OPERATING MANUAL

RTD series

Tipping bucket

rain gauges

EN

V1.0

senseca

Contents

1 General information

Read this document carefully and familiarize yourself with the operation of the device before using it. Keep this document ready to hand and in the immediate vicinity of the device so that it is always available to the personnel/user in case of doubt.

Only technically qualified persons are permitted to carry out commissioning, operation, maintenance and decommissioning. The personnel must have carefully read and understood the operating manual before starting any activity.

Legal notices

- For your safety, use only the manufacturer's original spare parts and accessories. We assume no responsibility for the use of other products and any resulting damage.
- The user must have adequate knowledge of the measuring process and use of the measurements. The user is liable in case of damage/danger due to misinterpretation of the measurements as a result of inadequate knowledge.
- The liability and warranty of the manufacturer for product damages and consequential damages are voided in the event of misuse, failure to comply with these operating instructions, failure to observe safety warnings, assignment to inadequately qualified technical personnel and arbitrary modifications of the device.
- No part of this document may be reproduced, modified or translated without prior written permission of the product manufacturer. In case of ambiguity between different language versions of this document, the English version applies.
- This document does not create any legally binding obligations for the product manufacturer. All legally binding obligations are included only in the General Terms and Conditions of Sale.

Correctness of content

- This document was checked for corrected contents and is subject to a continuous updating process. This does not rule out potential errors. In the event that errors are discovered or in case of suggestions to make this document more user-friendly, please inform us via the contact information given in this document.
- We reserve the right to change the product specifications and the contents of this document without prior notice.

Explanation of symbols used

Danger!
Warning of danger that could result in death, serious bodily injury, or serious property damage if not observed.

Caution!
Warning of potential danger or harmful situation that may cause damage to the device or the environment if not observed.

Attention!
Action that may have a direct effect on operation or may cause an unexpected behavior.

[▶ p.4] Reference to the indicated page number.

1.1 Product identification

Exact product name can be found on device side plate.

1.2 Safety information

Fault-free operation and operational safety of the device can only be guaranteed if the general safety requirements and the specific safety requirements in this document are observed.

Do not use the device in climatic conditions other than those specified in this document.

Do not use the device in places with:

- Rapid ambient temperature variations that may cause condensation.
- Direct vibrations / shocks to the device.
- High-intensity electromagnetic fields or static electricity.

Intended use

The device is an environmental sensor for measuring the amount of rainfall using a tipping bucket mechanism.

Foreseeable misuse

If the following notices are disregarded, personal injury or death, as well as property damage can occur.

Danger!

- Do not use in safety / emergency stop devices!
- Not suitable for use in hazardous areas (Ex-environments)!
- Not suitable for SIL (Safety Integrity Level)!
- Not suitable for children!
- Do not use as PPE (Personal Protection Equipment).

Caution!

Do not use if:

- There is visible damage to the device.
- The device is not working as expected.
- The device has been stored under unsuitable conditions for an extended period.

On suspicion that the device can no longer be operated without danger, it must be decommissioned and prevented from recommissioning with appropriate labelling.

In case of doubt, send the device to the manufacturer for repair or maintenance.

2 Technical specifications

The RTD series consists of tipping bucket rain gauges that allow to perform measurements according the recommendations of publication **WMO-No. 8** ("Guide to Instruments and Methods of Observation").

The rain gauges are formed by a metal base on which a tipping bucket is set. The rain collector cone, fixed to the aluminium cylinder, channels the water inside the tipping bucket: once the predefined level is reached, the calibrated bucked rotates under the action of its own weight, discharging the water.

The quantity of rainfall measured is based on the count of the number of times the bucket is emptied: the reed contact, normally closed, opens when the bucket rotates from one section to another. The number of impulses can be detected and recorded by a data logger or by a pulse counter.

The rain gauges are constructed entirely from corrosion-resistant materials to ensure long life.

A removable filter for periodic cleaning and maintenance is inserted in the water collector cone so as to prevent leaves or other elements blocking the end of the hole.

Depending on the model, the output can be Normally Closed voltage-free contact (NC), digital (RS485/SDI-12/MOSFET Open Drain), analog (4...20 mA or 0...10 V).

To ensure accurate measurements even with low temperature climatic conditions or during and after precipitations of snow, versions with heating system, automatically activated at around +4 °C, have been developed to prevent snow deposits and ice formations. In the models with digital and/or analog output, heating control is PID type, which allows for optimization of device consumption. In the models with only voltage-free contact output, heating control is ON/OFF type.

The different models differ in the collecting area, the tipping bucket resolution, the type of output and the presence or absence of heating:

RTD

Heating
0 = no
R = yes

Output
0 = voltage-free contact
F = RS485, SDI-12 and MOSFET Open Drain
D = RS485 and 4…20 mA
V = RS485 and 0…10 V

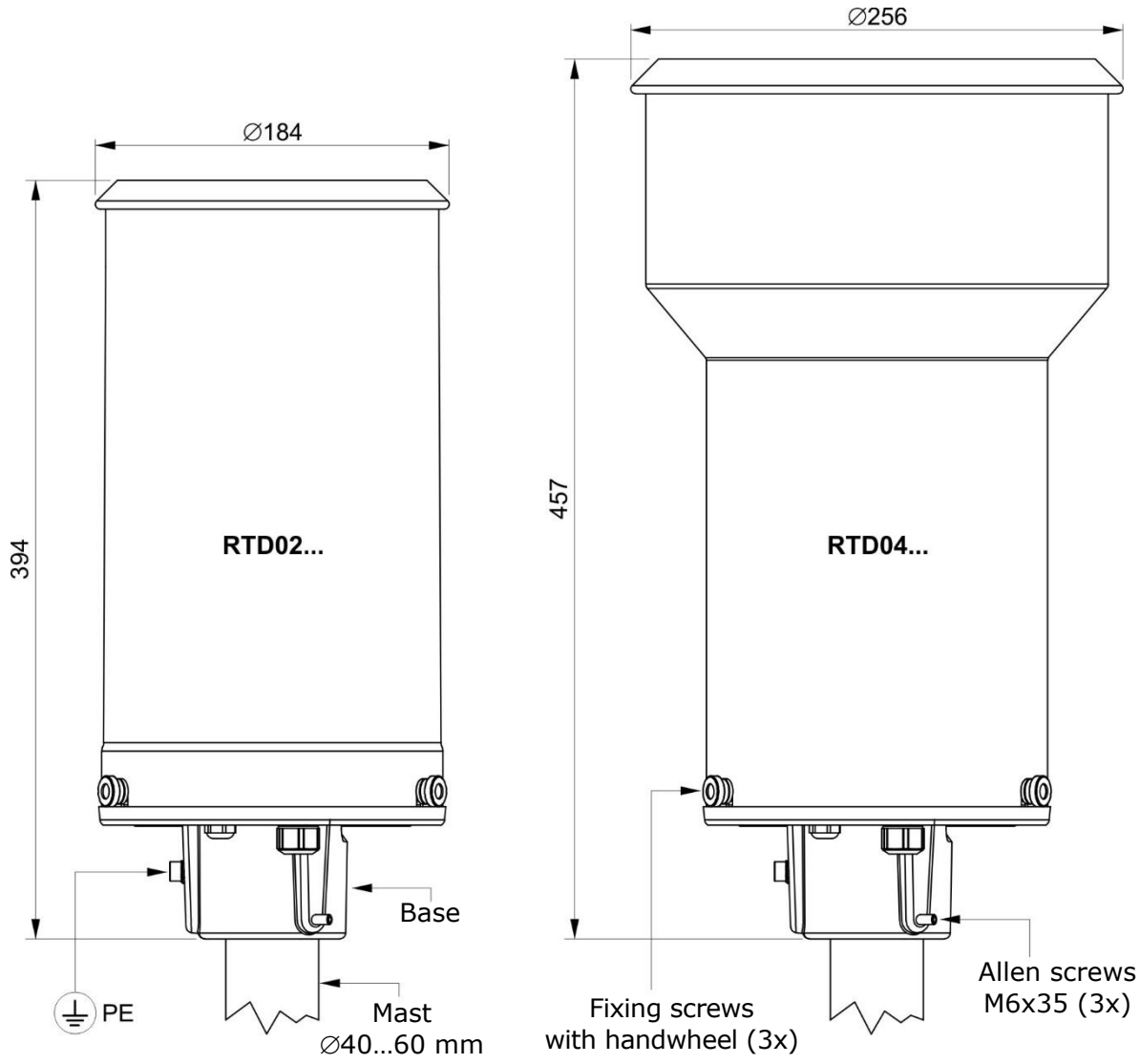
Resolution
1 = 0.1 mm
2 = 0.2 mm
5 = 0.5 mm

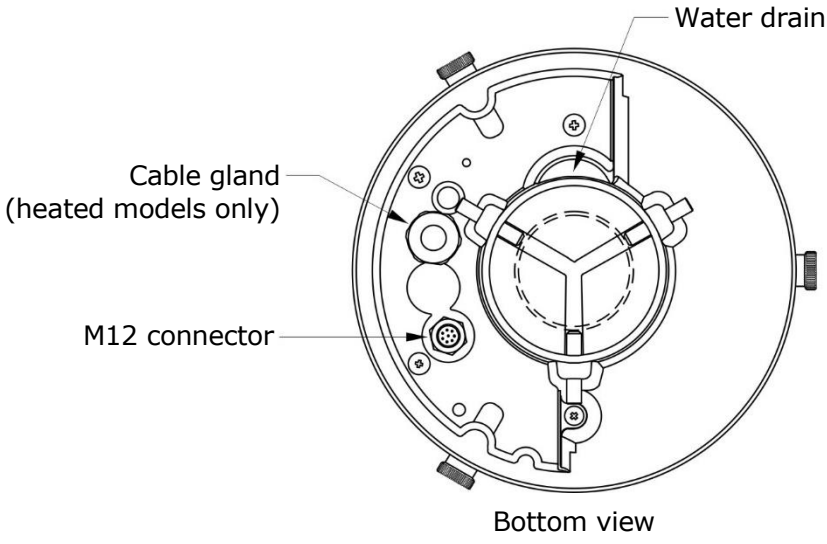
Collecting area
02 = 200 cm^2
04 = 400 cm^2

3 Technical specifications

Collecting area	200 cm² (RTD**02**…) / 400 cm² (RTD**04**…)
Power supply Heating excluded Heating	 7…30 Vdc (RTD…**F**x, RTD…**D**x and RTD…**V**x) RTD…**0**x does not require power supply 24 Vdc ± 10%
Consumption Heating excluded Heating only	 < 7 mA @ 24 Vdc (RTD…**F**x and RTD…**V**x) < 29 mA @ 24 Vdc (RTD…**D**x) RTD…**0**x has no consumption 75 W (RTD**02**…) / 110 W (RTD**04**…)
Output	Voltage-free NC contact (RTD…**0**x) RS485 (RTD…**F**x, RTD…**D**x and RTD…**V**x) SDI-12 (RTD…**F**x) MOSFET Open Drain (RTD…**F**x) 4…20 mA (RTD…**D**x) 0…10 V (RTD…**V**x)
Resolution	0.1 – 0.2 or 0.5 mm/tip depending on model
Accuracy	+2.5…-2.5% in the interval 0…100 mm/h (version with 0.2 mm @ 50 mm/h nominal resolution) +1.5…-1.5% in the interval 0…100 mm/h (version with 0.5 mm @ 50 mm/h nominal resolution) The error refers to the calculation of the amount of rain using the resolution stated in the rain gauge label. If the amount of rain is calculated using the correction curves as a function of the rainfall rate (see the graphs at the following page), the error is typically: < ± 2% for rainfall rate up to 200 mm/h < ± 4% for rainfall rate greater than 200 mm/h In the models with digital and/or analog output, the measurement is automatically corrected according to the correction curves.
Maximum rainfall rate	600 mm/h (versions with 0.1 and 0.2 mm nominal resolution) 1000 mm/h (version with 0.5 mm nominal resolution)
Operating temperature Without heating With heating	 0…+70 °C -25…+70 °C (heating intervention temperature +4 °C)
Connections	M12 connector for the output PG9 cable gland for the heating power supply
Protection degree	IP 65
Dimensions	∅184 x 394 mm (RTD**02**…) / ∅256 x 457 mm (RTD**04**…)
Weight	~2,5 kg (RTD**02**…) / ~3 kg (RTD**04**…)
Material	Anodized and painted aluminum alloy
Installation	On ∅40…60 mm mast

Dimensions (mm) **and description**





3.1 Correction curves

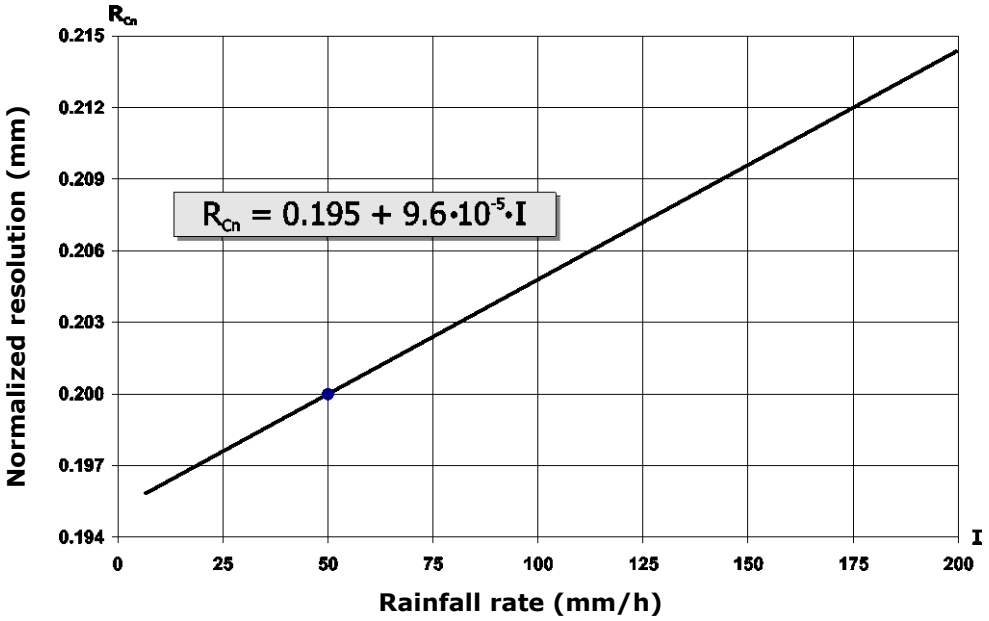


Fig. 3.1 – Normalized resolution (0.2 mm @ 50 mm/h) as a function of the rainfall rate

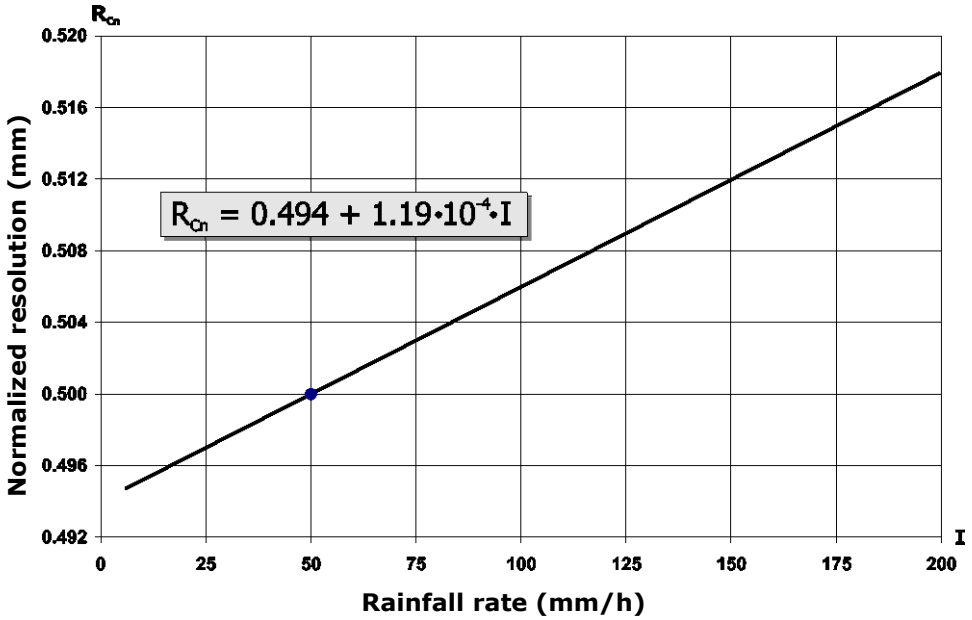


Fig. 3.2 – Normalized resolution (0.5 mm @ 50 mm/h) as a function of the rainfall rate

In models with digital and/or analog output, the measurement is automatically corrected according to the correction curves, stored in the rain gauge. In the models with only voltage-free contact output, in order to correct the measurement according to the rainfall rate, it is necessary to log not only the number of pulses but also the time at which they occur.

Example of measurement correction:

Let's assume that a rain gauge with nominal resolution R_N = 0.209 mm @ 50 mm/h has generated 25 pulses at the frequency of 1 pulse every 50 seconds.

The rainfall rate can be estimated considering the nominal resolution R_N and the interval between two successive pulses: I = 0.209 x 3600 / 50 ≈ 15 mm/h.

From equation in fig. 3.1, we obtain the normalized corrected resolution: R_{Cn} = 0.196 mm.

The corrected resolution of the rain gauge is: $R_C = R_{Cn} \times R_N / 0.2$ = 0.205 mm.

The amount of rain detected is 25 x 0.205 = 5.125 mm.

4 Installation

Danger!

- Wear appropriate personal protective equipment (gloves, safety shoes, …) during installation!
- Do not lift the rain gauge by grasping the outer cylinder: it could slip out, causing the base to fall. Always move the rain gauge by holding the base firmly!
- The heated versions have parts that could be at high temperature when powered! Before performing installation operations, be sure the heater power supply is disconnect and wait for the heater to cool down.

Caution!

Carry out mechanical installation with power supply disconnected.

Attention!

- Install in an open area, away from buildings, trees, etc., ensuring that the space above is free from objects which may obstruct the rain detection.
- Do not install in areas exposed to wind gusts, turbulences (for example on the top of a hill) as they may affect the measurements.
- Installation on slopes or tilted surfaces is not recommended. The area around the rain gauge should be as uniform as possible.
- Install in an easily accessible position for periodical cleaning of the filter.
- Follow the recommendations of publication **WMO-No. 8** ("Guide to Instruments and Methods of Observation") – Volume 1 (Measurement of Meteorological Variables).

The rain gauge is supplied already calibrated and the calibration value (resolution) is shown on the instrument label.

The rain gauge should be installed on a ∅40…60 mm mast and, typically, at a height of 0.5…1.5 m above the ground.

If a ∅40 mm mast is used, optional holders are available to fix the mast to the floor (HD2003.78, flat base) or in the ground (HD2003.75, spike).

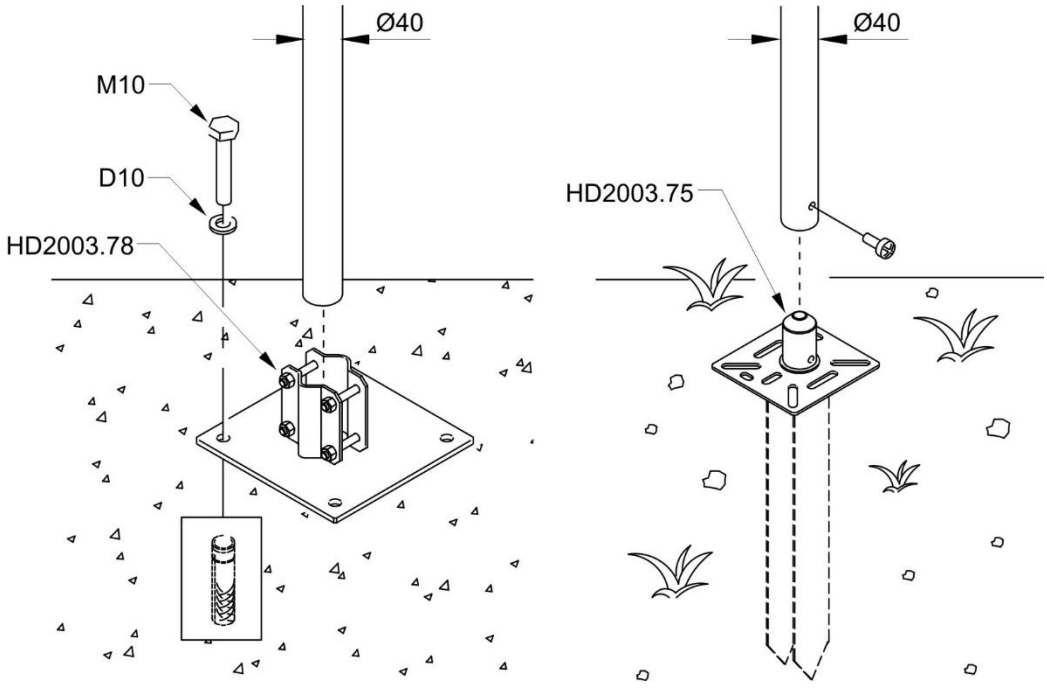


Fig. 4.1: fixing the mast to the floor or in the ground

Secure the base of the rain gauge to the mast using the three M6x35 Allen screws supplied.

For the correct operation of the tipping device, it is important that the rain gauge is placed perfectly levelled. On the base of the rain gauge there is a bubble level, which can be accessed by loosening the three fixing screws with handwheel located at the base of the cylinder supporting the water collecting cone and lifting the cylinder.

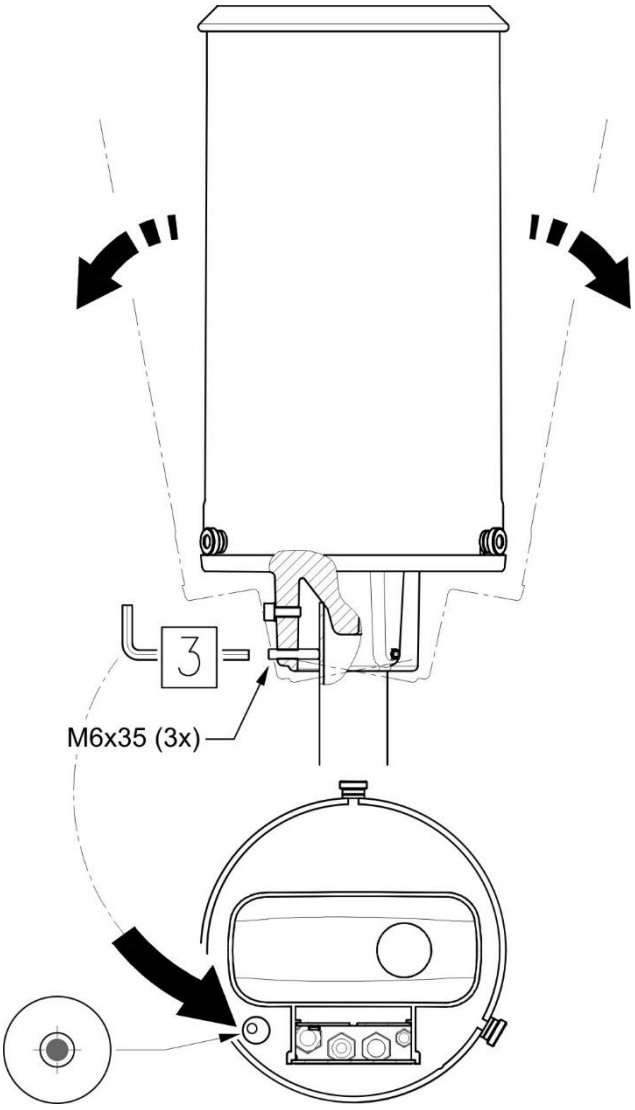


Fig. 4.2: fixing the rain gauge to a mast

Attention!

A heating resistor is fitted around the cone in the heated models, connected to the rest of the circuit via an internal cable with an M12 connector. To completely remove the cylinder and cone, unplug the connector [▶ Fig. 4.3].
Before reinstalling the cylinder, be sure to reconnect the connector.

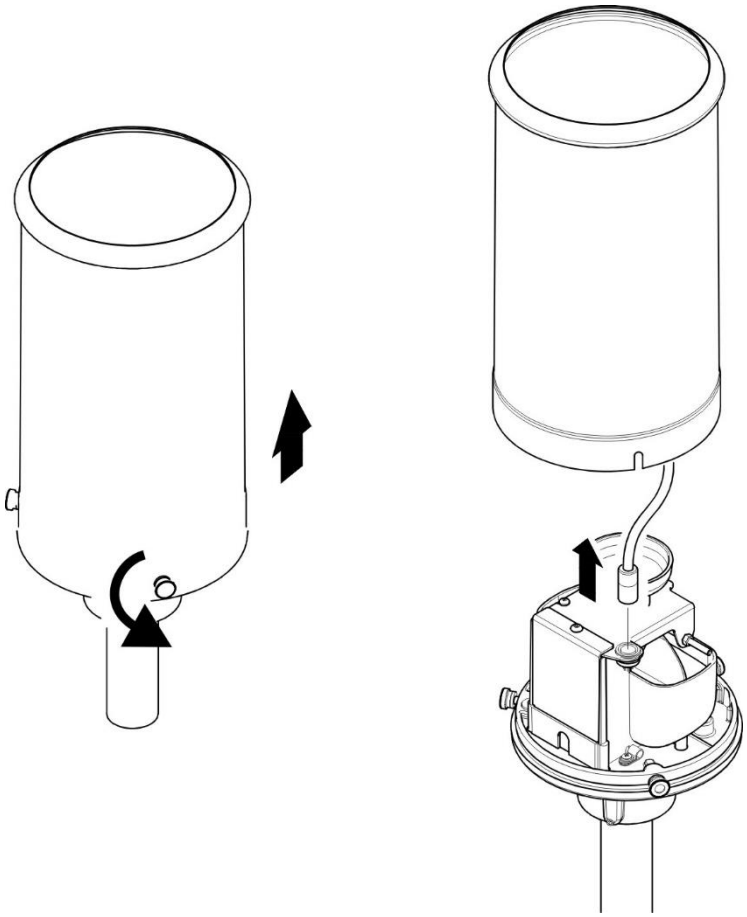


Fig. 4.3: connecting cable of the cone heating resistor

Bird spikes:
The **ACCR004** optional bird spikes kit can be fitted to the rain gauge, to be fastened around the outer cylinder of the rain gauge.

Danger!
The bird spikes kit consists of sharp needles: be careful not to get hurt! Wear appropriate personal protective equipment (safety glasses, gloves, heavy work clothing, …) during installation!

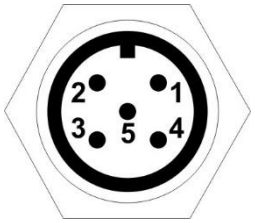
4.1 Electrical connection

Caution!

- Respect the power supply values indicated in the technical specifications and pay attention to the indicated polarities!
- Do not touch terminals or electronic parts directly with your hands! If necessary, be sure to discharge any static electricity from your body by touching metal parts connected to the ground!
- Ensure that there is a ground (Protective Earth) connection!

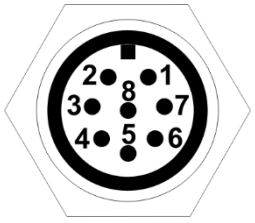
The output connects via the M12 connector under the base of the rain gauge. Models with only contact output have a 5-pin connector. Models with also digital and/or analog output have an 8-pin connector.

M12 connector pinout in RTD...0x

Rain gauge male connector (external view)		Function	CPM12-5... wire color
	1	Voltage-free contact (1st pole)	Brown
	2	Voltage-free contact (2nd pole)	White
	3	NC	Blue
	4	NC	Black
	5	NC	Grey
	Shell		Shield

NC = Not connected

M12 connector pinout in RTD...Fx, RTD...Dx and RTD...Vx models

Rain gauge male connector (external view)		Function	CPM12-8... wire color
	1	GND (Power supply negative)	Brown
	2	+Vdc (Power supply positive)	White
	3	OD_GND (reference for OD_OUT) (*)	Blue
	4	DATA – (RS485)	Black
	5	DATA + (RS485)	Grey
	6	SDI-12	Pink
	7	AOUT (Analog output positive)	Violet
	8	OD_OUT (Open Drain output)	Orange
	Shell		Shield

(*) OD_GND is internally shorted to GND.

Depending on the model, some signals may not be available.

Voltage-free contact:
The contact is normally closed (NC) and opens during the tipping bucket switching.

In RTD…**F**x, RTD…**D**x and RTD…**V**x models, the contact poles are not available on the M12 connector but on terminals 1 and 2 of the internal terminal block. In these models, to use the contact output, the INT/EXT switch must be set to EXT.

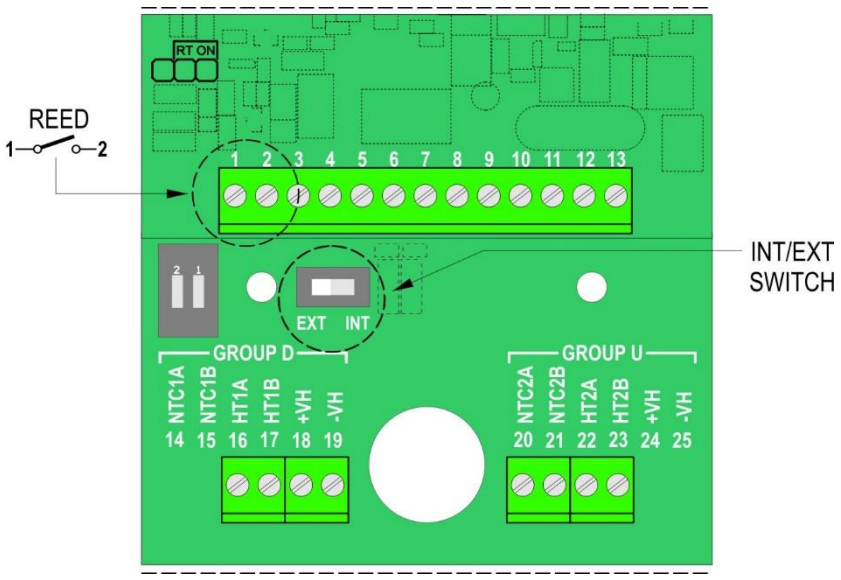


Fig. 4.4: contact output in RTD…Fx, RTD…Dx and RTD…Vx models

Attention!

By setting the INT/EXT switch to EXT, digital and/or analog output is disabled. It is not possible to use the voltage-free contact output and the digital and/or analog output simultaneously.

RS485/SDI-12 digital outputs:
The digital outputs are not isolated. Before connecting the rain gauge to the RS485 or SDI-12 network, set the address and, for the RS485 output, the communication parameters, if different from the factory preset (see "Configuration" chapter).

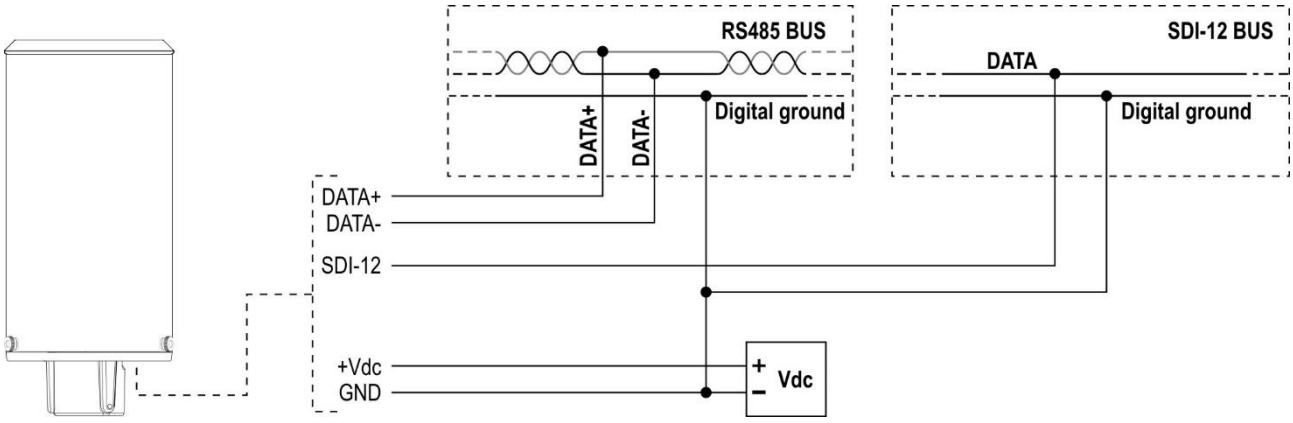


Fig. 4.5: connection of RS485/SDI-12 digital outputs

On the circuit board there is a built-in 120 Ω line termination, that can be connected or removed through a short jumper. To connect the termination, place the short jumper between the "RT" and "ON" indications. By default, the termination is not connected.

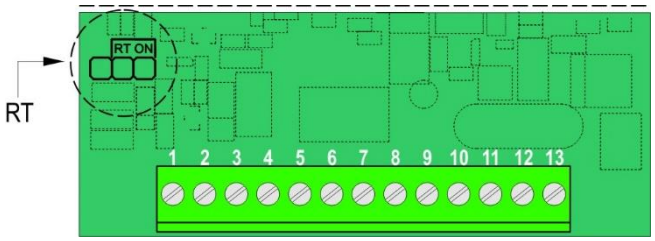


Fig. 4.6: connection of RS485/SDI-12 digital outputs

Analog output:
The output, not isolated, is 4…20 mA (RTD…**D**x) or 0…10 V (RTD…**V**x).

It is possible to alternatively set the 0…20 mA (RTD…**D**x) or 2…10 V (RTD…**V**x) analog output using the ASCII proprietary protocol commands or the Modbus registers.

The load resistance depends on the type of analog output: ≤ 500 Ω for current output, ≥ 100 kΩ for voltage output.

In the event of an anomaly in the measurement, the output goes to a value 10% higher than the full scale: 11 V if the output is 0...10 V, 22 mA if the output is 4…20 mA.

For long distances, a shielded cable is recommended.

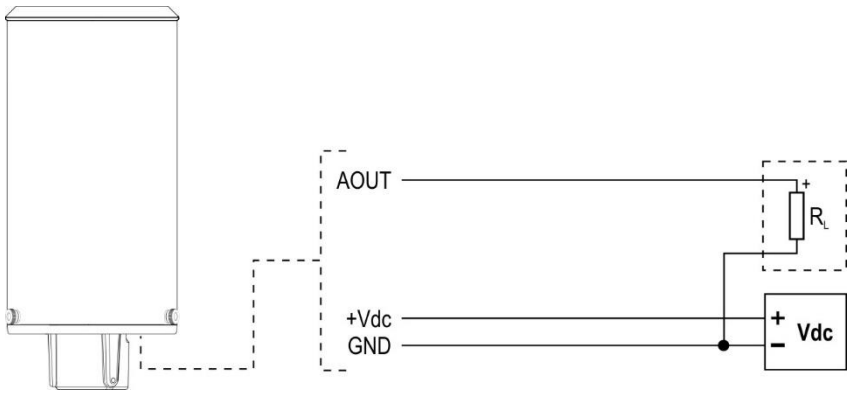


Fig. 4.7: connection of analog output

MOSFET Open Drain output:
In the diagram in Fig. 4.8, the MOSFET is represented by the contact. By default, the contact is normally closed (output connected to GND via an internal 10 Ω resistor) and opens for 50 ms when the tipping bucket switches. It is possible to set the contact as normally open with the **TOW** command of the ASCII proprietary protocol. Output max. load 1 A / 30 Vdc.

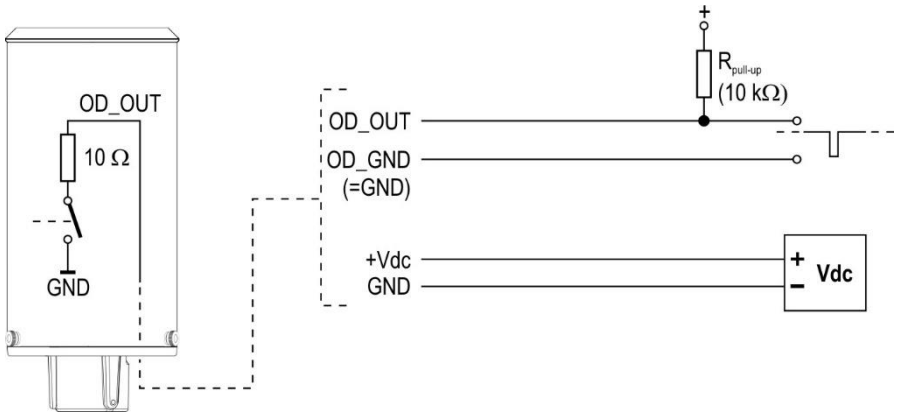


Fig. 4.8: MOSFET Open Drain output principle diagram

Connection of heating:

Heating, if any, power supply has to be connected to the internal screw terminals by running the cable through the cable gland under the base of the rain gauge.

To access the heating connection terminal header, loosen the three fixing screws with handwheel located at the base of the cylinder supporting the water collecting cone and lift the cylinder, then unscrew the electronic board protection cover.

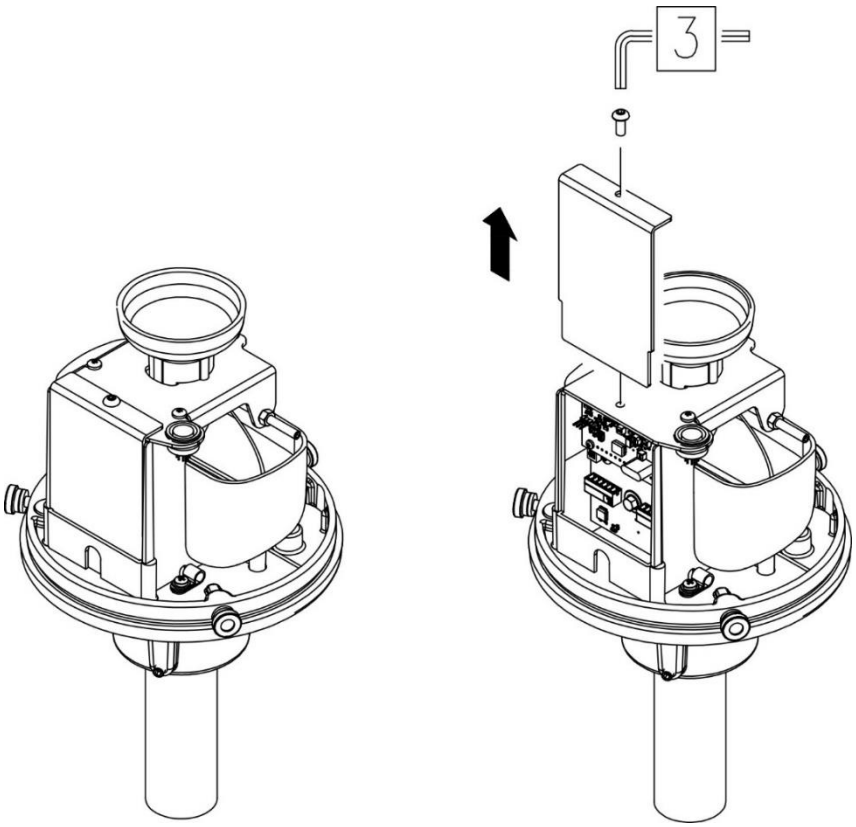
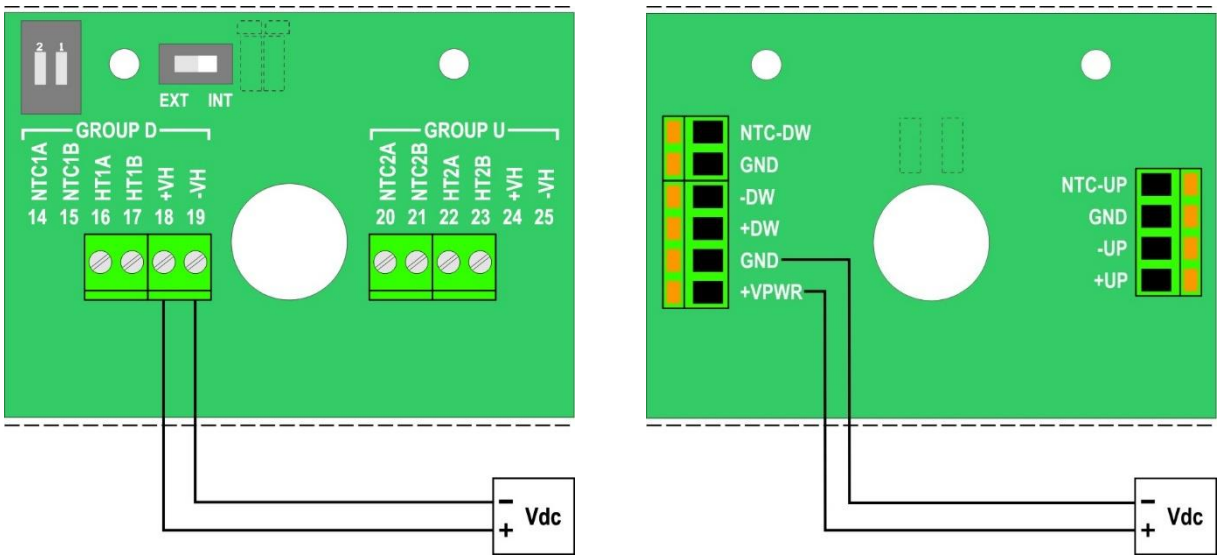


Fig. 4.9: removal of electronic board protection cover



RTD…**F**x, RTD…**D**x and RTD…**V**x models
Screw terminals

RTD…**0**x models
Spring terminals

Fig. 4.10: heating connection

For the heating power supply, use a cable with a 2.5 mm^2 minimum wire cross-section.

Grounding (Protective Earth) connection:

If the rain gauge is not connected to ground via the support mast, connect the ground cable, suitably terminated with an eyelet, to the threaded hole in the base of the rain gauge using the M6x16 screw and the knurled washer provided.

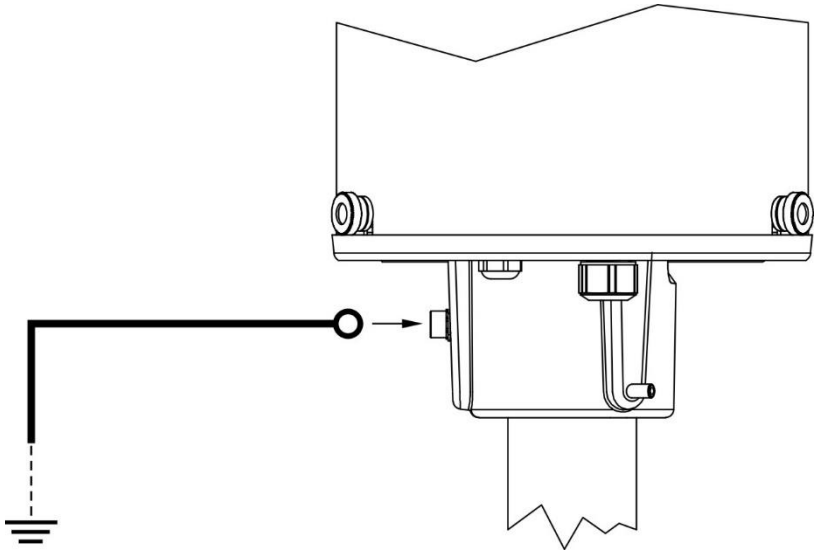


Fig. 4.11: connection of grounding cable

4.2 Unlocking the tipping bucket

The tipping bucket is locked with a plastic tie for the transport of the rain gauge. To unlock the bucket, cut and remove the tie.

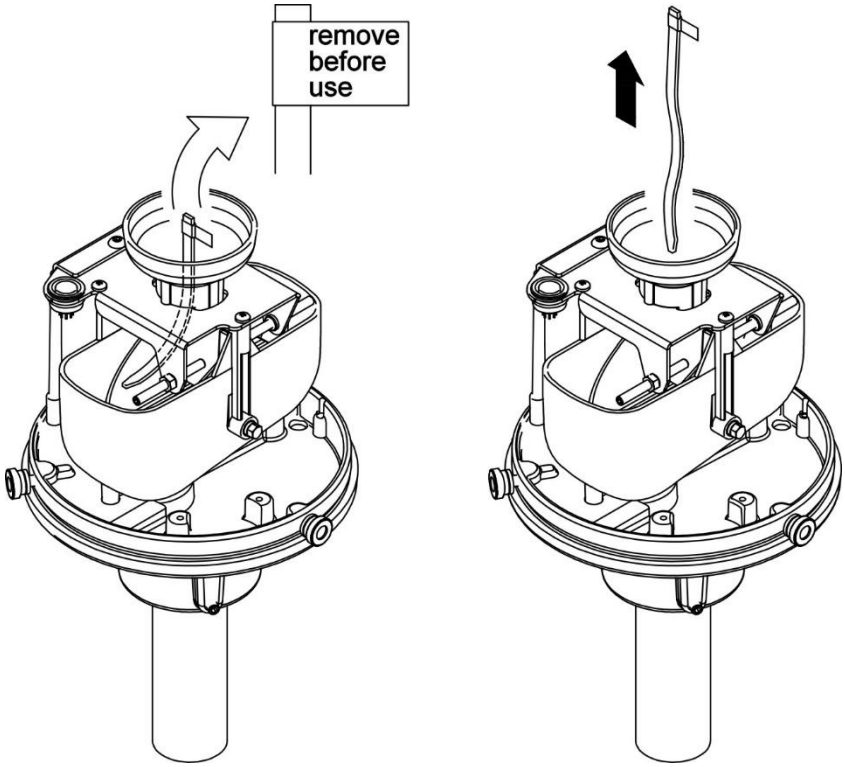


Fig. 4.12: unlocking the tipping bucket

5 Configuration

The configuration of the rain gauge can be done:

- By sending serial commands from a PC, via a standard communication program (see the chapter "ASCII proprietary protocol").
- Via "Coils" and "Holding Registers" in Modbus-RTU mode (see the chapter "Modbus-RTU protocol").
- Via the SDI-12 extended commands (see the chapter "SDI-12 protocol").
- Only for the analog output full scale, via the dip switches on the circuit board.

Analog output:

The analog output is proportional to the partial amount of rainfall (amount of rainfall from the last reset command). The analog output full scale can be configured via the **dip switches** on the circuit board or, if both the dip switches are set to ON (default), to a custom value via the available protocols.

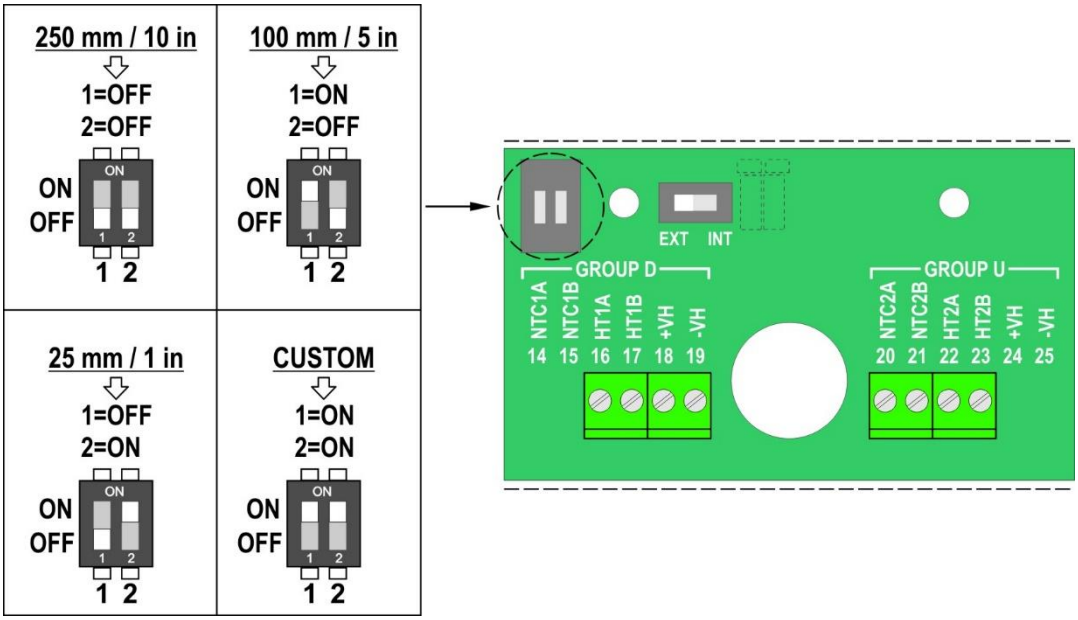


Fig. 5.1: analog output full scale dip switches

Attention!

After reaching the full scale value, the measurement is reset and the analog output returns to the initial scale value.

Connection to PC:

To connect the rain gauge to a PC USB port, to check or change the configuration, the **CP24B-8** optional cable can be used, which also allows the rain gauge to be powered via the USB port.

To use the CP24B-8 cable, the related USB drivers must be installed in the PC.

Alternatively, it is possible to use a standard RS485/USB or RS485/RS232 converter, powering the rain gauge separately (respecting the minimum supply voltage of the rain gauge).

6 ASCII proprietary protocol

To communicate with the rain gauge via the ASCII proprietary protocol:

1. Connect the rain gauge to the PC and start a standard serial communication program.
2. In the serial communication program, set the Baud Rate 57600, the parameters 8N2 and the COM port number to which the rain gauge is connected.
3. Power the rain gauge (or power cycle if already powered) and send the command **@** within 10 seconds from the instrument power on. The rain gauge replies **&|** if the command @ is recognized.

   Note: if the CP24B-8 cable is used, to power cycle the rain gauge, disconnect the cable for a few seconds from the PC USB port, then reconnect it.
4. To edit the settings, send the password (default **0**) with the **PWD** command. The password is not required to just read the settings.
5. Send the commands described in the tables below.

Attention!

- After 10 minutes of inactivity, the protected mode is restored; in this case, the password must be resent in order to continue with the settings.
- The protected mode can be immediately restored by sending a wrong password.
- To protect the parameters from unauthorized changes, it is advisable to set a password with the **SUP** command.

In the tables below, the column "PWD" indicates the password-protected commands.

Password management

Command	Reply	Description	PWD
PWDn…n	USER ACCESS OK or WRONG PASSWORD	Sends the password n…n (4 digits max.).	---
SUPn…n	PASS: n…n or INVALID PASSWORD	Sets n…n (4 digits max.) as password. Default=0	Yes

Instrument information:

Command	Reply	Description	PWD
G0	&*Model*|	Instrument model	No
G2	&SN=nnnnnnnn|	Instrument serial number	No
G3	&Firm.Ver.=x.y|	Instrument firmware revision	No
G4	&Firm.Date=yyyy/mm/dd|	Date of firmware revision	No

Date and time

Command	Reply	Description	PWD
DSyyyy/mm/dd hh:mm:ss	&|	Sets date and time.	Yes
DG	&yyyy/mm/dd hh:mm:ss|	Reads date and time.	No

Operating protocol

Command	Reply	Description	PWD
@	&|	Keeps the proprietary protocol operational even after 10 seconds from instrument power on, if sent within 10 seconds from power on.	No
DPn	&|	Sets the operating protocol: ▪ Proprietary if n=0 ▪ Modbus-RTU if n=1 (default)	Yes
GP	& n|	Reads the operating protocol set in the instrument.	No
SM	&|	Activates the Modbus-RTU protocol immediately.	No

Attention!

After sending the DP1 command, the instrument remains with the proprietary protocol. Send the command SM to activate the Modbus-RTU protocol immediately, or power cycle the instrument.

Modbus-RTU protocol

Command	Reply	Description	PWD
CMAn	&|	Sets the address to n (1…247, default=1).	Yes
RMA	& n|	Reads the address.	No
CMBn	&|	Sets the Baud Rate: ▪ 1200 if n=0 ▪ 2400 if n=1 ▪ 4800 if n=2 ▪ 9600 if n=3 ▪ 19200 if n=4 (default) ▪ 38400 if n=5 ▪ 57600 if n=6 ▪ 115200 if n=7	Yes
RMB	& n|	Reads Baud Rate setting.	No
CMPn	&|	Sets parity and stop bits (data bits = 8 fixed): ▪ 8N1 if n=0 ▪ 8N2 se n=1 ▪ 8E1 if n=2 (default) ▪ 8E2 se n=3 ▪ 8O1 if n=4 ▪ 8O2 se n=5	Yes
RMP	& n|	Reads the setting of parity and stop bits.	No
CMWn	&|	Sets waiting time after transmission: ▪ Immediate reception if n=0 (violates protocol) ▪ Waiting 3.5 characters if n=1 (respects protocol, default)	Yes
RMW	& n|	Reads the setting of waiting time after transmission.	No

SDI-12 protocol

Command	Reply	Description	PWD
CSAn	&|	Sets the address to n (0…9, A…Z, a…z, default=0).	Yes
RSA	& n|	Reads the address.	No

Measurements reading

Command	Reply	Description	PWD
S0	&|	Disables the continuous sending of the measurements enabled with S2.	No
S1	& *Measures*	Prints the measurements in the following sequence: ▪ Total amount of rainfall (since power on) ▪ Partial amount of rainfall (since last reset) ▪ Amount of rainfall in the current day ▪ Amount of rainfall in the previous day ▪ Instantaneous rain rate ▪ Lower heater temperature ▪ Upper heater temperature ▪ Lower heater current power (% of the max.) ▪ Upper heater current power (% of the max.) ▪ Diagnostic sensor pressure ▪ Diagnostic sensor temperature ▪ Diagnostic sensor relative humidity ▪ Tilt_X **(*)** ▪ Tilt_Y **(*)** ▪ Errors (*value to be converted into binary*): Bit 0 = 1 ⇒ Amount of rainfall error Bit 1 = 1 ⇒ Heater 1 temperature error Bit 2 = 1 ⇒ Heater 2 temperature error Bit 3 = 1 ⇒ Pressure diagnostic sensor error Bit 4 = 1 ⇒ Temperature diagnostic sensor error Bit 5 = 1 ⇒ Relative humidity diagnostic sensor error Bit 6 = 1 ⇒ Tilt sensor error The measurements are expressed in the set meas. units. Note: after reaching 99999.99, the total rainfall counter restarts from zero.	No
S2	& *Measures*	Enables the continuous sending of the measurements once per second. The reply of the instrument is in the same form described for the command S1.	No

(*) Tilt_X is the tilt of the horizontal axis of the board relative to a line parallel to the ground; Tilt_Y is the tilt of the vertical axis of the board relative to a line perpendicular to the ground. Both values must be zero if the rain gauge is correctly installed.

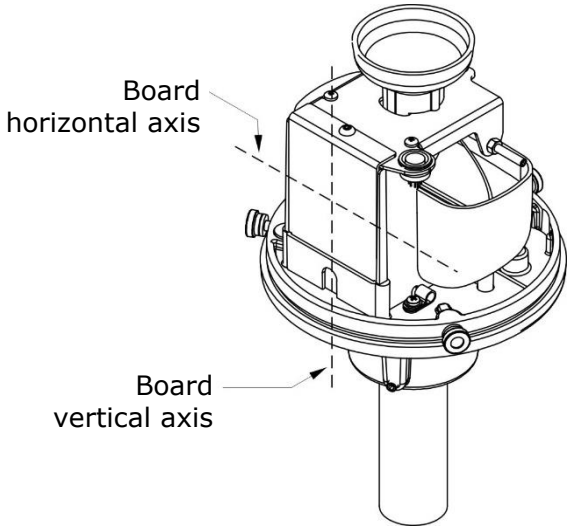


Fig. 6.1: Tilt measurement references

Unit of measurement

Command	Reply	Description	PWD
URWn	&|	Sets the amount of rainfall unit of measurement of index n: ▪ mm if n=0 (default) ▪ inches if n=1	Yes
URR	& n|	Reads the pressure unit of measurement.	No
TUWu	&|	Sets the temperature unit of measurement of index n: ▪ °C if n=0 (default) ▪ °F if n=1	Yes
TUR	& n|	Reads the temperature unit of measurement.	No
UPWn	&|	Sets the pressure unit of measurement of index n: ▪ Torr if n=0 ▪ Pa if n=1 ▪ hPa if n=2 (default) ▪ kPa if n=3 ▪ mbar if n=4 ▪ psi if n=5 ▪ kg/cm^2 if n=6 ▪ mmH_2O if n=7 ▪ mmHg if n=8 ▪ inH_2O if n=9 ▪ inHg if n=10 ▪ atm if n=11 ▪ bar if n=12	Yes
UPR	& n|	Reads the pressure unit of measurement.	No

Resolution

Command	Reply	Description	PWD
BWn	&|	Sets the resolution of index n: ▪ 0.1 mm if n=0 ▪ 0.2 mm if n=1 ▪ 0.25 mm if n=2 ▪ 0.5 mm if n=3 ▪ 1 mm if n=4 ▪ 0.254 mm (0.01 inches) if n=5 ▪ 0.508 mm (0.02 inches) if n=6 ▪ 1.016 mm (0.04 inches) if n=7 ▪ Custom value if n=X (default) The custom value is set via the CCW command.	Yes
BR	& n|	Reads the rain gauge resolution.	No
CCWn…n	&|	Sets n…n (0.001…10.00) as custom value of the resolution, considered in the unit of measurement (mm or inches) set in the instrument. Example: CCW+0.42 sets 0.42 mm or 0.42 inches, depending on the unit of measurement set. Default=Calibration value **Warning**: the command CCW sets the value but not the use of the custom resolution; to use the custom resolution, the command BWX should be sent (see the command BW described above).	Yes
CCR	& n…n|	Reads the custom value of the resolution. The value is considered in the unit of measurement set in the instrument.	No

Analog output

Command	Reply	Description	PWD
CPOE	&|	Enables the offset of the analog output initial value: 4…20 mA or 2…10 V.	Yes
CPOD	&|	Disables the offset of the analog output initial value: 0…20 mA or 0…10 V.	Yes
CPOR	&0/1|	Reads the enabling state of the offset of the analog output initial value: 0=disabled, 1=enabled. Default=enabled if the output is current, disabled if the output is voltage.	No
CRD	& n|	Reads the setting of the dip switches on the circuit board (DIP1 – DIP2): ▪ OFF – OFF if n=0 (f.s.=250 mm / 10 in) ▪ ON – OFF if n=1 (f.s.=100 mm / 5 in) ▪ OFF – ON if n=2 (f.s.=25 mm / 1 in) ▪ ON – ON if n=3 (f.s.=CUSTOM, default)	No
CRG	& n…n|	Reads the amount of rainfall corresponding to the analog output full scale, considering the dip switches setting on the circuit board.	No
CRWn…n	&|	Sets n…n (0.01…9999) as the "custom" amount of rainfall corresponding to the analog output full scale, considered in the unit of measurement (mm or inches) set in the instrument. Example: CRW+80 sets 80 mm or 80 inches, depending on the unit of measurement set, as value corresponding to 20 mA or 10 V. Default=10 **Warning**: the set value is considered by the instrument only if the dip switches on the circuit board are both set to ON.	Yes
CRR	& n…n|	Reads the "custom" amount of rainfall corresponding to the analog output full scale (used only if the dip switches on the circuit board are both set to ON). The value is considered in the unit of measurement set in the instrument.	No

MOSFET Open Drain output

Command	Reply	Description	PWD
TOWn	&|	Sets the MOSFET Open Drain output as: ▪ NC (normally connected to GND) if n=0 (default) ▪ NO (normally open) if n=1	Yes
TOR	& n|	Reads the MOSFET Open Drain output setting.	No

Reset

Command	Reply	Description	PWD
RES	&|	Resets the partial rainfall counter.	Yes
REA	&|	Resets all the rainfall counters.	Yes
HRS	&|	Resets the circuit board.	Yes
DFLT	&|	Restores the factory configuration.	Yes

Correction of the measurement

To increase the measurement accuracy, a measurement correction table as a function of the rainfall rate is stored in the models with digital and/or analog output at the factory.

The correction is useful because during the emptying time of the tipping bucket, rain is not collected from the bucket and the amount of rain in the absence of correction is therefore underestimated. The correction to be made is greater the higher is the rainfall rate (greater number of cycles in the time unit).

The correction table can be modified by the user. The rain gauge allows you to set ten multiplication factors (numbered from o to 9) of the nominal resolution, each corresponding to a range of rainfall rate.

Command	Reply	Description	PWD
TE	&|	Enables the measurement correction as a function of the rainfall rate.	Yes
TD	&|	Disables the measurement correction as a function of the rainfall rate.	Yes
TR	&0/1|	Reads the enabling state of the measurement correction as a function of the rainfall rate: 0=disabled, 1=enabled (default).	No
CTS	&CALIBRATION_STARTED|	Starts the correction table writing procedure.	Yes
CTE	&CALIBRATION_ENDED|	Ends the correction table writing procedure and saves the entered values.	Yes
CTWi+r…r+k…k	&|	Set the multiplication factor of index i to the value k…k. The multiplication factor is applied if the rainfall rate is between r…r (considered in mm/h or in/h depending on the unit of measurement set in the instrument) and the rate value defined for the multiplication factor of index i+1 (see the example below). The multiplication factor must be between 0.500 and 2.000.	Yes
CTRi	r…rk…k	Reads the multiplication factor of index i. Example: +50+1 indicates that the multiplication factor is 1 and the corresponding rainfall rate is 50 (mm/h or in/h).	No

When you set the correction table, it is mandatory to enter in ascending order all the ten multiplication factors. The rate corresponding to the multiplication factor of index *i* must be greater or equal to the rate corresponding to the multiplication factor of index *i*-1.

Example

To change the default table and implement the following correction table:

	Rainfall rate (mm/h)									
	0…25	25…75	75…100	100…150	150…200	200…250	250…300	300…350	350…400	400...
K	0.98	1	1.02	1.04	1.06	1.09	1.10	1.14	1.18	1.22

send, exactly in the order shown, the following commands:

CTS
CTW0+0+0.98
CTW1+25+1
CTW2+75+1.02
CTW3+100+1.04
CTW4+150+1.06
CTW5+200+1.09
CTW6+250+1.10
CTW7+300+1.14
CTW8+350+1.18
CTW9+400+1.22
CTE

Note that the sequence of the CTW commands must be preceded by the command CTS and followed by the command CTE.

7 Modbus-RTU protocol

By default, the instrument has Modbus address **1** and communication parameters 19200, 8E1. The address and the communication parameters can be changed by using the appropriate serial commands of the proprietary protocol or, alternatively, directly via the Modbus Coils and Holding Registers described later.

By default, the Modbus-RTU protocol is activated after 10 seconds from the transmitter power on.

In order to change the instrument configuration, the password must be written first in the Holding Register with address **0**. The protected mode can be immediately restored by writing a wrong password in the same register.

Attention!

- The default password is **0**. A different password can be set with the **SUP** command of the ASCII proprietary protocol.

Below is the list of registers.

Input Registers

Address	Description	Format
0	Status register: Bit 0 = 1 ⇒ Amount of rainfall error Bit 1 = 1 ⇒ Heater 1 temperature error Bit 2 = 1 ⇒ Heater 2 temperature error Bit 3 = 1 ⇒ Pressure diagnostic sensor error Bit 4 = 1 ⇒ Temperature diagnostic sensor error Bit 5 = 1 ⇒ Relative humidity diagnostic sensor error Bit 6 = 1 ⇒ Tilt sensor error	16-bit Integer
1	Not used	16-bit Integer
2 + 3	Total amount of rainfall (since power on), in the set unit of measurement [x1000 if mm, x10000 if inches]	32-bit Integer
4 + 5	Amount of rainfall in the current day, in the set unit of measurement [x1000 if mm, x10000 if inches]	32-bit Integer
6 + 7	Amount of rainfall in the previous day, in the set unit of measurement [x1000 if mm, x10000 if inches]	32-bit Integer
8 + 9	Partial amount of rainfall (since last reset), in the set unit of measurement [x1000 if mm, x10000 if inches]	32-bit Integer
10 + 11	Instantaneous rain rate, in the set unit of measurement [x1000 if mm/h, x10000 if inches/h]	32-bit Integer
12	Lower heater temperature, in the set unit of measurement [x10]	16-bit Integer
13	Upper heater temperature, in the set unit of measurement [x10]	16-bit Integer
14	Diagnostic sensor pressure, in the set unit of measurement (*see table below for the resolution*).	16-bit Integer
15	Diagnostic sensor temperature, in the set unit of measurement [x10]	16-bit Integer
16	Diagnostic sensor relative humidity, in % [x10]	16-bit Integer

Address	Description	Format
17	Tilt_X (*), in degrees [x10]	16-bit Integer signed
18	Tilt_Y (*), in degrees [x10]	16-bit Integer signed
19 + 20	Partial amount of rainfall, since last reading of this register, in the set unit of measurement [x1000 if mm, x10000 if inches].	32-bit Integer
21	Lower heater current power, in % of the max. [x10]	16-bit Integer
22	Upper heater current power, in % of the max. [x10]	16-bit Integer
23	Reads the setting of the dip switches on the circuit board (DIP1 – DIP2), relating to analog output full scale: 0=OFF – OFF (f.s.=250 mm / 10 in) 1=ON – OFF (f.s.=100 mm / 5 in) 2=OFF – ON (f.s.=25 mm / 1 in) 3=ON – ON (f.s.=CUSTOM, default)	16-bit Integer
24 + 25	Reads the amount of rainfall, in the set unit of measurement, corresponding to the analog output full scale, considering the dip switches setting on the circuit board.	32-bit Float

(*) For the meaning of the Tilt measurements, see page 20.

Pressure measurement resolution

Unit of measurement	Measurement resolution	Register value multiplier
Pa	10 Pa	/10
hPa	0.1 hPa	x10
kPa	0.01 kPa	X100
mbar	0.1 mbar	x10
bar	0.0001 bar	x1000
atm	0.0001 atm	x1000
psi	0.001 psi	x1000
mmHg	0.1 mmHg	x10
inHg	0.01 inHg	x100
mmH_2O	1 mmH_2O	x1
inH_2O	0.1 inH_2O	x10
kg/cm^2	0.0001 kg/cm^2	x1000
Torr	0.1 Torr	x10

Discrete inputs

Address	Description	Format
0	Current status of configuration password protection: 0=configuration cannot be changed (password not sent or expired due to timeout) 1=configuration can be changed (password sent and timeout not expired)	Bit

Coils

Address	Description	Format
0	Set 1 to restore the factory configuration. Bit zeroing is automatic.	Bit
1	Sets waiting time after Modbus transmission: 0=immediate reception (default) 1=waiting 3.5 characters	Bit
2	Enable/disable the measurement correction as a function of the rainfall rate: 0=correction disabled 1=correction enabled (default)	Bit
3	Reserved	Bit
4	Enable/disable the analog output offset: 0=offset disabled (default if the output is voltage) 1=offset enabled (default if the output is current)	Bit
5	Set 1 to reset all the rainfall counters. Bit zeroing is automatic.	Bit
6	Set 1 to reset the partial rainfall counter. Bit zeroing is automatic.	Bit

Holding Registers

Address	Description	Format
0	Write the instrument password (default 0) in this register to enable writing in Coils and Holding Registers. Write a wrong password to disable writing.	16-bit Integer
1	Modbus-RTU address (1…247, default=1).	16-bit Integer
2	RS485 Baud Rate: 0=1200 4=19200 (default) 1=2400 5=38400 2=4800 6=57600 3=9600 7=115200	16-bit Integer
3	RS485 parity and stop bits: 0=8N1 3=8E2 1=8N2 4=8O1 2=8E1 (default) 5=8O2	16-bit Integer
4	Sets the resolution of index n: 0=0.1 mm 1=0.2 mm 2=0.25 mm 3=0.5 mm 4=1 mm 5=0.254 mm (0,01 inches) 6=0.508 mm (0,02 inches) 7=1.016 mm (0,04 inches) 9=Custom value (default) The custom value is set with the 5 + 6 registers.	16-bit Integer
5 + 6	Custom value of the resolution, considered in the set unit of measurement. Default=Calibration value **Warning**: the custom resolution is only used if the register 4 contains 9.	32-bit Float

Address	Description	Format
7 + 8	"Custom" amount of rainfall, considered in the set unit of measurement, corresponding to the analog output full scale. Default=10 **Warning**: the set value is considered by the instrument only if the dip switches on the circuit board are both set to ON.	32-bit Float
9	Pressure unit of measurement: 0=Torr 1=Pa 2=hPa (default) 3=kPa 4=mbar 5=psi 6=kg/cm^2 7=mmH_2O 8=mmHg 9=mmH_2O 10=inHg 11=atm 12=bar	16-bit Integer
10	Temperature unit of measurement: 0=°C (default), 1=°F	16-bit Integer
11	Amount of rainfall unit of measurement: 0=mm (default), 1=inches	16-bit Integer
Date and time		
12	Year	16-bit Integer
13	Month	16-bit Integer
14	Day	16-bit Integer
15	Hour	16-bit Integer
16	Minutes	16-bit Integer
17	Seconds	16-bit Integer

Notes on the registers format:

1) To read a 32-bit value, both integer and float, the two consecutive registers indicated must be accessed. The register with lower address contains the less significant bits.
2) The value of the integer registers is unsigned unless otherwise specified.
3) The 32-bit float registers follow the IEEE 754 standard.

8 SDI-12 protocol

The rain gauge is compatible with version 1.3 of SDI-12 protocol.

The communication parameters are "1200, 7E1".

Communication with the instrument is performed by sending a command in the following format:

<Address><Command>!

With <Address> = address of the instrument the command is sent to
<Command> = type of operation requested to the instrument

The instrument reply is as follows:

<Address><Data><CR><LF>

With <Address> = address of the replying instrument
<Data> = information sent by the instrument
<CR> = ASCII character *Carriage Return*
<LF> = ASCII character *Line Feed*

The table below shows the available SDI-12 commands. For consistency with the documentation of the SDI-12 standard, the instrument address is indicated in the table with the letter **a**. The rain gauge leaves the factory with address preset to 0. The address can be changed by using the proper SDI-12 command reported in the table or with the **CSA** command of the ASCII proprietary protocol.

SDI-12 Commands

Command	Reply	Description
a!	a<CR><LF>	Verifies the presence of the instrument.
aI!	allccccccccmmmmmmvvvssssssss<CR><LF> with: a = address of the instrument (1 character) ll = SDI-12 compliant version (2 characters) cccccccc = manufacturer (8 characters) mmmmmm = instrument model (6 characters) vvv = firmware version (3 characters) ssssssss = serial number (8 characters)	Requests for information from the instrument.
aAb!	b<CR><LF> Change of the address from "a" to "b". If "b" is not an acceptable address, the instrument replies with a instead of b.	Change of the instrument address.
?!	a<CR><LF>	Request of the address of the instrument. If more than one sensor is connected to the bus, a conflict occurs.

Type M (start measurement) and C (start concurrent measurement) commands

The reply to aMx! and aCx! commands includes the number of seconds necessary for the instrument to make the measure available (ttt, 3 characters; 000 means datum immediately available) and the number of detected variables (n, 1 character for aMx!; nn, 2 characters for aCx!).

Command	Reply	Description
Total amount of rainfall		
aM! aC!	atttn<CR><LF> atttnn<CR><LF>	Request of detection of total amount of rainfall.
aD0!	a+n+r<CR><LF> with: n = number of emptying of the tipping bucket r = total amount of rainfall in the set unit of measurement ⇒ Example of response: 0+48+9.6 The instrument with address 0 has recorded 48 emptying of the tipping bucket; the total amount of rainfall is 9.6 mm or inches depending on the set unit. *Note*: after reaching 99999.99, the total rainfall counter restarts from zero.	Reads the total amount of rainfall.
Partial amount of rainfall		
aM1! aC1!	atttn<CR><LF> atttnn<CR><LF>	Request of detection of partial amount of rainfall.
aD0!	a+n+r<CR><LF> with: n = number of emptying of the tipping bucket r = partial amount of rainfall in the set unit of measurement ⇒ Example of response: 0+12+2.4 The instrument with address 0 has recorded 12 emptying of the tipping bucket; the partial amount of rainfall is 2.4 mm or inches depending on the set unit. *Note*: after reaching 99999.99, the partial rainfall counter restarts from zero.	Reads the partial amount of rainfall.
Amount of rainfall in the current day		
aM2! aC2!	atttn<CR><LF> atttnn<CR><LF>	Request of detection of amount of rainfall in the current day.
aD0!	a+n+r<CR><LF> with: n = number of emptying of the tipping bucket r = amount of rainfall in the current day in the set unit of measurement	Reads the amount of rainfall in the current day.

Command	Reply	Description
Amount of rainfall in the previous day		
aM3! aC3!	atttn<CR><LF> atttnn<CR><LF>	Request of detection of amount of rainfall in the previous day.
aD0!	a+n+r<CR><LF> with: n = number of emptying of the tipping bucket r = amount of rainfall in the previous day in the set unit of measurement	Reads the amount of rainfall in the previous day.
Rainfall rate and sensors status		
aM4! aC4!	atttn<CR><LF> atttnn<CR><LF>	Request of detection of current rainfall rate and sensors status.
aD0!	a+r+s<CR><LF> with: r = rainfall rate in the set unit of measurement (mm/h or in/h) s = sensors status, value to be converted to binary: bit 0 = 1 ⇒ amount of rainfall error bit 1 = 1 ⇒ heater 1 temperature error bit 2 = 1 ⇒ heater 2 temperature error bit 3 = 1 ⇒ pressure diagnostic sensor error bit 4 = 1 ⇒ temperature diagnostic sensor error bit 5 = 1 ⇒ RH diagnostic sensor error bit 6 = 1 ⇒ tilt sensor error	Reads the current rainfall rate and the sensors status.
Heating status		
aM5! aC5!	atttn<CR><LF> atttnn<CR><LF>	Request of heating status.
aD0!	a+t1+t2+p1+p2<CR><LF> with: t1 = lower heater temperature in the set unit of measurement t2 = upper heater temperature in the set unit of measurement p1 = lower heater current power (% of the max.) p2 = upper heater current power (% of the max.)	Reads the heating status.

Command	Reply	Description
Partial amount of rainfall with automatic counter reset		
aM6! aC6!	atttn<CR><LF> atttnn<CR><LF>	Request of detection of partial amount of rainfall and subsequent reset of corresponding counter.
aD0!	a+n+r<CR><LF> with: n = number of emptying of the tipping bucket r = partial amount of rainfall in the set unit of measurement	Reads the partial amount of rainfall and resets the corresponding counter. *Note: this counter is independent from the one readable with aM1!*
Pressure, temperature and relative humidity of diagnostic sensors		
aM7! aC7!	atttn<CR><LF> atttnn<CR><LF>	Request of detection of pressure, temperature and relative humidity of diagnostic sensors.
aD0!	a+p+t+h<CR><LF> with: p = diagnostic sensor pressure, in the set unit of measurement r = diagnostic sensor temperature, in the set unit of measurement h = diagnostic sensor relative humidity in %	Reads pressure, temperature and relative humidity of diagnostic sensors.
Tilt		
aM8! aC8!	atttn<CR><LF> atttnn<CR><LF>	Request of detection of Tilt info.
aD0!	a+tx+ty<CR><LF> with: tx = Tilt_X (*), in degrees ty = Tilt_Y (*), in degrees	Reads the Tilt info

(*) For the meaning of the Tilt measurements, see page 20.

Type R (continuous measurements) commands

Command	Reply	Description
aR0!	a+n+r<CR><LF> with: n = number of emptying of the tipping bucket r = total amount of rainfall in the set unit of measurement (mm or inches)	Reads the total amount of rainfall.
aR1!	a+n+r<CR><LF> with: n = number of emptying of the tipping bucket r = partial amount of rainfall in the set unit of measurement (mm or inches)	Reads the partial amount of rainfall.

Command	Reply	Description
aR2!	a+n+r<CR><LF> with: n = number of emptying of the tipping bucket r = amount of rainfall in the current day in the set unit of measurement (mm or inches)	Reads the amount of rainfall in the current day.
aR3!	a+n+r<CR><LF> with: n = number of emptying of the tipping bucket r = amount of rainfall in the previous day in the set unit of measurement (mm or inches)	Reads the amount of rainfall in the previous day.
aR4!	a+r<CR><LF> with: r = rainfall rate in the set unit of measurement (mm/h or in/h) s = sensors status, value to be converted to binary: bit 0 = 1 ⇒ amount of rainfall error bit 1 = 1 ⇒ heater 1 temperature error bit 2 = 1 ⇒ heater 2 temperature error bit 3 = 1 ⇒ pressure diagnostic sensor error bit 4 = 1 ⇒ temperature diagnostic sensor error bit 5 = 1 ⇒ RH diagnostic sensor error bit 6 = 1 ⇒ tilt sensor error	Reads the current rainfall rate and the sensors status.
aR5!	a+t1+t2+p1+p2<CR><LF> with: t1 = lower heater temperature in the set unit of measurement t2 = upper heater temperature in the set unit of measurement p1 = lower heater current power (% of the max.) p2 = upper heater current power (% of the max.)	Request of heating status.
aR6!	a+n+r<CR><LF> with: n = number of emptying of the tipping bucket r = partial amount of rainfall in the set unit of measurement (mm or inches)	Reads the partial amount of rainfall and resets the corresponding counter. *Note: this counter is independent from the one readable with aR1!*
aR7!	a+p+t+h<CR><LF> with: p = diagnostic sensor pressure, in the set unit of measurement r = diagnostic sensor temperature, in the set unit of measurement h = diagnostic sensor relative humidity in %	Reads pressure, temperature and relative humidity of diagnostic sensors.
aR8!	a+tx+ty<CR><LF> with: tx = Tilt_X (*), in degrees ty = Tilt_Y (*), in degrees	Reads the Tilt info

In addition to the above-mentioned commands, the rain gauge also implements the corresponding commands with CRC, that require to add a 3-character CRC code at the

end of the reply.

Type X (extended commands) commands

The extended commands allows setting the rain gauge.

The format of the commands is the following:

<Address>XD<Command>!

With <Address> = address of the instrument the command is sent to
<Command> = ASCII protocol command related to the setting to be made

The editing of the operating parameters requires sending a password via the command **aXDPWD***password***!** (**a** is the device address). By default, the password is **0**. To protect the parameters from unauthorized changes, it is advisable to set a password with the command **aXDSUP***password***!**. The password remains active for 10 minutes, after which you must resubmit it.

9 Maintenance

Danger!

The heated versions have parts that could be at high temperature when powered! Before performing maintenance operations, be sure the heater power supply is disconnect and wait for the heater to cool down.

Verify filters cleanliness periodically; check that there is no debris, leaves, dirt or anything else that might obstruct the flowing of water. Check that the tipping bucket contains no deposits of dirt, sand or any other obstruction. If necessary, the surfaces can be cleaned with non-aggressive detergent.

Adjustment

If necessary, the oscillation of the tipping bucket can be adjusted through the two threaded rods located at the sides of the bucket, as illustrated in the following figure.

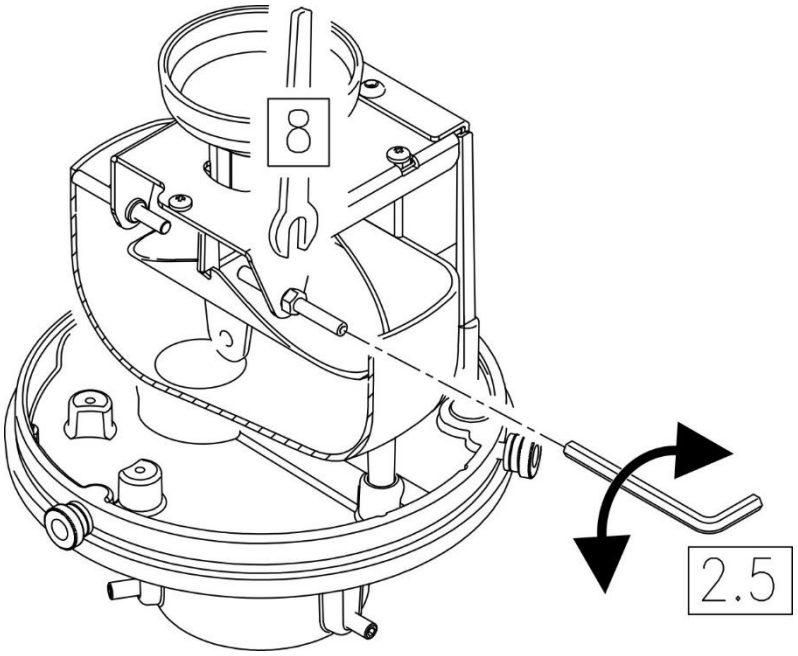


Fig. 9.1: adjustment of the tipping bucket

Attention!

Adjustment of the threaded bars by the user invalidates the calibration report supplied with the instrument!
Do not adjust the threaded rods unless you have the appropriate calibration equipment available!

Caution!

- Do not perform maintenance operations in adverse weather conditions.
- If the rain gauge is installed in an unattended location, before performing maintenance operations, be aware of the possible presence of dangerous insects.

10 Accessories ordering codes

The rain gauge is supplied with M12 female free connector (only if the optional cable is not ordered)., mast fastening screws and calibration report.

Cables and fixing accessories must be ordered separately.

Fixing accessories

POLT005	Mast ∅40 mm, length 500 mm.
POLT010	Mast ∅40 mm, length 1 m.
HD2003.75	Spike base for fixing a ∅40 mm mast to the ground.
HD2003.78	Flat base for fixing a ∅40 mm mast to a floor.

Installation cables

CPM12-5…	Cable with 5-pole M12 connector on one end, open wires on the other end. Length 5 m (CPM12-5.5) or 10 m (CPM12-5.10). **For RTD…0x models.**
CPM12-8…	Cable with 8-pole M12 connector on one end, open wires on the other end. Length 5 m (CPM12-8.5) or 10 m (CPM12-8.10). **For RTD…Fx, RTD…Dx and RTD…Vx models.**

PC connecting cables

CP24B-8	PC connecting cable for the configuration of the rain gauge. With built-in RS485/USB converter. 8-pole M12 connector on sensor side and A-type USB connector on PC side. **For RTD…Fx, RTD…Dx and RTD…Vx models.**

Other accessories

ACCR004	Bird spikes kit for RTD… series rain gauges.

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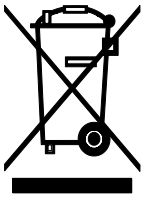
WARRANTY

The manufacturer is required to respond to the "factory warranty" only in those cases provided by Legislative Decree 6 September 2005 - n. 206. Each instrument is sold after rigorous inspections; if any manufacturing defect is found, it is necessary to contact the distributor where the instrument was purchased from. During the warranty period (24 months from the date of invoice) any manufacturing defects found will be repaired free of charge. Misuse, wear, neglect, lack or inefficient maintenance as well as theft and damage during transport are excluded. Warranty does not apply if changes, tampering or unauthorized repairs are made on the product. Solutions, probes, electrodes and microphones are not guaranteed as the improper use, even for a few minutes, may cause irreparable damages.
The manufacturer repairs the products that show defects of construction in accordance with the terms and conditions of warranty included in the manual of the product. For any dispute, the competent court is the Court of Padua. The Italian law and the "Convention on Contracts for the International Sales of Goods" apply.

TECHNICAL INFORMATION

The quality level of our instruments is the result of the continuous product development. This may lead to differences between the information reported in the manual and the instrument you have purchased.
We reserve the right to change technical specifications and dimensions to fit the product requirements without prior notice.

DISPOSAL INFORMATION



Electrical and electronic equipment marked with specific symbol in compliance with 2012/19/EU Directive must be disposed of separately from household waste. European users can hand them over to the dealer or to the manufacturer when purchasing a new electrical and electronic equipment, or to a WEEE collection point designated by local authorities. Illegal disposal is punished by law.

Disposing of electrical and electronic equipment separately from normal waste helps to preserve natural resources and allows materials to be recycled in an environmentally friendly way without risks to human health.

CE RoHS

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