INSTRUCTION MANUAL

SHM 30 Snow Depth Sensor

January 2015

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This equipment is warranted by CAMPBELL SCIENTIFIC (CANADA) CORP. ("CSC") to be free from defects in materials and workmanship under normal use and service for **twenty-four (24) months** from date of shipment unless specified otherwise. ***** **Batteries are not warranted.** ***** CSC's obligation under this warranty is limited to repairing or replacing (at CSC's option) defective products. The customer shall assume all costs of removing, reinstalling, and shipping defective products to CSC. CSC will return such products by surface carrier prepaid. This warranty shall not apply to any CSC products which have been subjected to modification, misuse, neglect, accidents of nature, or shipping damage. This warranty is in lieu of all other warranties, expressed or implied, including warranties of merchantability or fitness for a particular purpose. CSC is not liable for special, indirect, incidental, or consequential damages.

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SHM 30 Snow Depth Sensor

1. Introduction

The SHM 30 measures snow depth. The SHM 30 is able to reliably determine snow depths of up to 10 meters within seconds and with millimeter precision. Based on an opto-electronic distance sensor emitting visible, eye-safe laser light, the SHM 30 allows for probing distances of up to 30 m to detect the surface level.

The SHM 30 snow depth sensor emits modulated visible laser light and determines the distance to an object by comparing phase information. The SHM 30 allows for operation in automatic and polling mode for the digital output. Furthermore an analog current output is available for snow depth.

The SHM 30 is manufactured by Jenoptik.

Before using the SHM 30, please study:

- Section 2, Cautionary Statements
- Section 3, Initial Inspection
- Section 4, Quick Start

More details are available in the remaining sections.

2. Cautionary Statements

- For handling, shipment, or transportation, the SHM 30 must be duly packaged and placed in the correct transporting position.

2.1 Safety Labelling

Danger - Laser Hazard 

Danger - Electrical Hazard 

Caution -Warning of potential damage 

Caution - Warning of hot surface 

2.2 Standards and 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 harmonization 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 Instruction 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 raditation exposure!**
- **The Instruction 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'. You must ensure that under normal conditions, the voltage does not exceed 30 VDC and in case of a first malfunction 70 VDC.**
- **Do not open the inner sensor housing (with the label 'LDM 30.11'). There is 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 class 2 laser product, as defined in the standard IEC 60825-7:2007 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 blinking reflex and by turning the head away. This natural reflex may be impaired by medication, alcohol, and/or drugs. Although the product can be operated without taking special safety percautions, one should refrain from directly looking into the laser beam.
Caution: Class 2 laser radiation. Maximum laser power <1 mW, wavelength 650 nm (red laser light).
So not direct the laser beam towards other people(s)! Do not look into the beam!

2.5 Personnel Requirements

- The SHM 30 shall only be installed and commissioned by properly trained personnel having completely read and understood this Instruction 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 SHM 30 Labelling

Figure 2-1 Label at the bottom of the SHM 30

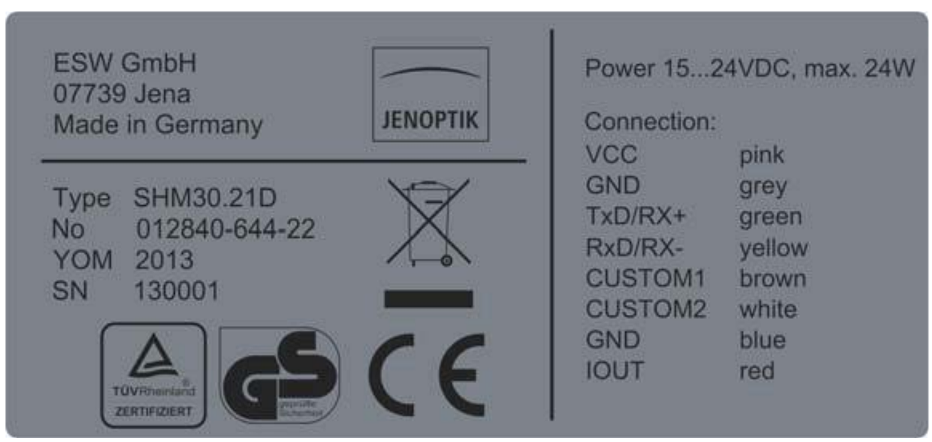


Figure 2-2 Close up of the label from the bottom of the SHM 30

Figure 2-3 Laser warning label in English (standard)

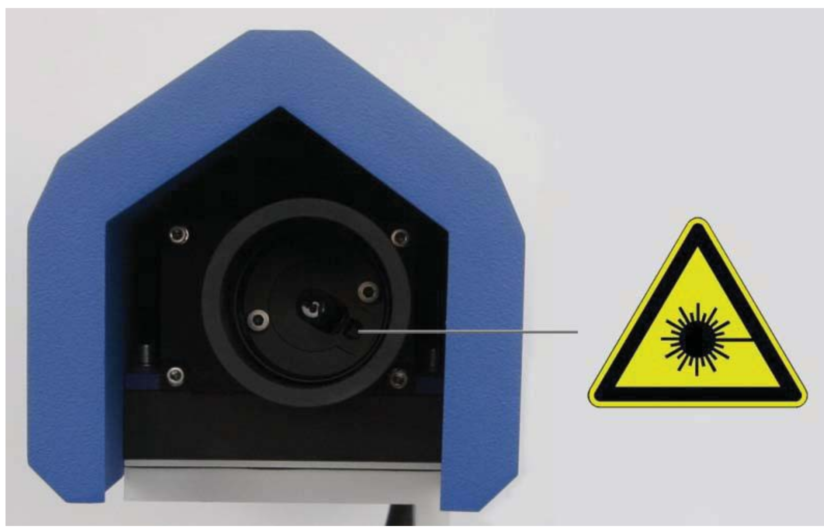


Figure 2-4 Laser exit

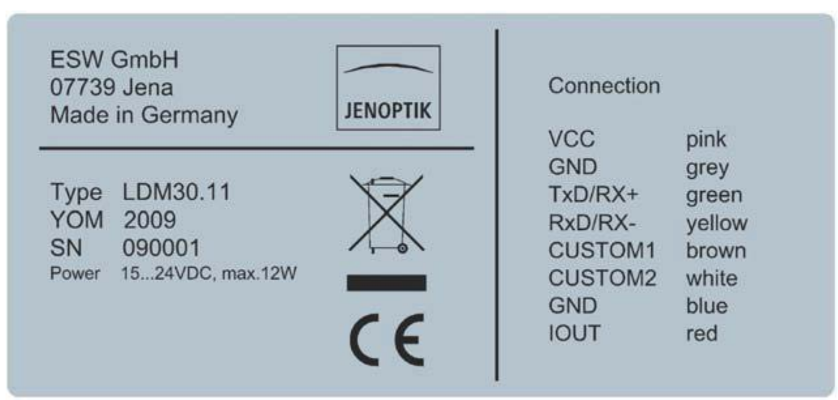


Figure 2-5 Label on inner housing (right hand side of housing)

3. Initial Inspection

- Check the contents of the shipment. If thers is a shortage (see Section 3.1, Ships With), contact Campbell Scientific. If any damage has occurred during transport, immediately file a claim with the carrier and contact Campbell Scientific to facilitate repair or replacement.

- Check the model number against the shipping documents to ensure the correct product is received.

3.1 Ships With

- Laser labels in local language (optional)
- Setup instructions and sensor protocol
- CD (software and manual)
- Mounting clamp (separate order required)
- Knurled screws
- 10 m interface cable

4. Overview

4.1 Mode of Operation

The SHM 30 show depth sensor emits modulated visible laser light and determines the distance to an object by comparing phase information (see Figure 4-1). Figure 4-1 demonstrated the SHM 30 measuring principle. A single measurement is done within 0.25 s, including time for data handling. The snow depth sensor is analyzing the intensity of waves (signal strength), the number of waves, and the vector to get a precise measurement. The precise distance is determined using five different frequencies. The redundancy in measurements higher accuracy on difficult targets or during precipitation events. For snow depth measurements, the longest time interval (average of 25 measurements at 0.25 s) is selected, so that the sensor can measure while filtering out noise effectively.

To calculate snow depths automatically, the user can first perform a baseline measurement, which is stored as an offset value in the instrument. A manual offset value for existing snow depths can also be set in either the SHM 30 or datalogger program.

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

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), by changing the parameter scale factor ‘sf.’

Note Unwanted measurement results (hard targets from snowflakes) are filtered out using a plausibility method and the measuring time.

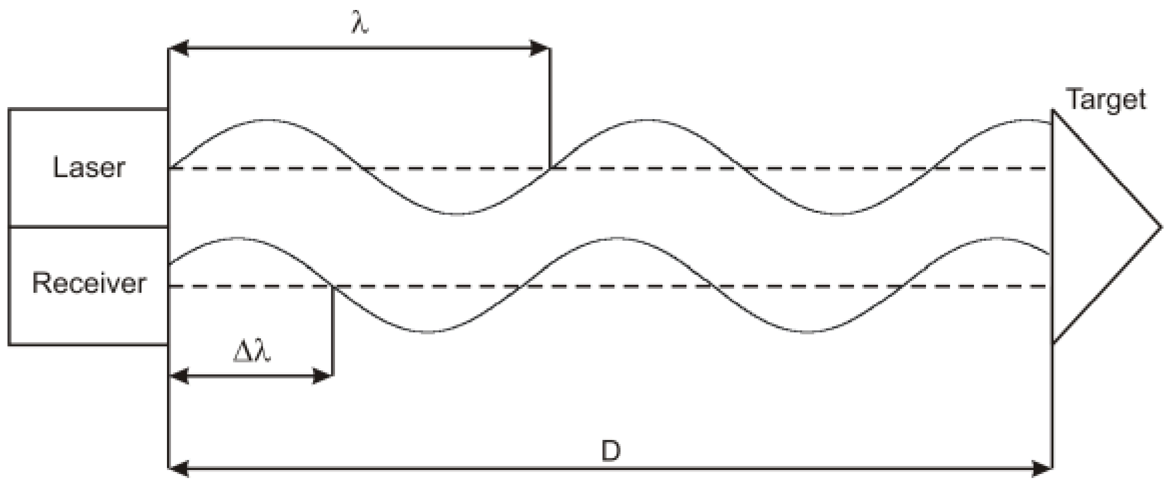


Figure 4-1 Measuring principle of the SHM 30

4.1.1 Timing Parameter

The timing parameter ‘xt’ defines the sequence of measurements. ‘xt’ will always be larger than the real-time internal measurement, which in general is 6.5 seconds, plus sufficient time needed to transmit the data message and communicate with the sensor. Due to the serial sequence of command processing, a sensor commincation throughout the measuring process is not available.

In the automatic measuring mode, the sensor transmits its message after each measurement. While in polling mode, in renews its measuring data in an internal buffer.

Note The user can query the snow depth message as often as wanted using the command ‘xw’ to receive the latest message.

4.1.2 SHM 30 Heater Control

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 discharging.

5. Specifications

Dimensions (l x w x h):	302 x 130 x 234 mm
Weight:	approx. 3.3 kg
Temperature Range:	-40°C to +50°C
Relative Humidity:	0 to 100%
Heating Activity:	<0°C programmable
Measurement Parameters	
Measurement Range:	0 to 10 m
Distance to Hard Targets:	0.1 to 30 m (without far field stray light protection on natural diffuse reflecting surfaces)
Reproducibility:	< ± 0.5 mm (on natural, diffuse reflecting surfaces)
Measuring Accuracy:	± 1 mm (on natural, diffuse reflecting surfaces; offset corrected sensor; 95% statistical spread)
Measuring Accuracy Snow:	< ± 5 mm (95% statistical spread)
Programmable Measuring Interval:	1 to 600 seconds
Time for Single Measurement:	≤ 10 seconds
Measured Distance Resolution:	0.1 mm
Signal Strength (white target with 85-90% reflectivity):	10 ± 3 (measuring range 0.8 – 10 m)
Signal Strength (black target with 5-7% reflectivity):	1 ± 0.5 (measuring range 0.8 – 10 m)
Interfaces	
Data Connection RS-232:	9600 Baud; 8N1
Data Interfaces:	RS-232, analog output
Interfaces Modes RS-232:	2.4 to 38.4 kBaud, 8N1 format
Analog Interface:	3 mA and 4 – 20 mA
Operating Modes:	Polling Automatic message
Client Software:	Any terminal program

Electrical Parameters

Power Consumption:	0.5 to 1 W (without heating) <12 W (with heading – heating cycle 0°C to -30°C, at 24 VDC) to 24 W
Operating Voltage:	10 to 30 VDC (without heating) 15 to 24 VDC (with heating)

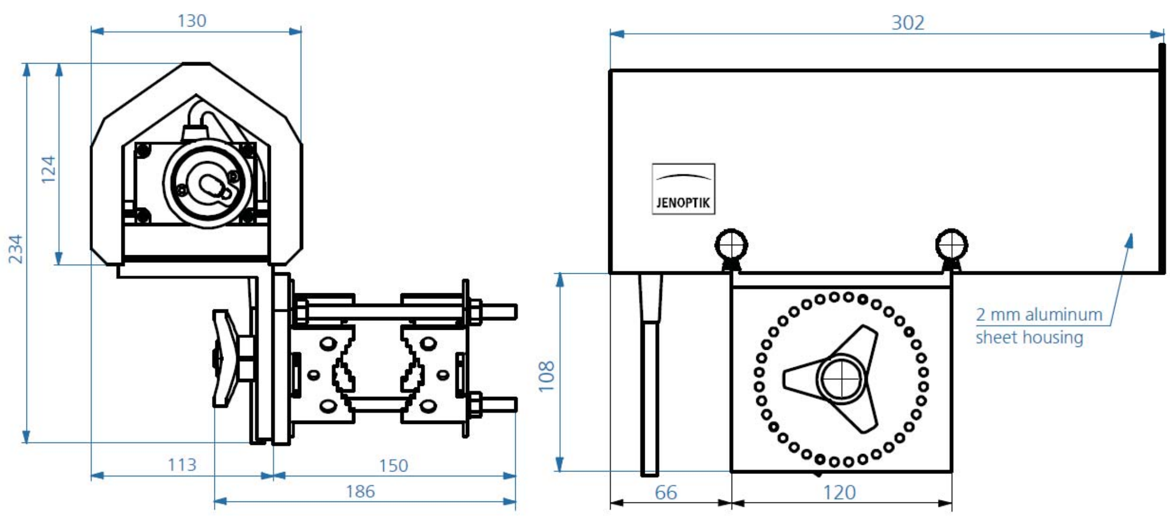


Figure 5-1 SHM 30 with dimensions

6. Installation

6.1 Siting

The SHM 30 is usually mounted tilted away from the sun. The best measurement results are achieved with an inclination angle between 10-30° (0° corresponds to vertical assembly) is ideal. The SHM 30 is mounted in this way to limit icicles and droplets falling from the mast of sensor from affecting the real snow depth just below the sensor.

The sensor should also be pointed away from the mast. This avoids wind shield or local thermal heating effects, which may be caused by the mast. Direct sunlight may lead to an E15 or E17 error (see Section 9.1 Errors Codes) if reflected sunlight from the snow surface hits the sensor.

Enusre that the assembly site will allow for measurements in undisturbed conditions, and that local laser safety guidelines are fulfilled.

6.1.1 Inclination Angle

The best measurement results are achieved with an inclination angle between 10-20°. To assist with achieving the proper inclination angle, part of the mounting piece is a punched disk with a fixed 10° pattern allowing for fast, easy installation.

If the mounting of the clamp to the mast cannot be precisely fixed or the mast itself is crooked, the total inclination angle must be measured.

The inclination angle must be communicated to the SHM 30 using a terminal program with the command ‘sp’. The sensor requires the ‘sp’ value to correct the distance measurement.

Note See Appendix A to calculate the correct inclination angle.

6.2 Mounting

The SHM 30 requires a suitable mast or crossbeam to be fixed to using one of its mounting clamps. The typical angle of inclination of the mounting base should be 10° or 20°.

Note The SHM 30 should be fixed at a height of 2 – 5 m, on a suitable mast.

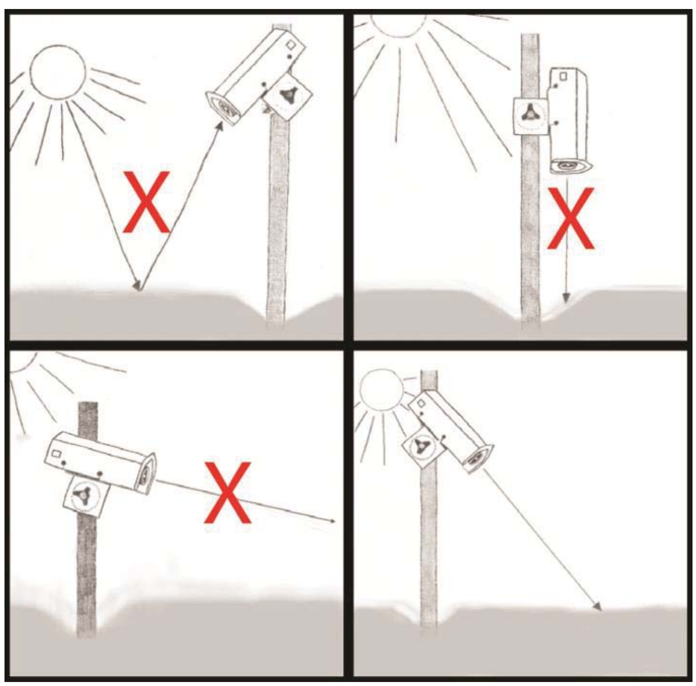


Figure 6-1 Installation guide.

6.2.1 Mounting Clamps

The SHM 30 is not shipped with mounting clamps. Figures 7-2 to 7-4 (inclusive) show three options of mounting clamps (including order number), which can be ordered with the SHM 30.

Figure 6-2 8365.610-11 - standard for a Ø <72 mm mast

Figure 6-3 8365.608-11 specified for a mast with Ø 80 mm

Figure 6-4 8365.609-11 for masts upto Ø 300 mm

Figure 6-5 Cable installation with mounting clamp 8365.610-11

Figure 6-6 Mounting clamp 8365.608-11 or 8365.609-11

6.3 Electrical Parameter

The SHM 30 has an identification plate where the electrical parameter and single strands from the data cable are described. The standard data interface is RS-232. 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 combined power and data cables. 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.

6.4 Data Configuration and Communication

After the supply voltage is connected, the sensor starts automatically loading the last parameter set. The factory defaults parameter set is used after the first successful installation (shown in Table 6-1).

Table 6-1 lists the commands available during setup. In normal operating mode, only a few parameters are needed for operating the snow depth sensor (see Table 6-2, as an example).

Note Commands can be entered in upper or lower case. All commands must finish with <CR> <LF>; <CR> or <LF>.

6.4.1 Start Up

The autostart command ‘as’ defines the start up mode after the power is connected. The preset value is ‘xm’ - the sensor starts automatically with a snow depth measurement.

‘sry’/‘srn’ define either a message that is transferred after a measurement or the sensor is waiting for a polling command.

After connecting the power for the first time, the distance between the sensor and the surface is measured and a negative value is transmitted. The transmitted snow depth value is calculated as follows:

Snow depth value = offset – measured distance

Table 6-1 Default Configuration Parameters

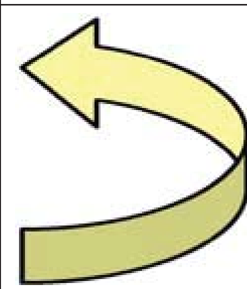
Command	Default	Description
asxm	XM	Sets ‘snow depth measurement mode’ ‘xm’ in autostart ‘as’. Other options are: ‘id’, ‘lo’.
br	9600	Queries/sets baud rate.
ESC $ 1B	Table text	Interrupt measuring mode, ESC (Keyboard) or in terminal window/script use HEX value $ 1B.
hf	4	Queries/turns Heater off Heater will be switched off at 4°C. An increase would lead to extended power consumption, but may help stop the sensor from freezing in harsh environments.
ho	2	Queries/turns Heater on Heater will be turned on below 2°C. Decreasing the temperature to -10°C is possible to save power. Check to see if the output window is misting up or starting to freeze.
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. Ex: 4 mA corresponds to 5 m.
re	5	Queries/sets end value for analog current output. Ex: 20 mA corresponds to 5 m.
sda sdb	Sda*	Message output in format a or b.
sf	1	Queries/sets scale factor. For example, change the meter scale (sf=1) in a feet scale (sf=3.2808399). After changing ‘sf’, other parameters such as ‘of’, ‘so’, and ‘xp’ are displayed in the revised scale factor. The scale factor is limited in the range of sf [0; 2000].
shd	10*	Queries/set signal for targets with high reflectivity in 5 distances d=[a;e] (85% standard target). The valid range for sh is 0<sh≤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≤100.
so		Measures the actual distance to the ground and automatically defines a new offset (‘of’). The value depends on ‘sp’. After changing ‘sp’, ‘so’ has to be set again or ‘of’ has to be set manually.
sp	0.0	Queries/sets correction for the inclination angle in degrees. 0° corresponds to a vertical downward viewing sensor.
sr sry srn	SRN	sr: queries mode sry: automatic mode srn: polling mode
ss	6	Sets the signal strength thresehold value used to set the snow flag in sdb message.
st	25	Queries/sets internal measuring time to approximately 6.5 seconds; use this value for snow depth measurements. For any other distance measurement, the value may be set to 0 … 25.
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 for easy setup and to avoid any E66 errors within the installation process. The value can be modified. For example, 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: when a new measurement is 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 the new value.
xt	30	Queries/sets repetitions rate of measurement. The default is every 30 seconds for a 6.25 second long measurement. To test the sensor within the configuration process, a 10 seconds or shorter time interval is useful. For short measuring periods (1 … 10 s), the measurement time ‘st’ has be adjusted from st25 to st={0 … 5}.
xw		Queries (polls) for actual snow depth.

* The default value depends on the sensor type. See the product protocol delivered with each sensor.

Table 6-2 Changing from automode ('sry') to polling mode ('srn')

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 message	
	Wait for the next poll (at least the time defined by ‘xt’ in seconds)	
xw	Poll for message	

To be able to configure the instrument, the serial interface RS-232 or RS-422 must be connected. Any terminal program can be used to set and query data. Standard terminal programs include Hyper Terminal or Bray’s Terminal.

Standard configuration for the COM Port:

- 9600 Baud, 8N1, Handshake none

Note If the initialization of the serial port/message format is set correctly, the sensor answers 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 (see Figure 6-7)
- ‘pa’ shows preset values (see Figure 6-8)

```
SHM 30, 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 message 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
```

Figure 6-7 ‘id’ for querying the list of commands

```
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
message 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].........................
```

Figure 6-8 'pa' example output for a parameter set in Firmware 9.09

6.5 Special Values for EEE.EEEE in Case of Errors

In case of errors (Table 8-1) the last valid measurement is repeated as the 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)

6.6 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 6-1 define the distances of the 4 … 20 mA interval.

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

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

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

6.7 Signal Strength (Signal Intensity)

The normalized signal strength value S_N or S_S is submitted at the second position in the data message 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 independently after a snow depth measurement and takes approximately 0.5 s, which corresponds to an average of about 10 single frequency measurements. It may be possible that the snow depth measurement has been stopped due to an error caused by too much background light, while the signal strength value is still transmitted.

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

This procedure was not precise enough to use the signal strength value for threshold methods like snow/no snow independent from the distance, because of the distance dependency. As a result, the number of distances used for reference targets are extended to 5. Firmware 9.09 supports these new settings first. 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 Jenoptik factory. 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.

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

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

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

$$SH(x) = SHa + \frac{(Shb - SHa)}{b - a} * (x - a)$$

The calculation of S_N is only valid when the measuring distance is known, meaning tha the signal strength S_N cannot be delivered in comparison to S_S, when the distance measurement cannot be achieved.

Note Users may change the SH and SL values to meet their specific needs.

6.7.1 Other Corrections

The signal strength depends on the sensor temperature. In cases of snow depth measurements, the relevant temperate range is small. In some cases, the signal strength should be used in large temperature ranges, compensation is useful. Initial measurements indicate the following dependency for targets with reflectivites >80:

$$S_N(T) = \ -0.125xT(°C) + S_N(24°C) + 3$$

At zero degrees, this correction leads to an increase of signal strength by 3.

6.8 SF in Analog Mode

Only in Firmware 9.05, the analog mode is not correctly displayed for SF≠1. If other scale factors have to be used, RE and RB have to be modified, as 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

6.9 Wiring

Table 6-3 Wiring			
Color Code 8 wire interface cable	**SHM 30**	**Connection**	**Pin on 12-pole binder connection**
Pink	Power	Power Supply +24V	G
Grey	Power Gnd	Power Supply Gnd	J
Green	Transmit – Tx	Datalogger Rx (C2/C4… or U2/U4…)	A
Yellow	Receive – Rx	Datalogger Tx (C1/C3… or U1/U3…)	B
Brown	Heater On/Off	Datalogger 12V	E
White	Not used	No connection	F
Blue	RS-232 Gnd, Iout Gnd	Datalogger G	L
Red	Iout	No connection	D

6.10 CR1000 Programming Example

```
'CR1000 Series Datalogger
'Program to read data from SHM30 Snow Depth sensor
SequentialMode

'---------------------------------------------------------------------------------------------
----------------------------
'Diagnostic variables
'---------------------------------------------------------------------------------------------
----------------------------
Public PTemp, batt_volt
Units PTemp = deg C
Units batt_volt = volts


'---------------------------------------------------------------------------------------------
----------------------------
' Variables for SHM30
'---------------------------------------------------------------------------------------------
----------------------------
Public SHM30_data(4)
```

```
Alias SHM30_data(1) = SHM30_SnowDepth
Units SHM30_SnowDepth = m
Alias SHM30_data(2) = SHM30_SignalStrength
Alias SHM30_data(3) = SHM30_Temp
Units SHM30_Temp = deg C
Alias SHM30_data(4) = SHM30_ErrorCode
Dim inputString As String * 64 'String to hold data string received from SHM30
Dim NBytesReturned
Dim shm30Check As Long 'Calculated checksum

'-----------------------------------------------------------------------------------------
----------------------------
'Wiring for SHM30
'-----------------------------------------------------------------------------------------
----------------------------
Const SHM30port = COM1 'Communications port used for connection to SHM30
'Pink        Power Supply 24V
'Grey        Power Supply G
'Green     CR1000 C2
'Yellow    CR1000 C1
'Blue       CR1000 G
'Brown    CR1000 12V

'-----------------------------------------------------------------------------------------
----------------------------
'Diagnostic data table
'-----------------------------------------------------------------------------------------
----------------------------
DataTable (Diagnostic,1,-1) 'Set table size to # of records, or -1 to autoallocate.
  DataInterval (0,24,Hr,10)
  Minimum (1,batt_volt,FP2,0,False)
  Maximum(1,batt_volt,FP2,0,False)
  Maximum (1,PTemp,FP2,False,False)
  Minimum (1,PTemp,FP2,False,False)
EndTable

'-----------------------------------------------------------------------------------------
----------------------------
'Snow depth data table
'-----------------------------------------------------------------------------------------
----------------------------
DataTable(HourlySnowDepth,1,-1)
  DataInterval(0,1,hr,10)
  Average(1,SHM30_SnowDepth,FP2,false)
EndTable


'Main Program
BeginProg
  'Open COM port for SHM30
  SerialOpen (SHM30port,9600,3,0,200)

  'Set up SHM30 for polled mode
  SerialOut (SHM30port,CHR(&h1B),"",1,10)
  SerialOut (SHM30port,"srn" & CHR(13),"",1,10)

  Scan (15,Sec,0,0)
    PanelTemp (PTemp,_60Hz)
    Battery (batt_volt)

    'Measure SHM30 once every 15 minutes
    If TimeIntoInterval(0,15,min) Then
      'Send the measurement command
      SerialOut (SHM30port,"xm" & CHR(13),"",1,0)
      'Wait for the sensor to make its measurement
      Delay (1,6500,mSec)
      'Request the data from the sensor
      SerialOut (SHM30port,"xw" & CHR(13),"",1,0)
```

```
      Delay(1,100,msec)
      'Receive the data from the sensor
      SerialInRecord (SHM30port,inputString,ASCII(">"),0,ASCII("<"),NBytesReturned,01)

      'Verify the checksum to ensure the sensor's response is valid
      shm30Check  = CheckSum (inputString,7,0 )
      If shm30Check = 0 Then
        SplitStr (SHM30_data(),inputString,"",4,0) 'If checksum good, extract values from
string
      Else 'If chesksum fails, write NAN to variables
        SHM30_data(1) = NAN
        SHM30_data(2) = NAN
        SHM30_data(3) = NAN
        SHM30_data(4) = NAN
      EndIf
    EndIf

    CallTable Diagnostic
    CallTable HourlySnowDepth
  NextScan
EndProg
```

7. Maintenance

Note Avoid looking directly into the laser beam.

TABLE 7-1. Cleaning Schedule and Action

Interval	**Cleaning Required**	**Supplies required**
Quarterly	Ensure the beam path is clean. Remove sediment, dust, and insects from the mechanical parts.	*Microfiber wipes *Neutral cleaning agent *Air pressure for insects in the optical tube
Annually (Before winter)	Check cable connector and mounting clamps. Clean stray light protection tube.	*Allen key *Microfiber wipes *Neutral cleaning agent *Air pressure for insects in the optical tube (See Figures 8-1 to 8-3)
As required	Remove snow and ice.	

Note Do not attempt to clean the optical components in the field. Remove the sensor, by unscrewing the tube and aperature in front of the sensor to clean the optical components properly.

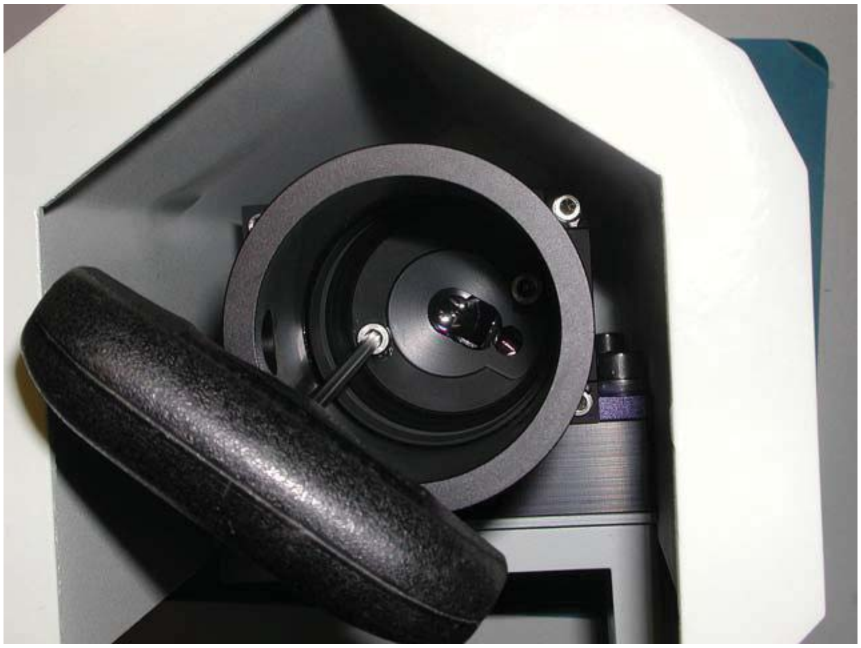


Figure 7-1 Unscrew the tube for stray light reduction to clean the mechanics and optics.

Figure 7-2 Cleaning supplies: bellows, Allen key (T handle), and tube with aperature.

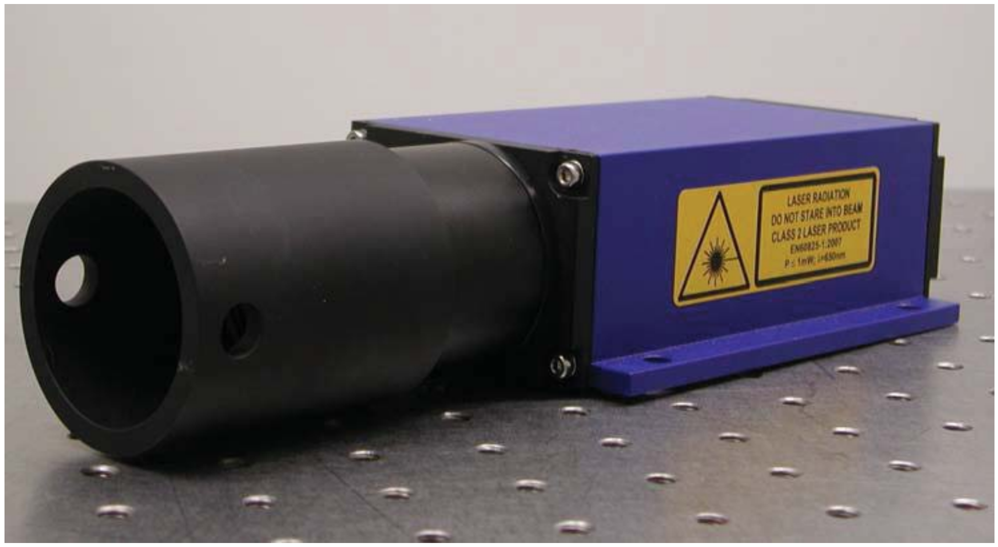


Figure 7-3 Core sensor module LDM30.11. In case of service, only these core components need to be exchanged in the field.

If it is necessary to exchange the measuring module, only the core module (shown in Figure 8-3) should be sent to Campbell Scientific (Canada) for repair.

8. Troubleshooting

8.1 Error Codes

The SHM 30 has several built-in error codes. The error codes are available if the sensor is connected to the RS-232 or RS-422 digital interfaces. The analog current output generates only a 3 mA (or 21 mA) current to indicate an error without further details.

In normal operating mode, the E15 to E24 errors indicate problems in running temperatures. E61, E65, and E67 may occur if the user communicates with the measurement.

In the event of hardware errors, the SHM 30 requires service.

TABLE 8-1. Error Codes	
Error Codes	**Description**
E15	Signal is too weak or distance is too short (<10 cm)
E16	Signal is too strong (relection 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. Return sensor for repair.
E51	APD voltage value failure (straylight of hardware error)
E52	Laser current is too high. Possibly a broken laser diode.
E53	Math (division by zero)
E54, E55	Hardware errors. Return sensor for repair.
E61	Invalid command in the RS-232 or RS-422 configuration
E62	1. Hardware error in the interface 2. Incorrect value in the interface communication (parity error S10)
E63	S10 overflow – check time for emitted signals in application software
E64	Framing error S10 – serial interface parameter not set correctly to 8N1
E65	Measurement was interrupted by a query from the user. Since firmware 9.05 this error no longer occurs if the running measurement is queried by a xw in polling mode. The result is transmitted once the measurement is complete.
E66	The variation of snow depth between 2 consecutive measurements is outside the limit set by xp. Instead, the last valid value is transmitted. Firmware 9.06 – after 60 measurements, the new value is accepted.
E67	Measurment was interrupted by the ‘ESC’ command

TABLE 8-2. Message Responses and Analog Feedback for Error Codes

Error Codes	RS-232/RS-422 Message Responses	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
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, 55	>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)

Note I_{out} {3; 21} depends upon the re, rb settings

8.1.1 Start up Error Responses

The following snow depth values are initialization values that will be transmitted in the data message. Whenever an error is detected immediately upon system start-up or whenever the xm start command is set, 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)

Note In other cases, the last valid measurement is repeated as eee.eeee.

Appendix A. Determining the Correct Inclination Angle

A.1 Reference Object Technique

The installer can use a reference object with a specified height *c* to determine the angle of inclination.

1. Stop measuring process (Esc) and change the measuring time interval to “xt10” to 10 seconds.
Set: “sp0” amd “of0”.
Ensure that “sf” is set up correctly and xp allowd for a high variability for the installation process.
Ex: if sf = 1, xp > c.

2. Mount the sensor at the desired angle position (ex.: 15°) and perform 1 distance measurement.

3. Start measurement ‘xm’. Wait 6 seconds. Press ‘xw’ in polling mode to query distance value.

4. Stop measurement (Esc) and note the distance.

5. Place object (B) and perform a new measurement.

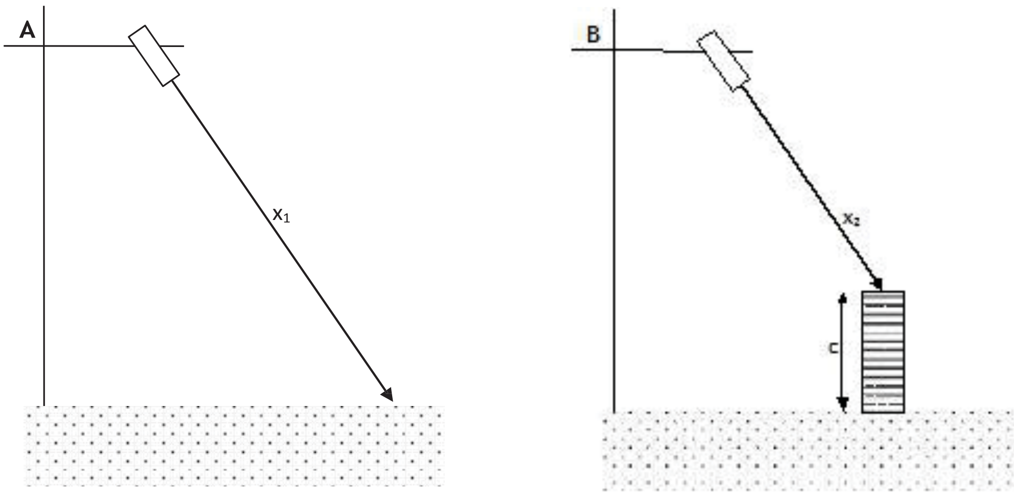
6. Calculate angle α (C) and use the ‘sp’ command to set the anlge.

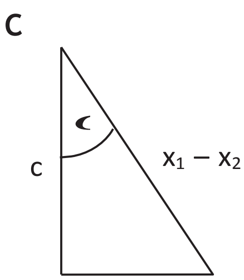
7. The measured distance values now correspond to the vertical distance. You will receive a negative value.

8. Perform offset measurement ‘so’.

9. Change :
‘xt’ to the final time interval
‘xp’ to the final variability

10. Restart the measurement process with ‘xm’.





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

$\therefore \alpha = 30.5°$

Figure 8-1 Technique for determining the angle of inclination

A.1.1 Absolute and Relative Error

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

A.2 Plumb Method

Using a perpendicular is a more precise method for determining the inclination angle of the sensor.

1. Mark the position of the perpendicular at the ground and measure the distance *y* at ground level to the laser spot.

2. Use the distance measured by the sensor (sp0, of0) and *y* to calculate correct angle of inclination.

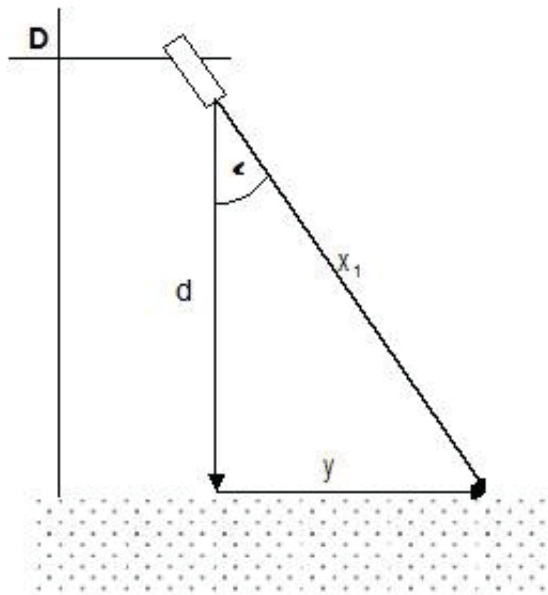


Figure 8-2 Plumb procedure: α = arcsin (y/ x1)

Appendix B. Firmware Release

Table 8-3 Firmware Releases		
Date	**Firmware Release**	**Description**
01.06.2009	9.04	Official market launch of SHM 30 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°. * normal reflectivity integrated (factory calibration to white ‘sh’ and black ‘sl’ targets). * output resolution modified from 1 mm to 0.1 mm. * Bug in message display solved for higher scale factor values. * Error 65 will no longer appear if measurement is interrupted by polling command. Measurement will now be finalized and the answer will be sent upon completion. *E67 added – appears when a 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	* 2 bugs have been fixed – in rare cases they lead to a frozen state in polling mode. * Commands can be entered in upper or lower case. * DMA – transfer will no longer be interrupted by measuring process.
1.11.2012	9.08	* Format for single digit temperature values in message corrected: Previously: TTT <space>+9 Now: TTT+09 * ‘sh’ and ‘sl’ are now limited [0, 100].
15.7.2013	9.09	* Message 2 (‘sdb’) added. * User variables M1 to M8 were added. * Normalization signal strength was revised. * ‘sld’ and ‘shd’ parameters were introduced. *Variable snow flag and threshold ‘ss’ were implemented.