SHM 30
Snow Depth Sensor

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Dear user,

please read the following information about the operation of the SHM 30 snow depth sensor carefully before you start to operate the device. By complying with the advice contained in this manual, optimum use of the functions can be made and damages caused by operational errors can be prevented.

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Date	Revision	Comment
August 2015	Revision F0	Lufft design
January 2014	Revision E0	Error codes updated in 5.1 & 8.1

CE

Note

1 Introduction

This User Manual provides the information that is required to operate the SHM 30 Snow Depth Sensor. The manual consists of eight chapters, each page indicating the chapter title in its headline. The bottom line of each page contains the revision state, date of issue and page number.

1.1 Intended Use

Operating safety can only be guaranteed when the SHM 30 snow depth sensor is operated as intended and in accordance with the information contained in this manual.

- Measuring distances to targets
- Determination of snow depth from a distance measurement to the snow surface
- Compliance with prescribed temperatures for measuring and storage
- Operation of correct voltage level: 15 V to 24 V direct voltage (SELV) for full operating temperature range, 10 to 30 V (SELV) for a limited operating temperature range without heater.
- Scheduled cleaning and maintenance cycles must be observed (refer to chapter 8.2)
- Installation and alignment of the SHM 30 sensor shall be conducted in a manner to avoid any laser irradiation of people at any time.
- For the transportation or shipping the user is advised to use the original transportation package designed for the SHM 30 sensor (refer to chapter 4). Exception: In case of a service issue in which it is clear that the error stems from the measuring module, the module should only be sent back to a Lufft facility. Please ship the module as shown in figure 30 in a suitable small package to avoid any transportation damage of the cover.

1.2 Mode of operation

The SHM 30 snow depth sensor emits modulated visible laser light and determines the distance to an object by comparing phase information. To calculate snow depths automatically the user can first perform a zero level measurement, which is stored as offset value in the instrument. A manual offset value for existing snow depths can also be set.

Unwanted measurement results, e.g. hard targets from snow flakes, are filtered out using a plausibility method and the measuring time.

The SHM 30 allows the operation in automatic and polling mode for the digital output. Furthermore an analog current output is available for the snow depth.

The timing parameter "xt" (refer to table 16) defines the sequence of measurements. “xt” shall be always larger than the real internal measuring time, which is in general 6.5 s plus sufficient time needed to transmit the data telegram and communicate with the sensor. Due to the serial sequence of command processing a sensor communication throughout the measuring process is not available.

In the automatic measuring mode the sensor transmits its telegram after each measurement, while in polling mode it renews its measuring data in an internal buffer. The user can query for the snow depth telegram as often as wanted using the command "xw" to receive the latest telegram.

In all modes the user can tilt the sensor and correct its position using a zenith-angle „sp“. Additionally the unit of measured values can be changed from meters (default) to e.g. ft by changing the parameter scale factor „sf“.

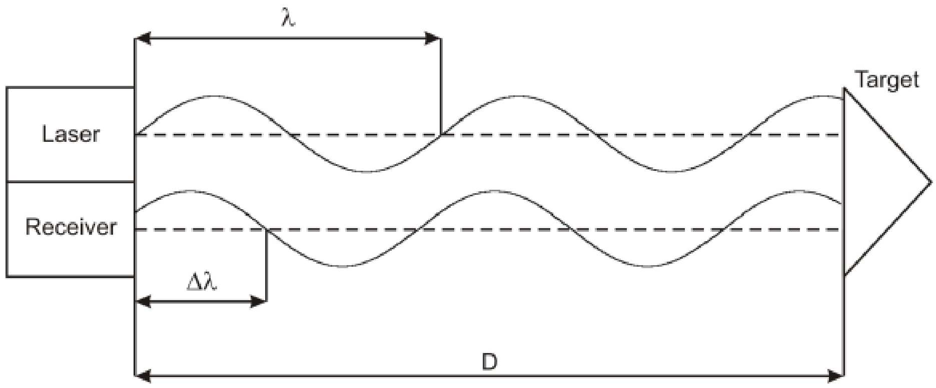

Fig. 1: Measuring principle SHM 30

Figure 1 illustrates the measuring principle. A single measurement is done within 0.25 s including time for data handling. The snow depth sensor is analysing the intensity of waves (signal strength) and the number of waves and the vector to get a precise measurement. The precise distance is determined by using 5 different frequencies. The repetition of measurements provides a higher accuracy on difficult targets, or during precipitation events. For snow depth measurements, the longest time interval (average over 25 measurements à 0.25 s) is selected, that the sensor can measure in order to filter out noise effectively.

2 Safety and Labels

2.1 Safety Labelling

DANGER
Laser hazard

DANGER
Electrical hazard

CAUTION
Warning of potential damage

CAUTION
Warning of hot surface

NOTE
Important note

NOTE
Important note regarding environmental protection

2.2 Standards & Directives

To guarantee the safe operation of laser devices, all binding standards, directives and instructions regarding laser safety and laser radiation protection must be observed by manufacturers and users (refer to Declaration of Conformity).

The SHM 30 Snow Depth Sensor is built and tested for compliance with the following standards and directives:

1. Council Directive 2004/108/EC
   on the harmonisation of the laws of the Member States relating to electromagnetic compatibility (EMC), conforming to EN 61326 standard requirements.
2. In accordance with IEC/ EN 60825-1:2007 and in terms of inherent risk potential, the SHM 30 qualifies as a class 2 laser device.

2.3 General Safety Measures

- **All safety notes in this User Manual, including any other applicable documents, must be duly observed and followed.**
- **Caution - Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure!**

- **This User Manual must be kept within easy reach of personnel at all times.**
- **The SHM 30 Snow Depth Sensor shall be powered by a safety extra low voltage source "SELV". It has to be ensured that under normal conditions the voltage does not exceed 30 VDC and in case of a first malfunction 70 VDC.**

- **Don't open the inner sensor housing (with the label „LDM 30.11"). There is a serious danger of laser radiation or electrical shock. Unauthorized intervention into the inner product will void any warranty claims.**
- **Cable connectors must not be plugged or unplugged, as long as voltage is supplied.**

2.4 Laser Classification

SHM 30 is a laser class 2 product as defined in the standard IEC 60825-1:2007 and a class II product under 21CFR1040.10. In case of an accidental short time laser exposure, the human eye is sufficiently protected by its own blink reflex and by turning away off the head. This natural reflex may be impaired by medication, alcohol and drugs. Although the product can be operated without taking special safety precautions, one should refrain from directly looking into the laser beam.

Caution: Class 2 laser radiation! Maximum laser power <1mW, wavelength 650 nm (red laser light).
Do not direct the laser beam onto persons! Do not look into the beam!

2.5 Requirements on Personnel

- The SHM 30 shall only be installed and commissioned by properly trained personnel having completely read and understood this Manual.
- Personnel working with the SHM 30 shall not be in a state of fatigue or under the influence of alcohol or medication or have physical impairments of any kind that might temporarily or lastingly restrict their attention or judgement.

2.6 Safety Notes Regarding Transportation, Installation, Commissioning & Cleaning

- For handling, shipment or transportation, the SHM 30 must be duly packaged and placed in the transporting position.
- The SHM 30 requires a suitable mast or crossbeam where it can be fixed using one of its mounting clamps. The typical inclination angle of the mounting base should be 10° or 20°.
- The assembly site shall be secured to allow measurements in undisturbed conditions and to fulfil local laser safety guidelines.

2.7 SHM 30 - Labelling

Fig. 2: Label at bottom side of SHM 30

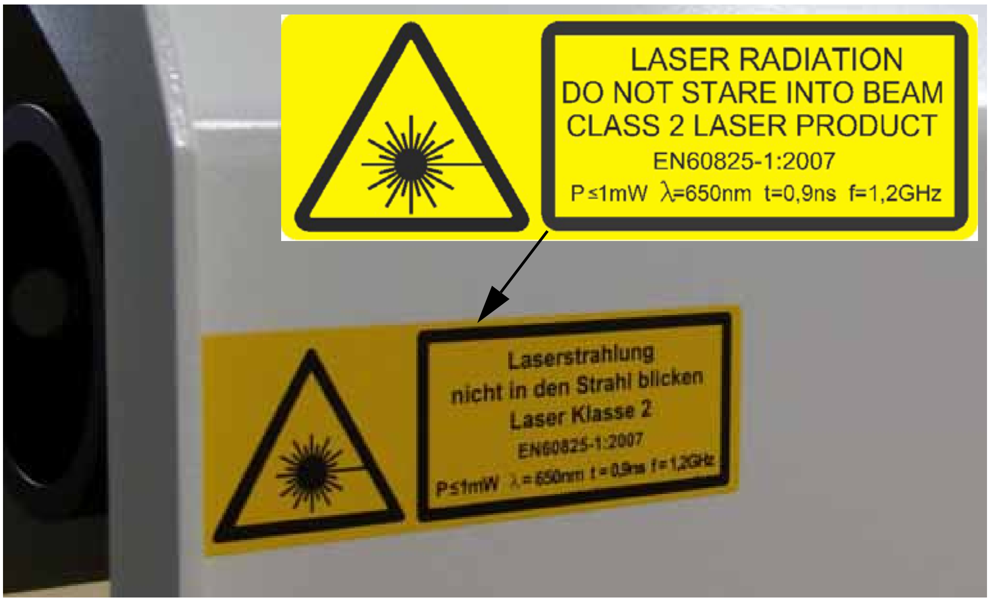

Fig. 3: Laser warning label at left side of SHM 30 in English (standard) or German

Fig. 4: Laser exit

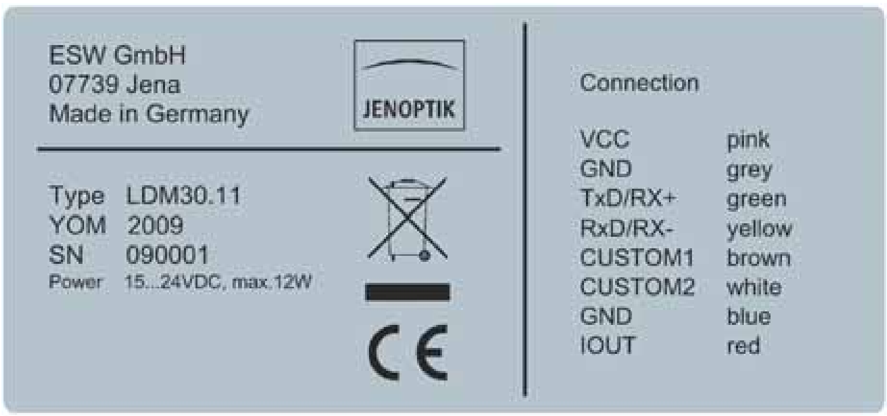

Fig. 5: Type label on inner housing.
The label is fixed on the right side of housing (see Fig. 16).

3 Technical Data

3.1 Specification

Device versions	Description	Part number
SHM 30.11	RS232, 10 m cable length	8365.10
SHM3 0.11H	RS232, heater off option, 10 m cable	8365.11
SHM 30.21	RS422, 10 m cable	8365.20
SHM 30.21D	RS422, 5 m cable, special firmware settings	8365.50

Table 1: SHM device versions, description & part numbers

Accessories	Part number
Mounting clamp with a steel band - specified in length for mast with a diameter of 80 mm	8365.608-11
Mounting clamp with a steel band - for all masts with a diameter up to 300 mm (can be shorten by the user)	8365.609-11
Mounting clamp for all mast with a diameter up to 72 mm consisting of two opposing metal tongs, which are connected by threaded rods	8365.610-11
Power supply 24 Vdc, 2.5A	
Customer documentation (hardcopy)	

Table 2: Accessories, mounting clamps & part numbers

Device versions	Description	Part number
LDM 30.11	spare parts module for SHM 30.11	8365.630-26
LDM 30.11H	spare parts module for SHM 30.11H	8365.631-26
LDM 30.21	spare parts module for SHM 30.21	8365.632-26
LDM 30.21D	spare parts module for SHM 30.21D	8365.644-26

Table 3: Spare parts, description & part numbers

Laser parameter	
Laser:	650 nm laser diode (red light)
Laser class:	laser class 2, conforming to standard IEC825-1/EN60825, class II (FDA21 CFR)
Output power:	< 1 mW
Laser divergence:	0.6 mrad
Beam diameter:	< 11 mm at 10 m distance

Table 4: Laser parameter

Measuring parameter: Snow depth	
Snow depth	0 ... 10 m
Measuring accuracy on snow (95% statistical spread)	< ± 5 mm
Programmable measuring interval	1 ... 600 s
Reproducibility	≤ 0.5 mm
Time for single measurement (ST25)	6.5 s
Measured distance resolution	0.1 mm
Signal strength (white target with 85 % - 90 % reflectivity)	10 ± 3 (in measuring range 0.8 - 10 m)
Signal strength (black target with 5 % - 7 % reflectivity)	1 ± 0.5 (in measuring range 0.8 - 10 m)

Table 5: Measuring parameter: Snow depth and signal strength

Measuring parameter: Distance to hard targets	
Distance range (on natural diffuse reflecting surfaces, without extra stray light protection)	0.1 ... 30 m
Measuring time, selectable with parameter “st”; st=[1,25]	0.16 ... 6.5 s

Table 6: Measuring parameter: Distance to hard targets

Electrical parameters	
Power consumption	0.5 ...1 W (without heating) < 24 W (max. with heating @ 24 VDC)
Power supply	10 ... 30 VDC (without heating) 15 ... 24 VDC (with heating)
Heating activity (programmable):	default on: <2 °C, off >4 °C

Table 7: Electrical parameters

Safety & environmental parameters	
Environmental conditions	ISO 10109-11
Internal protection	IP 65
EMC	EN 61326-1:2006
Safety requirements for electrical equipment	EN 61010-1:2001
Temperature range	-40 °C ... +50 °C
Relative humidity	0 % ... 100 %

Table 8: Safety & environmental parameters

Data connection	
RS232 / RS422: connection parameter	9600 Baud, 8N1, Handshaking none
Polling mode: time delay between query and “start-bit” from reply	standard: 300 µs (no measurement) during a measurement: up to 6.5 s, refer table 21
transmission time of data telegram	30 ms @ 9600 Baud

Table 9: Data connection

Dimensions and weight	
Dimensions Sensor (L × W × H)	303 mm × 130 mm × 234 mm
Weight sensor	2.5 kg
Weight mounting clamp	0.7 kg
Transportation package (L x W x H)	440 mm x 290 mm x 250 mm
Weight Transportation package	5.4 kg

Table 10: Dimensions and weight

3.2 Dimensions

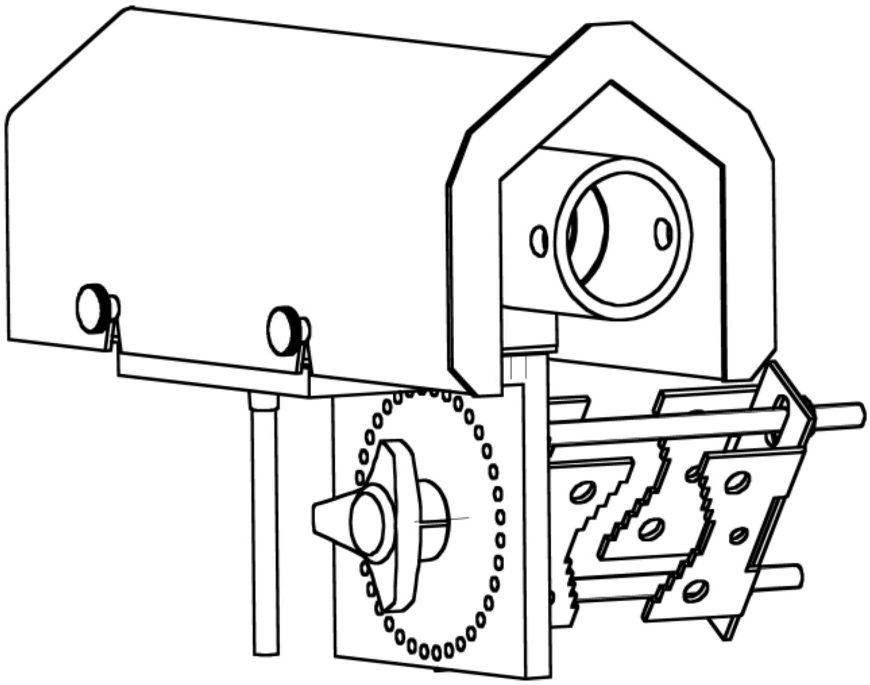

Fig. 6: 3D-Construction model SHM 30

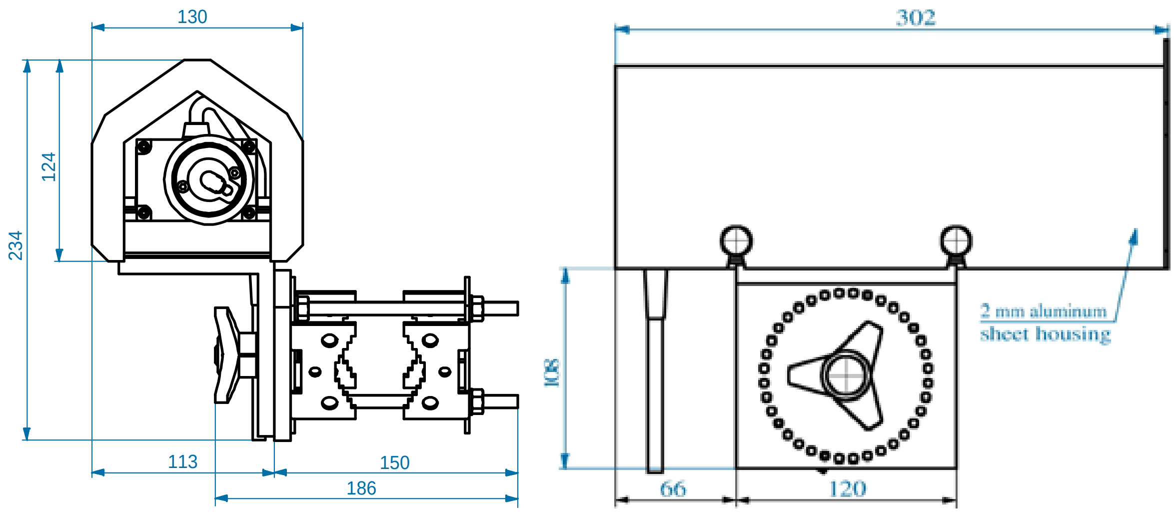

Fig. 7: Dimensions SHM 30

3.3 Interface Cable

The interface cable is selected to withstand harsh environmental conditions.
Caution: Bare cable ends! The user is responsible to take precautions to prevent any kind of shorts.

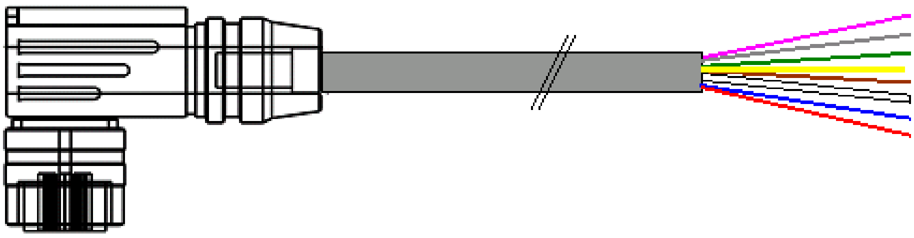

Fig. 8: Interface cable SHM 30 with AWG24 wires (4 x 2 x 0.25 mm²)

Color code 8 wires interface cable	SHM 30 standard	Pin on 12-pole Binder connector
pink	VCC	G
grey	GND-VCC	J
green	TxD	A
yellow	RxD	B
brown	Custom1	E
white	Custom2	F
blue	GND-RS232, GND-Iout	L
red	Iout	D

Table 11: Color code description of interface cable with RS232 connector, devices: 8365.10 / 8365.11

Color code 8 wires interface cable	**SHM 30 standard**	**Pin on 12-pole Binder connector**
pink	VCC	G
grey	GND-VCC	J
green	Rx+	A
yellow	Rx-	B
brown	Tx-	E
white	Tx+	F
blue	GND-Iout	L
red	Iout	D

Table 12: Color code description interface cable with RS 422 connector, devices: 8365.20 / 8365.50

If the user is working in analog measuring mode with open RS232 wires a termination shall be connected (see Fig. 9).

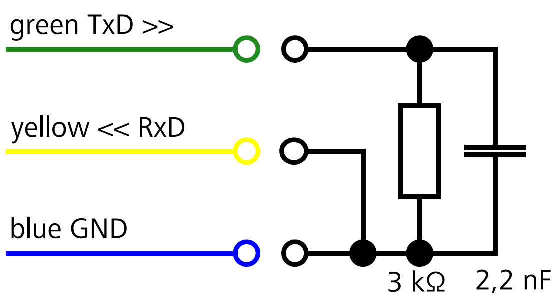

Fig. 9: Recommended cable termination for digital wires in pure analog measuring mode
when TxD/Rx+, RxD/ Rx- are not connected.

The cable length for RS232 connections is limited at a transmission speed of 19200 baud to 15 m in length. For longer cables to use the RS422 interface is recommended. When cable lengths of > 20 m are required the voltage loss has to be taken into account! A separate cable for the power supply or a nearby power supply has to be considered.

3.4 SHM 30 with "heater off" option

The SHM 30 "8365.11" has an additional heater off option.

The user must apply a 5 to 24 VDC to the brown "CUSTOM1" wire to switch on the internal heater function mode. A supplied voltage between 0 to 0.4 VDC or a disconnected "CUSTOM1" wire, switches off the internal heater permanently.

The function was integrated to prevent battery powered systems from discharge.

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Color code 8 wires interface cable	**SHM 30 standard**	**Pin on 12-pole Binder connector**
pink	VCC	G
grey	GND	J
green	TxD	A
yellow	RxD	B
brown	Heater on	E
white	Custom2	F
blue	GND	L
red	Iout	D

Table 13: Color code description interface cable with “heater off” option

3.5 Power consumption

The SHM 30 power consumption is about 500 mW (19 -25 mA, 24 V) in standard operation mode without the build in heater. The exact value depends on the duty cycle (laser on / laser off) selected by the user.

The maximum power consumption is 24 W at 24 VDC voltage supply mainly used by the build in heater, which is needed to keep the laser diode above -10 degree Celsius. The heater operates continuously at temperatures close to -40 °C.
The main reason to heat the laser diode at low temperatures is to increase its lifetime / work within the specs over years.

4 Scope of delivery

Figure 10 shows the scope of delivery of the Snow Depth Sensor SHM 30. The different types of the sensor 8365.10, 8365.11, 8365.20 and 8365.50 will be packed similarly.

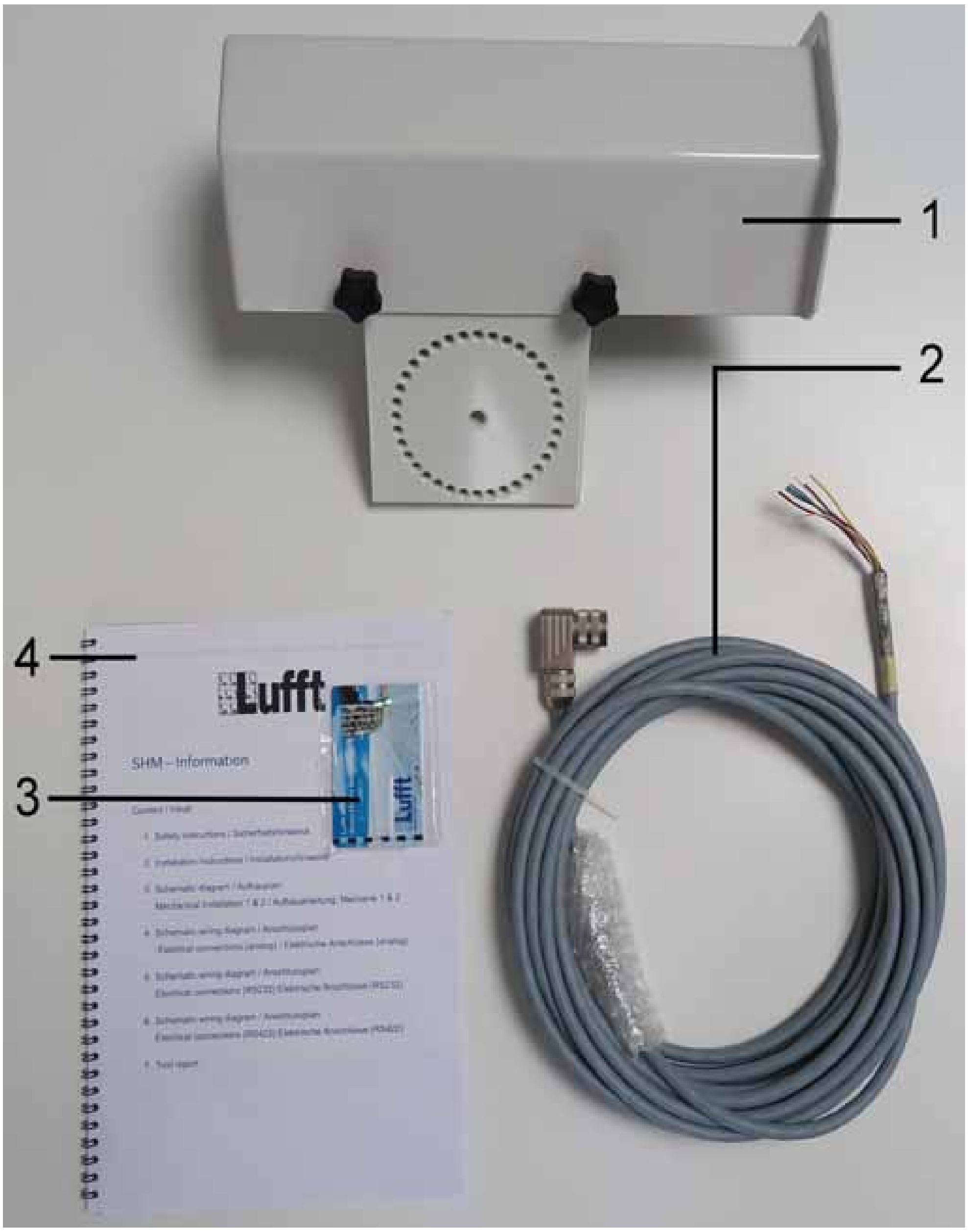


Fig. 10: Scope of delivery

1. SHM 30 Snow Depth Sensor
2. Interface cable - length of 10m (standardized, other cable lengths available)
3. USB stick (Software and Manual)
4. Setup instructions and sensor protocol

4.1 Mounting clamps

The basic snow depth sensor SHM 30 doesn't contain any mounting clamp. It is possible to order one of three kinds of mounting clamps, additional. Each mounting clamp contains a counterpart to the punched disk defining the installation angle. The following three pictures show the different types of the mounting clamps with the order number.

Fig. 11: Mounting clamp (8365.610-11) - standard - for mast Ø <72 mm

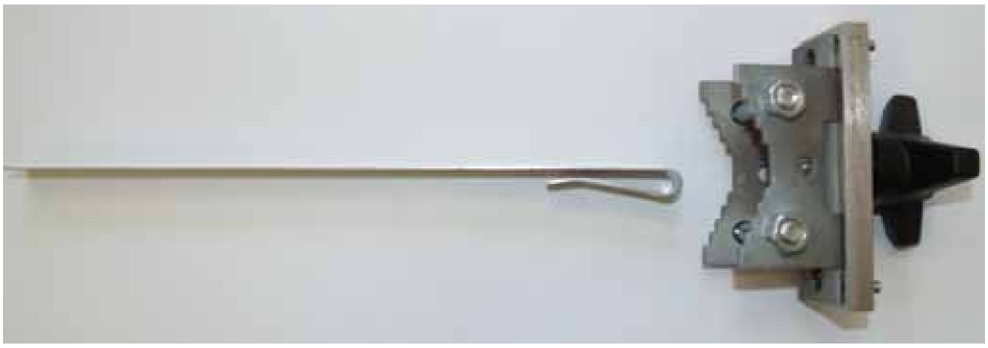


Fig. 12: Mounting clamp (8365.608-11) specified for mast with a Ø 80 mm.

Fig. 13: Mounting clamp (8365.609-11) for masts to Ø 300 mm
(can be shorten by the user)

4.2 Packing Sequence

The following pictures show the packing sequence of the SHM 30 without any mounting clamp.

Fig. 14: Package content: Fully packed (left), SHM 30 (right)

Fig. 15: Package content: Interface cable 10 m (left),
USB stick and setup instructions and sensor protocol (right)

In general it is not necessary to dismount the full sensor from its installation place in service cases. It is sufficient to dismount just the sensor module, like it is shown in figure 30. Mounting clamp, housing, cable can be left on site.

4.3 Accessories

These components can be ordered upon request:

1. Power supply 24 VDC for rail mounting
2. Special cable lengths (5 m, 10 m, 20 m)
3. White, black, grey standard reflection targets to test the signal strength
4. PC with terminal software for sensor communication

5 Installation and Start-up

The SHM 30 provides an identification plate where electrical parameter and single strands from the data cable are described. The standard data interface is RS232. Beside the digital interface output an analog 4 mA - 20 mA current output for snow depth measurements is available.

The snow depth sensor is connected by a combined power and data cables (see figure 16 and chapter 3.3). The power supply is limited to values between 15 VDC and 24 VDC due to the installed heating. This is necessary to operate the sensor within the specified temperature range. The less restricted voltage range without heating activities is 10 - 30 VDC. It can be used for indoor tests or whenever the heater is switched off manually.

The pictures 16 and 17 show the installation of the sensor with different mounting clamps. The sensor SHM 30 shall be fixed in 2 m - 5 m height on a suitable mast.

Fig. 16: Cable installation and mounting clamp 8365.610-11

The sensor should be mounted tilted away from the sun (Figure 18). An inclination angle between 10° and 30° (0° corresponds to vertical assembly) shall be foreseen when the sensor is mounted.

The main reason is that icicles and droplets falling from the installation mast or sensor itself may affect the real snow depth just below the sensor.

Wind shield or local thermal heating effects cause by the mast can also be avoided by pointing the sensor away from the mast. Direct sun light may lead to an E15 or E17 error if reflected sun-light from snow surface hits the sensor. In critical regions it may help to point the sensor, e.g. in the north direction (Fig. 18).

Part of the mounting piece is the punched disk with a fixed 10° pattern allowing an easy and fast installation. For typical usage this pattern is precise enough to be directly used as inclination angle. If the mounting of the clamp to the mast can't be fixed precisely or the mast itself is crooked the total installation angle has to be measured, see also chapter 6 for further instructions. In any case the installation angle must be communicated to the SHM 30 using a terminal program with the command "sp". The sensor needs this value to be able to correct the distance measurement.

Fig. 17: Installation of mounting clamp 8365.608-11 or 8365.609-11

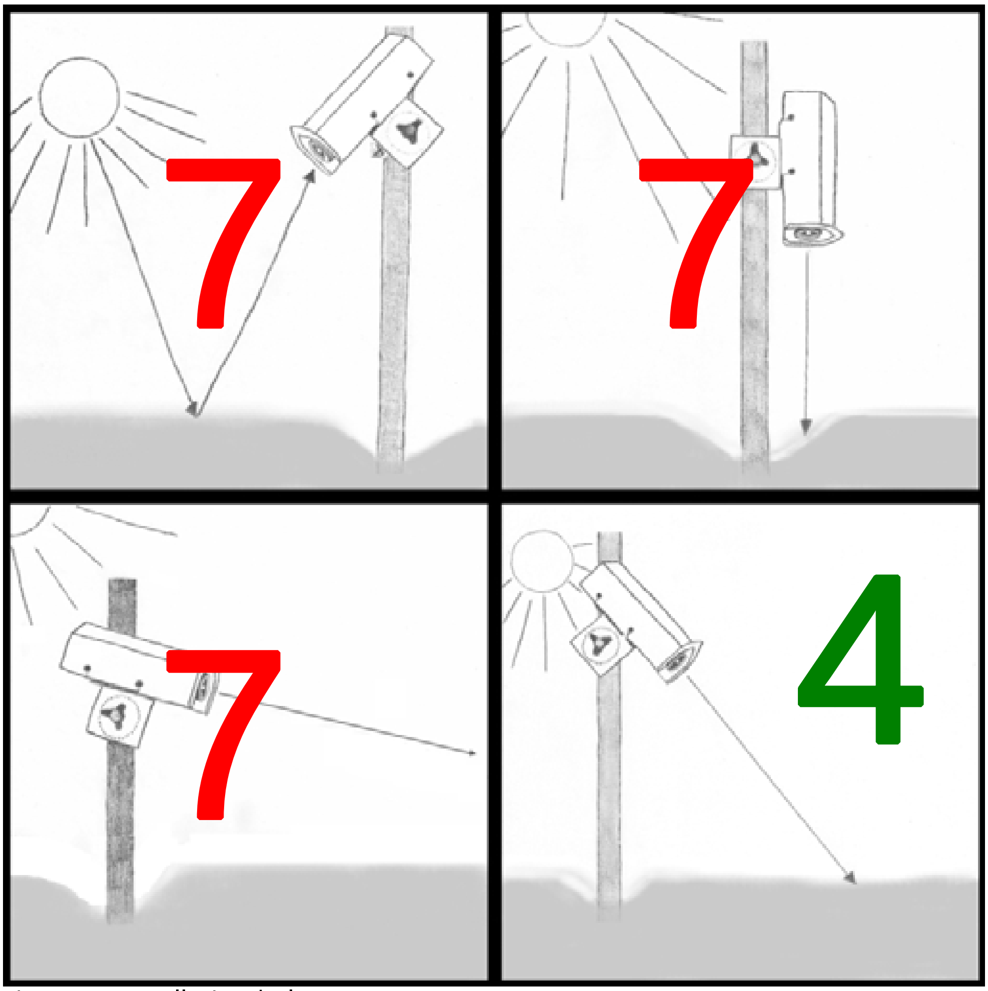


Fig. 18: Installation help

The best performance is achieved with an installation angle between 10° and 20°.

5.1 Data Configuration & Communication

After the supply voltage is connected the sensors starts automatically loading the last parameter set. The factory defaults parameter set, shown in table 16, is used after the first successful installation.

To be able to configure the instrument the serial interface RS232 or RS422 has to be connected. Any terminal program can be used to set and query data. Standard terminal programs are for example Hyper Terminal or Bray's Terminal.

- Standard configuration for the COM Port:
  9600 Baud, 8N1, Handshake none

If the initialization of the serial port/ telegram format is set incorrectly the sensor answers with error codes “E62” to “E64”!

The sensor status can be queried using the following commands:

- Command “**id**” shows sensor commands, software release and serial number (table 15).
- “**pa**” shows preset values (table 14).

Commands can be entered as lower or upper case letters. All commands have to be finished with <CR> <LF>; <CR> or <LF>. The sensor replies simple commands with the command itself and the value, e.g. the command “xt” will be answered with xt25.

Notes on specific firmware releases:

- In query mode up to firmware 9.06 communication interruptions were observed with upper case letters.
- Firmware <9.05 only! Before configuring the sensor the measurement mode should be interrupted using the ”ESC” command by pressing the keyboard or sending the command via script. Without stopping the error E65, may occur, see table 21.
- Firmware ≥9.05: Any data query or setting command will be accepted by the firmware within the measuring process without generating E65. The telegram will be transferred or the new value will be set after the measurement is done.

Users with limitations to reply time like data loggers are requested to poll the instrument again after a delay of 6.5 s the standard measuring time. The standard time delay between a stop-bit from a query process to the first bit from reply will be within 30 ± 5 µs. The full telegram is transferred within 30 ms outside a measurement process.

```
autostart command[AS]..................xm
baud rate[BR]..........................9600
heating on[HO].........................2
heating off[HF]........................4
distance offset[OF]...................0
distance of Iout=4mA [RB].............-5
distance of Iout=20mA [RE]............5
average value[SA].....................1
telegram format[SD]...................a
error mode[SE]........................1
scale factor[SF]......................1
tilt angle[SP]........................0
transmit result[SR]...................n
measure time[ST]......................25
reflectivity bright target A [SHA].....15.6695
reflectivity bright target B [SHB].....20.5645
reflectivity bright target C [SHC].....10.7353
reflectivity bright target D [SHD].....14.5077
reflectivity bright target E [SHE].....4.14621
reflectivity dark target A [SLA].......0.729548
reflectivity dark target B [SLB].......1.56198
reflectivity dark target C [SLC].......1.09263
reflectivity dark target D [SLD].......1.4683
reflectivity dark target E [SLE].......0.428003
measurement sequence[XT]..............59
max change between 2 measurements[XP]..10
memory 1 [M1].........................
memory 2 [M2].........................
memory 3 [M3].........................
memory 4 [M4].........................
memory 5 [M5].........................
memory 6 [M6].........................
memory 7 [M7].........................
memory 8 [M8].........................
```

Table 14: "PA" example output for a parameters set in firmware 9.09.
In older firmware releases the user memory Md wasn't available and the reflectivity value was only set for a single distance (Shd, SLd).

```
SHM30, SN 080880, V 9.09
Measurement Commands:
XM[Enter]....................start measurement snow height
XW[Enter]....................display snow height and signal power
DM[Enter]....................distance measurement
DS[Enter]....................distance tracking 7m
DT[Enter]....................distance tracking
DW[Enter]....................distance tracking with cooperative target (10Hz)
Some useful commands:
LO[Enter]....................laser on
LF[Enter]....................laser off
MR[Enter]....................display all memory
SLd#[Enter]..................set reflectivity of dark target d=[a/b/c/d/e]
SHd#[Enter]..................set reflectivity of bright target d=[a/b/c/d/e]
SO[Enter]....................set current distance to offset (offset = - distance)
TP[Enter]....................internal temperature [°C]
Settings:
AS[Enter] / ASd[Enter]........display/set autostart command [DM/DS/DT/DW/TP/LO/ID/
XM]
BR[Enter] / BRx[Enter]........display/set baud rate [2400..38400]
HO[Enter] / HOx[Enter]........display/set temperature of heating on [-40°C ... +70°C]
HF[Enter] / HFx[Enter]........display/set temperature of heating off[-40°C ... +70°C]
Mx[Enter] / Mxd[Enter]........display/set memory x [1...8] [1 ... 10 ASCII-characters]
OF[Enter] / OFx.x[Enter]......display/set distance offset
RB[Enter] / RBx.x[Enter]......display/set distance of Iout=4mA
RE[Enter] / REx.x[Enter]......display/set distance of Iout=20mA
SA[Enter] / SAx[Enter]........display/set average value [1...20]
SD[Enter] / SDd[Enter]........display/set telegram format d=[a/b]
SE[Enter] / SEx[Enter]........display/set error mode [0/1/2]
                              0..Iout=const., ALARM=const.
                              1..Iout: 3mA @RE>RB, 21mA @RE<RB, ON@AH<0
                              2..Iout: 21mA @RE>RB, 3mA @RE<RB, OFF@AH<0
SF[Enter] / SFx.x[Enter]......display/set scale factor
SP[Enter] / SPx.x[Enter]......display/set tilt angle [0.0°...90.0°]
SR[Enter] / SRd[Enter]........display/set transmit result with each measurement [y/n]
ST[Enter] / STx[Enter]........display/set measure time [0...25]
XT[Enter] / XTx[Enter]........display/set measurement sequence [1 ... 600s]
XP[Enter] / XPx.x[Enter]......display/set max. allowed change in snow height between
two measurements
PA[Enter]....................display settings
PR[Enter]....................reset settings
```

Table 15: “ID” for querying the list of commands; example for firmware 9.09

Table 16 lists the available commands during setup. In normal operation mode only a few parameter are needed for operating the snow depth sensor, see Table 17 as an example.

The autostart command “as” defines the start up mode after the power is connected. The preset value is “xm” that means the sensor starts automatically with a snow depth measurement.
“SRY” / “SRN” defines, either a telegram is transferred after a measurement or the sensor waits for a polling command.

The first time after connecting the power the distance between the sensor and the surface is measured and a negative value is transmitted. The transmitted snow depth value is calculated as following:
Snow depth Value = offset - measured distance.

Command	Default	Description
asxm	XM	Sets “Snow depth measurement mode” “xm” in autostart “as”. Other option “id”, “lo”,..
br	9600	Queries / sets baud rate
ESC $1B		Interrupt measuring mode, ESC (Keyboard) or in terminal window / script use HEX value $1B
hf	4	Queries / sets Heater off Heater will be switched off at 4 °C. Increase leads to extended power consumption but may help to stop the freezing of the sensor in harsh environments.
ho	2	Queries / sets Heater on Heater will be turned on below 2°C. Decreasing temperature to -10 °C is possible to save power. Please check if output window is misting up or start freezing.
id		Queries for sensor information
mr mxd		Queries for all user memories 1 - 8. Sets one of the eight, x=[1; 8], user memories with up to d=10 characters.
of	0	Queries / sets offset, see „so“.
pa		Queries for preset parameter values
rb	-5	Queries / sets start value for analog current output Example: 4 mA corresponds here to -5 m
re	5	Queries / sets end value for analog current output. Example: 20 mA corresponds here to 5 m.
sda sdb	sda*	Telegram ouput in format a or b
sf	1	Queries / sets scale factor, e.g. to change the meter scale (sf=1) in a feet scale (sf = 3.2808399). After changing „sf“ other parameter like „of“ / „so“ / „xp“ are displayed with this scale factor. The scale factor is limited in the range sf [0; 2000].

Table 16: List of configuration parameter,
*default value depends on sensor type, see specific protocol delivered with each sensor

Command	Default	Description
shd	10*	Queries / sets signal for targets with high reflectivity in 5 distances d=[a; e] (85 % standard target), The valid range for sh is: $0 < sh \leq 100$.
sld	1*	Queries / sets signal for targets with low reflectivity in 5 distances d=[a; e] (6 % standard target), The valid range for sl is: $0 < sl \leq 100$.
so		Measures actual distance to ground and automatically defines a new offset („of“). The value depends on „sp“. After changing „sp“, „so“ has to set again or „of“ has to be set manually.
sp	0.0	Queries / sets correction for the inclination angle in degree; 0° corresponds to a vertical downward viewing sensor.
sr sry srn	SRN	sr: queries mode sry: automatic mode srn: polling mode
ss	6	Sets signal strength threshold value used to set the snow flag in telegram sdb.
st	25	Queries / sets internal measuring time to approx. 6.5 s. Please use this value for snow depth measurements, for any other the distance measurements the value may be set to 0 ... 25. The value st0 is an automatic mode, the measuring time may vary between 0.25 and 6.5 s. st1 is a single measurement, which takes roughly 0.25s. st25 is an average over 25 measurements.
xm		Starts snow depth measurement.
xp	10	Queries / sets maximum variation between two running measurement values. Factory Default is 10 m (sf=1) to allow easy setup and avoid any E66 errors within the installation process. The value can be modified, e.g. to 0.02 (2 cm if sf=1). A 2 cm variation in snow depth per minute is a reasonable value. Firmware 9.06 or newer: In cases, whenever new measurements are permanently out of tolerance, e.g. due to an avalanche, E66 is reset after 60 measurements and the current snow depth value is accepted as new value.
xt	30	Queries / sets repetitions rate of measurements. Default is every 30 seconds a 6.25 s long measurement. To test the sensor within the configuration process a 10 s or even shorter time interval can be useful. For short measuring periods (1 ... 10 s) the measurement time “st” has to be adjusted from st25 to st= {0....5}.
xw		Queries (polls) for actual snow depth

Table 16: List of configuration parameter,
*default value depends on sensor type, see specific protocol delivered with each sensor

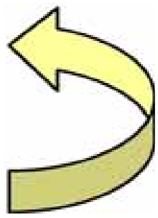
Command	Description	
ESC $1B	Interrupt measuring mode ESC (Keyboard) or in terminal window / script use HEX value $1B	
srn	Set polling mode	
xm	Start measuring mode	
	Wait at least 6.5 seconds	
xw	Poll for telegram	
	Wait for next poll at least the time defined by “xt” in seconds.	
xw	Poll for telegram	

Table 17: Change from automode (sry) to polling mode (srn).
Command “xw” used for querying data telegrams.

Scale factor sf	unit	telegram
1	m	>+01.0445 035.294 +22 66 ™<
1000	mm	>+01044.5 033.977 +22 66 “<
2000 (upper limit)		>+02088.9 034.956 +22 66 ˆ<
0.001	km	>+00.0010 035.470 +22 66 ª<
3.2808399	ft	>+03.4268 035.495 +22 66 ¤<

Table 18: Example for different scale factors sf

5.2 Data telegrams

The SHM 30 firmware 9.09 from July 2013 supports two data telegrams and a switch “sda”, “sdb” to change between these two telegrams. Telegram “sda” is similar to the single telegram known from previous firmware releases.

5.2.1 sda telegram

The transmitted data telegram has the following format:

>eee.eeee sss.sss TTT EE P< [CR] [LF]

e ... snow depth in m for sf=1, for sf=10 the decimal point is shifted to eeee.eee

s ... signal strength/ signal intensity,

T ... temperature

EE ... error code,

P ... check byte

The check byte is defined as follows:
All ASCII - codes between brackets > < totalizes to zero in low byte.

Example telegram: >+01.0445 035.294 +22 66 ™<

Snow depth = 1.0445 m

Signal strength = 35.294

Temperature = +22 °C

Error code = E66 (check Table 21)

Check byte = ™ (ANSI-Character of Dec 153/ Hex 99)

Byte #	Dec-value	HEX-value	ASCII - code	Remark
1	43	2B	+	Start snow depth
2	48	30	0	
3	49	31	1	
4	46	2E	.	
5	48	30	0	
6	52	34	4	
7	52	34	4	
8	53	35	5	
9	32	20		Space
10	48	30	0	Start signal strength
11	51	33	3	
12	53	35	5	
13	46	2E	.	
14	50	32	2	
15	57	39	9	
16	52	34	4	
17	32	20		Space
18	43	2B	+	Start temperature
19	50	32	2	
20	50	32	2	
21	32	20		Space
22	54	36	6	Error code (Table 21)
23	54	36	6	
24	32	20		Space
25	153	99	™	Check-byte
Sum	1280	500		Σ Bytes 1 to 25 = 500, Test: lowest Byte of 500 is zero: ✓

Table 19: Telegram example for format sda & test.

The check byte is calculated in the following manner:

Create unsigned byte array of **+01.0445 035.294 +22 66**

and build the sum (HEX): 2B + 30 + 31 + 2E + ... 20 + 36 + 36 + 20 = 467

build two's complement = FB99, take low byte = 99

5.2.2 sdb data telegram (firmware 9.09)

The snow flag "x" has been added to the data telegram "sdb". The check byte is presented as HEX value and instead of the > < characters the control characters [STX] and [ETX] are used to show the start and end of the message.

[STX]eee.eeee sss.sss X TTT EE PP[CR][LF][ETX]

e, s, T and E are explained in section 5.2.1.

X = 0 (snow flag), if the signal strength S < ss and X = 1, if S > ss.

The check byte P from 5.2.1 is given here as a 2-digit hex value rather than ASCII character. Therefore the test specification has to be changed. In comparison with the example in table 19 it shows that the hex value 99 is transmitted now and not the trademark character TM anymore.

New example for a telegram output in cm, (SF=100). The printable part of the telegram is: **+0000.03 +04.464 0 +43 00 67**

Byte #	dec-value	hex value	ASCII - character	Remark
1	43	2B	+	Start snow depth
2	48	30	0	
3	48	30	0	
4	48	30	0	
5	48	30	0	
6	46	2E	.	
7	48	30	0	
8	51	33	3	
9	32	20		Space
10	43	2B	+	Start signal strength
11	48	30	0	
12	52	34	4	
13	46	2E	.	
14	52	34	4	
15	54	36	6	

Table 20: SDB format telegram example & test

16	52	34	4	
17	32	20		Space
18	48	30	0	Snow flag
19	32	20		Space
20	43	2B	+	Start temperature
21	52	34	4	
22	51	33	3	
23	32	20		Space
24	48	30	0	Error code (Table 21)
25	48	30	0	
26	32	20		Space, end of ASCII telegram
Sum	1177	499		Sum of bytes 1 to 26
27/ 28	103	67	g	+ 67 hex
Sum	1280	500		= 500 hex, Test: lowest byte equals zero 4

Table 20: SDB format telegram example & test

5.3 Special values for eee.eeee in case of errors

In cases of errors (see table 22) the last valid measurement is repeated as eee.eeee value, while an “E” error code indicates whether the given value is usable or not. **Directly after xm start command eee.eeee contains its initialization values as follows:**

eee.eeee := rb (start value of range) (firmware 9.06, consistent with I_{out})

eee.eeee := 0 m (only firmware 9.05)

eee.eeee := -99 m (firmware 9.04 and earlier)

5.4 Analog Output

In the analog output mode measured values are transformed to a 4 ... 20 mA current level. The parameter RE and RB in table 16 are defining the distances of the 4 ... 20 mA interval.

$$RE > RB : Iout(mA) = 4mA + 16 \cdot \left(\frac{Dist. - RB}{RE - RB} \right) mA$$

$$RB > RE : Iout(mA) = 20mA - 16 \cdot \left(\frac{Dist. - RE}{RB - RE} \right) mA$$

Error messages are transformed to 3 mA (RE > RB), or 21 mA (RB > RE).

5.5 Signal strength (signal intensity)

The normalized signal strength value S_N or S_S is submitted at the second position in the data telegram using the format "sss.sss". $S_N(S_S)$ are calculated from the measured signal strength value S_M. The S_M measurement is performed independent after a snow depth measurement and takes approx. 0.5 s, which corresponds to an averaged about 10 single frequency measurements. It might be possible that the snow depth measurement has been stopped due to an error, caused by to much background light, while the signal strength value is still transmitted.

Since firmware 9.05 S_S is defined as normalized signal intensity values. The normalization process has been performed on a standard target in 15 m distance. The normalized signal strength value S_S should be comparable between different sensors in the range 0.5 for dark targets and 10 for bright targets.

This procedure wasn't precise enough to use the signal strength value for threshold methods like snow / no snow independent from the distance, because of the distance dependency like it is shown in figure 19. As a result the number of distances for reference targets are extended to 5. Firmware 9.09 supports these new settings first of all. Additionally a set of standard targets with 6.25 % and 86 % reflectivity is introduced to allow field checks of the sensor. Instead of S_S the new signal strength value S_N is used.

The normalization of the signal strength value is done within the test procedure for each sensor at the Lufft facility. The normalization parameters SLd (signal strength on black target) and SHd (signal strength on white target) are saved for the 5 distances d in the sensor flash memory and are also written in the test report handed out with each instrument.

$$S_S = \frac{10 - (0,5)}{SH - SL} \cdot (S_M - SL) + 0,5$$

$$S_N(x) = 9 \cdot \frac{S_M - SL(x)}{SH(x) - SL(x)} + 1$$

To be able to calculate $S_N(x)$ first of all the signal strength values SL(x) and SH(x) in the measured distance must be determined from reference points. As an example the calculation process is listed here for the special case that the measured distance is between the reference points a and b.

.

$$SH(x) = SHa + \frac{(SHb - SHa)}{b - a} \cdot (x - a)$$

The calculation of S_N is only valid, when the measuring distance is known, meaning that the signal strength S_N can not be delivered in comparison to S_S, when the distance measurement can not be achieved!

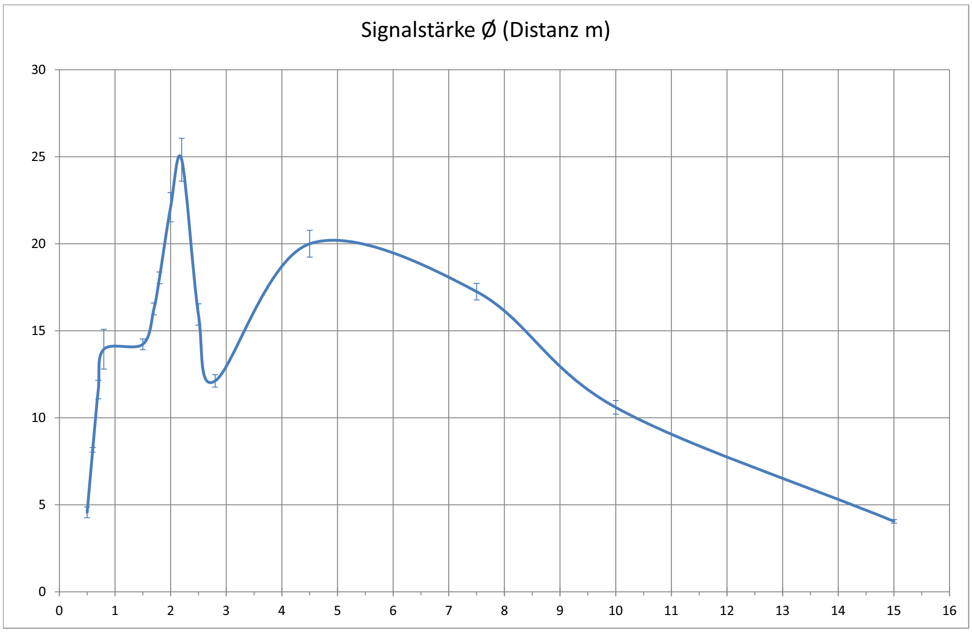


Fig. 19: Dependency of the signal strength S_M from distance

Users might change the SH, SL values to their specific needs.

Other corrections:

The signal strength depends from the sensor temperature. In case of snow depth measurements the relevant temperature range is small. In cases the signal strength should be used in large temperature ranges, a compensation may be useful. Initial measurements indicate the following dependency for targets with reflectivities >80:
$S_N(T)= -0.125xT\ (°C)+S_N(24\ °C)+3$.
At zero degrees, this correction leads to an increase of the signal strength by 3.

5.6 SF in analog mode

Only in firmware 9.05 the analog mode is not displayed correctly for SF≠1. If other scale factors have to be used RE and RB have to be modified like shown in the following (typical) example:

RB= -1 m, RE = 4, SF =1: okay

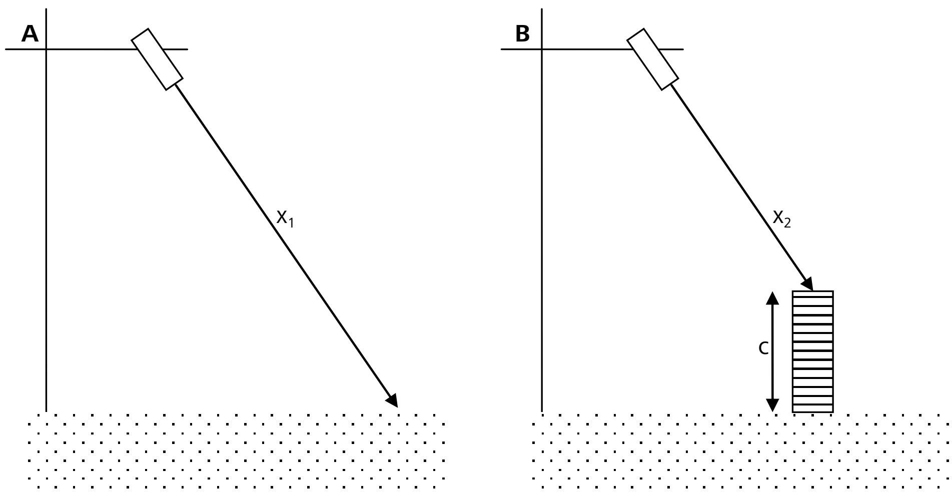
For SF=2: set RB=-2 and RE=8, enter SF=2

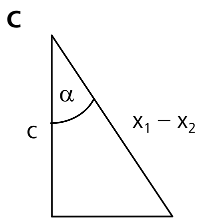
6 How to define the correct inclination angle?

6.1 Technique using a reference object

The installer can use a reference object with a specified height c to find out the inclination angle (see figure 20).

- Stop measuring process (ESC) and change measuring time interval “xt10” to 10 seconds. Set: “sp0” and “of0“. Check if “sf” is set correctly and xp allows a high variability for the installation process, e.g. if sf=1, xp > c.
- Mount sensor in the desired angle position, e.g. 15 ° and perform one distance measurement (A).
- Start measurement “xm” – wait 6 seconds – press “xw” in polling mode to query distance value
- stop measurement with (ESC) – note distance.
- Place object (B) and perform a new measurement.
- Calculate angle α (C) and use “sp” command to set the angle.
- Now, the measured distance values are corresponding to the vertical distance. A negative value will be received.
- Perform offset measurement “so”.
- Change “xt” to final time interval, “xp” to final variability and restart with “xm” the measurement process.





Calculation of the installation angle:

$$\alpha = \arccos\left(\frac{c}{x_1 - x_2}\right).$$

Example: x_1= 4.38 m, x_2 = 3.8 m, c = 0.5 m

$\Rightarrow \alpha = 30.5°$

Fig. 20: Technique to determine inclination angle using a reference object

Absolute and relative error: If the height of the reference object ***c*** is not well defined the corresponding error in ***a*** is leading to 1:1 error in the measured distance between sensor and surface. Even if the relative error between two snow depth measurements is much smaller it is worth to use a precise and not to short reference object.

6.2 Plumb procedure

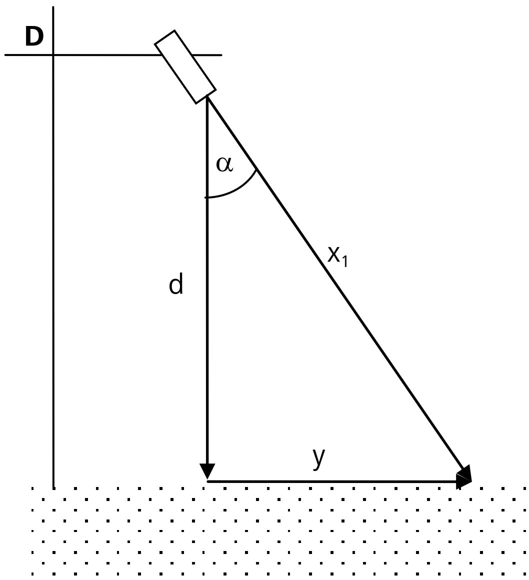


Fig. 21: Plumb procedure: *a* = arcsin (y / x1)

Using a perpendicular is a more precise method to determine the inclination angle of the sensor. Figure 21 illustrates the procedure. Mark the position of the perpendicular at ground and measure the distance y at ground level to the laser spot. Use the distance measured by the sensor (sp0, of0) and y to calculate in a precise way.

Example/ Error:

Sensor is mounted in 4 meters height under an angle of 30°.

An error in the measurement of y of 5 cm is resulting in a systematic absolute error in d of 3 cm.

Having corrected the offset (so) only a relative error has to be taken into account.

In this case the snow depth measurement has an error between 0.01 % and 0.1 % depending of the real snow depth (0 m to 3.5 m).

7 Measurement Examples

The chapter is showing some examples for snow depth measurements.

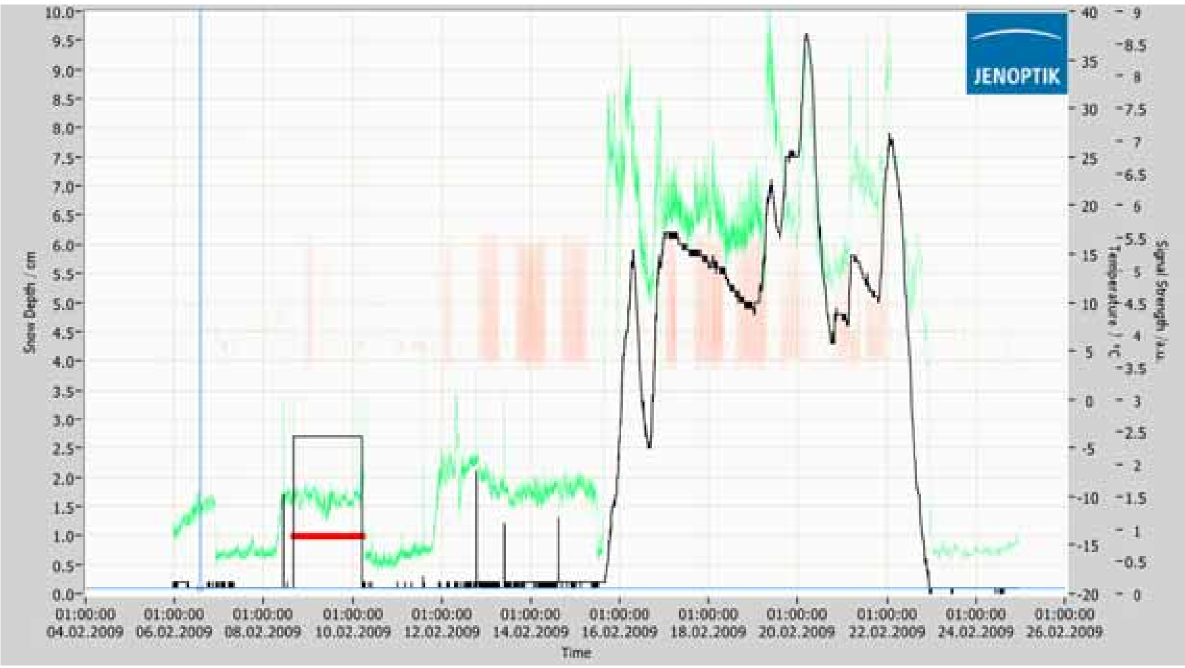


Fig. 22: Example of 22 days snow depth measurement in lowland area in Germany black curve indicates the snow depth, the green curve the signal strength, the red dots are error indicators and rose curve indicates the heater activity.

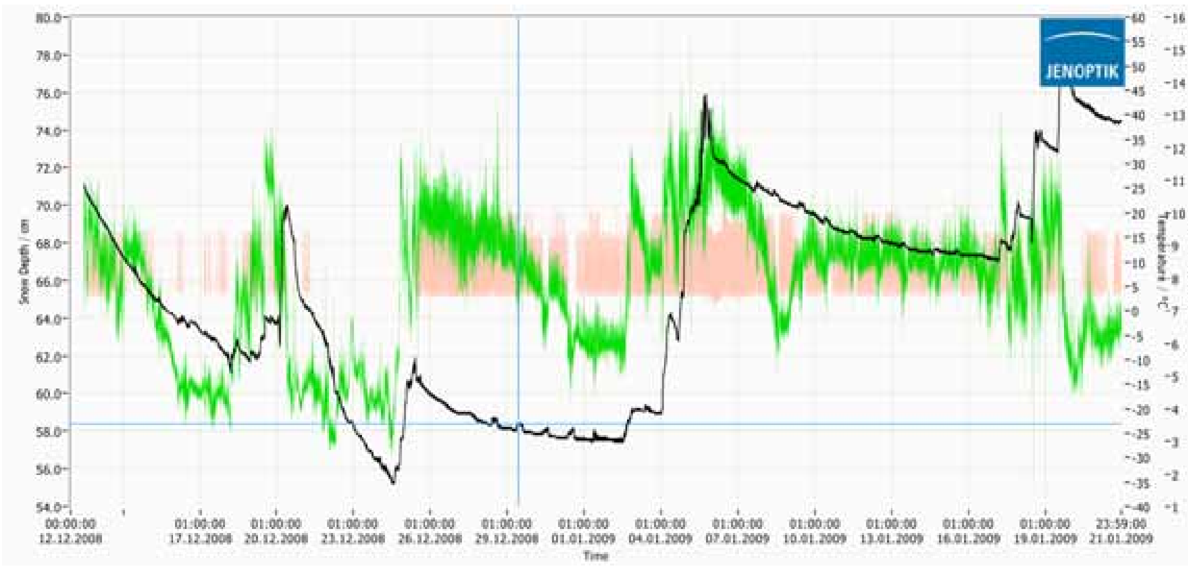


Fig. 23: Example of 40 days snow depth measurement in a low mountain range environment in Germany.

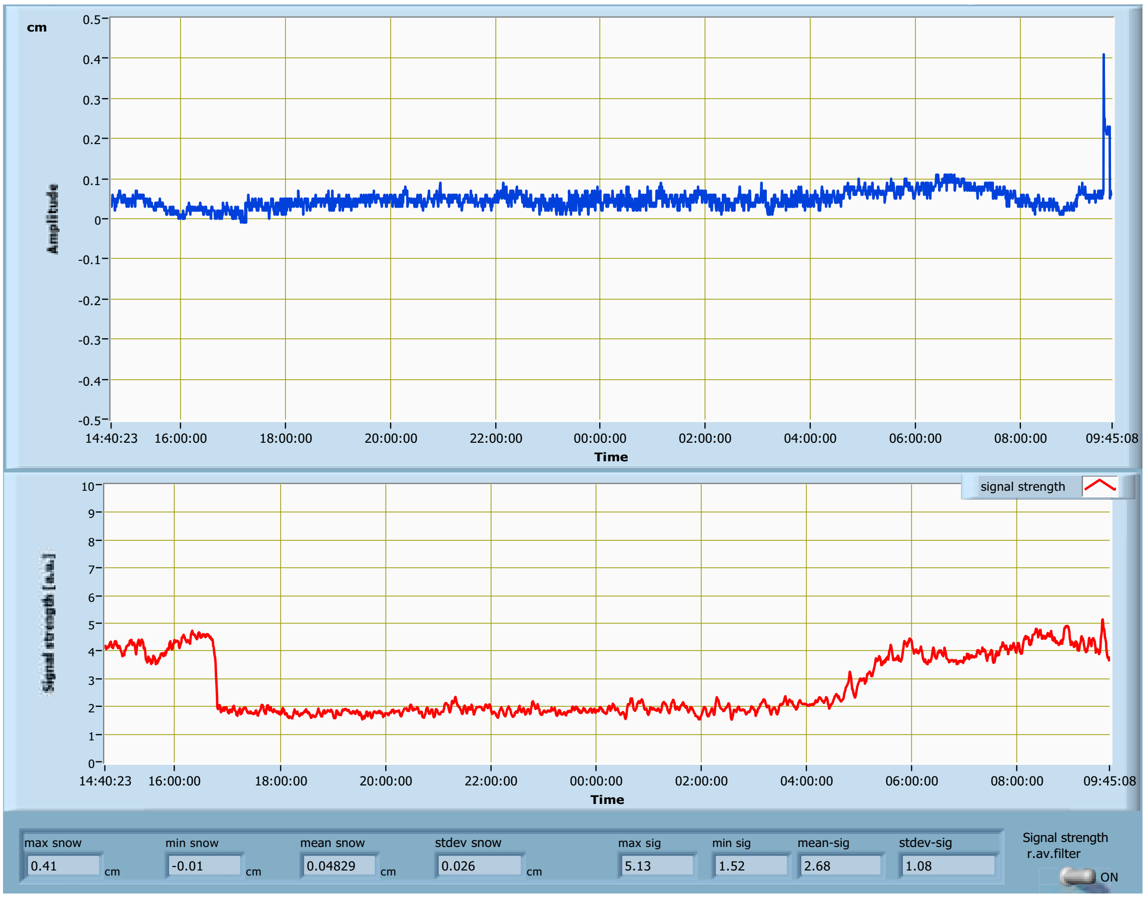


Fig. 24: SHM 30 snow depth- (top) and signal strength measurement (bottom)
Illustration of the variation of the snow depth and the signal strength in 19 hours. At 4:45 pm (UTC) it starts raining and the reflectivity of a reference target plate at ground changes. The plate is drying in the morning. At 9:30 am a 1 mm thick grey card with 50 % reflectivity is put onto the target plate for some minutes.

Fig. 25: reference grey card as an example for 50 % reflection target.

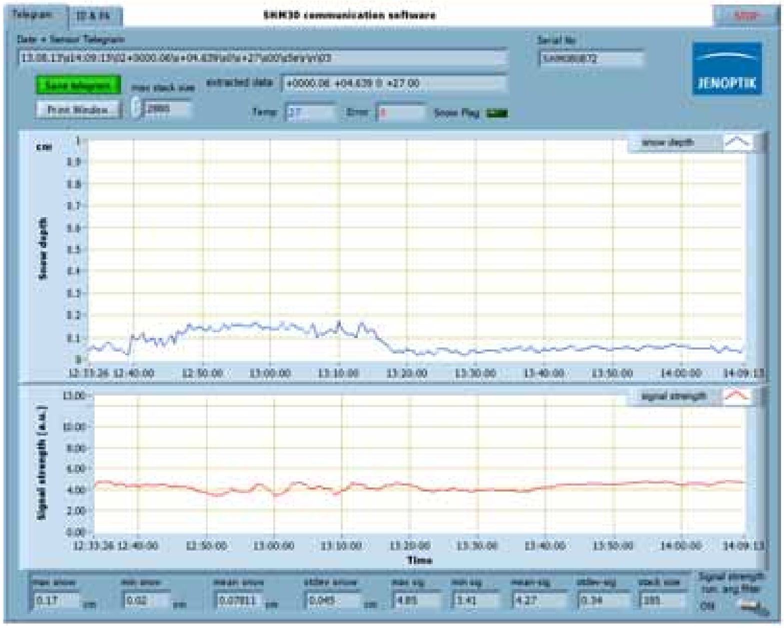


Fig. 26: SHM 30 communication software

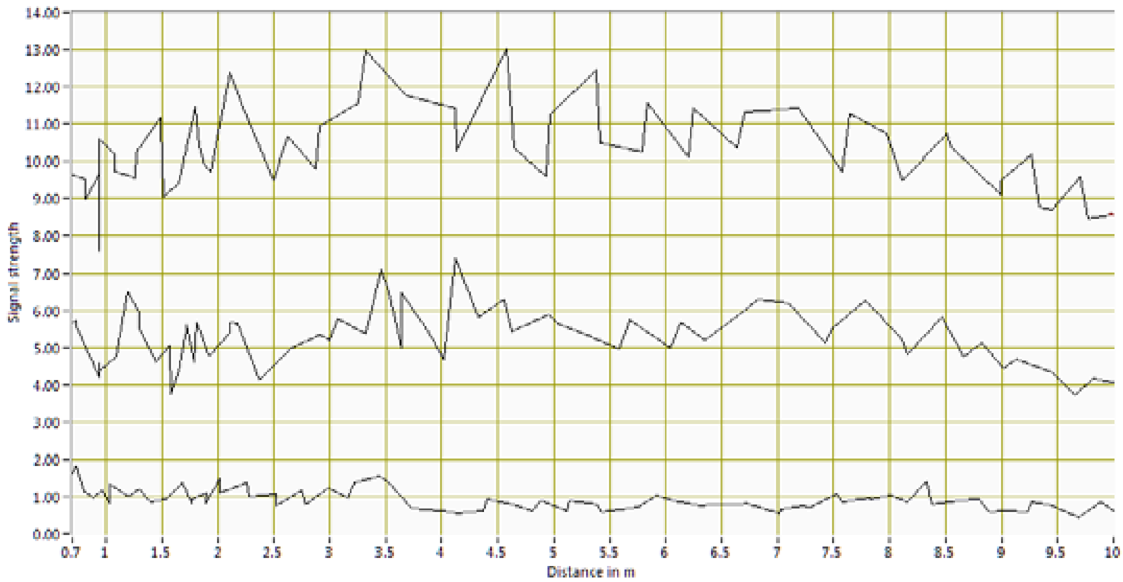


Fig. 27: Variation of the signal strength
with distance and from reference cards with different reflectivities (top 86 %, middle 50 %, bottom 6,25 %) after the normalization regarding section 5.5. The reference cards with 86 % (SHd) and 6,25 % (SLd) match the white and black signal values stored in the sensor for the 5 different distances.

8 Service

8.1 Error Codes

The SHM 30 has several build in error codes. The codes are fully available if the sensor is connected to digital interfaces (RS232, RS422). The analog current output generates only a general 3 mA (or 21 mA) current to indicate an error without further details. In normal operation mode the E15 to E24 errors are showing problems in running measurements. E61, E65 and E67 may happen if the user communicates with the instrument.

In case of hardware errors the SHM 30 needs in general a service by G. Lufft GmbH.

Error codes	Descriptions
E15	Signal too weak or distance too short (<10 cm)
E16	Signal too strong (reflexes from mirrors)
E17	Background light error
E18, E19	DX mode only (industrial sensor error - not used for SHM)
E23	Temperature below -10 °C
E24	Temperature above +60 °C
E31	Hardware error, faulty EEPROM checksum, reship sensor
E51	APD voltage value failure (stray light or hardware error)
E52	Laser current too high, broken laser diode possible
E53	Math (division by zero)
E54, E55	Hardware errors, sensor must be reshipped for repair
E61	Invalid command in RS232, RS422 configuration
E62	1. Hardware error in interface: 2. wrong value in interface communication (parity error SIO)
E63	SIO overflow, check time for emitted signals in application software
E64	Framing- error SIO, serial interface parameter not set correctly to 8N1
E65	Measurement was interrupted by a query from the user. since firmware 9.05: This error doesn't occurs anymore if the running measurement is queried by a xw in polling mode. The result is transmitted after the measurement has been done.
E66	Variation of snow depth between 2 consecutively measurements is outside limit set by xp. The last valid value is transmitted instead. Firmware 9.06: after 60 measurements the new value is accepted.
E67	Measurement was interrupted by "ESC" command

Table 21: List of error codes

Error codes	RS232 / RS422 telegram respond	I_{out} (current value 3...21 mA)
E15	>eee.eeee sss.sss TTT 15 P<	3, 21 mA
E16	>eee.eeee sss.sss TTT 16 P<	3, 21 mA
E17	>eee.eeee sss.sss TTT 17 P<	3, 21 mA
E23	>eee.eeee sss.sss TTT 23 P<	3, 21 mA
E24	>eee.eeee sss.sss TTT 24 P<	3, 21 mA

Table 22: Telegram respond and analog feedback after a specific error occurred I_{out} {3; 21} depends on re, rb settings

Error codes	RS232 / RS422 telegram respond	I_{out} (current value 3...21 mA)
E31	E31	3, 21 mA (firmware 9.06) last value (firmware 9.01 - 9.05)
E51	>eee.eeee sss.sss TTT 51 P<	3, 21 mA
E52	>eee.eeee sss.sss TTT 52 P<	3, 21 mA
E53	>eee.eeee sss.sss TTT 53 P<	3, 21 mA
E54, E55	>eee.eeee sss.sss TTT 54 P<	3, 21 mA
E61	E61	last value
E62, E63, E64	E62, E63, E64	last value
E65	>eee.eeee sss.sss TTT 65 P<	4 mA (firmware 9.06) last value (firmware 9.02 - 9.05)
E66	>eee.eeee sss.sss TTT 66 P<	3, 21 mA (firmware 9.06) last value (firmware 9.02 - 9.05)
E67	E67	4 mA (firmware 9.06), last value (firmware 9.05)

Table 22: Telegram respond and analog feedback after a specific error occurred
I_{out} {3; 21} depends on re, rb settings

Special start-up error responds:
The following snow depth values are initialization values and will be transmitted in the data telegram, whenever an error is detected directly after a system start or whenever the xm start command is set and an error occurs:

eee.eeee := RB (start value of range) (firmware 9.06, consistent with I_{out})

eee.eeee := 0 m (only firmware 9.05)

eee.eeee := -99 m (firmware 9.04 and earlier)

In any other cases the last valid measurement is repeated as eee.eeee value!

8.2 Cleaning & Maintenance

Before cleaning, be aware!

Class 2 laser radiation. Please avoid to look directly into the laser beam.

Interval	Cleaning	Comment/ Aids
Quarterly	Check if the beam path is clean, remove sedimentations, dust, insects from mechanical parts	Micro-fibre wipes, water, neutral cleaning agents, air pressure for insects in the optical tube
Annually, before winter season	Check cable connector, mounting clamps, clean stray light protection tube	Allen key, check figures 28 and 29, cleaning (see above)
As required	Remove snow and ice	

Table 23: Cleaning schedule and cleaning action

Please don‘t try to clean the optical parts in the field with alcohol and lens tissues or Q-Tips! Afterwards you probably must dismount the sensor, unscrew the tube and aperture in front of the sensor and clean the optics in a professional way. Please contact Lufft if you have questions.

The stray light reduction tube in the front of the sensor can be unscrewed for cleaning, see figure 28 to 30.

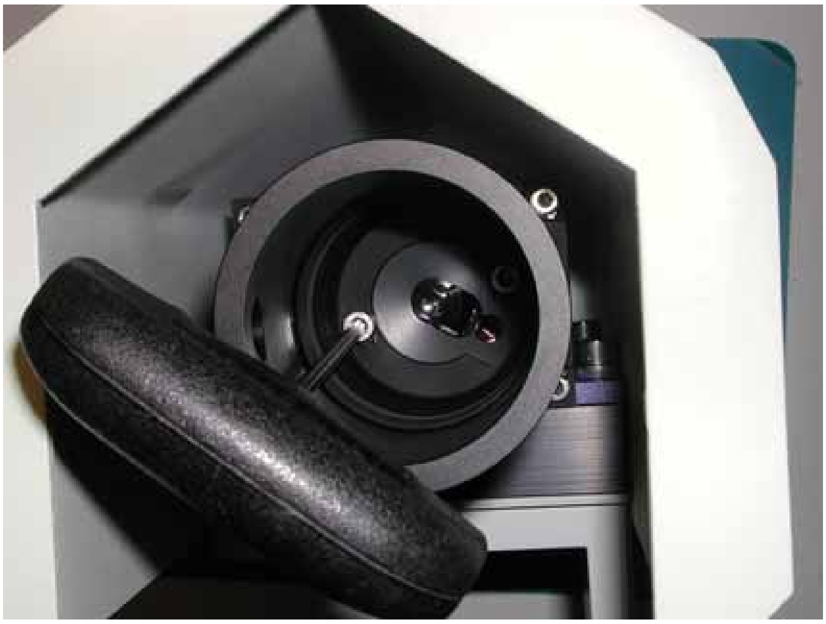


Fig. 28: Unscrew tube for stray light reduction to clean mechanics and optics.

Fig. 29: Cleaning utilities:
bellows (photo), allen key T handle (M3) and tube with aperture

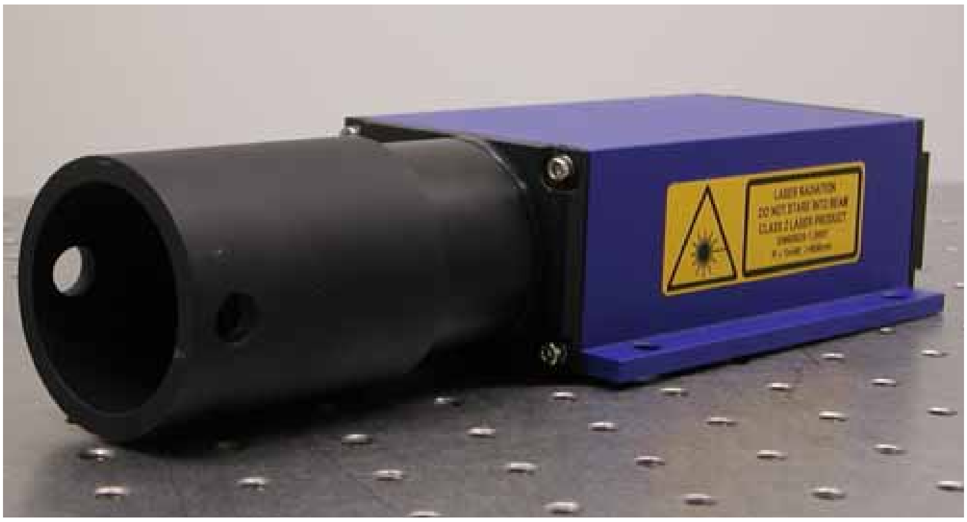


Fig. 30: Core sensor module LDM30.11
In case of service only this core part has to be exchanged in field

Whenever it is necessary to exchange the measuring module only the core module LDM30.11 should be send to Lufft (figure 30) for repair:

- to save transportation costs,
- to keep the (de-)installation effort (before) after repair as little as possible,
- avoid transport damage on housing parts.

Caution - Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure! Open of the inner housing usually leads to loss of warranty!

8.3 Firmware Release

Date	Firmware release	Description
01.06.2009	9.04	Official market launch of SHM30 in August 2009 with Firmware 9.04
01.09.2011	9.05	- angle precision "SP" corrected by a factor of 10 from 1° to 1.0° - reflectivity normal integrated (factory calibration to white "SH" and black "SL" targets). - output resolution modified from 1 mm to 0.1mm - bug in telegram display solved for higher scale factor values. - error E65 will no longer appear if measurement is interrupted by polling command. Now: Measurement will be finalized and the answer will be send after completion. - E67 added, appears when measurement has been stopped by ESC command
15.11.2011	9.06	- error handling for E66 (xp out of range) changed, new value is accepted after 60 measurements, analog current mode shows 3 mA/ 21 mA instead of last value
09.07.2012	9.07	- There have been fixed 2 bugs; they led in rare cases to a frozen state in polling mode: - entering lower or upper case for commands does not matter anymore. - DMA - transfer won't be interrupted by measuring process anymore.
01.11.2012	9.08	- Format for single digits temperature values in telegram corrected: old: TTT <space>+9 new: TTT +09 - SH, SL are limited now [0, 100]
15.07.2013	9.09	- telegram 2 (sdb) added - user variables M1 ... M8 added - normalization signal strength revised, SLd, SHd parameter introduced - variable snow flag and treshold "ss" implemented
01.10.2014	9.10	- internal Jenoptik update to be conform with modernized test bench software, no effect on SHM30 applications

Table 24: Firmware Release

CERTIFIED
DIN EN ISO 9001
NR 70100222
CERTIFICADO

Lufft

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EC Declaration of Conformity

Product: **Snow Depth Sensor**

Type: **SHM 30 (Order No. 8365.XX)**

We herewith declare, represented by the signatories that the above mentioned equipment agrees with the Directive of Electromagnetic Compatibility 2004/108/EC.

The following harmonized standards were considered:

EN 61326-1:2006	Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 1: General requirements (IEC 61326-1:2005)

Fellbach, July, 24th, 2015

Axel Schmitz-Hübsch
(Managing Director)

Trade register and local district court Stuttgart HRB 721373 Managing directors: Dipl.-Wirtsch.-Ing. Klaus Hirzel, Dipl.-Ing. Axel Schmitz-Hübsch
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