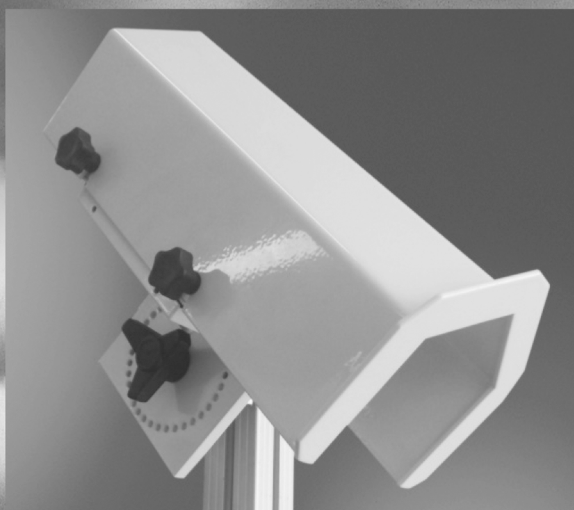
User Manual

SHM31
Snow Depth Sensor

passion for precision · passion pour la précision · pasión por la precisión · passione per la precisione · a passio



www.lufft.de

Lufft
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Dear User,

Please read this user manual carefully before commissioning the SHM 31 snow depth sensor. We reserve the right to further develop this device in line with technical progress.

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This manual was published in: June 2023
Document number: 48.7230-SHM31EN

Date	Issue	Change log
30/04/2017	Rev. 1.0	Published for the first time
08/05/2018	Rev. 1.3	Sections 7 and 11 revised; various minor changes
20/06/2018	Rev. 1.4	Modbus section inserted
08/11/2018	Rev. 1.9	‘SDI-12 for v1.4’ section extended; various revisions
30/06/2023	Rev. 2.1	Safety instructions, new data telegrams, various revisions

Contents

1. Read before commissioning

Please read the operating manual carefully and keep it for future reference. Please note that various components of the device and the described software may look slightly different from the figures provided in this operating manual.

1.1 Symbols used

Warning – potential hazards for the user

Important information for correct device functioning

Reference to potential hazards for the user due to laser radiation

1.2 Safety instructions

- Only adequately qualified specialists may assemble and commission the device.
- Never take measurements on or touch live parts.
- The sensor has a dead weight of approx. 2 kg and can cause injuries if dropped. Carry the sensor with both hands to prevent the weatherproof protective hood from sliding off the sensor.
- Parts can fall off, especially during assembly. Avoid risks by first of all transporting and fully assembling the sensor without the hood and only putting the weatherproof protective hood on the sensor afterwards. Ensure that no components can come loose and fall down once installation is complete.
- The mast mount may have sharp edges due to the manufacturing process.
- Use suitable occupational safety equipment during assembly and take safety measures to prevent injuries.
- Observe the technical data, storage conditions and operating conditions.

1.3 Notes on laser safety and laser classification

The SHM 31 is a Laser Class 2 product according to the international standard IEC 60825-1: 2014-03. Class 2 laser products are only safe for short-time exposure of the beam to the eyes (< 0.25 s). Prolonged exposure to the laser beam may damage the eyes. Avoid staring into the beam or pointing it towards humans or animals. The wavelength of the laser measuring device used here is in the red, visible spectral range. Living creatures' natural eyelid reflex helps to ensure that no damage occurs. But you should still deliberately turn your head away when the laser beam's light enters your eyes. Especially in low ambient light conditions, Laser Class 2 products can lead to temporary dazzling and considerable distraction.

Maximum radiant output power	0.95 mW
Wavelength	635 nm
Pulse duration	> 400 ps
Pulse repetition rate	320 MHz
Beam divergence	0.16 mrad x 0.6 mrad

Attention

Do not look into the laser beam or point the laser beam towards people or animals! Only authorised, trained personnel should have access to the laser sensor.

1.4 Intended use

- The device must only be operated within the range of the specified technical data.
- The device must only be used under the conditions and for the purposes it was designed for.
- The device must not be modified or converted; its operational safety and functionality are then no longer guaranteed.

The following basic use is considered to be intended:

- Measuring distances from fixed targets.
- Measuring snow depth as a distance from the snow surface.
- Assembling the sensor on a mast or mast bracket with the line of sight below a tilt angle towards the ground, (also see the notes on laser safety).
- Regular cleaning, checking measured results and maintenance.

1.5 Incorrect use

If the device is not assembled correctly:

- It may not work, or may only work to a limited extent
- It may be permanently damaged
- It may fall down and hurt someone

If the device is not connected properly:

- It may not work
- It may be permanently damaged
- It may cause an electric shock under certain circumstances

1.6 Brand names used

All brand names used in this manual are subject to the valid trademark rights and ownership rights of the respective owner without restriction.

2. Item names and technical data

Item	Item number
SHM 31 snow depth sensor	8365.30
Mast strap clamp for mast measuring up to 80 mm in diameter	8365.608-11
Mast strap clamp for mast measuring up to 300 mm in diameter	8365.609-11
Mast clamp (variable) for mast measuring up to 72 mm in diameter	8365.610-11
Connection cable (15 m)	8365.KAB015
Reference target plate set	8365.KWK-SET
UMB ConfigTool.NET software	https://www.lufft.com/download/software-lufft-configtool-net/
Replacement sensor module	8365.30-SEN

Table 1: Item numbers

2.1. Labelling

The following stickers are attached to the product.

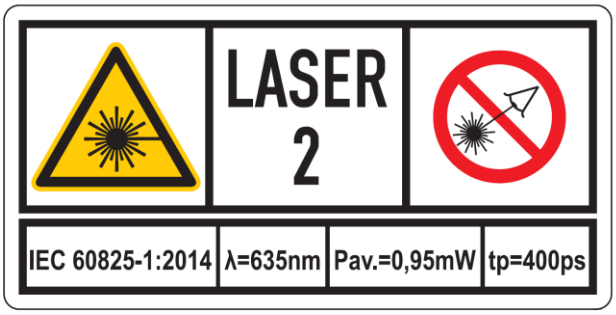


Figure 1: Laser warning with technical data

Figure 2: Rating plate with serial number

2.2. Technical data

Category	Name	Value
Measuring parameters	Snow depth	0 – 15 m
	Accuracy	± (5 mm + 0.06%)
	Repeatability	0.6 mm
	Precision, reproducibility	5 mm
	Signal intensity (normalised)	0 – 255
Installation	Assembly height / measuring distance	0.1 – 16 m
	Tilt angle to the vertical position	10 – 30 degrees
Data interface	RS485	- UMB binary protocol (19200 Bd, variable) - UMB-ASCII 2.0 - Modbus RTU - Modbus ASCII
	SDI-12	- SDI-12 protocol
	RS232	- UMB-ASCII 2.0 protocol (9600 Bd, fixed)
	RS485 and SDI-12 share the same connectors and cannot be used in parallel. RS232 uses separate connectors and can be operated in parallel with RS485 or SDI-12.	
	Data transfer	Polling: UMB, UMB-ASCII 2.0, SDI-12, Modbus Auto Send function: UMB-ASCII 2.0
Operating parameters	Temperature range: Without heating:	-40°C – + 50°C -10°C – +50°C (laser inactive < -15°C)
	Rel. humidity	0 – 100%
	Power supply	12 or 24 V DC, tolerance ±15%
	Connected load with heating	18 W
	Average consumption without heating	0.7 W
	Average consumption with 10 s measurement interval and window heating switched on	3.4 W
	MTBF @ 25°C / 40°C	88,000 h / 50,000 h
	Connection cable length while using the RS232 interface[1]	≤ 15 m
Safety	Laser safety	Laser Class 2 (IEC 60825-1:2014)
	Protection rating	IP68
	EMC	EN 61326-1:2012 (industrial standard)
	EU Directive	EMC 2014/30/EU, ROHS 2011/65/EU
Size, weight	Sensor size (LxWxH)	302 x 130 x 234 mm
	Sensor weight	2.35 kg
	Packaging size	400 x 240 x 180 mm
	Weight incl. packaging	3.4 kg
Storage conditions	Temperature; rel. humidity	T={-25°C – +70°C}; rH < 100%

Table 2: Technical data

[1]If connection cables > 15 m are used, transfer problems may occur over RS232. Additionally, the voltage drop over the cable length must be taken into account.

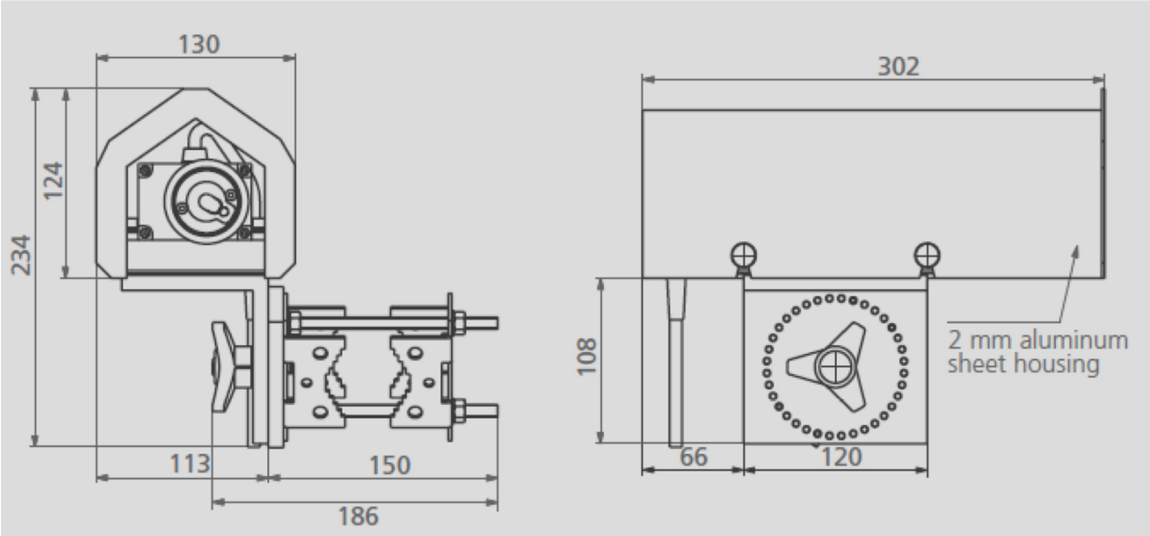


Figure 3: SHM 31 dimensions, technical drawing

2.3. Scope of delivery

Depending on the order, the delivery consists of the standard scope of delivery (see Figure 4) and additional components (see Figure 5 to Figure 9).

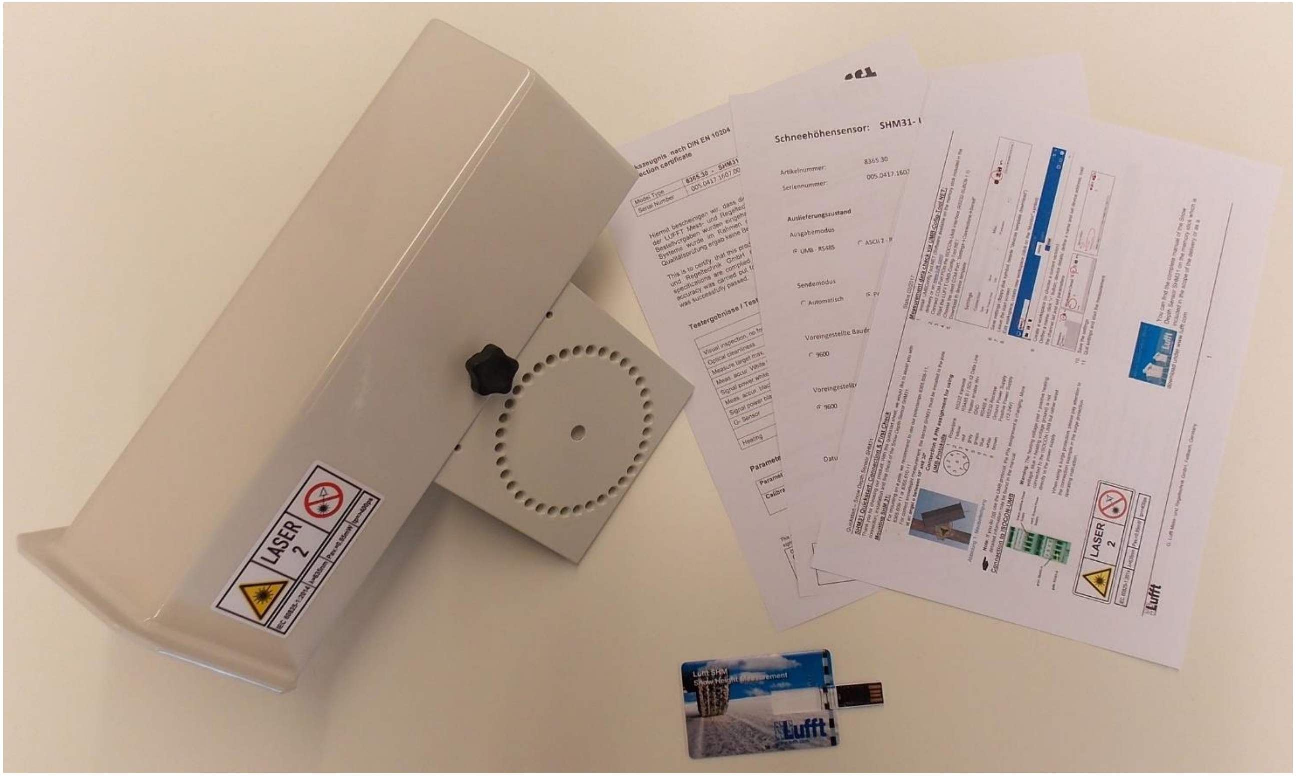


Figure 4: Standard scope of delivery 8365.30, consisting of sensor, test report, quick start guide and USB stick with additional software and documents

SHM 31
8365.30

Mast mount
8365.610-11

Connection cable
8365.KAB015

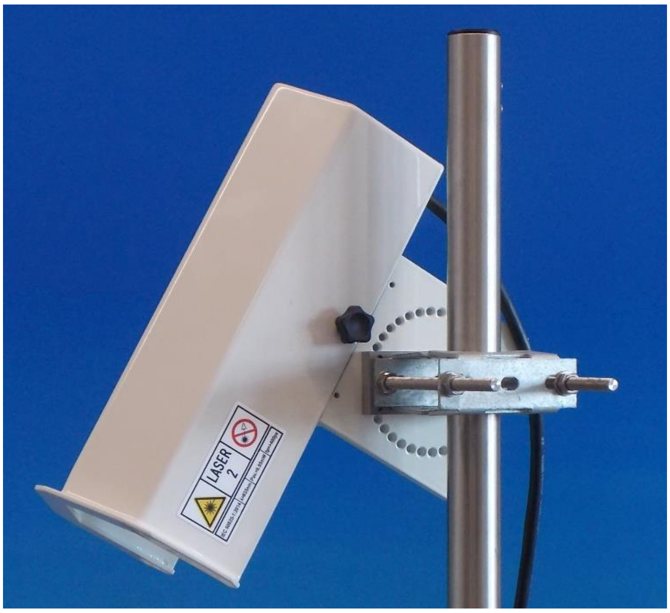


Figure 5: SHM 31 sensor, here with mast mount 8365.610-11 and connection cable

Mast mount
8365.610-11

Figure 6: Mast mount 8365.610-11

Mast mounts with steel strap

8365.608-11

or

8365.609-11

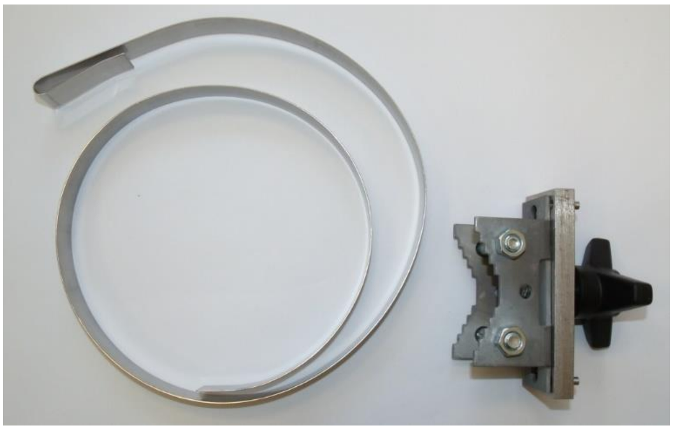


Figure 7: Mast mount with assembly clamp and steel strap, here for masts up to Ø = 300 mm (l = 1,000 mm)

Connection cable
8365.KAB015

Figure 8: SHM 31 connection cable, standard length 15 m

Reference target plate set
8365.KWK-SET

Figure 9: Target plate set, consisting of black and white coloured cards

Documentation

- Quick start guide
- Test report
- Configuration overview

USB stick: Operating manual and UMB ConfigTool.NET software

2.4. Additional documents and software

The free UMB ConfigTool.NET configuration software is available on the supplied USB stick, and can be downloaded from the website www.lufft.com. The software is available for download for the Windows and Android operating systems. In future, it will also be available for individual Linux operating systems.

You will find the following documents and software available for download on the internet at www.lufft.com:

- Operating manual…………This document
- UMB protocol…………….Communication protocol for UMB devices
- UMB ConfigTool.NET……Communication software for UMB devices
- Firmware…………………..The device's current firmware

3. Description of the device

3.1. Basic principles of the measurement method

The SHM 31 snow depth sensor applies the phase measurement method to precisely measure distances from objects. In the phase measurement method used here, a laser diode emits short laser pulses, which are amplitude modulated with a defined frequency. The laser light is scattered to objects and detected with a photo diode. Unlike the SHM 30 snow depth sensor, when using this method no continuously modulated laser light is emitted. Instead, individual pulses that are in a fixed relationship to one another are emitted. All in all, the advantage of the newer method is that the contrast has been improved, thereby reducing the dependency on background light. The short pulses also mean that no speckle patterns are generated due to the pulses' short coherence time, which would otherwise lead to lower precision in the distance measurement.

The emitted laser light that hits the surface is scattered back towards the sensor in small particles. This part of the light is compared to a reference signal to measure the distance from the surface. In addition to measuring the distance, the sensor also evaluates the signal intensity. At OTT HydroMet, the signal intensity is normalised as a function of the distance during the production process on target plates. The method enables a rough distinction between surfaces of different reflectivity – to differentiate between snow and grass, for example. Another purpose of normalisation is to make the sensors comparable with one another. More information about this can be found in the section entitled: 'Testing and error descriptions'.

3.2. Introduction to assembly and commissioning

The snow depth sensor is mounted on a mast using the mast clamps provided. Assembly on a mast cantilever is also possible, but not necessary. The sensor is aligned in the direction of the surface. The angle the sensor is assembled at (tilt angle α) should be between 10 and 30 degrees to prevent snow falling from the mast or the sensor itself from affecting the measured result. If an angle is too large, this causes the laser beam to hit the ground at too flat an angle, which may give a vague and inconsistent distance measurement result.

Following installation, the user performs an automatic zero measurement to measure the distance d_0 from the surface, as well as the installation angle α. The measured values are stored in the internal memory as reference values; see Figure 10 and Figure 11. An existing snow depth during device commissioning can be manually communicated to the sensor as an offset value.

The snow depth h_1 is calculated according to the following formula:

$$h_1 = h_r - h = h_r - mean(d) \cdot \cos(\alpha)$$

where h_r is the installation height at the laser exit window and mean(d) is the averaged measured distance value.

Three interfaces are implemented in the SHM 31 snow depth sensor:

- RS485 (half duplex),
- RS232
- SDI-12

The RS232 interface can always be used at the same time as the RS485 or SDI-12 interface. The SDI-12 and RS485 interfaces use a common connection cable, so they cannot be used together. The device configuration defines which interface is active.

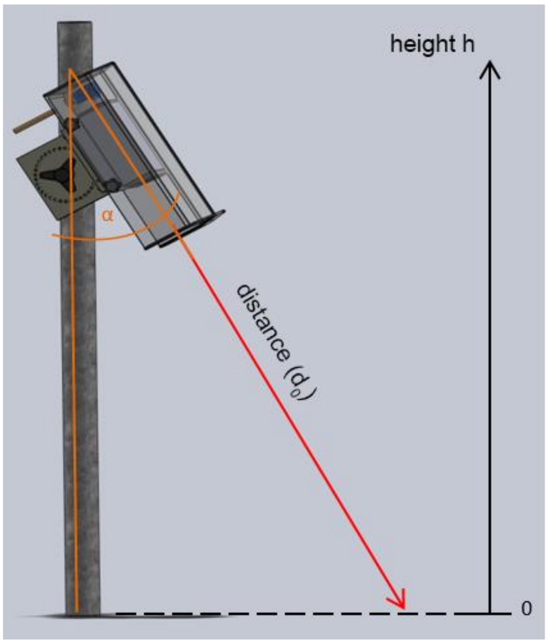


Figure 10: SHM 31 assembly, determining the distance and angle.

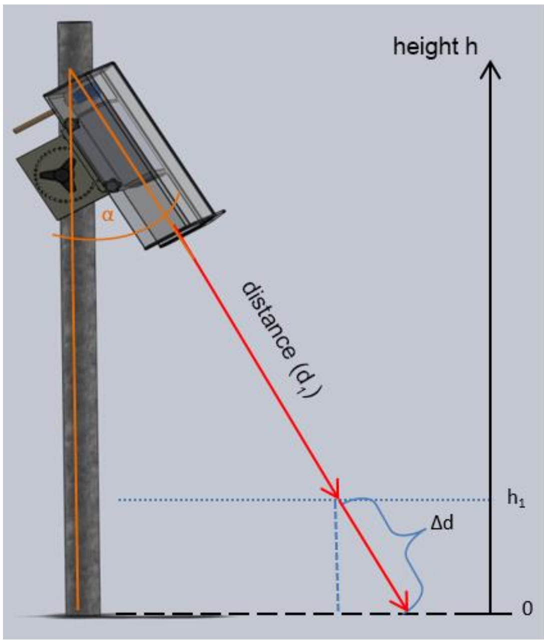


Figure 11: Calculating the snow depth h1 from the angle and the difference in distance

Types of communication:

Communication over the RS232 interface takes place using the UMB-ASCII 2.0 protocol. Data telegrams can be requested using the 'polling method', or an automatic transmission mode can be set.

The configuration of the RS232 interface is: 9600 baud, 8N1 (8 bit, none parity, 1 stop bit, no handshaking).

The default configuration of the RS485 interface is: 19200 baud, 8N1. This interface can be used to communicate either using the UMB-ASCII 2.0 protocol (query or automatic transmission mode) or using the UMB binary protocol (pure query mode). Various tools are available here for the UMB binary protocol in particular, such as the Lufft UMB ConfigTool.NET software, as well as connection to other Lufft-specific communication and database solutions such as ViewMondo.

Modbus RTU and Modbus ASCII are also available over the RS485 interface from firmware version v16.

The specifications for the SDI-12 interface can be found in section 10.

3.3. Sensor heating

The SHM 31 has two integrated heating circuits. One circuit brings the laser to the right temperature and prevents fogging of the optical window as far as possible. One heating circuit can be parameterised and is used in 'defrost mode' to de-ice the pane. Significant warming of the inner housing compared to the outside temperature corresponds to the sensor's normal operating behaviour.

4. Generating the measured values

4.1. Measured values (curr, avg)

Factory setting: The current measured values are measured values averaged over 60 s. A new measurement is performed internally every 10 s. So, for the current measured values, averages are taken and provided for 6 out of these 10 seconds.

The measured values labelled avg, min and max are output as averages over 10 minutes with the default settings.

4.2. Normal mode

The snow depth sensor is switched on and off by connecting and disconnecting the power supply.

After the sensor is switched on, it will require a start-up time of a few seconds before communication is possible. In the first few seconds after a restart, the sensor is ready to receive UMB commands over the RS485 interface. This also applies if the user is using the SDI-12 protocol and ensures that it is always possible to exit the SDI-12 mode in this way.

5. Assembly

5.1. Assembly instructions

Do not look into the laser beam of the SHM 31.

Do not switch on the SHM 31 until it has been assembled and aligned.

5.2. Assembly

The snow depth sensor is mounted on a mast using the mast clamps provided. The sensor is aligned in the direction of the surface. The angle the sensor is assembled at (tilt angle α) should be between 10 and 30 degrees to prevent snow falling from the mast or the sensor itself from affecting the measured result (Fig. 15). If an angle is too large, this causes the laser beam to hit the ground at too flat an angle, which may give a vague and inconsistent distance measurement result. Additionally, the accuracy of the snow depth calculation decreases at larger tilt angles due to the influence the angle measurement has.

Figure 12: SHM 31 sensors with mast clamp 8365.610-11 (top left), mast clamp 8365.608-11 (bottom left) and SHM 30 sensor with mast clamp 8365.608-11 (middle right).

During assembly, the mast clamp should first of all be firmly assembled on the mast. The sequence of whether the connection cable should be assembled on the sensor first or whether the sensor should be assembled on the mast clamp first using the tristar knob is not specified and depends on the local conditions.

To connect the cable, first of all loosen the three knurled screws and remove the hood. Then the cable with the strain relief sleeve can be inserted into the recess in the side of the base plate and the connector screwed tight; see Figure 12 and Figure 14.

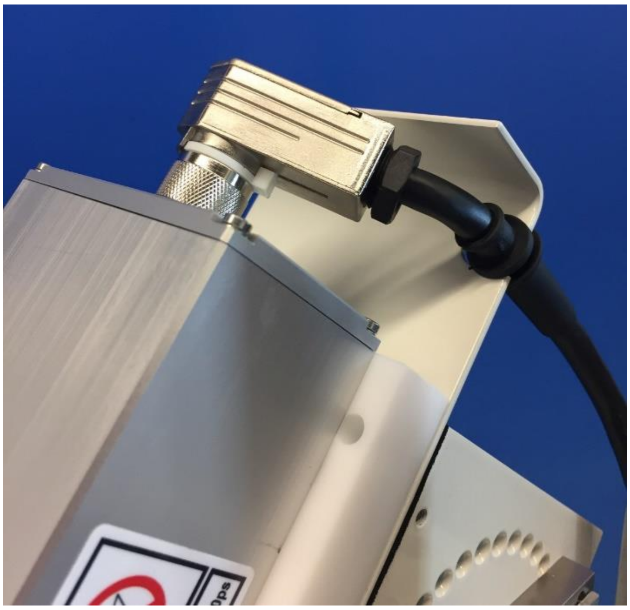


Figure 13: Assembling the connection cable on the sensor. The strain relief sleeve is inserted into the recess in the base plate during cable assembly. The angle of the Amphenol connector can be adjusted (in increments of 45°) as needed once the mounting ring has been loosened.

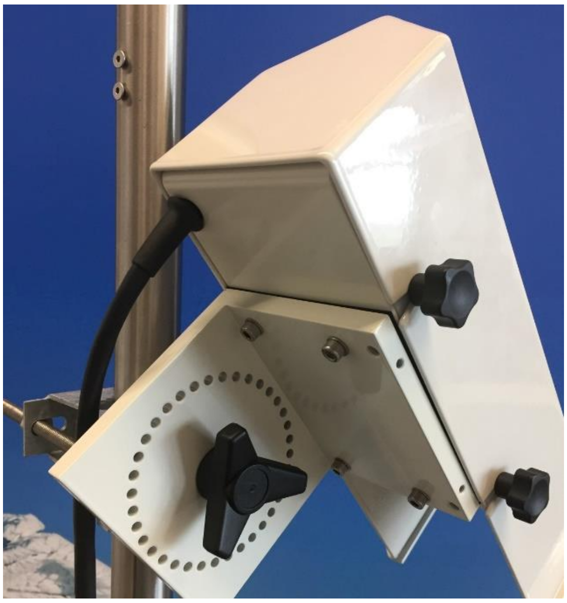


Figure 14: Sensor assembled with hood. After attaching the cable, the weatherproof protective hood is fixed again using the three knurled screws.

The sensor can be placed on the pins of the mast clamp by means of its 360° perforated ring and locked in place using the tristar knob. The perforated ring has a 10° grading and enables rough adjustment of the sensor tilt.

Figure 15 shows the general installation conditions. The criterion of not aligning the sensor towards the sun has been softened somewhat with the SHM 31, since no restrictions have yet been established regarding the radiation power due to sunlight reflected on the snow's surface. However, higher measurement uncertainties cannot be ruled out where there is strong solar radiation in the high mountains.

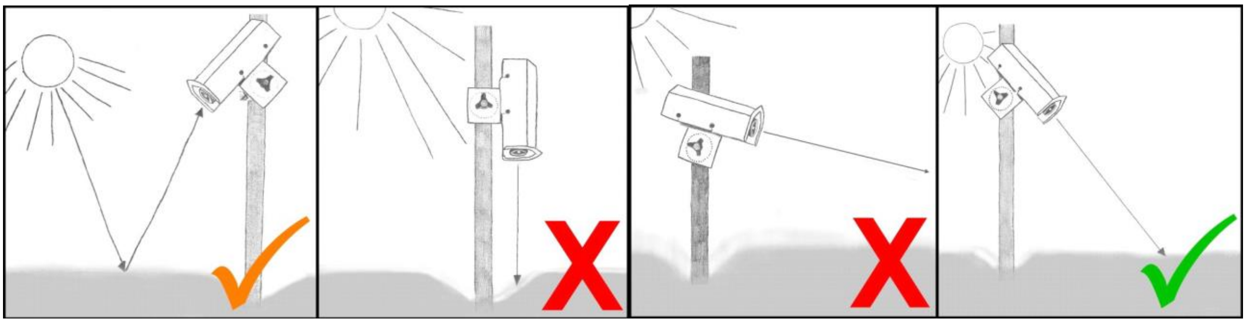


Figure 15: Assembly direction and angle of the SHM 31

Unlike the SHM 30, the angle of the SHM 31 no longer has to be measured manually and transferred to the sensor. The SHM 31 has a built-in tilt sensor.

In the delivery state, the reference angle is used to calculate the snow depth. The reference angle is determined after installation along with the reference height during the zero measurement. However, the current angle can also be used for the calculation. The corresponding measurement channels for the angles are listed in the list of UMB channels in this manual.

6. Connections

There is an 8-pin plug-in screw connector on the device’s housing. It is used to connect the supply voltage and the data interface.

A connection cable measuring 15 m long is offered separately.

6.1. Connecting the device

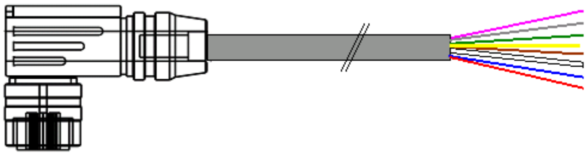


Figure 16: Connection cable (schematic), designation of the connector:

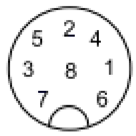


Figure 17: View of soldered connection of the cable box with notch.

The Amphenol C091D series connector has a locking ring (white). Loosening the ring enables variation of the direction of the cable outlet to the notch in increments of 45°.

6.2. Connector pin assignment

Interface cable / core	SHM 31	Name	Connector pin #
Green	A_RS485	RS485 A	5
Yellow	B_RS485 / SDI-12	RS485 B / SDI-12 Data Line	2
Pink	RS232_TX	RS232 transmission line	1
Blue	RS232_RX	RS232 receiving line	6
Grey	GND	RS232 / RS485 ground	4
Red	EXT_TRIG_IN	Heating release +	3
Brown	V_IN_+	Supply voltage +	8
White	V_IN_-	Supply voltage – SDI-12 ground	7

Table 3: SHM 31 connector pin assignment

6.3. Recommended cable shield connection

The shielding of the SHM 31’s connection cable must be connected to earth in the switch box, as there is usually no secure, electrically conductive connection to an earthed mast via the screw joints and mast clamp.

6.4. Supply voltage

The snow depth sensor is supplied with a DC voltage of

12 V DC ±15% or 24 V DC ±15%.

6.5. Data interfaces

The device has a half-duplex, two-wire RS485 interface for measured value queries and firmware updates, an SDI-12 interface, and an RS232 interface.

6.6. Heating release

The sensor can be configured such that the heating is only switched on after a positive voltage signal (typically 5 – 12 V DC with 12 V DC operating voltage or 24 V DC with 24 V DC operating voltage) has been applied. This allows the user to operate the heating in battery mode, for example, regardless of the internal heating configuration.

7. Commissioning

7.1. Important information for commissioning

The following points must be noted:

Using the RS485 configuration over UMB

- Learn how the UMB ConfigTool.NET software works. The current version of the software can be downloaded from the Lufft website at: https://www.lufft.com/download/software-lufft-configtool-net/. The software contains a Help function that provides further explanations on using the software. A quick start guide specifically for the SHM 31 forms part of this operating manual.

Laser safety

- Do not look into the laser when the sensor is switched on. To ensure that the laser is transmitting periodically, use a sheet of paper, for example, and hold it in the laser beam. Observe the laser beam indirectly!

Mechanical and electrical connection

- Ensure that the SHM 31 has been connected and installed according to its intended use.

7.2. Switching on

As soon as the SHM 31 is supplied with power, it starts its internal measuring cycle and can be addressed over RS232, as well as over RS485 or SDI-12 – depending on the selected setting.

7.2.1. Settings over RS232 or RS485

If you would like to address the SHM 31 sensor over RS232, you can use a terminal program with the UMB-ASCII protocol. For communication over RS485, you can choose between the UMB-ASCII 2.0 and the UMB binary protocol. We recommend using the ConfigTool.NET software with UMB binary protocol to conveniently set up the sensor over RS485. The setting options and parameter lists for operation over UMB-ASCII 2.0 or UMB binary protocols are listed in the following sections.

7.3. UMB ConfigTool.NET

The ConfigTool.NET software is available for various operating system platforms. It can basically communicate with sensors over a serial, a Bluetooth or a network interface. ConfigTool.NET allows the following communication steps:

1. Reading out the sensor's individual UMB channels; also see section 9
2. Automatically querying, graphically displaying and storing the measured data
3. Performing firmware updates
4. Controlling the sensor using parameter lists
5. Control commands, such as determining reference values, defrost mode, etc.

7.3.1. Basic installation with ConfigTool.NET and a serial interface

The following steps can be performed to work with the UMB ConfigTool.NET software during initial installation:

1. Install and launch the current UMB ConfigTool.NET software
2. Preparatory settings:
   a) On the ConfigTool.NET start screen, click on the 'Settings' cogwheel icon in the top right-hand corner.

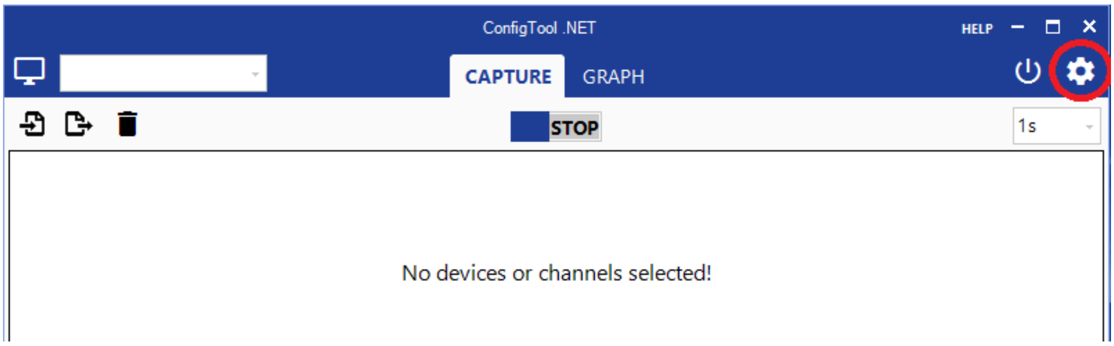


Figure 18: Cogwheel icon to access the settings (start screen)

b) If necessary, create or select the folder that ConfigTool.NET should save the log file for your measurements in.

c) Use the device template download function to update the list of available UMB channels. OTT HydroMet regularly expands the list of UMB channels and updates it with respect to the latest sensors / sensor options. An internet connection is required for this step.

d) Confirm the changes with 'OK', or click on 'Cancel' to return to the start screen.

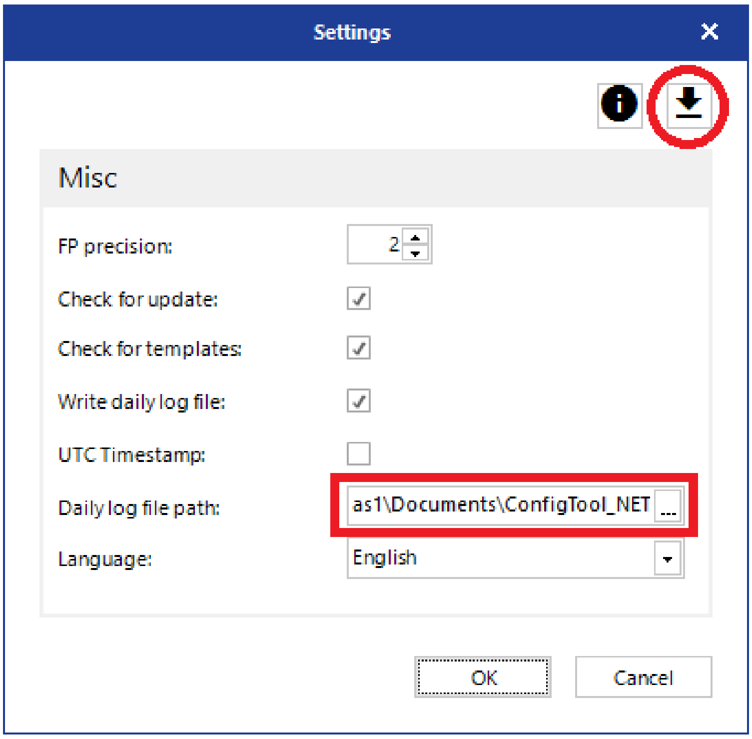


Figure 19:The basic settings for log files and communication with the sensor

3. You can set up different workspaces in ConfigTool.NET to manage your sensor settings and measurements. You can access the workspace options by clicking on the button in the top left-hand corner of the start screen.

   a) Click on the ‘Edit Workspaces’ icon. This creates a new workspace if no already created workspace has been selected in the drop-down list.

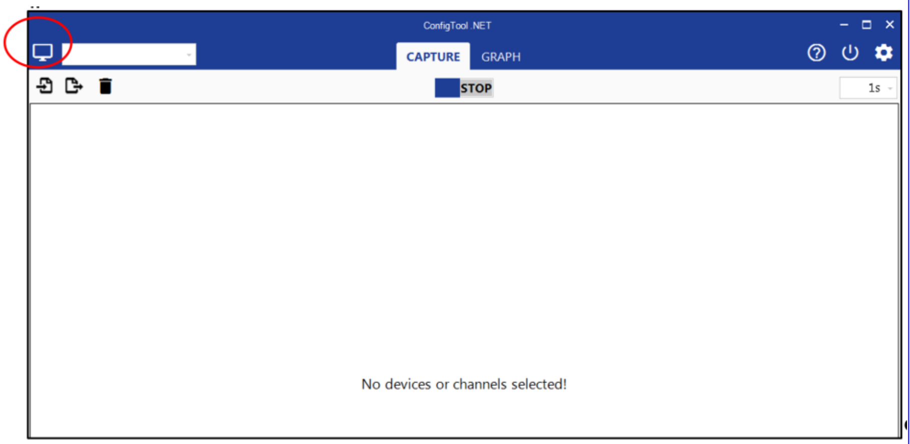


Figure 20: The position of the ‘Workspaces’ menu on the ConfigTool.NET main page

   b) Appropriate connection settings must be made for each new workspace. For this example, select the ‘Serial’ connection type and your serial adapter’s corresponding COM port.

   c) Confirm the changes with ‘OK’ to go to the ‘Workspace Details’.

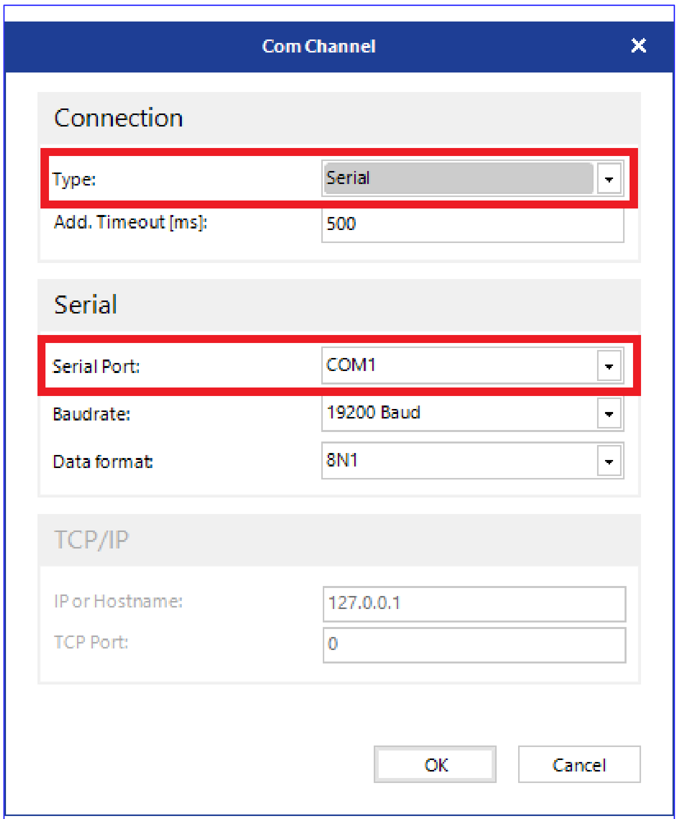


Figure 21: Connection settings for the current workspace

d) On the ‘Workspace Details’ page, enter any name for the workspace first of all. To assign a sensor to the new workspace, click on ‘Add Device’: +

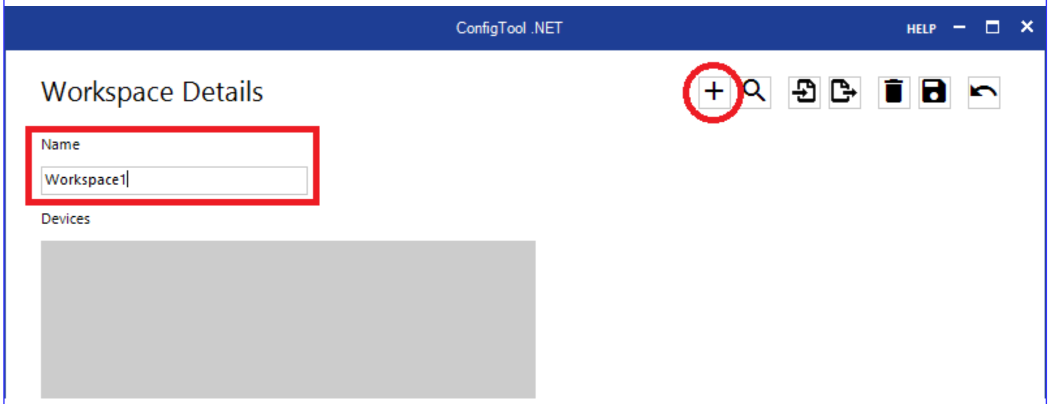


Figure 22: Various workspaces can be set up in the ‘Workspace Details’

e) In the ‘Add Device’ window, you can assign any name for the SHM 31. Then select the ‘SHMx-UMB’ entry from the ‘Device Class’ drop-down menu.

f) Confirm the changes with ‘OK’ to make further settings.

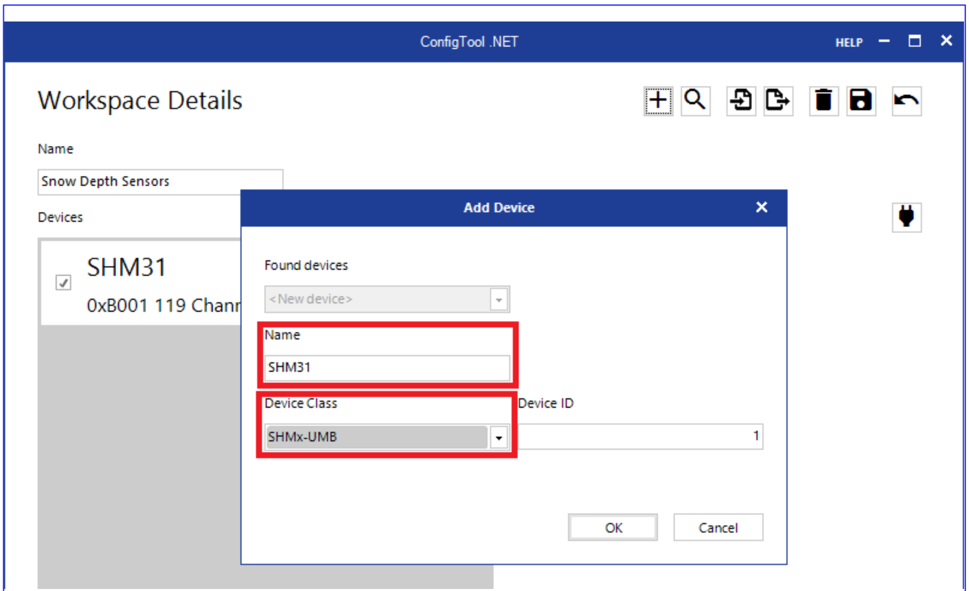


Figure 23: The SHM 31 sensor is added to the current workspace in the ‘Add Device’ window

g) The SHM 31 is now displayed under ‘Devices’ on the ‘Workspace Details’ page. Clicking on the sensor’s row takes you to the ‘Device Details’ page.

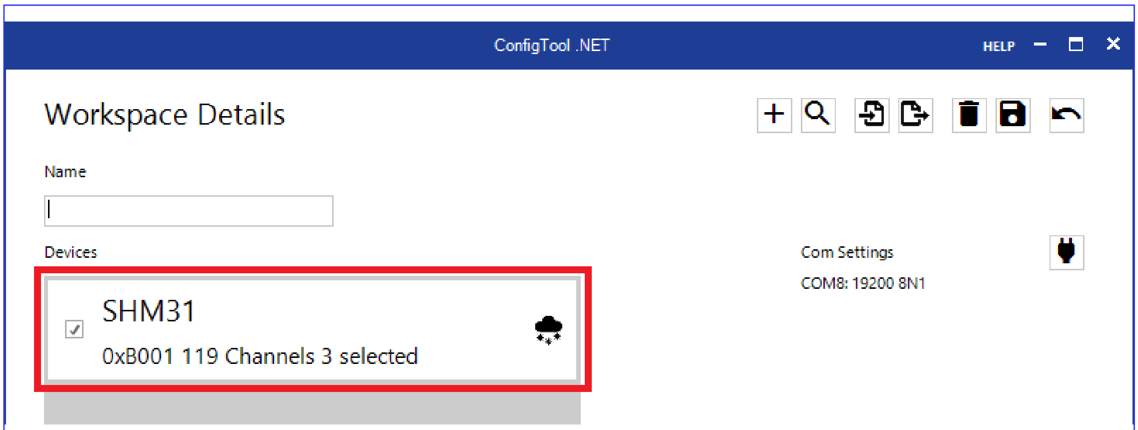


Figure 24: The added sensors can be selected for additional settings on the 'Workspace Details' page

h) The following steps are necessary to calibrate the device for use after setup.

Click on the cogwheel icon to go to the 'Device settings' page.

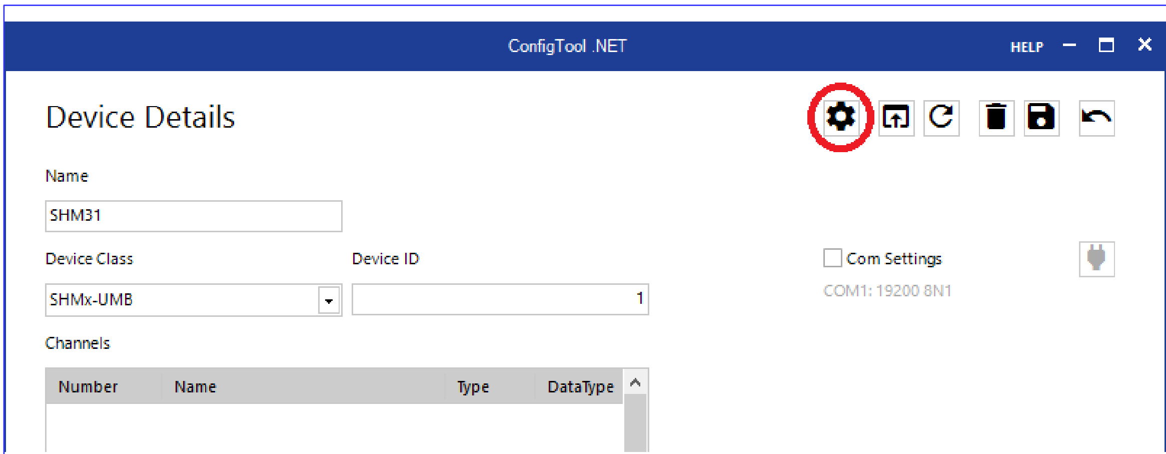


Figure 25: You can access the device's settings from the 'Device Details' page. This is where calibration can be carried out, among other things

i) Then click on 'Calibration': 

On the 'Calibration' page, select the 'Device Calibration' tab. Here, click on 'Start reference measurement'. The sensor will now automatically measure its angle and distance from the ground and use the measured values as references for future measurements. This process takes about two minutes. Your device is now calibrated for measurement.

Use the 'Back' icon to exit the page: 

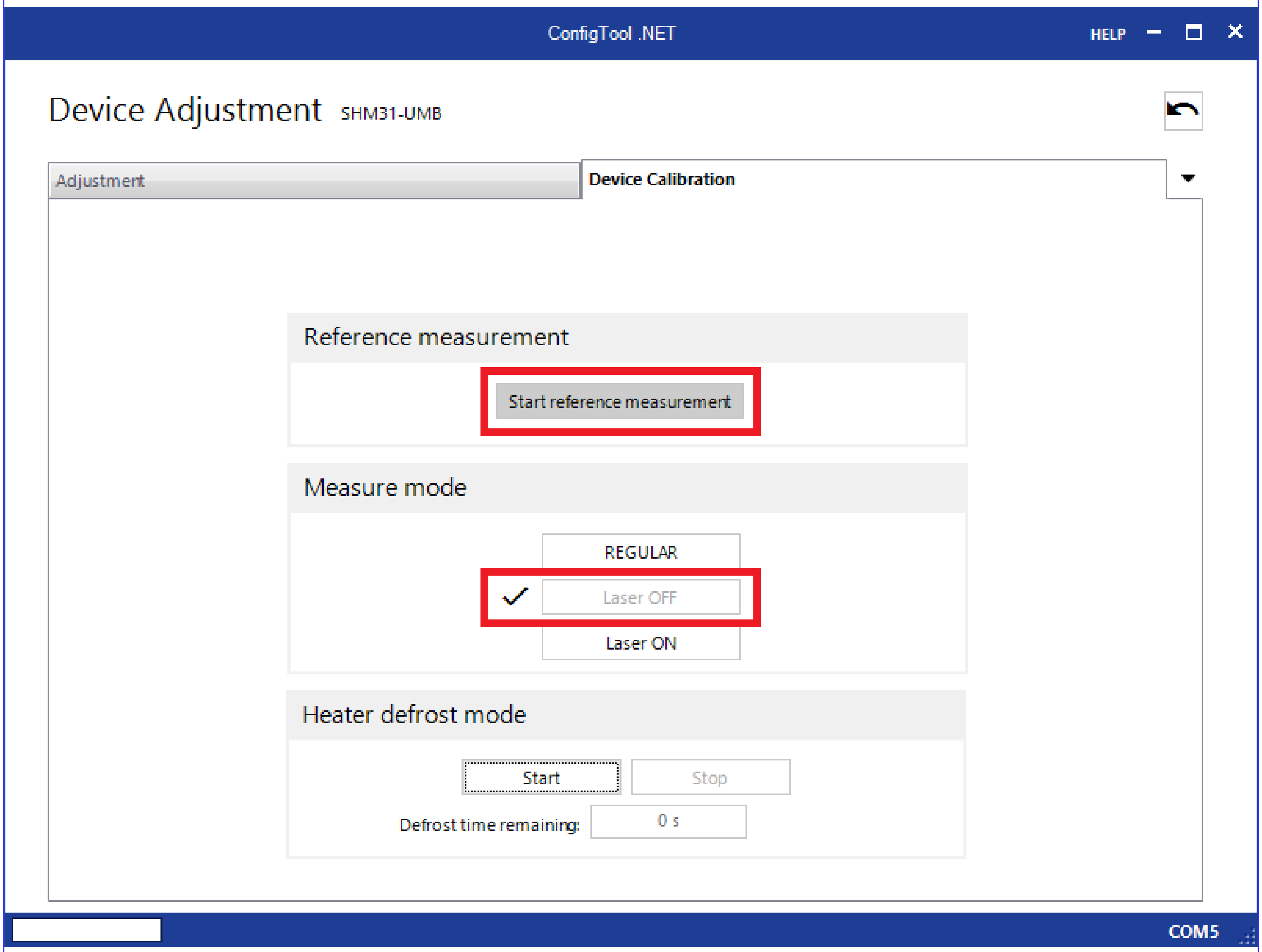


Figure 26: The SHM 31 is calibrated in the 'Calibration' menu

j) You can now make additional sensor settings. The 'Transmission interval [s]' parameter can be found in the 'UMB-ASCII 2.0' section of the 'Device Settings' page. This value determines how often the sensor will provide new snow depth data. Use the 'Laser interval [ms]' parameter under 'Laser parameters' to set the sensor's measurement interval. All individual measurements taken within a transmission interval are averaged over this period of time.

Attention: The laser interval should not be less than 5,000 ms, since under certain conditions – such as a dark target surface – the duration of an individual measurement can be significantly increased.

More detailed insights into the setting options under the 'Device Settings' menu are provided in the following section. Be sure to transfer the changes you have made to the sensor. This is done by clicking on: 
The sensor is automatically restarted once the changes have been transferred, thus activating the adjustments, by previously highlighting the 'Restart' selection (top left-hand corner).

Click on 'Back' to return to the 'Device Details' menu.

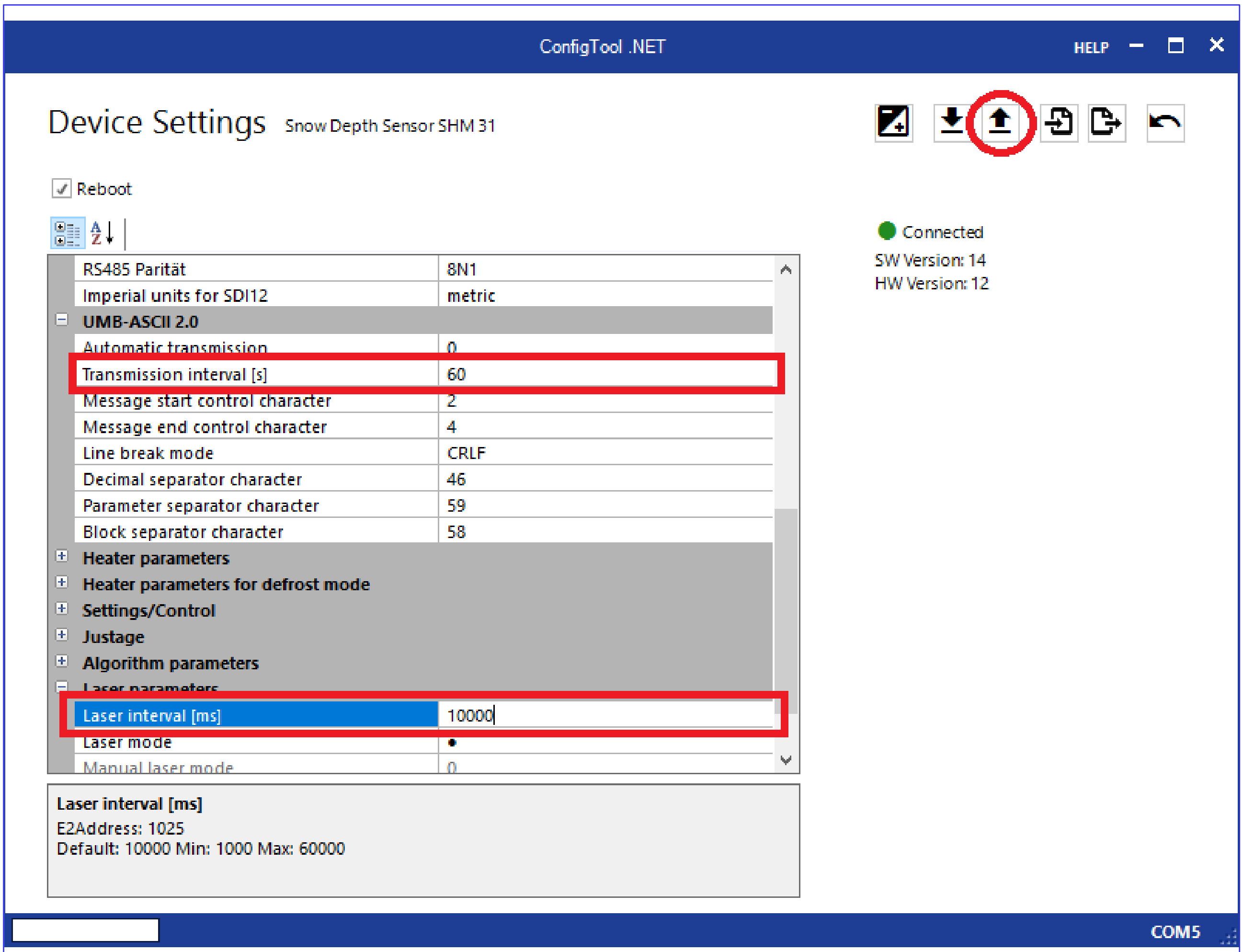


Figure 27: The 'Device Settings' menu

k) To check the sensor's functionality, you can select all the channels that ConfigTool.NET can read. These channels are displayed as soon as you click on 'Load channel list': 

For an initial sensor check, we recommend selecting channels 500, 600, 650, 660, 700 and 800. You can change the channel selection again at any time. Click on 'Save device' to return to the Workspace menu.

l) If necessary, ensure that you save your workspace.

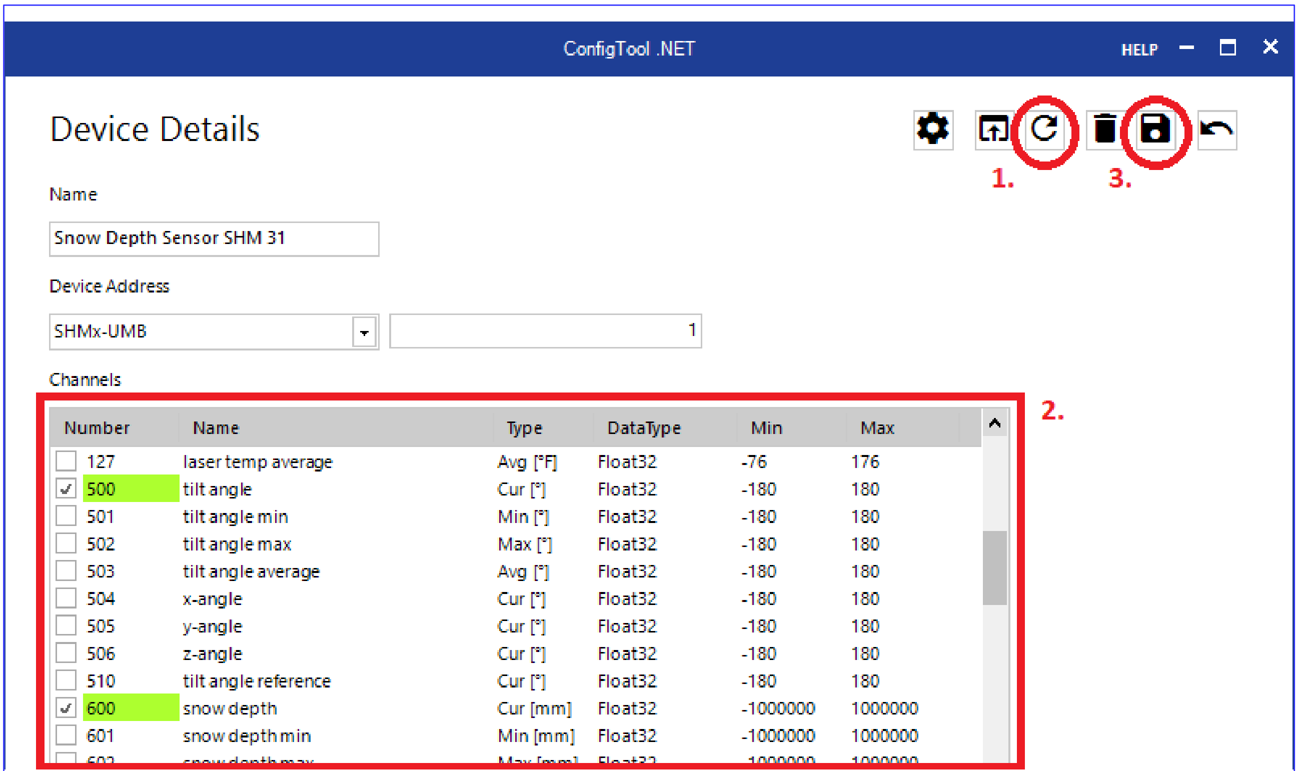


Figure 28: Basic settings for log files and communication with the sensor

4. ConfigTool.NET has now prepared columns for the sensor channels' measured values on the start screen. All channels previously selected in the 'Device Details' menu should already be visible there. In the 'Query rate' drop-down menu on the right-hand side, you can now set how often measured values are to be queried from the sensor. These measured values are then also written to the log file at the interval set here. However, the interval does not change the sensor's measuring sequence previously defined in the device settings.
To start a measurement, move the switch in the middle of the start screen to the 'RUN' position. The sensor's measured values should now appear at the previously set interval.

Attention: To prevent data clones, do not set the query rate lower than the transmission interval. The sensor returns the available measured values.

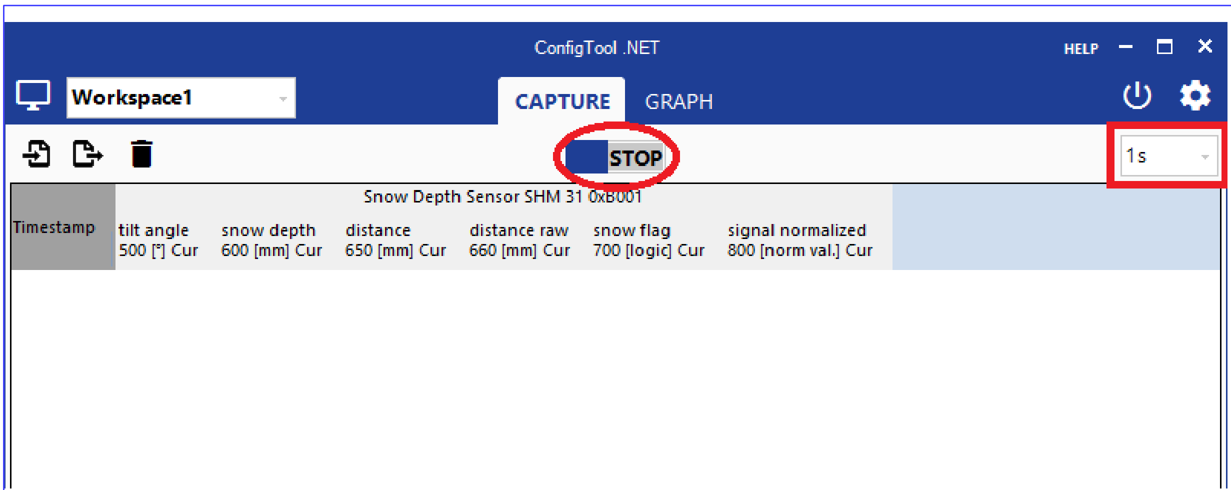


Figure 29: Setting the query rate. The measurement starts by moving the switch to 'RUN' (the switch shows the current state, not the one to be selected)

7.3.2. The SHM 31's sensor parameters

To take full advantage of all the benefits the SHM 31 snow depth sensor has to offer, we recommend taking a closer look at the parameters the sensor uses internally. As already mentioned in the previous section, the 'Device Settings' menu contains a large number of adjustable parameters and thus also a comprehensive tool for defining a measurement routine for the sensor in advance. The purpose of the table below is to provide an overview of this menu's *adjustable* parameters.

Parameter name	**Default value**	**Domain**	**Description**
Device parameters			
Device-ID	1	1 … 255	Sensor-ID, to be set when using more than one sensor in the bus (e.g. UMB or SDI-12)
Description	snow depth sensor	max. char. 39	...
Station-ID	0	0 … 99999	Additional ID (optional)
Baudrate	19200	[1200, … , 57600]	Communication Baudrate.
Protocol	umb-binary	umb-binary, umb-ascii 2.0, sdi-12, modbus	The communication protocol used by the sensor
Timeout for protocol change [min.]	10	1 … 60	Duration after which the protocol is being reactivated in the case of a temporary changeover
RS485 Parity	8n1	8n1, 8e1, 7e1 (sdi-12), 8n2	Serial port parity setting
Imperial units for SDI-12	metric	metric, sdi-12 us-units	...
UMB-ASCII 2.0			
Automatic transmission	0	0 … 99	0 = polling mode, 1 = available data telegram
Transmission interval [s]	60	0 … 65535	Processing rate for measurements (calculation of snow depth, averages, etc. and preparing the data string for transmission)
Message start control character	2	0 … 127	Protocol start character
Message end control character	4	0 … 127	Protocol end character
Line break mode	crlf	cr, lf	Protocol line feed character
Decimal separator char.	46	0 … 127	Decimal mark character used
Parameter separator character	59	0 … 127	Parameter delimiter character used
Block separator character	58	0 … 127	Block delimiter character used
Parameter name	Default value	Domain	Description
Heater parameters			
Operating mode of the window heater	automatic	off, automatic, defrost	Heater mode for the sensor window
Operating mode of the block heater	automatic	off, automatic, defrost	Heater mode for the sensor housing
Target temperature of the window heater [°C]	20	-50 … 50	Mean target temperature of window
Target temperature of the block heater [°C]	7.5	-50 … 50	Mean target temperature of housing

Hysteresis for window heating [°C]	2.5	0 … 5	Switching point below (heating on) and above (heating off) target temperature
Hysteresis for block heating [°C]	2.5	0 … 5	Switching point below (heating on) and above (heating off) target temperature
Voltage threshold of heating [V]	17	12 … 19	If internal supply voltage exceeds this value, heaters are operated in 24 V mode instead of 12 V mode
Heating control via external input	disabled	enabled, disabled	If enabled wire *heating release (+)* needs to be connected to (+), see section 6.5
Heater parameters for defrost mode			
Target temperature of the window heater defrost mode [°C]	25	-50 … 50	The window heater will maintain the selected temperature during defrost mode
Target temperature of the block heater defrost mode [°C]	35	-50 … 50	The block heater will maintain the selected temperature during defrost mode
Hold time for window defrost [min.]	15	1 … 255	Select the duration of the window defrost procedure
Hold time for block defrost [min.]	15	1 … 255	Select the duration of the housing defrost procedure
Automatic defrost after startup	no	n/y	...
Settings/Control			
Standby	-	-	Not yet implemented
Auto start command	MST	MST, LON	Boot up mode for the sensor. MST = starting measurements LON = laser on
Scaling factor	1	0 … 40000	Change of units, e.g. meter (sf = 1) to foot (sf = 3.2808399). After a change of the scaling factor SCF the parameters AOF, MSD and the distance value in the telegram are converted into the new units.
Channel average count	10	1 … 120	Number of measurements used to calculate the values for averaged UMB channels (*_avg) and the min/max values
Justage			
Reference height [mm]	0	-20000 … 20000	Will be automatically set during the device calibration procedure or can be set manually
Reference angle [°]	0	-180 … 180	Will be automatically set during the device calibration procedure or can be set manually
Algorithm parameters			
Use accelerometer angle	0	0, 1	0 = use reference angle from calibration, 1 = use the sensors accelerometer value as reference during each measurement
Signal threshold for snow	130	0 … 255	Sets the signal intensity as threshold for the snow-flag
Maximum snow depth change [mm]	20	-10000 … 10000	Maximum of allowed snow depth changes between two measurements.

			Use 10000 as value for installation to prevent error messages due to vast changes in measured distances (e.g. due to obstruction).
Accept time for changed snow depth [s]	600	0 … 65535	Time interval for the snow depth value to be accepted, allthough exceeding the sensors maximum snow depth change rate
Laser parameters			
Laser interval [ms]	10000	1000 … 60000	Time interval for the laser-measurement of the sensor. **Use below 5000 ms not recommended!**
Laser mode	-	-	Not yet implemented

Table 4: The SHM 31's sensor parameters

8. Communication over UMB-ASCII 2.0

This section describes the communication and output of measured values of the SHM 31 over the UMB-ASCII 2.0 data protocol. Communication is available over the RS232 and RS485 interfaces.

8.1. Syntax

The parts in the square brackets are optional:

Request <Add>:<No>:<Payload><CR><LF>
Response <STX><Add>:<No>:<Payload>:< UMB Status>:<Checksum><CR><LF><EOT>
Payload <Cmd>[;<Param0>;…;ParamN][=<Value0>;…;<ValueN>]

The individual blocks of the protocol are separated by a colon. This block separator is adjustable. <Add> is the sensor's UMB address, 4 hex characters, with leading zeros, in the range 0001 – FFFF. Messages with an incorrect address are ignored by the sensor. The <No> field can be set to any two hex characters by the sender during the request. The sensor adopts these characters and includes them in its response. <No> can be used as a time reference, for example, if there is a possibility of the request and the response not arriving directly one after the other.
<Payload> is the telegram's actual payload. It contains the command with its parameters and values. The <Status> field consists of two hex characters, with leading zeros. If a command is unknown or incorrect, the payload contains the command, and the status contains the corresponding error code. Requests and responses end with the characters <CR><LF> (adjustable). A sensor's response is additionally framed by the control characters <STX> and <EOT>.

The payload contains the command along with its information. Commands can have one or more parameters, separated by a semicolon. This parameter separator is adjustable. If a request's payload contains an equal's sign, it is a write command. The <Value> value can be one of the supported data types, including strings, depending on the command. Several values can be transferred here too, separated by semicolons. A point is used as the decimal separator (adjustable).

The length of a request should not exceed 128 characters; the length of a response should not exceed 512 characters.

8.2. Checksum

Responses from the sensor have a <Checksum> checksum to ensure the integrity of the data. The checksum is the complement on two of the 8-bit sum of all characters, including control characters, excluding the checksum itself. It is expressed by two hex characters with a leading zero.

8.3. Examples

For the following examples it is used: **<Add> = B001, <Nr> =4E** (default: 00)

Reset: B001:4E:RST<CR><LF>

<STX>B001:4E:RST:00:<Checksum><CR><LF><EOT>

Auto transmit interval (calculation interval):
B001:4E:ATI=60<CR><LF>
<STX>B001:4E:ATI=60:<Checksum><CR><LF><EOT>

Polling (querying the data telegram):

B001:4E:SS;1<CR><LF>

<STX>B001:4E:SS;1=085;003.0117;+02.1253;185;+15;17.8;00:00:94
<CR><LF><EOT>

Read channel (reading out a UMB measuring channel):

B001:4E:CHN;100<CR><LF>
<STX>B001:4E:CHN;100=+23.45:00:<Checksum><CR><LF><EOT>

B001:4E:CHN;110<CR><LF>
<STX>7001:4E:CHN;110:28:<Checksum><CR><LF><EOT>
(Channel busy)

B001:4E:CHN;523<CR><LF>
<STX>B001:4E:CHN;523:24:<Checksum><CR><LF><EOT>
(Channel unknown)

8.4. Description of the data telegram #1 with an example

<Add>:<No>:Payload:UMBStatus:Checksum of data telegram no. 1

B001:4E:SS;1=085;003.0117;+02.1253;185;+15;17.8;15:00:8E

Example	Length in bytes	Description
B001:4E:SS;1=	13	Repeat request command, address, ...
085	3	Telegram number (only incremented during automatic transfer. In polling mode=000)
;	1	Delimiter, user adjustable
003.0117	8	First 8 digits of the serial number, consecutive number.production date xxx.mmyy
;	1	Delimiter, user adjustable
+02.1253	8	Snow depth, variable use of the scaling factor. Decimal place not fixed
;	1	Delimiter, user adjustable
185	3	Signal strength [0;255]
;	1	Delimiter, user adjustable
+15	3	Window temperature
;	1	Delimiter, user adjustable
17.8	4	Tilt angle
;	1	Delimiter, user adjustable
15:	3	Error code (E15)
00:	3	UMB status code
8E	2	Checksum
	56	Sum

Table 5: ASCII telegram example

8.5. Additional data telegrams

As of firmware version 2.0, additional data telegrams are predefined: SS;2 to SS;6.

Example: SS;3:

```
B001:00:SS;3=000;0;+0000.98;1719.9;224;21.4;+27;096.0422;020;00:
00:B2
```

Example	Length in bytes	Description
B001:00:SS;3=	13	Rep. the request command, address, etc.
000	3	Telegram number (only incremented during automatic transfer. In polling mode= 000)
;	1	Separator; can be configured by the user
0	1	Snow flag
;	1	Separator; can be configured by the user
+0000.98	8	Snow depth, fixed to cm with defined output format <Sign>4.2 cm
;	1	Separator; can be configured by the user
1719.9	6	Current laser -> surface distance
;	1	Separator; can be configured by the user
224	3	Signal intensity [0;255]
;	1	Separator; can be configured by the user
21.4	4	Tilt angle
;	1	Separator; can be configured by the user
+27	3	Window temperature in °C
;	1	Separator; can be configured by the user
096.0422	8	Serial number: consecutive no. in production month, month and year
;	1	Separator; can be configured by the user
020	3	Firmware version
;	1	Separator; can be configured by the user
00:	3	SHM error code
00:	3	UMB status code
B2	2	Checksum
	68	Sum

Table 6: Additional ASCII data telegrams, sample telegram 3

The additional ASCII telegrams are delivered with predefined scaling factors.

The following telegrams are currently available. They are structured according to Table 6:

#2: Snow depth output in m (format +02.1253)

#3: Snow depth output in cm (format +0212.53)

#4: Snow depth output in mm (format +02125.3)

#5: Snow depth output in inches (format +0083.67)

Telegram 6 was implemented as the information telegram:

#6: Protocol outputs the serial number, station ID and description.

Example: SS;6

B001:00:SS;6=000;096.0422;010;020;Description;9999:00:03

Example	Length in bytes	Description
B001:00:SS;6=	13	Rep. the request command, address, etc.
000	3	Telegram number (only incremented during automatic transfer. In polling mode= 000)
;	1	Separator; can be configured by the user
096.0422	8	Serial number: consecutive no. in production month, month and year
;	1	Separator; can be configured by the user
010	3	Serial number: Device version
;	1	Separator; can be configured by the user
020	3	Firmware version
;	1	Separator; can be configured by the user
Description	Text length	Adjustable station description
;	1	Separator; can be configured by the user
9999:	4	Adjustable station ID number
;	1	Separator; can be configured by the user
00:	3	UMB status code
03	2	Checksum

Table 7: Additional ASCII data telegrams, sample telegram 6

8.6. Angle adjustment

For automatic calibration, the commands:

MEN, **ARV** and **MST** are required one after the other. The **AOF** and **AAN** commands are required for manual angle adjustment.

8.7. Overview of ASCII commands

UMB-ASCII 2.0 command	Default value	Read, Write, command	Name	Description
IFO		R	Info	Sensor information query
SID		RW	Station ID	Station ID
NAM		R	SHM 31-UMB (fixed)	Name
SRN		R	Serial number	Lufft serial number
DSC		RW	Description	Description

Table 8: Sensor information

Sensor information query (IFO). From parameter 20 onwards, a valid channel number must be included as a second parameter.

Examples

B001:4E:IFO;12 supplies the version number, or

B001:4E:IFO;20;100 supplies the name of UMB channel 100

IFO query parameters	Additional parameter: UMB channel	Name	Example: additional parameter output
10	–	Name	
11	–	Description	
12	–	Hardware and firmware version	
13	–	General device data	
15	–	Number of channels; blocks	
16	Example: block 0	Output of the valid channel numbers with regard to blocks	100; 101; 102; etc.
20	Example: channel 100	UMB channel name	Block temperature
21	Example: 100	UMB channel measuring range	-40.00, +100.00
22	Example: 600	UMB channel unit	mm
23	Example: 100	UMB channel data type	16
24	Example: 100	UMB channel type	10
30	Example: 100	UMB channel info (name, unit, channel type, data type, measuring range)	

Table 9: IFO command, list of intended parameters

UMB-ASCII 2.0 command (new)	Default value	Read, Write, command	Name	Description
MEN		C	Measurement end	Cancels the measuring process and the calculation
MST		C	Measurement start	Starts the automatic snow depth measurement
SS<;> <SS-No>		C	Standard set, telegram format	Queries the current measured value telegram in format according to <SS-No> (SS-No = 1 – 6 possible)
ATI	60	RW	Auto transmit interval	Measurement repetition rate (snow depth is calculated; telegram is provided or sent)
ATM	0	RW	Auto transmit mode	0=polling, 1,2, etc. 6=telegram format number
PST	<STX>	RW	Protocol: Start character	Protocol start character
PEN	<EOT>	RW	Protocol: End character	Protocol end character
PCR	<CR><LF>	RW	Protocol: line feed character	Protocol line feed character
PDS	.	RW	Protocol: decimal mark character	Protocol decimal separator

UMB-ASCII 2.0 command (new)	**Default value**	**Read, Write, command**	**Name**	**Description**
PBS	:	RW	Protocol: delimiter character	Protocol block separator
PPS	;	RW	Protocol: parameter delimiter character	Protocol parameter separator (also values in telegram)
CHN<;><ChnNum>		R	Channel; channel number	Queries a UMB channel

Table 10: ASCII parameters for measurements and querying data

UMB-ASCII 2.0 command	**Default value**	**Read, Write, command**	**Name**	**Description**
ID	1	RW	ID	UMB device ID (1 – 255)
BAU	6	RW	Baud rate	Queries / sets the baud rate for the RS485 / SDI-12 interface 2: 57600 4: 28800 6: 19200 8: 14400 12: 9600 24: 4800 48: 2400 96: 1200 (Baud rate = 115200/n) The device must be reset after the baud rate is changed.
SCF	1	RW	Scaling factor	Allows the unit to be changed, e.g. from metres (sf=1) to feet (sf=3.2808399). Once the SCF has been changed, the AOF and MSD parameters and the distance information in telegram 1 are displayed with the new scaling factor. The scaling factor is defined in the number range [0;40000].
PRT		RW	Protocol	User interface: RS485 / SDI-12 (0=UMB, 9=ASCII 2.0, 3=SDI-12, 5=Modbus RTU, 6=Modbus ASCII)
PRY		RW	Parity	Queries / sets the parity 0: 8N1 (default) 1: 8E1 (Modbus default request) 2: 7E1 (SDI-12) 3: 8N2 (alternative to Modbus)
ASC	MST	RW	Auto start command	Command that is executed when the sensor is started: MST=Start snow depth measurement. LON=Laser flashes for adjustment
LON		C	Laser on	Switches on flashing laser for adjustment
LOF		C	Laser off	Switches laser off after (LON). Measuring mode must be restarted using MST.
RST		C	Reset	Resets immediately

UMB-ASCII 2.0 command	Default value	Read, Write, command	Name	Description
RST=<Value>		C	Reset in <Value> ms	Resets after <Value> ms
RSD		C	Reset default values	Resets the values to default parameters
UMB		C		Temporarily switches to UMB
CAC	10	RW	channel_average_counts	*Number of 'ATI' measurements used in the averaged UMB channels (*_avg) and for the min and max values.*

Table 11: ASCII parameters for settings and controls

UMB-ASCII 2.0 command	Default value	Read, Write, command	Name	Description
ARV		C	Adjustment reference values	Measures the current distance and the reference angle from the tilt sensor and uses it to set the 'AOF' offset and the 'AAN' angle correction value.
ARH		C	Adjustment reference height	Measures the current distance and determines the offset ('AOF') using the stored reference angle.
AOF	0	RW	Adjustment offset	'Offset' (distance from the ground (vertical)), see 'ARV'
AAN	0.0	RW	Adjustment angle	Installation angle (0.0° corresponds to the vertical line of sight to the ground)
ASH<;><No>		R	Adj.SignalHighReflectivity <No>	Signal calibration values for targets with 85% reflectivity at five distances, <No> = [1.5] Corresponds to the distances (1=a, 2=b, ..., 5=e)
ASL<;><No>		R	Adj.SignalLowReflectivity <No>	Signal calibration values for targets with 6% reflectivity at five distances, <No> = [1.5]

Table 12: ASCII parameters for adjustments

UMB-ASCII 2.0 command	Default value	Read, Write, command	Name	Description
HEP	0	RW	HeaterEnablePin	Using the hardware switch (EXT_TRIG_IN): 0=No, 1=Yes
HBM	1	RW	HeaterBlockMode	Block heating mode: 0= Off; 1= Automatic: heat to target temperature and maintain; see 'HBT', 'HBH'; 2= Switch on defrost heating cycle once; 3=End current defrost heating cycle and switch to previous mode (0 or 1)
HBT	7.5	RW	HeaterBlockTemperature	Target temperature in °C by which the inside temperature should fluctuate in automatic mode ('HBM' =1)
HBH	2.5	RW	HeaterBlockHysteresis	Hysteresis for switch-off and switch-on point below and above the target value
HWM	1	RW	HeaterWindowMode	Window heating mode: 0= Off; 1= Automatic (heat to target temperature and maintain, see 'HBT', 'HBH'); 2= Switch on defrost heating cycle once; 3= End current defrost heating cycle and switch to previous mode (0 or 1)
HWT	20	RW	HeaterWindowTemperature	Target temperature in °C by which the external temperature should fluctuate in automatic mode ('HWM' =1)
HWH	2.5	RW	HeaterWindowHysteresis	Hysteresis for switch-off and switch-on point below and above the target value
HDS		C	HeaterDefrostStart	Start defrost mode temporarily (with values 'HDP', 'HDR', 'HDB' and 'HDW' for both heating types (block and window heating))
HDE		C	HeaterDefrostEnd	End current defrost mode 'HBM' and 'HWM' are switched back to the previous mode
HDM	1	RW	HeaterDefrostMode	Defrost mode: 0 = Always off, 1= Switch on at sensor start (with values 'HDP', 'HDR', 'HDB' and 'HDW' for both heating types (block and window heating))
HDP	15	RW	HeaterDefrostPeriod Block	Defrost: Duration of the defrost heating cycle in min for block heating
HDR	15	RW	HeaterDefrostPeriod Window	Defrost: Duration of the defrost heating cycle in min for window heating

UMB-ASCII 2.0 command	Default value	Read, Write, command	Name	Description
HDB	35	RW	HeaterDefrostBlock	Defrost: Target temperature in °C for block heating
HDW	25	RW	HeaterDefrostWindow	Defrost: Target temperature in °C for window heating

Table 13: ASCII parameters for regulating the heating

UMB-ASCII 2.0 command	Default value	Read, Write, command	Name	Description
LMI	10000	RW	Laser Measurement Interval	Laser interval (ms interval in which the laser performs a measurement)
SIT	130	RW	Signal Intensity Threshold	Sets the signal intensity threshold used to set the ‘snow flag’ in the data telegram.
UAA	0	RW	Use Accelerometer Angle	Switch for snow depth calculation angle, 0=Reference angle (AAN), 1=Current angle from G-sensor
MSD	0.02	RW	Maximum SnowDepth Difference	Maximum allowed distance between two snow depth measurements. The factory setting is 0.02 m. A value of 10 m should be set during installation. This enables easy installation and prevents the E65 / E66 error from occurring during installation. This value can be modified after commissioning; e.g. to 0.02 (2 cm if sf=1). A 2 cm per minute change in snow depth is a reasonable value.
MSA	600	RW	Maximum SnowDepth Acceptance Time	Indicates after how many seconds the snow depth is accepted, even though the change in snow depth is greater than the ‘MSD’.

Table 14: ASCII parameters for the algorithms

9. UMB communication

9.1. Factory settings

In the delivery state, the SHM 31 has the following settings:

Class ID:.. 11 (cannot be changed)

Device ID:.. 1 (results in address B001 (hex) = 45057)

Baud rate:.. 19200

RS485 protocol: .... UMB binary

9.2. Overview of measuring channels

The channel assignment applies to the data request in the UMB protocol.

UMB channel					
act	**min**	**max**	**avg**	**Measured variable (float32)**	**Unit**
100	101	102	103	block temperature	°C
104	105	106	107	block temperature	°F
108	109	110	111	ambient temperature (window inside)	°C
112	113	114	115	ambient temperature (window inside)	°F
120	121	122	123	laser temperature	°C
124	125	126	127	laser temperature	°F
500	501	502	503	tilt angle	°
504				x-angle	°
505				y-angle	°
506				z-angle	°
510				tilt angle reference	°

Table 15: Measuring channels SHM31: 100 – 599 (float 32 data type)

UMB channel					
act	**min**	**max**	**avg**	**Measured variable (float32)**	**Unit**
600	601	602	603	snow depth	mm
604	605	606	607	snow depth	cm
608	609	610	611	snow depth	m
612	613	614	615	snow depth	inch
650				Distance (corrected)	mm
651				Distance (corrected)	inch
660				distance (raw value)	mm
661				distance (raw value)	inch
690				sensor altitude	mm

Table 16: Measuring channels SHM31: 600 - 690 (float32 data type)

UMB channel						
act	**min**	**max**	**avg**	**Measured variable**	**Data type**	**Unit**
700				snow flag	uint8	logic
800	801	802	803	signal normalized	uint8	norm value
4000				device status *if not 0 please contact support*	uint16	digits
4002				Flash status		
4003				RS485 status *if not 0 please contact support*	uint16	digits
4005				Attended time		
4006				Reset status		
4007				system time	uint32	s
4010				heater block state *0: off* *1: active in 12 V mode* *2: active in 24 V mode* *3: defrost mode (12 V)* *4: defrost mode (24 V)* *5: heating via external input EXT_TRIG_IN deactivated* *6: deactivated due to internal voltage control error* *7: deactivated due to wrong configuration or faulty temp. value*	uint16	digits
4011				internal NTC temp *raw value for internal temperature*	float32	°C
4013				block defrost time *remaining time in defrost mode*	uint16	s
4020				heater window state *0: off* *1: active in 12 V mode* *2: active in 24 V mode* *3: defrost mode (12 V)* *4: defrost mode (24 V)* *5: heating via external input EXT_TRIG_IN deactivated* *6: deactivated due to internal voltage control error* *7: deactivated due to wrong configuration or faulty temp. value*	uint16	digits
4021				external NTC temp *raw value for external temperature*	float32	°C
4023				window defrost time *remaining time in defrost mode*	uint16	s
4050				FW update status		
4100				shm31 error *the error codes for the device are listed in* Table 30	uint8	shm30 code
4101				shm31 error (current) *internal error handling*	uint8	shm30 code

Table 17: Measuring channels 700 – 4999

UMB channel						
act	**min**	**max**	**avg**	**Measured variable**	**Data type**	**Unit**
5000				laser gain	uint8	raw code
5001				laser sig. strength	int32	µV
5002				laser distance	float32	mm
5003				laser temperature	float32	°C

10000				vin monitor	float32	V

Table 18: Measuring channels starting from 5000

9.3. Communication in binary protocol

In this case, communication with the snow depth sensor takes place using the RS485 connection e.g. with UMB ConfigTool.NET. Please refer to the UMB protocol manual, if desired, for a general description of communication in the UMB binary protocol over the RS485 interface. The description of the UMB protocol can be downloaded from the Lufft website at www.lufft.com.

9.3.1. Data frame

The data frame is constructed as follows:

1	2	3 - 4	5 - 6	7	8	9	10	11 ... (8 + len) optional	9 + len	10 + len 11 + len	12 + len
SOH	<ver>	<to>	<from>	<len>	STX	<cmd>	<verc>	<payload>	ETX	<cs>	EOT

SOH	Control character for the start of a frame (01h); 1 byte
<ver>	Header version number, e.g.: V 1.0 → <ver> = 10h = 16d; 1 byte
<to>	Receiver address; 2 bytes
<from>	Sender address; 2 bytes
<len>	Number of data bytes between STX and ETX; 1 byte
STX	Control character for the start of payload transmission (02h); 1 byte
<cmd>	Command; 1 byte
<verc>	Version number of the command; 1 byte
<payload>	Data bytes; 0 – 210 bytes
ETX	Control character for the end of payload transmission (03h); 1 byte
<cs>	Check sum, 16 bit CRC; 2 bytes
EOT	Control character for the end of the frame (04h); 1 byte

Control characters: SOH (01h), STX (02h), ETX (03h), EOT (04h).

9.3.2. Addressing with class ID and device ID

Addressing is performed using a 16-bit address. This is split into a class ID and a device ID.

Address (2 bytes = 16 bit)				
Bits 15 – 12 (upper 4 bits)		Bits 11 – 8 (middle 4 bits)	Bits 7 – 0 (lower 8 bits)	
Class ID (0 to 15)		Reserve	**Device ID** (0 – 255)	
0	Broadcast		0	Broadcast
11	SHM31 Snow Depth Sensor		1 - 255	Available
15	Master or control devices			

ID = 0 is provided as broadcast for classes and devices. Thus, it is possible to transmit a broadcast on a specific class. However this only makes sense if there is only one device of this class on the bus; or in the case of a command, e.g. reset.

9.3.3. Example of creating addresses.

If an SHM 31 sensor is to be addressed with the device ID 001, this is done as follows:

The class ID is: 11d = Bh; the device ID is: 001d = 001h

Combining the class ID and the device ID creates the address B001h (45057d).

9.3.4. Example of a binary protocol query

If, for example, a sensor with the device ID 001 is polled from a PC for the current snow depth, this takes place as follows:

Sensor:

The target address for the SHM31 is B001h.

PC:

The class ID for the PC (master unit) is 15 = Fh; the PC ID is e.g. 001d = 01h.

Putting the class and device IDs together gives a sender address of F001h.

The length <len> for the online data request command is 4d = 04h;

The command for the online data request is 23h;

The version number of the command is 1.0 = 10h.

The channel number is in <payload>; as can be seen from the channel list in section 9.2 the current snow depth in cm is in channel 604d = 25Ch.

The calculated CRC is 5930h.

SOH	<ver>	<to>		<from>		<len>	STX	<cmd>	<verc>	<channel>		ETX	<cs>		EOT
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
01h	10h	01h	B0h	01h	F0h	04h	02h	23h	10h	5Ch	02h	03h	30h	59h	04h

Table 19: UMB binary example, query command to the sensor

SOH	<ver>	<to>		<from>		<len>	STX	<cmd>	<verc>	<status>	<channel>		<typ>
1	2	3	4	5	6	7	8	9	10	11	12	13	14
01h	10h	01h	F0h	01h	B0h	0Ah	02h	23h	10h	00h	5Ch	02h	16h
<value>				ETX	<cs>		EOT						
15	16	17	18	19	20	21	22						
B1h	FFh	0Dh	42h	03h	DEh	BCh	04h						

Table 20: UMB binary example, response from the sensor

The received snow depth in cm from channel 604 is 420DFFB1h = 35.4997 cm.

The conversion process follows the rules of IEEE-754 (float) conversion.

9.3.5. Status and error codes in the UMB binary protocol

If the measured value query supplies the <status> 00h, then the sensor is working properly. A complete list of status and error codes can be found in the description of the UMB protocol. The following is an extract from the list:

<status>	Description
00h (0d)	Command successful; no error; all o.k.
10h (16d)	Unknown command; not supported by this device
11h (17d)	Invalid parameter
24h (36d)	Invalid channel
28h (40d)	Device not ready; e.g. initialization / calibration in progress
50h (80d)	Measurement variable (+offset) is outside the set display range
51h (81d)	
52h (82d)	Measurement value (physical) is outside the measuring range (e.g. ADC over range)
53h (83d)	
54h (84d)	Error in measurement data or no valid data available
55h (85d)	Device / sensor is unable to perform valid measurement due to ambient conditions

9.3.6. CRC calculation

The CRC is calculated according to the following rules:

Norm: CRC-CCITT

Polynomial: 1021h = $x^{16} + x^{12} + x^5 + 1$ (LSB first mode)

Start value: FFFFh

For more information, see the description of a CRC calculation in the UMB protocol.

10. Communication in SDI-12 mode

Communication in SDI-12 mode corresponds to the:

'SDI-12: A Serial-Digital Interface Standard for Microprocessor-Based Sensors – Version 1.3 – January 12, 2009'. SDI-12 v1.4 is also supported as of firmware version v16. The SHM 31-UMB can be operated in Bus mode with other SDI-12 sensors on an SDI master (logger).

10.1. Connector pin assignment

In SDI-12 mode, the following is used:

- SDI-12 signal line (yellow)
- SDI-12 ground of line V_IN- / SDI-12_GND (white)

Also see the table SHM 31 connector pin assignment, page 17.

10.2. Settings for using SDI-12

Since the interface settings according to the SDI standard differ from the UMB sensors' settings, the corresponding parameters must be set with the help of ConfigTool.NET or using the UMB-ASCII 2.0 protocol.

The following parameter settings must be made (the ASCII 2.0 commands are listed in brackets):

Baud rate:	1200	(BAU=96)
RS485 parity:	7E1	(PRY=2)
Protocol mode:	SDI-12	(PRT=3)
Reset:		(RST)

After setting the parameters, the sensor must be restarted (reset or power off / on).

The measured data can be transferred in either metric or in US units. This setting can also be made using UMB or SDI-12. An ASCII 2.0 command is not available for this.

10.3. Exiting SDI mode

If the SHM 31-UMB is operated in SDI-12 mode, access with ConfigTool.NET is no longer possible during ongoing operation due to the different interface settings.

One option is to exit SDI-12 mode over the RS232 interface with ASCII commands and to reconfigure the interface to UMB protocol.

To be able to access the RS485 interface directly again, the interface is operated in standard UMB mode (19200 8N1) for the first 5 seconds after switch-on or after a reset. The UMB device ID is switched to 200 for this period of time. This also makes devices with unknown IDs accessible. If a valid UMB query is received within these 5 s, the device remains in UMB mode for the configured switching time (10 minutes as default) so that the configuration can be edited:

- Connect the PC to the SHM 31 sensor using an RS485 converter
- Launch ConfigTool.NET and create SHM 31-UMB with ID 200 and activate at least one sensor. Start the measurement with a 1 sec sampling rate
- Trigger a device reset (operating voltage off / on)
- When the SHM 31-UMB responds, the measurement can be ended; the interface is now open for configuration

Note: The 5 seconds of UMB communication are available from sensor start. Taking this operating system start into account, the device is ready for SDI-12 queries after approx. 7 – 7.5 sec. This time specification only refers to cold starts. Otherwise, the device responds within the response times required by the standard.

10.4. Command overview

Details about the SDI-12 protocol can be found in the above-mentioned standard document. Of the commands listed there, the following are available for the SHM 31-UMB:

In the examples in the following sections, logger queries are always shown in italics (*0V!*)

Command	Function
?!	Address search (Wildcard request, one device only on bus!)
a!	Request device active?
aI!	Request device identification
aAb!	Address change to b (0 … 9, A …Z, a … z)
aM!	Perform measurement; basic data set minimal
aM1!	Perform measurement; angles
aM2!	Perform measurement; flags
aMC!	Perform measurement; basic data set minimal, transmit values with CRC
aMC1! … *aMC2!*	Perform measurement (assignment of values as for aMn! commands), transmit values with CRC
aC!	Perform measurement; full basic data set; simultaneous
aC1! … *aC2!*	Perform concurrent measurement, assignment of values as for aMn! commands, partly extended data sets
aCC!	Perform concurrent measurement, transmit values with CRC
aCC1! … *aCC2!*	Perform concurrent measurement, assignment of values as for aMn! commands, partly extended data sets, transmit values with CRC
aD0!	Data request buffer 0
aD1!	Data request buffer 1
aR0!	Data request from continuous measurement, data set 0
aR1!	Data request from continuous measurement, data set 1
aRC0!	Data request from continuous measurement, data set 0 with CRC
aRC1!	Data request from continuous measurement, data set 1 with CRC
aV!	Command verification: Evaluate sensor status and heating temperatures, data request with aD0!, aD1!
aXU<u/m>!	Switchover between metric and US units
aXRS!	Device reset
	Firmware version v16 and newer (SDI-12 v1.4)
aIM! *aIMC!* *aIMn!* *aIMCn!* *aIC!* *aICC!* *aICCn!* *aIVn!*	Request the number of measurement values
aIM_00m! *aIMC_00m!* *aIMn_00m!* *aIMCn_00m!* *aIC_00m!* *aICC_00m!* *aICCn_00m!* *aIRn_00m!*	Request the measurement value parameters

Table 21: Command set for sensor with SDI-12 address 'a' (UMB ID 37 (0x25))

The scope of the minimal and the full basic data set is currently identical. The same applies to the extended measuring commands (aM1!, aC1!, etc.).

Due to the measurement methods used, the SHM 31 sensors always measure continuously, unlike the standard sensors described in the SDI-12 documents. As a result, this operating mode has some special features:

The device does not need to be ‘woken up’ and does not have a sleep mode.

Data retrieved with M or C commands is always available immediately. The device always responds with a000n or a000nn respectively. This means that the device does not send a service request and ignores signals to cancel the measurement. The master should retrieve the data immediately.

10.5. Setting the address

The UMB device ID and the SDI-12 address are connected to one another. The different address ranges have to be taken into account in this regard, as must the fact that the UMB addresses are numbers and the SDI-12 addresses are ASCII characters. The SDI-12 address is therefore derived from the set UMB device ID as follows:

UMB device ID 1 (default) corresponds to SDI-12 address ‘0’ (SDI-12 default).

Changing the SDI-12 address with the SDI-12 setting command also changes the UMB device ID accordingly.

UMB (dec)			SDI-12 (ASCII)		
1	to	10	‘0’	to	‘9’
11	to	36	‘A’	to	‘Z’
37	to	62	‘a’	to	‘z’

Table 22: SDI-12, permissible address ranges

10.6. Measured data telegrams

In the interests of making evaluation easier, the assignment of the measured values to the measured value buffers ‘0’ to ‘9’ was defined in a uniform manner. The C queries are therefore also answered with a maximum data length of 35 bytes, even though 75 bytes would be permissible here. The buffers ‘0’ to ‘1’ are used at present.

The SHM 31-UMB does not currently use the C commands’ advanced possibilities; the responses to M and C queries are identical.

If the measured value is unavailable for any reason, e.g. sensor error, +999999 or -9999999 – or 99 / -99 for 8-bit values – is displayed. The logger can then determine the cause of the error more precisely using the verification query aV! (see below). In the tables below, the measured variables are listed in the order in which they appear in the telegram (see example).

Depending on the device’s configuration, the measured values are output in metric or in US units.

The configured system of units is not displayed in the data telegrams. The logger may retrieve the setting using the I command and set the evaluation of data telegrams accordingly (see below).

10.6.1. Example: C and M queries of the SHM 31-UMB

0M! or 0C!	
00008<CR><LF>	8 measurement values available for immediate retrieval
0D0!	
0+2346+0.1000+45.7-2.8<CR><LF> 0+2346+0.0+0.0+0.0<CR><LF>	Time stamp 2346sec, snow depth 0.1m, block temperature 45.7°C, ambient temperature -2.8°C If “MEN” has been set (MeasurementEnd, 10.11.3)
0D1!	
0+51.5+12+11.9+0<CR><LF> 0+0.0+0+0.0+67<CR><LF>	Laser temperature 51.5°C, normalised signal 12, tilt angle 11.9°, SHM31 error status 0 If “MEN” has been set (MeasurementEnd, 10.11.3)

10.6.2. Buffer assignment – basic data – SHM 31-UMB

Measurement Value	UMB-Channel	Min	Max	Unit
Puffer ‘0’				
Run time	4007	0	9999999	Sec
Snow depth (cur)	608	-16.0000	16.0000	m
Block temperature(cur)	100	-40,0	100,0	°C
Ambient temperature(cur)	108	-50,0	100,0	°C
Puffer ‘1’				
Laser temperature (cur)	120	-60,0	80,0	°C
Signal normalised (cur)	800	0	255	-
Tilt angle (cur)	500	-180,0	180,0	°
SHM31 error	4100	0	255	code

Table 23: SDI-12, device configured for measurements in metric units

Example: Query buffer ‘0’: `0+2346+0.1000+45.7-2.8<CR><LF>`

Timestamp 2,346 sec, snow depth 0.1 m, block temperature 45.7°C, ambient temperature-2.8°C

Measurement Value	UMB-Channel	Min	Max	Unit
Puffer ‘0’				
Run time	4007	0	9999999	Sec
Snow depth (cur)	612	-629.9	629.9	inch
Block temperature(cur)	104	-40,0	212,0	°F
Ambient temperature(cur)	112	-58,0	212,0	°F
Puffer ‘1’				
Laser temperature (cur)	124	-76,0	176,0	°F
Signal normalised (cur)	800	0	255	-
Tilt angle (cur)	500	-180,0	180,0	°
SHM31 error	4100	0	255	code

Table 24: SDI-12, device configured for measurements in metric units

10.7. Additional measuring commands

With the additional measuring commands

`aM1! … aM2!`

`aMC1! … aMC2!` (M command, data transfer with CRC)

`aC1! … aC2!`

`aCC1! … aCC2!` (C command, data transfer with CRC)

additional measured values can be retrieved.
As with the basic data, a maximum of 9 measured values can be retrieved with an M command; 20 places are available with C commands.

The buffer assignment documented below is therefore structured such that buffers D0 and D1 are allocated to the respective M command. If more measured values are available for the sensor type, the buffers D2 to D4, if applicable, are also allocated to the corresponding C command.

M1 / C1	Angles	M: 6 values	C: 6 values
M2 / C2	Flags	M: 7 values	C: 7 values

Measurand	UMB-Channel	Min	Max	Unit
Buffer ‘0’				
Run time	4007	0	9999999	s
Tilt angle (cur)	500	-180,0	180,0	°
X angle (cur)	504	-180,0	180,0	°
Buffer ‘1’				
Y angle (cur)	505	-180,0	180,0	°
Z angle (cur)	506	-180,0	180,0	°
Tilt angle reference (cur)	510	-180,0	180,0	°

Table 25: SDI-12, additional values (M1 / C1: Angles) configured in metric or in US units

Measurand	UMB-Channel	Min	Max	Unit
Buffer ‘0’				
Run time	4007	0	9999999	s
snow depth (cur)	600	-16000.0	16000.0	in
snow flag (cur)	700	0	1	code
fogging flag (cur)	710	0	1	code
signal normalized	800	0	255	-
Buffer ‘1’				
distance	650	-500.0	21000.0	mm
SHM31 error	4100	0	255	code

Table 26: SDI-12, additional values (M1 / C2: Flags) configured in metric units. The fog flag is not calculated at present.

Measurand	UMB-Channel	Min	Max	Unit
Buffer ‘0’				
Run time	4007	0	9999999	s
snow depth (cur)	612	-629.9	629.9	mm
snow flag (cur)	700	0	1	code
fogging flag (cur)	710	0	1	code
signal normalized	800	0	255	-
Buffer ‘1’				
distance	650	-19.7	826.8	mm
SHM31 error	4100	0	255	code

Table 27: SDI-12, additional values (M1 / C2: Flags) configured in US units. The fog flag is not calculated at present.

10.8. Device identification telegram

The device identification query is answered with the following telegram (example of SDI-12 device address ‘0’:

0I!

`013Lufft.deSHM31xnnn`

x: Metric / US units (m = metric, u = US), nnn: Software version

i.e. for an SHM 31-UMB set to US units:

0I!

`013Lufft.deSHM31u010`

10.9. Telegram verification

The command verification *aV!* is used to identify the device’s status information. The query is answered with

`a0002<CR><LF>`

i.e. two measured values are available in the buffers.

The measured values, transferred in buffer 0, contain the status information of the device’s measuring channels.

The channels’ status data is combined to form ‘pseudo-measurements’, where each digit represents a status. See below for the states’ coding. Positions listed as ‘reserved’ in the table are allocated to ‘0’.

Buffer ‘0’	
Status group 1: +nnnn	Block temperature status, ambient temperature status, laser temperature status, tilt angle status
Status group 2: +nnnn	x/y/z angle status, snow depth status, calibration distance status, flags status

Sensor status coding:

Sensor status	Code
OK	0
INVALID_CHANNEL	1
E2_CAL_ERROR E2_CRC_KAL_ERR FLASH_CRC_ERR FLASH_WRITE_ERR FLASH_FLOAT_ERR	2
MEAS_ERROR	3
MEAS_UNABLE	4
INIT_ERROR	5
VALUE_OVERFLOW CHANNEL_OVERRANGE	6
VALUE_UNDERFLOW CHANNEL_UNDERRANGE	7
BUSY	8
Other sensor status	9

Table 28: SDI-12, sensor status coding (for more information, also see documentation on the Lufft UMB protocol)

Example (SHM 31-UMB, SDI-12 address ‘0’, no errors):

0V!

00002<CR><LF>

0D0!

0+0000+0000<CR><LF>

Example (SHM 31-UMB, SDI-12 address ‘0’, laser temperature measurement failed):

0V!

00002<CR><LF>

0D0!

0+0030+0000<CR><LF>

10.10. Query measured value parameter command (SDI-12 v1.4)

The command retrieves the measured value identification of each individual measured value.

Command: *aI<Measuring command>_0mm!*

Measuring command: *M, MC, M1 – M9, MC1 – MC9, C, CC, C1 – C9, CC1 – CC9, R1 – R9, V*

mm: Position of the measured value

Response: a, <Measured value code>,<Unit>,<Measured value type><CR><LF>

Value Code	Measured Value
TBK	Block temperature
TAM	Ambient temperature
TLA	Laser temperature
ATL	Tilt angle
ATX	X angle
ATY	Y angle
ATZ	Z angle
ARF	Reference angle
HSN	Snow depth

DSTC	Calibrated distance
OSF	Snow flag
OFF	Fog flag
OSN	Normalised signal intensity
ER	SHM31 error
DSTA	Device status
STA1	Sensor status 1
STA2	Sensor status 2
DRT	System time at query

Example:

0IM_002!

`0,HSN,mm,cur<CR><LF>`

10.11. Switching commands

Switching commands are implemented as manufacturer-defined SDI-12 ‘extended’ telegrams and are used to trigger procedures.

Switching commands are composed of the prefix X defined in the SDI-12 standard and a three-digit individual code. The code corresponds in most cases to the corresponding code of the ASCII2 protocol.

If the command was successfully received, the telegram is answered with ‘OK’ added to the command code.

If the command cannot be executed, e.g. because other procedures are still ongoing, the telegram is answered with ‘busy’ added to the command code.

If the three-character command code is unknown,

`aX_noCmd<CR><LF>`

will be the response.

10.11.1. Unit system changeover command

The command is used to change the system of units used to display the SDI-12 data between metric and US units. The command is implemented as an X command.

The parameter change is applied immediately and stored in the sensor’s configuration memory.

Command: *aXUN<U/M>!*

Response: `aXUN<U/M><CR><LF>`

U: US units

M: Metric units

Example: change to metric units

0XUNM!

`0XUNMok<CR><LF>`

10.11.2. Device reset command

The command initiates a device reset.

Command: *aXRES!*

Response: `aXRESok<CR><LF>`

This is followed by a reset, i.e. the device cannot be reached for a few seconds

Example:

0XRES!

0XRESok<CR><LF>

10.11.3. End measurement command

The command ends the automatic snow depth measurement, e.g. for setting and calibration work.

Command: *aXMEN!*

Response: aXMENok<CR><LF>

If procedures that prohibit execution of the command are active,

aXMENbusy<CR><LF>

will be the response and the command will be ignored.

10.11.4. Start measurement command

The command starts the automatic snow depth measurement if it was disabled, e.g. for setting and calibration work.

Command: *aXMST!*

Response: aXMSTok<CR><LF>

If procedures that prohibit execution of the command are active,

aXMSTbusy<CR><LF>

will be the response and the command will be ignored.

10.11.5. Laser on command

The command switches the laser on continuously, e.g. for setting the measuring point.

Command: *aXLON!*

Response: aXLONok<CR><LF>

If procedures that prohibit execution of the command are active,

aXLONbusy<CR><LF>

will be the response and the command will be ignored.

10.11.6. Laser off command

The command switches the laser that was previously switched on continuously off again.

Command: *aXLOF!*

Response: aXLOFok<CR><LF>

If procedures that prohibit execution of the command are active,

aXLOFbusy<CR><LF>

will be the response and the command will be ignored.

10.11.7. Calibrate offset and angle command

The command starts a measuring process to determine distances and angle. The determined values are set as offsets / reference heights and angle correction values.

Command: *aXARV!*

Response: aXARVok<CR><LF>

If procedures that prohibit execution of the command are active,

aXARVbusy<CR><LF>

will be the response and the command will be ignored.

10.11.8. Calibrate offset command

The command starts a measuring process to determine the distance. The determined values are set as offsets / reference heights using the stored reference angle.

Command: *aXARH!*

Response: aXARHok<CR><LF>

If procedures that prohibit execution of the command are active,

aXARHbusy<CR><LF>

will be the response and the command will be ignored.

10.11.9. Switch on defrost heating cycle command

The command starts the defrost heating cycle.

Command: *aXHDS!*

Response: aXHDSok<CR><LF>

10.11.10. Switch off defrost heating cycle command

The command switches off an ongoing defrost heating cycle if necessary.

Command: *aXHDE!*

Response: aXHDEok<CR><LF>

10.12. Parameter setting commands

Parameter setting commands are implemented as manufacturer-defined SDI-12 'extended' telegrams and are used to read out and set parameters.

Parameter setting commands are composed of the prefix X defined in the SDI-12 standard, an additional prefix 'P' for parameter, and a three-digit individual code. The code corresponds in most cases to the corresponding code of the ASCII2.0 protocol.

If the command is sent without a setting value added, the currently valid parameter value is returned.

The setting value is to be formatted according to SDI-12 number conventions (i.e. always with a leading sign and a maximum of seven digits, plus a decimal point if necessary). Regardless of the number type of the parameter to be set, both floating point and integer values are accepted. For integer parameters, a floating point entry is rounded if necessary.

The given setting value is checked against the respective parameter's limits. If the permissible range is exceeded, the command is rejected with 'invalid' or 'invalid-' (impermissible negative value) added.

If the command with setting value was successfully received, the telegram is answered with the set value added to the command code.

If the three-character command code is unknown,

aX_noCmd<CR><LF>

will be the response.

10.12.1. Retrieving the current parameter setting

Command: *aXPccc!*

ccc: Three-character parameter code; see table

Response: aXPccc<+/->nnn<CR><LF> for integer parameters, nnn: Parameter

aXPccc <+/->fff.f<CR><LF> for floating point parameters

The number of nnn or fff digits is variable according to the parameter value:

aX_noCmd<CR><LF> in case of unknown parameter code ccc

Example: Retrieving the currently set laser measurement intervals, SHM 31-UMB with SDI-12 ID '0'

0XPLMI!

`0XPLMI+5000<CR><LF>`

10.12.2. Setting the parameter setting

Command: *aXPccc<+/->nnn!*

aXPccc<+/->fff.f!

ccc: Three-character parameter code; see table

nnn, fff.f: Parameter value to be set, number of digits as required

The entry can be made both as an integer and as a floating point number, regardless of the parameter's number type, and the value is rounded if necessary.

Response: aXPccc<+/->nnn<CR><LF> for integer parameters
nnn: New parameter

aXPccc<+/->ff.f<CR><LF> for floating point parameters
ff.f: New parameter

The number of nnn or fff digits is variable according to the parameter value.

aXP_invalid<CR><LF> if the new parameter value is beyond the limits

aXP_invalid-<CR><LF> parameter without a leading sign, but with a negative number set

aX_noCmd<CR><LF> in case of unknown parameter code ccc

Example: Setting the laser measurement interval, SHM 31-UMB with SDI-12 ID '0'

0XPLMI+2500! or *0XPLMI+2500.0!*

0XPLMI+2500<CR><LF>

Code	Function	Number type	Permissible values*	Units
ATI	Measurement interval	uint16	0 … **60**	s
HWM	Window heating mode	uint8	0 / **1**	-
HBM	Block heating mode	uint8	0 / **1**	-
HEP	Enable external switching of heating	uint8	**0** / 1	-
HDM	Heating defrost after power on	uint8	**0** / 1	-
AOF	Distance offset	float	**0.0** … 16000.0	mm
AAN	Correction angle	float	**0.0** … 180.0	°
UAA	Use measured correction angle	uint8	**0** / 1	-
MSA	Time constant for suppression of short term depth changes	uint16	0 … **600** … 65535	s
MSD	Maximum accepted change of snow depth per interval	float	-20000.0 … **20.0** … 20000.0	mm
LMM	Laser measure mode	uint8	**0**	-
LMI	Laser measurement interval	uint32	1000 … 1**0000** … 60000	ms

Table 29: SDI-12, setting the parameter settings
* factory settings in bold characters

11. Communication in Modbus mode

To make integrating the SHM 31-UMB into PLC environments easier, communication according to the Modbus protocol is provided.

The measured values are mapped to Modbus input registers. Essentially, the same range of measured values is available as in the UMB protocols, including the conversion to different systems of units.

In the interests of safe device commissioning, the use of register pairs for floating point or 32-bit integer display – which is not described in the actual Modbus standard – has been dispensed with. All the measured values are mapped to the 16-bit registers by means of appropriate scaling.

A basic understanding of Modbus communication is assumed below. Details can be found in the Modbus_Application_Protocol and Modbus_over_serial_line documents, for example. These documents can be downloaded from www.modbus.org/specs.php.

11.1. Modbus connection and communication parameters

The SHM 31-UMB is connected to a Modbus logger or a Modbus network over the RS485 interface.

The SHM 31-UMB can be configured for either MODBUS RTU or MODBUS ASCII.

Basic configuration is performed with ConfigTool.NET.

Modbus operating modes: MODBUS RTU, MODBUS ASCII

Baud rate: 19200 (9600, 4800 and smaller)

Interface setting 8E1, 8N1, 8N2

Note: Modbus communication was tested with a polling rate of 1 sec. Faultless Modbus communication of the SHM 31-UMB is not guaranteed for higher polling rates.

11.2. Addressing

The Modbus address is taken from the UMB device ID (see section 7.3).

A device with the UMB device ID 1 also has the Modbus address 1, etc.

The valid Modbus address range of 1 – 247 is smaller than the range of the UMB device IDs. If a UMB device ID > 247 has been set, the Modbus address is set to 247.

11.3. Modbus functions

The functions of Conformance Class 0 and 1 are implemented as far as they are applicable to the SHM 31-UMB (i.e. all the functions that work at register level).

Modbus Function		**Use**
	Conformance Class 0	
0x03	Read Holding Registers	Selected configuration settings
0x16	Write Multiple Registers	Selected configuration settings
	Conformance Class 1	
0x04	Read Input Registers	Measurement values and status information
0x06	Write Single Register	Selected configuration settings
0x07	Read Exception Status	Currently not used
	Diagnostics	
0x11	Report Responder ID	(responds also to broadcast address)

11.3.1. 0x03 Read Holding Registers, 0x06 Write Single Register, 0x16 Write Multiple Registers function

The holding registers are used to make a selected set of adjustable parameters and actions also accessible using Modbus.

Like the measured values, the parameters are mapped to 16-bit integer values, with a scaling factor if necessary.

Registers that are allocated to parameters return the parameter's currently active value when read.

When writing to a parameter register, the new value is entered into the permanent memory, but is only active after a device reset. In other words, the register only supplies the new value when read after a reset. The value to be written is checked to ensure it is permissible. If the set limits are exceeded, the sensor responds with an ‘Illegal Data Value’ Modbus exception and does not execute the command.

The actions are executed when the value 0x3247 (hex) or 12871 (decimal) is written to the corresponding register. If the action cannot be executed, the sensor responds with an ‘Illegal Data Value’ Modbus exception.

Action registers always return 0 when read.

Action register

Reg. Nr.	Reg. Adr.	Function	Description
1	0	Sensor Reset	Initiated a sensor reset. During the reset process Modbus communication is interrupted for a few seconds
2	1	Measurement Start	Starts normal measurement operation *)
3	2	Measurement End	Ends normal measurement operation *)
4	3	Laser On	Laser permanently on (e.g. for sensor alignment) *)
5	4	Laser Off	Turn laser off after “Laser On” *)
6	5	Automatic Calibration	Automatic Calibration of reference angle and height *)
7	6	Automatic Height Calibration	Automatic Calibration of reference height *)
8	7	Start defrosting	Start defrosting process
9	8	End defrosting	Ends defrosting process

*) Action can only be executed if the current operating state allows it. If not, the write process is answered with the ‘ILLEGAL_DATA_VALUE’ Modbus exception. This is also the case if an action to be started is already active.

Parameter register

Reg. Nr.	Reg. Adr.	Function	Values	Factor
10	9	Operating mode block heating	0 = OFF 1 = automatic 2 = start single defrost operation 3 = end defrost operation	1
11	10	Operating mode window heating	0 = OFF 1 = automatic 2 = start single defrost operation 3 = end defrost operation	1
12	11	Enable external heating control	0 = ignore ext. control pin 1 = enable ext. control pin	1
13	12	Automatic defrosting after power on	0 = OFF 1 = ON	1
14	13	Reference height	Reference height above measurement point in mm Range: -16000 … +16000	1
15	14	Sensor tilt angle	Reference angle in ° Range -180 … +180	1
16	15	Use accelerometer angle	Use current angle from accelerometer for calculation 0 = use stored reference angle 1 = use current accelerometer angle	1
17	16	Acceptance time for snow height change	Time to accept snow height change exceeding the configured max. snow height difference [sec] Range: 0 … 65535	1

18	17	Maximum snow height difference	Maximum accepted snow height difference between two measurements [mm] Range: -20000 … +20000	1
19	18	Laser operating mode	Not yet implemented	1
20	19	Laser measurement interval	Laser mesurement interval [msec] Range 1000 … 60000 **Values less than 5000ms are not recommended!**	1

11.3.2. 0x04 Read Input Registers function

The input registers contain the measured values of the SHM 31-UMB and related status information.

The measured values are mapped to the 16-bit registers by scaling (0 to max. 65530 for values without a leading sign, -32762 to 32762 for values with a leading sign).

The values 65535 (0xffff) or 32767 are used to display faulty or unavailable measured values. A more precise specification of the error can be determined from the status registers (see below).

The assignment of the measured values to the register addresses (0 – 119) was chosen so that the user can read out the usual data with as few register block retrievals as possible (ideally only one retrieval).

The following blocks were therefore formed:

- Status information
- Standard data set in metric units
- Standard data set in US units
- Distances
- Temperatures in metric units
- Temperatures in US units
- Angle
- Logical and normalised values
- Service channels

The table below lists the input registers with the scaling factors and the information as to whether the read register value is to be interpreted as signed (S) or unsigned (U)

A scaling factor of 10 means that the register value must be divided by 10 to obtain a value with a resolution of one decimal place.

Reg. No.	Reg. Adr.	Measurement value	Description	Factor	Signed / unsigned
			Status Information		
1	0	Device Identification	High Byte: Device subtype Low Byte: Software version	1	U
2	1	Device status	lower 16bit of the device status	1	U
3	2	Device-Status	upper 16bit of the device status	1	U
4	3	Status block heating	0 = Heating off 1 = Heating on	1	U
5	4	Status window heating	0 = Heating off 1 = Heating on	1	U
6	5	Status block temperature	UMB status code (see chapter 9.3.5)	1	U
7	6	Status ambient temperature	UMB status code (see chapter 9.3.5)	1	U
8	7	Status laser temperature	UMB status code (see chapter 9.3.5)	1	U
9	8	Status tilt angle	UMB status code (see chapter 9.3.5)	1	U
10	9	Status snow height	UMB status code (see chapter 9.3.5)	1	U
11	10	Status distance	UMB status code (see chapter 9.3.5)	1	U
12	11	Status normalized signal	UMB status code (see chapter 9.3.5)	1	U
13	12	reserved			
14	13	reserved			

15	14	SHM31 error code	(see chapter 13.3.3)	1	U
16	15	SHM31 error code (cur)	(see chapter 13.3.3)	1	U
17	16	Accumulated operating time	lower 16bit of attended time [sec]	1	U
18	17	Accumulated operating time	upper 16bit of attended time [sec]	1	U
19	18	System time	lower 16bit of system time [sec]	1	U
20	19	System time	upper 16bit of system time [sec]	1	U
			Standard data set metric		
21	20	Snow height mm (cur)	Range: -16000 … 16000	1	S
22	21	Block temperature °C (cur)	Range: -400 … 1000 → -40.0 … 100.0	10	S
23	22	Ambient temperature °C (cur)	Range: -500 … 1000 → -50.0 … 100.0	10	S
24	23	Laser temperature °C (cur)	Range: -600 … 800 → -60.0 … 80.0	10	S
25	24	Normalized signal	Range: 0 … 255	1	U
26	25	Tilt angle ° (cur)	Range: -1800 … 1800 → -180.0 … 180.0	10	S
27	26	SHM31 error code	Range: 0 … 255 (see chapter 13.3.3)	1	U
28	27	reserved			
29	28	reserved			
30	29	reserved			
			Standard data set imperial		
31	30	Snow height in (cur)	Range: -12598 … 12598 → -629.9 … 629.9	20	S
32	31	Block temperature °F (cur)	Range: -400 … 2120 → -40.0 … 212.0	10	S
33	32	Ambient temperature °F (cur)	Range: -580 … 2120 → -58.0 … 212.0	10	S
34	33	Laser temperature °F (cur)	Range: -760 … 1760 → -76.0 … 176.0	10	S
35	34	Normalized signal	Range: 0 … 255	1	U
36	35	Tilt angle ° (cur)	Range: -1800 … 1800 → -180.0 … 180.0	10	S
37	36	SHM31 Error-Code	Range: 0 … 255 (see chapter 13.3.3)	1	U
38	37	reserved			
39	38	reserved			
40	39	reserved			
			Distances		
41	40	Snow height mm (cur)	Range: -16000 … 16000	1	S
42	41	Snow height mm (min)	Range: -16000 … 16000	1	S
43	42	Snow height mm (max)	Range: -16000 … 16000	1	S
44	43	Snow height mm (avg)	Range: -16000 … 16000	1	S
45	44	Distance calibrated mm (cur)	Range: -500 … 21000	1	S
46	45	Distance raw mm (cur)	Range: -500 … 21000	1	S
47	46	Snow height in (cur)	Range: -12598 … 12598 → -629.9 … 629.9	20	S
48	47	Snow height in (min)	Range: -12598 … 12598 → -629.9 … 629.9	20	S
49	48	Snow height in (max)	Range: -12598 … 12598 → -629.9 … 629.9	20	S
50	49	Snow height in (avg)	Range: -12598 … 12598 → -629.9 … 629.9	20	S
51	50	Distance calibrated in (cur)	Range: -394 … 16536 → -19.7 … 826.8	20	S
52	51	Distance raw in (cur)	Range: -394 … 16536 → -19.7 … 826.8	20	S
53	52	Reference height mm	Range: 0 … 16000	1	S
54	53	Snow height mm, high resolution	Range (mit Offset 1000.0): 0 … 64000 → -1000.0 … 5400.0	10	U
55	54	reserved			
			Temperatures metric		
56	55	Block temperature °C (cur)	Range: -400 … 1000 → -40.0 … 100.0	10	S
57	56	Block temperature °C (min)	Range: -400 … 1000 → -40.0 … 100.0	10	S

58	57	Block temperature °C (max)	Range: -400 … 1000 → -40.0 … 100.0	10	S
59	58	Block temperature °C (avg)	Range: -400 … 1000 → -40.0 … 100.0	10	S
60	59	Ambient temperature °C (cur)	Range: -500 … 1000 → -50.0 … 100.0	10	S
61	60	Ambient temperature °C (min)	Range: -500 … 1000 → -50.0 … 100.0	10	S
62	61	Ambient temperature °C (max)	Range: -500 … 1000 → -50.0 … 100.0	10	S
63	62	Ambient temperature °C (avg)	Range: -500 … 1000 → -50.0 … 100.0	10	S
64	63	Laser temperature °C (cur)	Range: -600 … 800 → -60.0 … 80.0	10	S
65	64	Laser temperature °C (min)	Range: -600 … 800 → -60.0 … 80.0	10	S
66	65	Laser temperature °C (max)	Range: -600 … 800 → -60.0 … 80.0	10	S
67	66	Laser temperature °C (avg)	Range: -600 … 800 → -60.0 … 80.0	10	S
68	67	reserved			
69	68	reserved			
70	69	reserved			
			Temperatures imperial		
71	70	Block temperature °F (cur)	Range: -400 … 2120 → -40.0 … 212.0	10	S
72	71	Block temperature °F (min)	Range: -400 … 2120 → -40.0 … 212.0	10	S
73	72	Block temperature °F (max)	Range: -400 … 2120 → -40.0 … 212.0	10	S
74	73	Block temperature °F (avg)	Range: -400 … 2120 → -40.0 … 212.0	10	S
75	74	Ambient temperature °F (cur)	Range: -580 … 2120 → -58.0 … 212.0	10	S
76	75	Ambient temperature °F (min)	Range: -580 … 2120 → -58.0 … 212.0	10	S
77	76	Ambient temperature °F (max)	Range: -580 … 2120 → -58.0 … 212.0	10	S
78	77	Ambient temperature °F (avg)	Range: -580 … 2120 → -58.0 … 212.0	10	S
79	78	Laser temperature °F (cur)	Range: -760 … 1760 → -76.0 … 176.0	10	S
80	79	Laser temperature °F (min)	Range: -760 … 1760 → -76.0 … 176.0	10	S
81	80	Laser temperature °F (max)	Range: -760 … 1760 → -76.0 … 176.0	10	S
82	81	Laser temperature °F (avg)	Range: -760 … 1760 → -76.0 … 176.0	10	S
83	82	reserved			
84	83	reserved			
85	84	reserved			
			Angles		
86	85	Tilt angle ° (cur)	Range: -1800 … 1800 → -180.0 … 180.0	10	S
87	86	Tilt angle ° (min)	Range: -1800 … 1800 → -180.0 … 180.0	10	S
88	87	Tilt angle ° (max)	Range: -1800 … 1800 → -180.0 … 180.0	10	S
89	88	Tilt angle ° (avg)	Range: -1800 … 1800 → -180.0 … 180.0	10	S
90	89	X angle ° (cur)	Range: -1800 … 1800 → -180.0 … 180.0	10	S
91	90	Y angle ° (cur)	Range: -1800 … 1800 → -180.0 … 180.0	10	S
92	91	Z angle ° (cur)	Range: -1800 … 1800 → -180.0 … 180.0	10	S
93	92	Tilt angle ° Reference	Range: -1800 … 1800 → -180.0 … 180.0	10	S
94	93	reserved			
95	94	reserved			
			Logic and normalized values		
96	95	Snow flag	0: no snow 1: snow		
98	97	Normalized signal (cur)	Range: 0 … 255	1	U
99	98	Normalized signal (min)	Range: 0 … 255	1	U

100	99	Normalized signal (max)	Range: 0 … 255	1	U
101	100	Normalized signal (avg)	Range: 0 … 255	1	U
102	101	reserved			
103	102	reserved			
104	103	reserved			
105	104	reserved			
			Service channels		
106	105	Status block heating	0 = Off 1 = In 12 V mode 2 = In 24 V mode 3 = In 12 V defrost mode 4 = In 24 V defrost mode 5 = Heating disabled due to EXT_TRIG_IN 6 = Out of operation due to internal voltage control error 7= Out of operation due to incorrect config. or incorrect temperature values 0 = Heating off 1 = Heating on	1	U
107	106	Internal NTC temperature °C	Range: -400 … 1000 → -40,0 … 100,0	10	S
108	107	reserved			
109	108	Block heating defrost time sec	Range: 0 … 65535	1	U
110	109	Status window heating	0 = Off 1 = In 12 V mode 2 = In 24 V mode 3 = In 12 V defrost mode 4 = In 24 V defrost mode 5 = Heating disabled due to EXT_TRIG_IN 6 = Out of operation due to internal voltage control error 7 = Out of operation due to incorrect config. or incorrect temperature values	1	U
111	110	External NTC temperature °C	Range: -500 … 1000 → -50,0 … 100,0	10	S
112	111	reserved			
113	112	Window heating defrost time sec	Range: 0 … 65535	1	U
114	113	Laser gain code	Range: 0 … 255	1	U
115	114	Laser signal intensity (µV)		0,1	S
116	115	Laser distance mm	Range: 0 … 32000	1	U
117	116	Laser temperature °C	Range: -600 … 8000 → -60,0 … 80,0	10	S
118	117	Operating voltage V	Range: -400 … 400 → -40.0 … 40.0	10	S
119	118	reserved			
120	119	reserved			

12. Checking the signal quality

(Instructions for using the target plate set 8365.KWK-SET)

The sensor's signal quality can be checked at the measuring location with the help of the target plate set. The set consists of the following DIN A4-sized, high-quality plastic plates:

- White card 8365.KWK-WS in protective cover, approx. 85% reflectance
- Black card 8365.KWK-SW in protective cover, approx. 6% reflectance

The card can be cleaned with water and some washing-up liquid. Please do not use any harsh cleaning products or solvents.

Remove residual moisture or residues of cleaning products with a lint-free cotton cloth.

12.1. Application

The target plates enable users of snow depth sensors to check the respective sensors' signal intensity. Here, the signal intensity can be tested with the distance as a function of the target plates and different reflectivities. The curves in Figure 30 show the different signal intensities determined with different target plates, including the white card 8365.KWK-WS and the black card 8365.KWK-SW.

The reflectivity of the white and black target plates corresponds to the light and dark targets that are stored in the sensor for five different distances during factory normalisation.

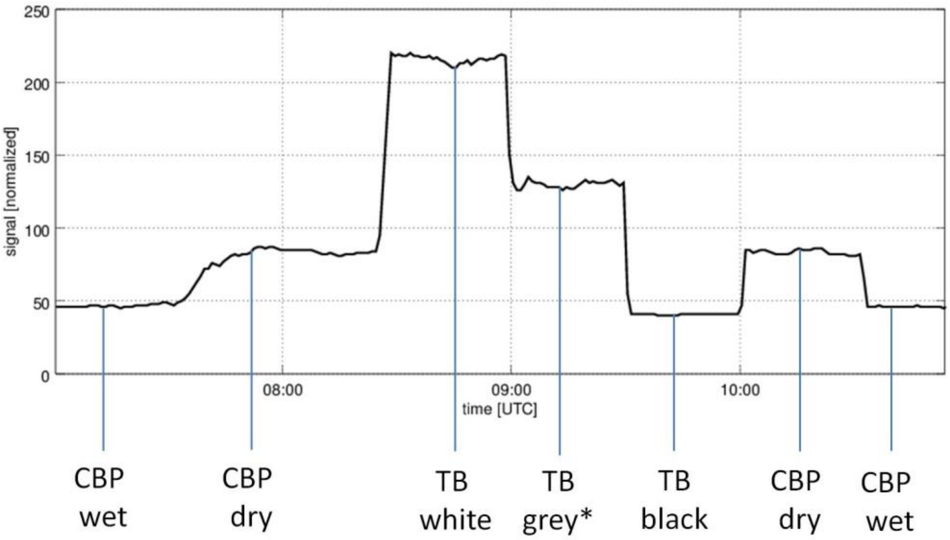


Figure 30: Variation of the signal intensity using different target plates. BP: Base plate, TP: Target plate

A basic measurement setup is shown in Figure 31.

Figure 31: Checking the signal quality with the white card 8365.KWK-WS

The measurements shown in Figure 30 were obtained with the measurement setup shown in Figure 31.

The domain for the signal intensity (signal normalised) is between 0 and 255. The sensors are set to achieve a value of approximately 50 for the black plate and 200 for the white plate. The exact values for the calibration are documented in the factory certificate.

In this sample measurement, these values were compared with the measured values on the concrete slab in dry and wet conditions. Another card with a 50% reflectance was also used.

The SHM 31 sensors' tolerances in signal intensity are in the order of 20%. This allows a rough distinction to be made between a dark surface (grass, asphalt) and snow coverage. The threshold is stored in the sensor at 130 as the default value and can be adjusted if necessary. The 'snow flag' = 1 is set above the threshold. It is zero below the threshold.

If the user suspects that the sensor is no longer measuring adequately due to ageing or for other reasons, the procedure described here provides a test option that is easy to carry out.

13. Service, maintenance and technical support

13.1. Firmware update

To keep the sensor up to date with the latest technology, we recommend regularly checking whether new firmware is available for the SHM 31 sensor. You can obtain the firmware from lufft.com/en-gb/downloads.
You can conveniently perform the firmware update on site with the UMB ConfigTool.NET software. Simply follow the steps below:

1. Download the sensor firmware

2. Launch ConfigTool.NET and switch to the 'Workspace Details' menu

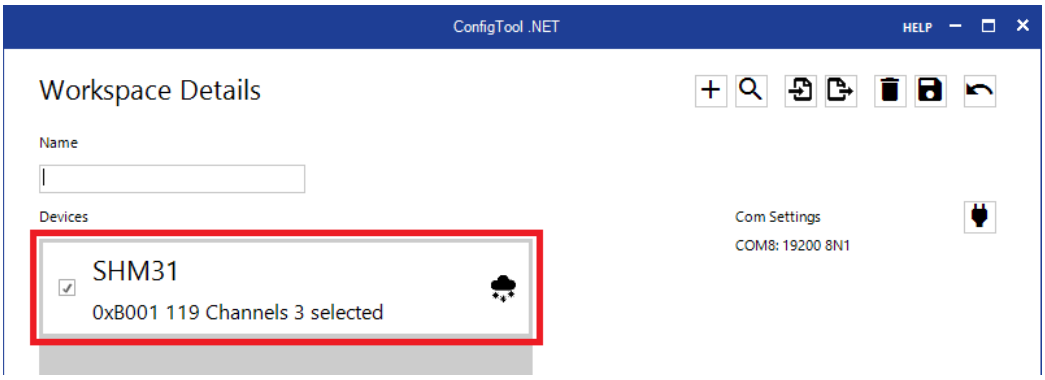


Figure 32: Select a device

3. Select SHM 31 from the list of devices (Figure 32)

4. Click on the update icon and select the downloaded firmware file in the 'Firmware Update' window. Then click on 'Update' (Figure 33)

   Note: If 'Restart' is not highlighted, only the firmware is transferred, but the sensor does not work with the new firmware yet.

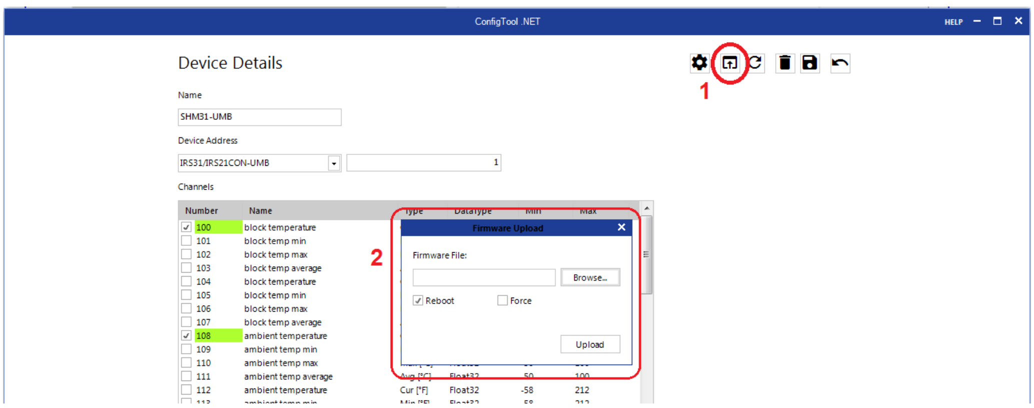


Figure 33: Performing a firmware update

13.2. Maintenance

Note: Switch off the power to the snow depth sensor during maintenance / cleaning!

Cleaning the front pane

If the glass pane of the transmitter / receiver is dirty, clean it with a damp, wrung-out cloth. Then dry the panes with a dry, lint-free cotton cloth.

Also remove dust and dirt from the housing.

Do not use solvents such as cleaning solvent, thinner, alcohol, kitchen cleaners, etc., to clean the sensor, as these products can damage the housing and the optical parts.

If you use a chemical cleaning cloth, be sure to follow the accompanying instructions.

13.3. Faults

13.3.1. Possible indications of error on the snow depth sensor

Description of error	Cause and remedy
The device cannot be queried or is not responding	• Check the supply voltage • Check the cable • Check the interface connection. If necessary, use the RS232 interface to determine whether the error is only with the RS485 interface.
The device provides implausible values	• Check whether the assembly instructions were followed when attaching the sensor • Check the reference values; see the 'Checking the signal quality' section

13.3.2. Potential interferences that may affect correct functioning

- The snow depth sensor's transmitting and receiving window is dirty.
  A reflective surface / icy surface is reflecting most of the laser beam. This may also mean that the laser beam is reflected back into the laser when the sensor is assembled vertically. This can also lead to an error message.
- The target is ambiguous, e.g. due to a water column on the substrate

13.3.3. Error codes

The status codes for the SHM 31 snow depth sensor can be retrieved in the UMB channels 4100 and 4101. The status is also output in the UMB-ASCII 2.0 data telegram.

The codes are based on those of the SHM 30 snow depth sensor and have been specifically expanded.

Error codes	Description
E15	Laser: Signal too weak; distance too short
E16	Laser: Signal too strong (mirror reflection effect)
E17	Laser: Background light level too strong
E18	Laser: Measurement disturbed (precipitation, movement, etc.)
E19	Laser switched off due to too many timeouts
E20	Laser communication error (unknown command)
E21	Laser communication error (interface)
E22	Laser communication error (invalid response)
E23	Laser temperature below -15°C
E24	Laser temperature above +50°C
E31	Hardware error; EEPROM checksum incorrect (sensor must be sent in for repair)
E32	Laser: Hardware error; EEPROM checksum incorrect (sensor must be sent in for repair)
E51	Laser: APD power failure (scattered light or hardware error)
E52	Laser current too high; defective laser (sensor must be sent in for repair)
E53	Mathematics (division by 0)
E54	Laser: Hardware error (sensor must be sent in for repair)
E55	Hardware error (sensor must be sent in for repair)

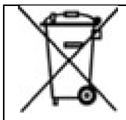
Error codes	Description
E61	Hardware error in the interface
E62	Incorrect value in the interface communication (SIO parity error)
E63	SIO overflow; check time for output signals in application software
E64	SIO framing error; serial interface parameter not set correctly to 8N1
E65	Evaluation routine: In some cases, measurements in the calculation interval were ignored because they would have exceeded the maximum permitted change in snow depth.
E66	Evaluation routine: The most recently valid snow depth was output, as all measurements in the calculation interval would have exceeded the maximum permitted snow depth change.
E67	Measurement was cancelled by ‘MEN’
E68	No valid telegram available yet (e.g. after starting the measurement with ‘MST’)
E70	Evaluation routine could not read settings
E71	Evaluation routine has not received any data from the laser
E72	Evaluation routine has no valid laser temperature values
E73	Evaluation routine has no valid block temperature values
E74	Evaluation routine has no valid outside temperature values
E75	Evaluation routine has no valid laser distance measurement values
E76	Evaluation routine: G-sensor vector is an invalid length
E77	Evaluation routine is using the reference angle, as the current angle is invalid
E78	Evaluation routine: Signal calibration: signal_high <= signal_low
E79	Evaluation routine: Signal calibration: Signal too small
E80	Evaluation routine: Signal calibration: Signal too large
E81	Evaluation routine: Signal calibration: no angle correction, as angle > 90 degrees
E82	Evaluation routine: channel_average_count too large
E83	Evaluation routine could not initialise ring buffer for avg / min / max channels

Table 30: Error codes

13.4. UMB status codes

The UMB status codes are also used for error and status analysis. A description can be found in the general UMB description.

13.5. Disposal information – within the EU

	The device must be disposed of in accordance with European Directive 2012/19/EU and national regulations. Electrical devices marked with this symbol must not be disposed of in European household or public waste disposal systems. Return old or used devices to the manufacturer for disposal free of charge.

13.6. Disposal information – outside the EU

Please observe the respective country's local regulations governing the proper disposal of waste electrical and electronic equipment.

13.7. Repair / maintenance

Only have a defective device checked and, if necessary, repaired by the manufacturer. Do not open the device or attempt to repair it yourself.

If the device needs repaired, please contact your local sales representative or

OTT HydroMet Fellbach GmbH

Gutenbergstrasse 20
70736 Fellbach

PO Box 4252
70719 Fellbach

Germany

Tel.: +49 711 51822-0

Email: met-repair@otthydromet.com

13.8. Technical support

If you have any technical questions, please contact our hotline on the following email address:

Email: met-support@otthydromet.com

an OTT HydroMet brand