct sun to reduce the risk of overheating. This is essential in hot environments to ensure valid measurement conditions. The RoX will switch off when the internal temperature exceeds 55°C. Temperature sensors allow to track the temperature of the instrument. It is good practice to regularly drop and replace drying agent in the case (e.g. silica). Humidity of the instrument can be tracked via two internal sensors. Remote data download can be realized using the SERIAL INTERFACE.

Power

The RoX is rated 15 W peak power and requires a 12 V DC input. However the average consumption is usually lower and very low during standby periods. Running the RoX from the grid power using the included AC/DC adapter ensures complete datasets. In off grid scenarios a solar driven setup including a buffer battery is possible and can be provided by JB. However this can lead to data gaps during very dark weather periods. To allow a battery driven operation, the RoX internal DC/DC converter allow an input voltage range of 10-14 V. Higher or lower voltage will lead to a shutdown of the instrument. Further, the RoX is

polarity protected. To implement the instrument in existing 12 V power grids, an additional plug is included. Refer to Figure 3 for pin layout of the plug.

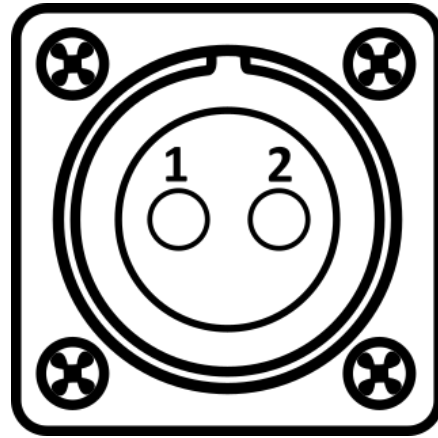


Figure 3 Electrical layout of the power socket of the RoX instrument, mounted to the front wall.

1 = 12 V Power in (positive)

2 = Ground (negative)

Safety

During all installation and operation take precaution for your own safety. Especially do not climb unsafe towers and take precaution if AC wiring is performed. Ask trained personnel or JB whenever you're in doubt on a safety question.

Environmental hazards

If the tower of the RoX is the highest structure in the surrounding, it needs a lightning conductor. Eventually use fences to keep humans or cattle out. The use of a webcam watching the instrument and the vegetation is very useful for scientific and monitoring purpose.



RoX RAW DATA

Last Update: 2020-10-26 RoX Firmware: 2.22a

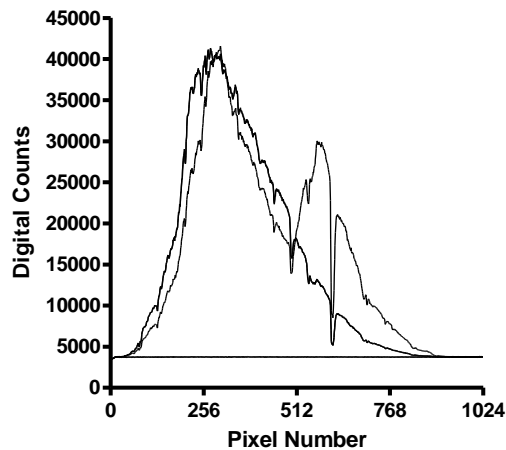


Figure 1 Typical spectral data as stored in the RoX measurement file. The spectra show the upward and downward looking channel raw data (counts) and the recorded dark current for each channel.

SD Card Content

The RoX uses a standard SD card with a size up to 32 gb as data storage. If no SD card is inserted or the SD card is full, the instrument will not store data. In the root folder of the RoX, the "config.txt" is located (see *Overview and Operation*). In an empty SD card, the RoX will generate a new config file with standard parameters. In the root folder, the instrument creates a folder for each day it was active. This folder is labelled after the RoX clock time date (YYMMDD). Inside this folder, the RoX creates two files containing spectral measurements. The file storing the spectra begins with "F" followed by the time, the instrument was switched on (hhddmm). The file can be opened via a generic text editor and many other software suits. It is good practice to make a backup of the SD card content whenever the field site of the instrument is visited. Typically one file for each spectrometer is generated each day. If the instrument is switched on several times a day, (eg. solar power low)

multiple files can appear within the same folder. To limit the file size, a new file will be generated if 1000 cycles are exceeded. A nightlog file shows internal measurement parameters, to track the conditions during night.

Raw Data Structure

The spectral data inside the measurement files is raw data, thus digital counts are stored. To convert these digital counts to actual physical values (eg. radiance) and to calculate fluorescence or other results, a post-processing is required (see *POST PROCESSING*). Most users are interested in the processed products, however the structure and content of the data files is explained in the following. One measurement cycle is stored within 6 lines, whereas the first line is the header containing metadata. In line 2-6, the spectral data is given in the order: 1 upward looking (WR1), 2 downward looking (VEG), 3 upward looking (WR2), 4 dark current of WR, 5 dark current of VEG. Since the upward looking and downward looking channels have different integration time to achieve an optimal use of the dynamic range, they may be affected by different dark currents. This is accounted for, by acquiring two dark current measurements with the two different integration times. Further the instrument measures twice the upward looking channel to quantify the stability of illumination during the measurement. The spectrometer stores 1024 pixels for each spectrum. A typical spectrum is given in Figure 1. The metadata within the header of each measurement contains essential data for processing, such as integration time or the actual time of the measurement. Further it contains

RoX RAW DATA

Last Update: 2020-10-26 RoX Firmware: 2.22a

additional sensor values such as temperature and humidity measures to assess the instruments operational state. An implemented GPS sensor is used whenever GPS signal is available to also store UTC time and date as well as the approximate position of the instrument. Additional parameters are appended to the header and differ with firmware versions.

Table 1 Metadata of the RoX header line. Field indicates the position of the described value in the semicolon separated line.

Field	Label	Unit	Description
1	Cycle Number		Increments with each measurement cycle
2	Date	YYMMDD	Current Date, User Defined
3	Time	hhmmss	Current Time, User Defined
4	Mode	auto or manual	Indicates the mode of operation
6	IT_WR	µs	Integration Time of the upward looking channel
8	IT_VEG	µs	Integration time of the downward looking channel
10	Cycle Duration	ms	Time that the measurement cycle took
12	Mainboard temperature	°C	Temperature of the mainboard
14	Mainboard Humidity	°C	Humidity at the main controller
15	Firmware and ID		Running firmware and Device Identifier
17	GPS Time UTC	hhmmss	Time as retrieved from GPS satellite
19	GPS Date UTC	YYMMDD	Date as retrieved from GPS satellite
21	GPS Latitude	decimal degree	Latitude from GPS
23	GPS Longitude	decimal degree	Longitude from GPS
25	Voltage	V	Level of supply voltage
34	gps_CPU	ms	CPU Time of the last GPS timestamp
38	veg_CPU	ms	CPU Time of the VEG measurement

RoX SERIAL INTERFACE

Last Update: 2020-10-26 RoX Firmware: 2.22a

Introduction

Extending the standard unsupervised operation, the RoX provides an interface for advanced control. The interface is based on the common RS-232 protocol and accessible via micro USB socket appearing as emulated COM port on a host computer. This means a direct serial connection can be established by plugging a micro USB cable to the RoX' socket next to the SD card and any computer regardless of the operating system. Connecting this with any given computer will open the same serial channel enabling extended commands and data download. On most operating systems, the drivers for will install automatically (contact JB to get troubleshoot).

Serial Operation

To activate the serial connection, first switch on the RoX and second connect the USB cable to the computer. Make sure a new COM port appears in your device and note the number or identifier of this COM port. Use any available interface software to open the COM port (eg. Terminate) with a Baudrate of 57600. Ensure the software will append a newline character "\n" to submitted ASCII commands. In automatic operation, the instrument will stream the collected data via the serial port after each measurement

cycle. If the serial connection was properly established, a data stream will be received periodically from the instrument. Between cycles, the instrument will wait for serial commands. To stop automatic measurements and switch to manual mode send a "C" via the serial terminal. This will command the RoX to halt measurements after the current cycle is completed and then send a list of possible serial commands. Commands are single or double case sensitive letters. Some commands require a following number, which is given after the command, separated with a blank. All commands will send a reply or lead to a measurement action of the instrument. Invalid commands are ignored. Note that a couple of commands will alter the instrument settings and thus change the content of the config.txt, being valid immediately and also persist after RoX reboot. Changes can also be made directly to the config.txt using a text editor.

Table 1 Serial Commands for file handling and data transfer

ASCII Command	Standard Value/Example	Description
		*will apply to config.txt
ff		Send the file folder structure of the SD card
f1		Send the current FLUO raw file
f2		Send the current FULL raw file
fn		Send all files acquired today
fd YYMMDD	fd 190203	Send all files acquired at the specified data
fc		Send calibration file
ss	Off	Toggles serial stream, providing extended feedback *
S x	S 20	Defines the resolution of the serial stream spectra *
st	On	Toggles serial data transfer, to send data after cycle *
DM	DM 2	Set the power mode of the optional embedded computer * (0=always on, 1=on during day, 2=only once after off)

RoX SERIAL INTERFACE

Last Update: 2020-10-26 RoX Firmware: 2.22a

ASCII Command	Standard Value/Example	Description
*will apply to config.txt		
O		Optimise integration time without measurement
M		Measure without optimising integration time
m		Measure with optimizing. Equivalent to normal cycle or pressing the button in manual mode.
I2 x	I2 100	Sets the FULL integration time to x ms (10 ms to 10s)
a2 x	a1 1	Sets the number of averages for the FULL *
i x	i 60	Sets the interval between measurements * to x s (range 0 s to 3600 s)
G		Send the current GPS data
c		Send the config.txt settings
T		Set date&time. You'll be asked to set YY, MM, DD, mm, ss
V	v 10.0	Set the threshold for low voltage shutdown. * Chose this value to protect the power supply battery.
On hh	On 8	Sets the starting hour to hh *
Off hh	Off 20	Sets the shutdown hour to hh *

Table 2 Serial Commands for instrument control. Note, that beyond the given list, a number of additional commands exist for calibration and special purpose.

Remote Data Access

If a RoX instrument is installed in a remote area without direct access, data can be downloaded using the serial interface. The actual technical implementation is site dependent but will require a computer with internet access. This computer is connected either via cable or Xbee modem to the RoX. data can be streamed directly while measurements are running with serial transfer (st) enabled or retrieved in the evening (fn). The computer needs to log this serial stream to the harddrive (eg. Termite->Logfile). A download of this daily logfile can be handled via scripts or additional programs. The RoX can be equipped with an internal embedded computer

featuring an interface software to download the data. This solution is preferred, since the RoX can activate this computer only once per day (DM = 2) to push the data to a server. This will save a maximum of power. The embedded computer however requires integration into existing internet structure via wireless LAN or Ethernet. A mobile network internet access is possible but reliability is case dependent.

Note that Remote Data Access is under development and will expand in the near future supporting FTP upload and other options.

RoX DATA PROCESSING

Last Update: 2020-10-27 GUI vs: 14.4

Overview

The FloX data processing is entirely based on the open source R software (R Core Team, 2017, preferable version 4.0.2). The core functions of the data processing are contained in two R packages (FieldSpectroscopyCC and FieldSpectroscopyDP) openly available on GitHub platform at <https://github.com/tommasojulitta> and released under the licence GNU v3.0. The Graphical User Interface is provided to FloX customers as an R script to facilitate the analysis of the data collected, although the source code is available to JB customers and potentially adaptable to user's needs.

Processing chain concept

The concept behind the processing of the data follows a specific workflow:

1. Reading of input files (raw data, see *Raw Data*)
2. Conversion of raw data to radiance data (using the JB provided calibration files)
3. Calculation of apparent reflectance factors
4. Spectral convolution on Incoming and reflected radiance if specified by the user
5. Smoothing of the reflectance factor according to smoothing spline (degree of freedom to be defined by the user)
6. Calculation of Reflectance based Spectral Vegetation Indices (SVIs).
7. Calculation of QA/QC routines

Graphical User Interface

The RoX processing GUI runs on Windows OS (XP, 7, 10). It requires R software (version 3.3.2 and later) and RStudio to be installed in the pc. The following steps need to be followed in order to launch the GUI:

- 1) Open R studio;
- 2) Browse to code, source code;
- 3) Select the GUI.R to be processed (e.g. GUI_RoX_V14.4.R).

On first usage of the GUI the dependencies on other R packages are

loaded. Before proceeding with data processing check if all the dependencies are loaded correctly and no errors appear.

RoX Processing GUI appears as reported in Figure 1.

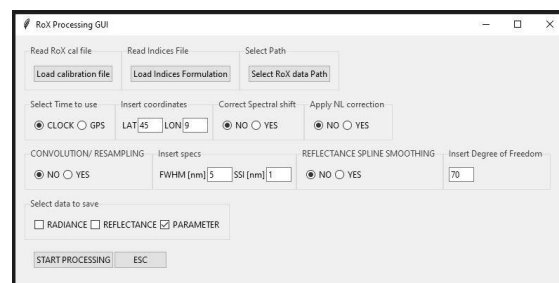


Figure 1 FloX Processing GUI.

The user is requested to make the following actions:

- 1) Load the calibration file
- 2) Load the indices file
- 3) Select the path where the RoX data are stored
- 4) Select the time to be used for the data processing
- 5) In case clock time is selected insert the LAT LON values. If GPS time is selected coordinates will be automatically retrieved from FloX raw data.
- 6) Select if the possible spectral shift of the spectrometer has to be automatically corrected.
- 7) Select if the data processing needs to account for spectrometer non linearity (NL) correction.
- 8) Select if the spectral convolution needs to be applied.
- 9) Specify the full width at half maximum (FWHM) of the deconvolved spectrum and the related spectral sampling interval (SSI). In nanometer.
- 10) Select if the spline smoothing needs to be applied on reflectance factor.
- 11) Specify the related degree of freedom.
- 12) Select the output data to be saved.
- 13) Launch the processing with the start processing button.

ROX DATA PROCESSING

Last Update: 2020-10-27 GUI vs: 14.4

GUI Input

Input of the GUI are:

1) Calibration file

Calibration files are provided from JB at the moment of the ROX delivery and contain the information related to spectral and radiometric factors to convert raw data into physical units ($\text{W m}^{-2} \text{sr}^{-1} \text{nm}^{-1} \text{ms}^{-1}$). WARNING: If calibration file is provided accounting for non-linearity the processing must be launched applying the non-linearity correction.

2) Indices file

Indices file is a .txt file format containing the vegetation indices information. Each index is defined by 5 fields: Index name (Index, e.g. NDVI), bands center (wl, "800;670"), band width in nanometers (fwhm, e.g. "10;10"), index formulation (expression, e.g. $(a-b)/(a+b)$), convolution in the selected spectral range (convolution, e.g. mean or gaussian), Spectrum where to calculate the indices (e.g. R for reflectance, L for reflected radiance). The indices file is open to modification by the users, who is free to add as many reflectance based indices as desired, appending them as new lines in the file.

3) RoX data path

Path where the RoX data are stored. WARNING: path refers to the main folder where the subfolders named as the day of the measurements are contained, as from the SD card data structure. RoC files smaller than 100 KB are excluded from the processing.

4) Time to use

Two options are available: FloX internal clock and FloX GPS module. For outdoor installation GPS time is recommended. For indoor measurements GPS time could be not

available and clock time is preferred.

5) Coordinates

In case GPS time is selected this information is discarded. If clock time is selected the users can manually insert the coordinates. Warning: after coordinates insertion press enter.

6) Select data to save

Three options are available: Radiance, Reflectance and Parameter. In case Radiance or reflectance are selected radiances or reflectance files are generated and saved during the data processing. If Parameter selected a summary file is produced during the processing (see Output for details).

7) FULL shift correction

A correction based on the position of atmospheric absorption feature can be applied to compensate for this changes.

8) NL correction

Non linearity correction can be applied by selecting the relative flag. WARNING: This selection should be aligned with the calibration file provided by JB. In case of doubt contact JB directly.

9) CONVOLUTION/RESAMPLING

Specify if the user wants to deconvolve and resample the spectrum of Incoming and Reflected radiance and Reflectance. In case the user is asked to define the FWHM and SSI of the deconvolution/resampling.

10) REFLECTANCE SPLINE SMOOTHING

Specify if the user wants to apply a spline smoothing to the reflectance factor. In case the user is asked to specify the degree of freedom for the spline function.



RoX DATA PROCESSING

Last Update: 2020-10-27 GUI vs: 14.4

GUI Output

Output files are saved in the main paths defined by the user. If radiance and reflectance output are selected to be saved, related files are stored in the same folder of the raw data. Output are saved separately for each channel: Incoming or reflected radiance.

The summary parameter file is saved in the main root aside a report of the data processing routine containing information on the number of measurements and days processed, the calibration files used and the processing configuration settings.

The parameter file contains a list of files sorted by date and structured as reported in the following table.



RoX DATA PROCESSING

Last Update: 2020-10-27 GUI vs: 14.4

Field	Label	Description
1	doy.dayfract	Day of the year and day fraction
2	datetime [UTC]	Date time, format UTC
3	SZA	Solar Zenith Angle
4	Lat	Latitude
5	Lon	Longitude
6	temp4 [C]	Temperature of RoX
7	h1 [%]	Humidity at the main controller
8	Incoming at 750nm [W m-2nm-1sr-1]	Incoming radiance at wavelength 750 nm
9	Reflected 750 [W m-2nm-1sr-1]	Reflected radiance at wavelength 760 nm
10	PAR inc [W m-2]	Photosynthetically Active Radiation
11	PAR ref [W m-2]	Reflected Photosynthetically Active Radiation
12	Reflected 760 [W m-2nm-1sr-1]	Reflected radiance at wavelength 760 nm
13	Reflected 687 [W m-2nm-1sr-1]	Reflected radiance at wavelength 687 nm
14	Reflectance 750 [-]	Reflectance at wavelength 750 nm
15	Reflectance 760 [-]	Reflectance at wavelength 760 nm
16	E_stability [%]	Percentage difference between WR1 and WR2.
17	sat value L	Saturation value of upward channel 1.
18	sat value E	Saturation value of upward channel 2. Fluo range
19	sat value E2	Saturation value of upward channel 1.
20	Dynamic range E [%]	Dynamic range covered of downward channel.
21	Dynamic range L [%]	Dynamic range covered of downward channel. Fluo range
22	SSHIFT	Spectral shift of Full range spectrometer
23	Vis	Various VIs defined in indices.txt file
24	doy.dayfract	Day of the year and day fraction
25	datetime [UTC]	Date time, format UTC
26	SZA	Solar Zenith Angle
27	Lat	Latitude
28	Lon	Longitude

RoX DATA PROCESSING

Last Update: 2020-10-27 GUI vs: 14.4

Field	Label	Description
29	temp4 [C]	Temperature of RoX
30	h1 [%]	Humidity at the main controller
31	Incoming at 750nm [W m-2nm-1sr-1]	Incoming radiance at wavelength 750 nm
32	Reflected 750 [W m-2nm-1sr-1]	Reflected radiance at wavelength 760 nm
33	PAR inc [W m-2]	Photosynthetically Active Radiation
34	PAR ref [W m-2]	Reflected Photosynthetically Active Radiation
35	Reflected 760 [W m-2nm-1sr-1]	Reflected radiance at wavelength 760 nm
36	Reflected 687 [W m-2nm-1sr-1]	Reflected radiance at wavelength 687 nm
37	Reflectance 750 [-]	Reflectance at wavelength 750 nm
38	Reflectance 760 [-]	Reflectance at wavelength 760 nm
39	E_stability [%]	Percentage difference between WR1 and WR2.
40	sat value L	Saturation value of upward channel 1.
41	sat value E	Saturation value of upward channel 2. Fluo range
42	sat value E2	Saturation value of upward channel 1.
43	Dynamic range E [%]	Dynamic range covered of downward channel.
44	SSHIFT	Spectral shift of Full range spectrometer
45	Vis	Various VIs defined in indices.txt file

Appendix



**HYPERSPECTRAL
DEVICES**



DUST & BIRD PROTECTION

Last Update: 2020-10-26 RoX Firmware: 2.22a

Overview

The upward looking cosine receptors of JB Hyperspectral instruments are exposed directly to environmental hazards. To increase longevity, the Dust & Bird Protection system is used to keep the surface of the cosine receptor clean and to prevent bird damage. The active airstream also provides some protection against settling of insects, rain and snow on the optics. Further the Dust & Bird Protection is designed for robust attachment to tower structures and accurate levelling. The device, including the fan is completely weatherproof.

Setup Considerations

The Dust & Bird Protection requires a careful setup to achieve reliable measurements (ref. PERMANENT INSTALLATION). The system should be positioned at the highest possible mounting point of the tower with nothing around, which obstructs the hemispherical field of view. The length of the optical fibres and the length of the 12 V power supply cable needs to be considered. Before setup, make sure there is a way to properly level the Dust & Bird protection using the bubble level on the device itself.

How To

To mount the cosine receptors into the Dust & Bird protection, first remove the fan by unscrewing the screws in the 4 corners. Lead the fibers through the vertical openings in the back and fix the cosine receptors in the upper holder using the small screws. Make sure both cosine receptors are rising 1-2 mm above the holder. Eventually use tape or silicon to seal the vertical openings in the back. Again mount the fan, with the blowing direction upwards.

To attach the Dust & Bird Protection to a mast, use U-Double-Screws or any other given option. A variety of standard spacings are supported by the mounting holes of the device. However it's fine to drill additional holes in the baseplate to support other ways of mounting.

After mounting to the mast, perform an accurate levelling of the device in order to achieve the optimum cosine response. Use the bubble level on top.

See Figure 1 for details on dimensions and positions.

Electrical Connections

The Dust & Bird Protection fan runs on 12 V and requires 1 Watt peak power. Polarity is given on the cables (Tests have shown the fans are reverse polarity protected). Make sure the fan is always powered and running since only a consistent airstream will prevent settling of dust on the optics. In an off-grid power scenario it is recommended to wire the fan directly to the buffer battery, thus bypassing any charge controller which could eventually switch the fan off due to low battery.

Warning Notes

When climbing towers and ladders ensure you've a safe stand and proper safety gear. Do not work alone.

Do not bend the optical fibres below a radius of 8 cm. A lower radius will alter the calibration and a narrow bending can break the fibre.

DUST & BIRD PROTECTION

Last Update: 2020-10-26 RoX Firmware: 2.22a

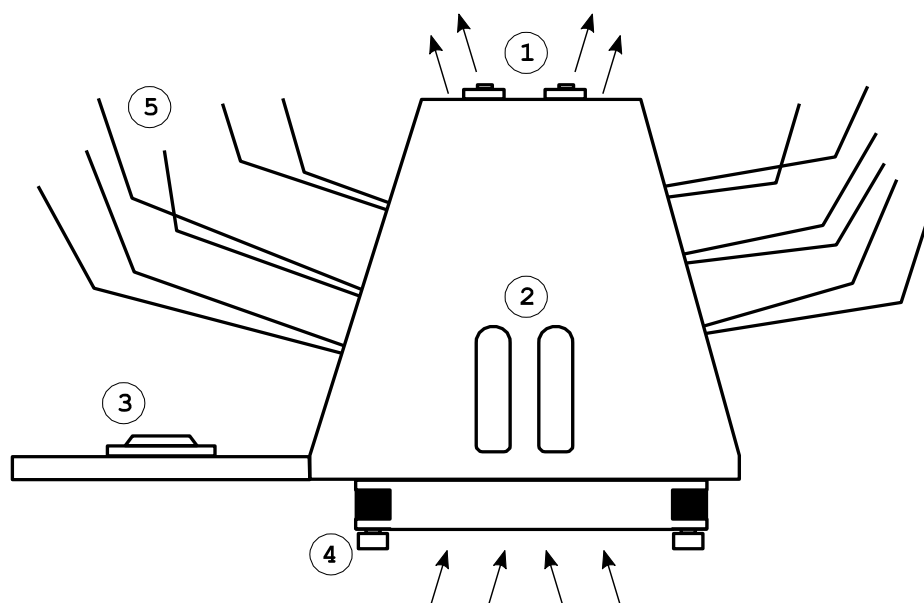
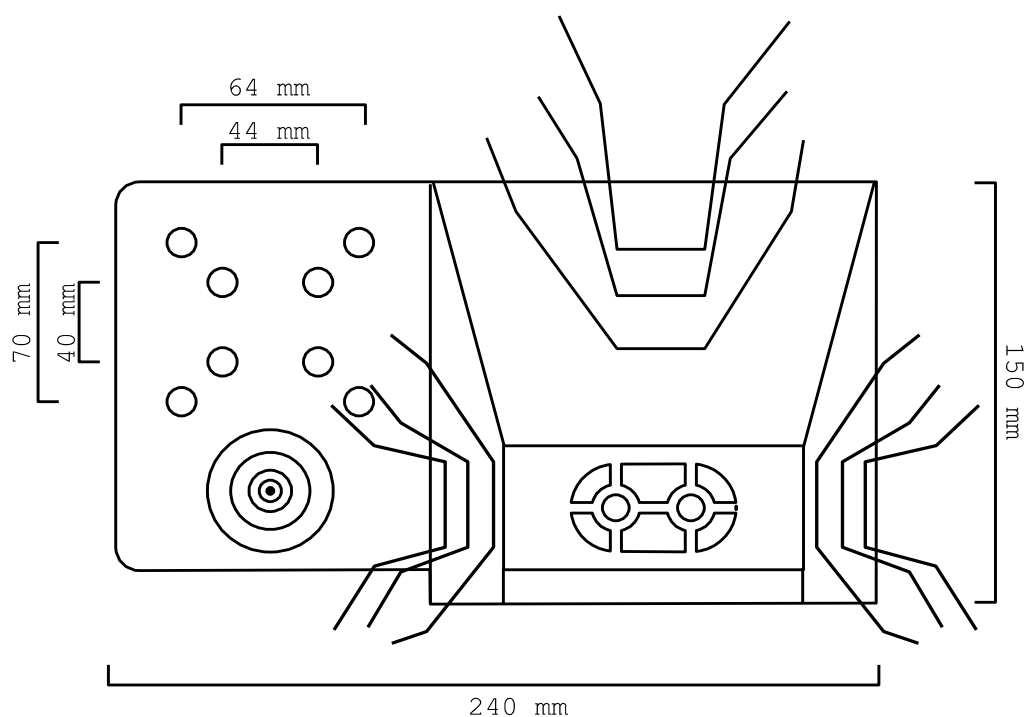


Figure 1 Top: Top view of the Dust & Bird protection, including dimensions (measured from hole center for spacings)

Figure 1 Bottom: Back view of the device. Arrows are indicating the direction of the airstream. 1) Cosine Receptors 2) Fiber Intakes 3) Levelling Bubble 4) Fan with screws 5) Spikes to make birds feels uncomfortable