SMA-2

Snow melt analyzer

User Manual

Setup version 3.10

2019-03-12

Sommer GmbH

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Validity

This manual applies to the SMA-2 snow pack analyzer and is valid for the setup version 3.10 with all its subversions.

The firmware version can be viewed with the function *Device status* and is listed in the boot message.

Created:	Last update:	Approved:	File:
jofri 2019-03-12	-	wosom 2019-03-12	manual_SMA-2_en.docx

CE compliance

This product is in conformity with the following standards

LVD	**Directive 2014/35/EU**	**EN 62368-1**
		EN 61010
EMV	**Richtline 89/336/EEC**	**EWG EN 61326**
RoHS II	**Directive 2011/65/EU**	
RoHS III	**Delegated Directive (EU) 2015/863**	

Safety information

Please read this manual carefully before installing or operating this equipment. Non-compliance with the instructions given in this manual can result in failure or damage of the equipment or may put people at risk by injuries through electrical or mechanic impact.

- Installation and electrical connections must be carried out by qualified personnel familiar with the applicable regulations and standards.
- Some parts of the device are heavy or long. For their handling contact your safety officer or consult applicable safety regulations for precautions and proper personal safety equipment.
- Do not perform any installations in bad weather conditions, e.g. thunderstorms.
- Prior to installation of equipment inform the owner of the measurement site or the authority responsible for it. Upon completion, secure the installation from trespassers.
- Maintenance and repair must be performed by trained personnel or an engineer of Sommer GmbH. Only replacement parts supplied by Sommer GmbH should be used for repairs.
- Make sure that NO power is connected to the equipment during installation and wiring.
- Only use a power supply that complies with the power rating specified for this equipment.
- Keep equipment dry during wiring and maintenance.
- If applicable, it is recommended to use accessories of Sommer GmbH with this equipment.

Disposal

After this device has reached the end of its lifetime, it must not be disposed of with household waste! Instead, dispose of the device by returning it to a designated collection point for the recycling of waste electrical and electronic equipment.

Content

1 Introduction

Determination of snowpack-properties can be very challenging as they vary significantly in space and time. The SMA-2 snow melt analyzer measures the volumetric contents of ice and water and determines the snow density. This is achieved by recording the complex impedance of a ribbon-shaped sensor that rests in the snow pack. This device provides an automatic measurement system to continuously monitor the snowpack development for hydrological and other applications.

2 Unpacking

When unpacking your SMA-2 please make sure that the following items are present:

ID	Description	Quantity
1	Base-profile right, L-shaped	1
2	Base-profile left, L-shaped	1
3	Cross-profile with winch	1
4	Cross-profile with pulleys	1
5	SMA ribbon-sensor with sensor cable	1
6	Tension spring for SMA ribbon-sensor	1
7	Stainless steel extension cable with shackle	1
8	Pair of plastic clips	4
11	Anti-twist support, pair	4
12	Control cabinet with SPA-controller	1
13	Peg for anchoring	4

Table 1: Parts list

Bolts and nuts are pre-mounted. In case of missing or damaged items please contact your Sommer sales partner.

The following items are available as options:

- Commander software
- USB to RS485 converter cable

3 Quick start

This section will guide you through the most important steps to set up a fully operating system to measure snowpack properties with the SMA-2. It is divided into three main parts: installation, connection to a PC and sensor configuration.

3.1 Installation

1. Select a representative measurement site (Section *6.1*)
2. Install the SMA-2 frame, sensors and control cabinet (Section *6.2*)

3.2 Connection of the SMA-2 to a computer

1. Install the Commander software
2. Connect the SMA-2 to your computer using the USB to RS485 converter cable (Section *7.2*)
3. Connect a 9…28 VDC power supply to the SMA-2 data cable
4. Start the Commander software and establish a connection with the SMA-2 (Section *7.2*)

3.3 Sensor configuration

1. Select language and decimal character (Section *8.3*)
2. Select the measurement trigger and measurement interval (Section *8.3*)
3. Calibrate the SMA-2 by measuring the capacities of the ribbon sensors in air (Section *8.4*)
4. Optional: measure the capacities of the ribbon sensors with a reference plate (Section *8.4*))
5. Define the format and timing of the data output (Section *8.6*)

Upon successful configuration the SMA-2 may be connected to a data logger for continuous monitoring (Section *7.3*).

4 Specifications

Physical and environmental	
Power supply	9…28 VDC; Reverse voltage protection, overvoltage protection
Power consumption at 12 V	max. 65 mA active; 1 mA in sleep mode
Operating temperature	-35…60 °C (-31…140 °F)
Storage temperature	-35…60 °C (-31…140 °F)
Protection rating	IP 54; IP66 with SMA-2 controller in electrical cabinet
Lightning protection	Integrated protection against indirect lightning with a discharge capacity of 6 kA Ppp
Frame material	Aluminium
Size L x W	3000 x 600 mm (118.11 x 23.62 in)
SMA-sensor	
Size L x W	2600 x 60 mm (102.36 x 2.36 in)
Material	weatherproof, UV resistant ribbon, reinforced with Kevlar cords
SPA-controller	
Inputs	up to 4 SMA ribbon-sensors (only applicable for SPA-2) 4x Analog 0 ... 2.5 V, 16 bit 2x Trigger input, low: 0…0.6 V, high: 2…26 V 1x RS-485 1x SDI-12
Outputs	4x Switched power supply, max. 0.2 A each 1x RS-485 1x SDI-12
Measurement range and accuracy	
Snow density	0 … 1000 kg/m^3 (±5% FS)
Volumetric water content	0 … 100 % (±2% FS)
Volumetric ice content	0 … 100 % (±2% FS)

Table 2: Specifications

5 Principles of operation

A snowpack has strong spatial variability and transforms considerably over time. The evaluation of snow properties and the assessment of snow conditions mostly relies on spot observations. The snow melt analyzer SMA-2 breaks these limitations and provides information about the snow pack by measuring the dielectric properties of a large snow volume. It provides relevant snow properties like density and contents of liquid water and ice.

Snow consists of ice, water and air, which have distinctly different dielectric properties. By measuring the complex impedance along a ribbon sensor (SMA-sensor) at two different frequencies, ice, water and air can be distinguished and their relative volume contents can be determined. In *Figure 1* the cross section of a SMA-sensor and its surrounding electric field are illustrated.

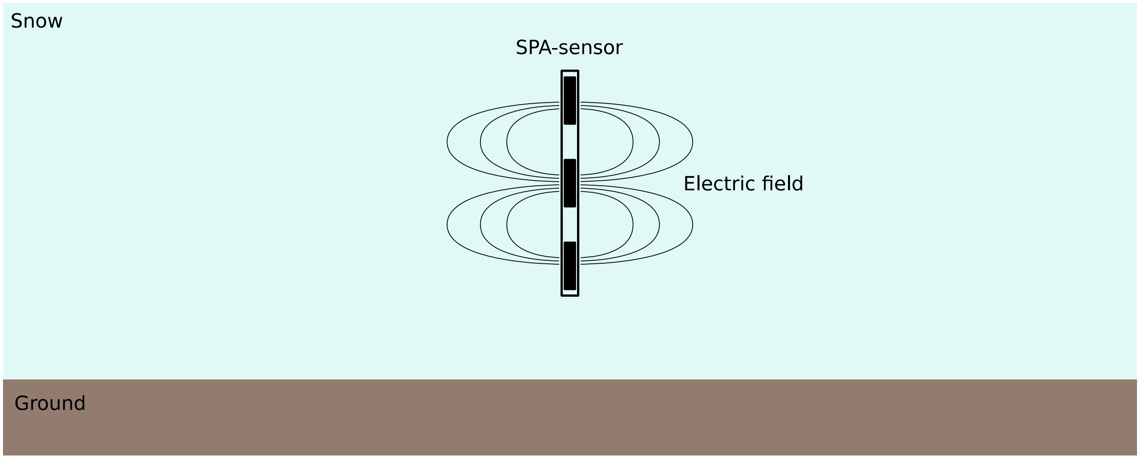


Figure 1: Measurement principle of a SMA-sensor

The SMA-sensor is a 60 mm wide, reinforced rubber ribbon containing three parallel copper wires. As soon as an alternating current flows through the wires, an electric field builds up that penetrates up to 4 cm into the surrounding snowpack.

6 Installation

6.1 Selection of the measurement site

The selection of a suitable site is crucial to gain information of the snowpack that is representative of the monitored area. Several aspects have to be considered when choosing a measurement site:

1. The selected site should be flat with no dips and rises.
2. The measurement spot should be representative of the monitored area.
3. There should be no boulders, trees, fences or other objects in the vicinity of the measurement spot. Any obstacle can cause snow drift and thus affect the measurement results.
4. If feasible, the SMA-2 should be installed in the direction of the main wind. This minimizes disturbances by snow drifts.
5. The site must be safe from avalanches.

6.2 Assembly

⚠ **Attention**	To avoid erroneous measurements, the SMA-2 must be installed on firm ground. If there is a risk of subsiding ground, reinforce the surface with logs or concrete slabs and install the SMA-2 on top of it.

6.2.1 Tools

Prepare the following tools for installation of the SMA-2:

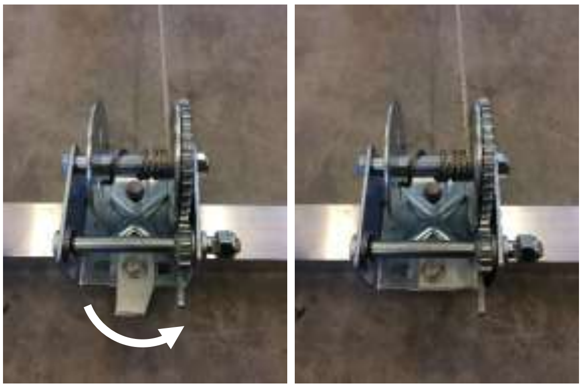
- 1x flat spanner 19 mm
- 1x flat spanner 13 mm
- 1x flat spanner 10 mm
- Allen-keys 3 mm
- Side cutter
- Folding rule

6.2.2 Supporting frame

Follow the steps below to assemble the supporting frame:

1. Join the base- and cross-profiles with the provided bolts.
2. Attach the ribbon-sensor to the clamp of the cross-profile. Make sure that the sensor cable is pointing upwards and that the ring-nut can turn in the clamp-gap!
3. Hinge one end of the extension cable to the far end of the ribbon-sensor and guide it around the pulleys of the cross-profile. Make sure that the ribbon-sensor is not twisted!
4. Hinge the tension spring to the other end of the extension cable and to the cable of the winch.
5. Tighten the spring to a length of 323 ±5 mm by operating the winch in clockwise direction.

6. Secure the winch by turning the lug into its right position.



7. Secure the sensor cable with the provided clamp.
8. Attach the 4 plastic clips onto the ribbon-sensor with the supplied bolts. The spaces between the clips should be equal along the ribbon (65 cm). Make sure the thickened edges of the ribbon are placed in the notches of the clips.
9. Attach the positioning supports to the clips.

6.2.3 Control cabinet

1. Mount the control cabinet to its dedicated place (frame of SMA-frame or mast in the vicinity).
2. Feed the sensor cable of the SMA ribbon-sensor and the cable of the power supply through the cable glands into the cabinet and secure them with the provided nuts.

6.2.4 Wiring

1. Connect the SMA-sensor cable to the I1 terminal of the controller. The sensor wires are connected to the SMA-2 controller as illustrated below.

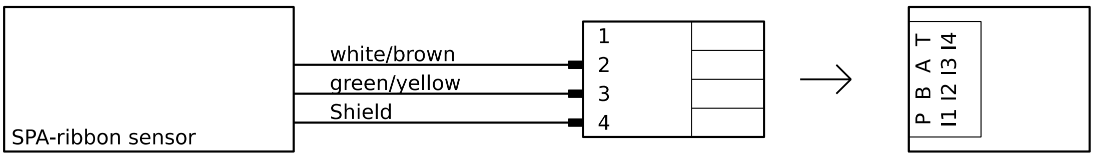


Figure 2: Wiring of SMA ribbon-sensor

Wire color	Pin	Function	Description
-	1	-	not connected
white/brown	2	Receive	Received signal
green/yellow	3	Transmit	Transmitted signal
shield	4	-	cable shield

Table 3: Connection wires of SMA ribbon-sensor

6.2.5 Power supply

The SMA-2 is designed for extreme environmental conditions at remote sites with no grid connection. The sensor switches automatically into standby-mode between measurements and thus consumes only approx. 0.1 Ah per day at a typical measurement interval between 5 to 10 minutes. Thus, the device can be powered by a 12V-solar-generator mounted in the vicinity.

The installation of the SMA-2 is now complete. Please follow the instructions in *Configuration* to complete the setup.

6.3 Lightning protection

If the underground at the measurement site permits sufficient current dissipation it is strongly recommended to equip the device with properly dimensioned lightning protection. Consult an expert for advice.

6.4 Maintenance

The SMA-2 generally does not require any special maintenance. However, we recommend to check the following regularly:

- Sits the installation firmly on the ground?
- Is the SMA ribbon-sensor damaged and tightly stretched? Are the clips in the upright position?
- Is the sensor cable and its protection tubing intact or broken, e.g. damage by rodents?

7 Communication

7.1 SMA-2 controller

The controller of the SMA-2 triggers the measurements of the connected sensor, acquires data and calculates the snow parameters. It returns the data via RS-485 or SDI-12.

7.1.1 Connection terminals

All available connection terminals are listed in *Table 4*.

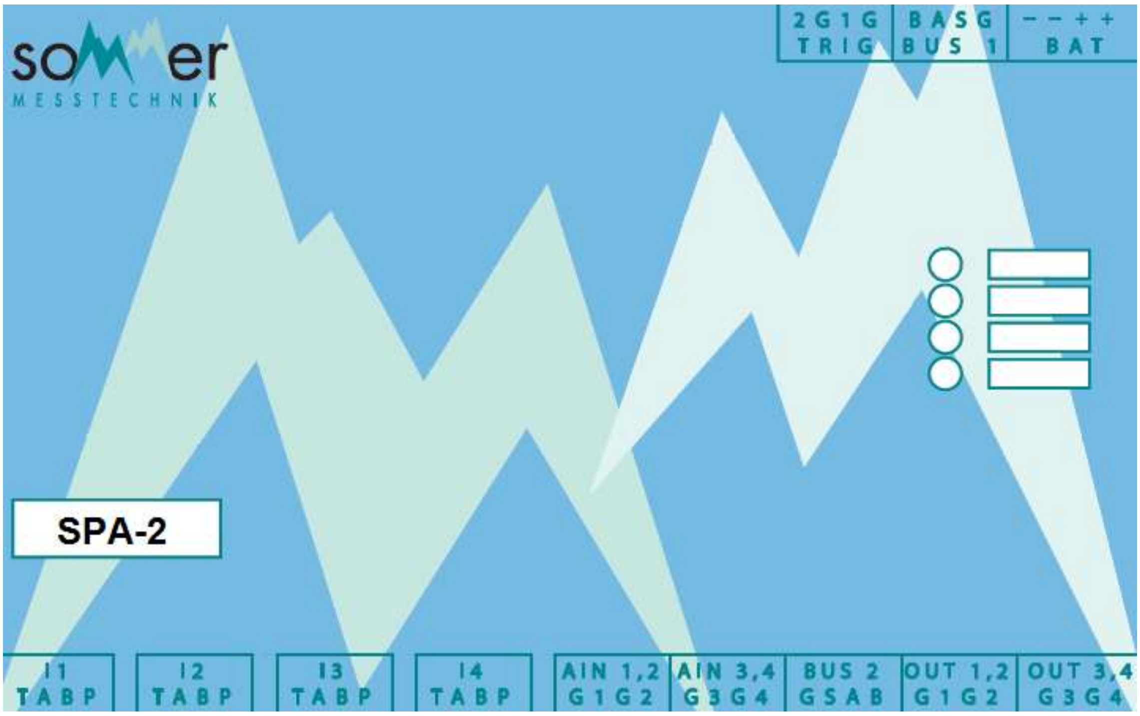


Figure 3: Connection terminals of SP-2 controller

Terminal	PIN	Description
TRIG	2	Trigger input 2 (not available)
	G	Ground
	1	Trigger input 1
	G	Ground
BUS 1	B	RS-485 B (to data acquisition device)
	A	RS-485 A (to data acquisition device)
	S	SDI-12 (to data acquisition device)
	G	Ground
BAT	-	Supply voltage (-)
	-	Supply voltage (-)
	+	Supply Voltage (+), 9.0 to 24.0 VDC
	+	Supply Voltage (+), 9.0 to 24.0 VDC

I1	T	Optional temperature input
	A	SMA ribbon-sensor
	B	SMA ribbon-sensor
	P	Shield of SMA ribbon-sensor
I2	T	Optional temperature input
	A	Used with SMA-2 (ribbon sensor)
	B	Used with SMA-2 (ribbon sensor)
	P	Used with SMA-2 (ribbon sensor)
I3	T	Optional temperature input
	A	Used with SMA-2 (ribbon sensor)
	B	Used with SMA-2 (ribbon sensor)
	P	Used with SMA-2 (ribbon sensor)
I4	T	Optional temperature input
	A	Used with SMA-2 (ribbon sensor)
	B	Used with SMA-2 (ribbon sensor)
	P	Used with SMA-2 (ribbon sensor)
AIN 1,2	G	Ground
	1	Analog input 1
	2	Analog input 2
AIN 3,4	G	Ground
	3	Analog input 3
	4	Analog input 4
BUS 2	G	Ground
	S	SDI-12 (from sensor)
	A	RS-485 A (from sensor)
	B	RS-485 B (from sensor)
OUT 1,2	G	Ground
	1	Switched supply voltage 1
	2	Switched supply voltage 2
OUT 3,4	G	Ground
	3	Switched supply voltage 3
	4	Switched supply voltage 4

Table 4: Connection terminals of SMA-2 controller

7.2 Communication with a PC

Communication between the SMA-2 and a PC can be established with a USB to RS-485 converter. Perform the following steps to set up the communication between the SMA-2 and your PC:

1. Install the Commander software on your PC.
2. If not already done, install the driver of the USB to RS-485 converter.
3. Connect the USB to RS-485 converter to a USB-port on your PC and the BUS 1 terminal of the SMA-2 as illustrated in *Figure 4*.

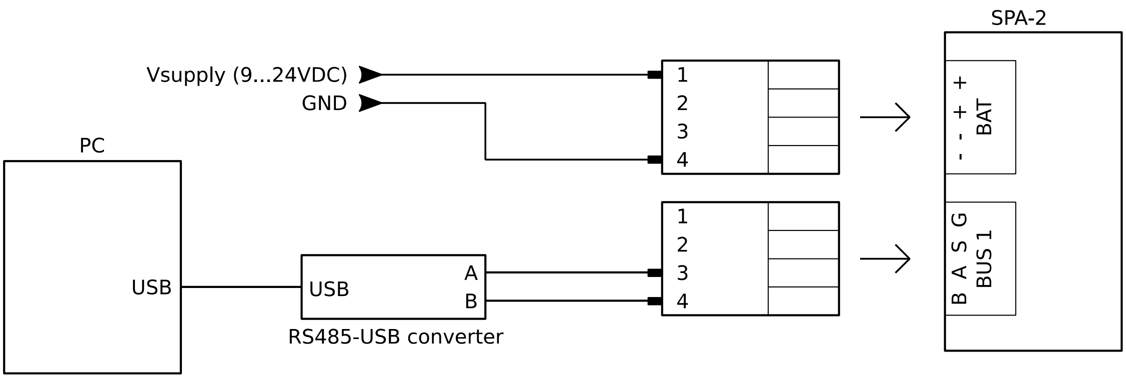
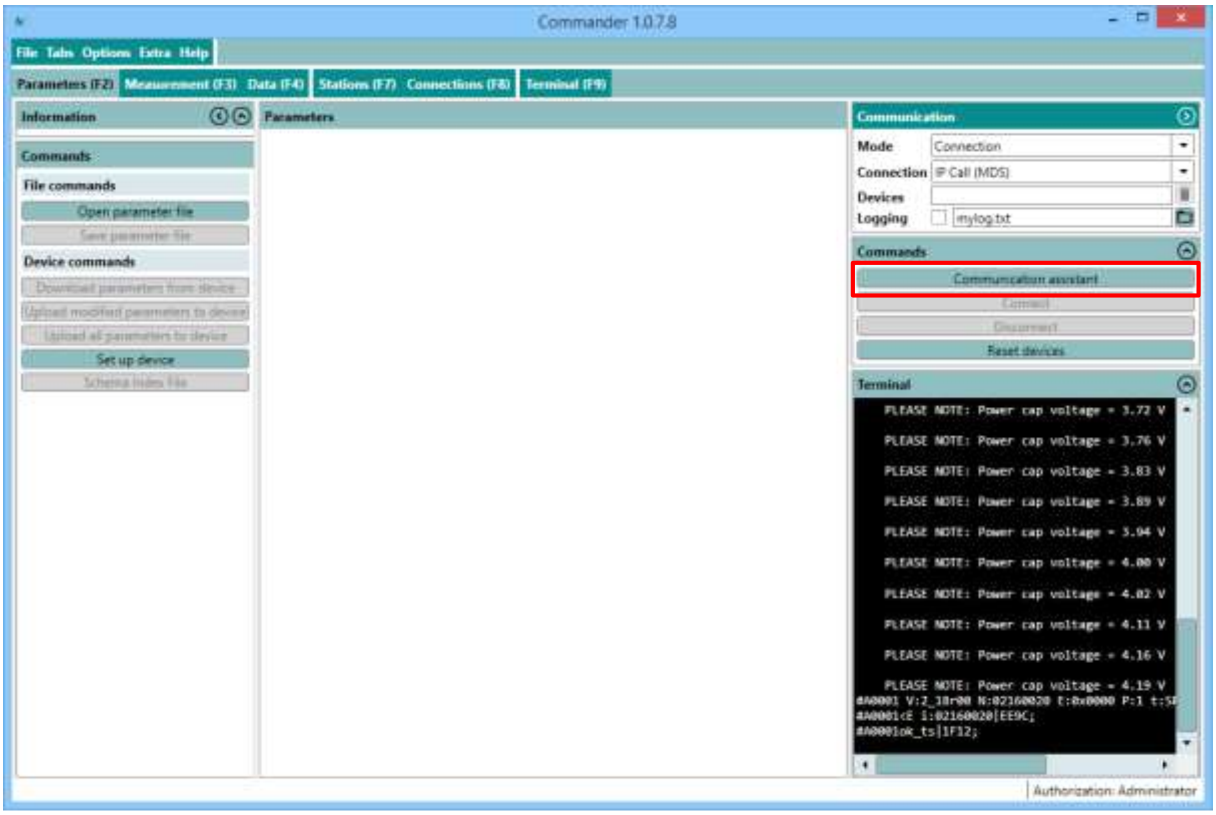
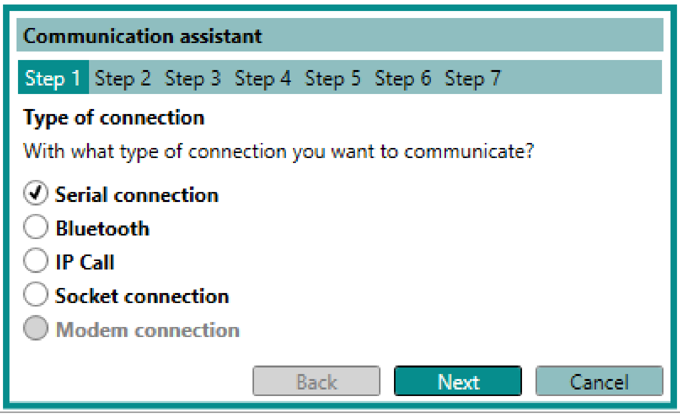


Figure 4: Connection of USB to RS-485 converter

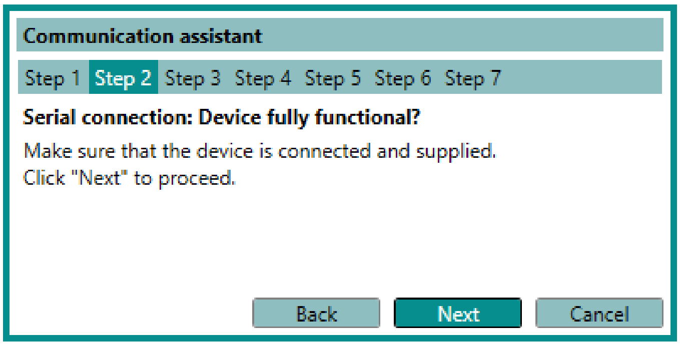
4. Start the Commander Software.
5. Click on *Communication assistant* on the right-hand side of the Commander window.



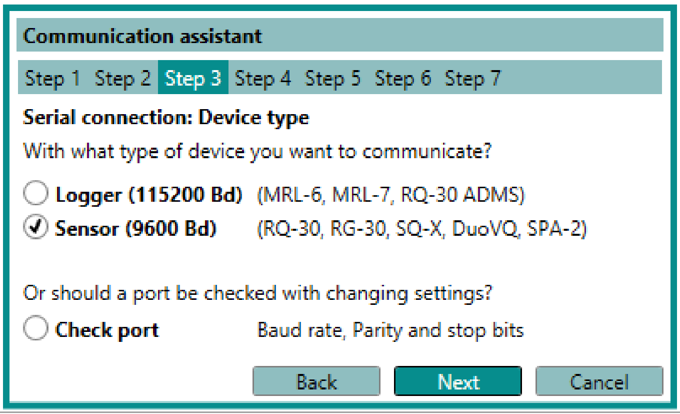
6. Select *Serial Connection* and press *Next*.



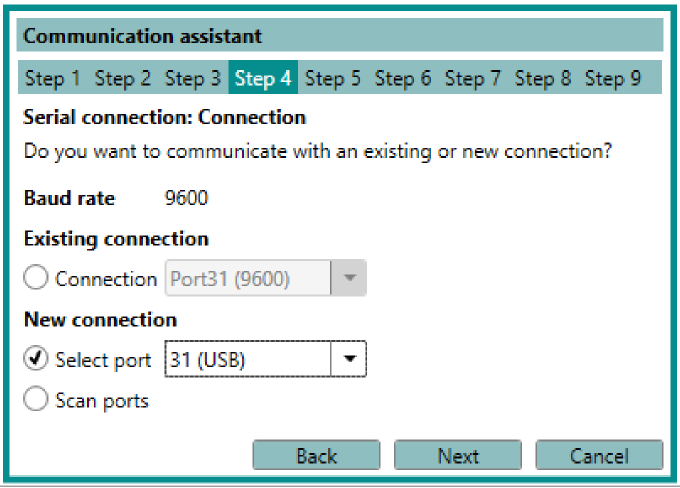
7. Make sure the SMA-2 is powered and press *Next*.



8. Select *Sensor (9600 Bd)* and press *Next*.

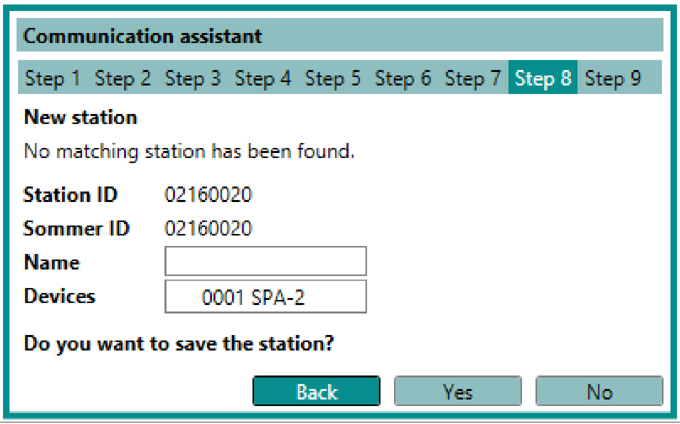


9. Tick *Select port* and select the COM port that was assigned to the USB/RS-232 converter; then click *Next*.

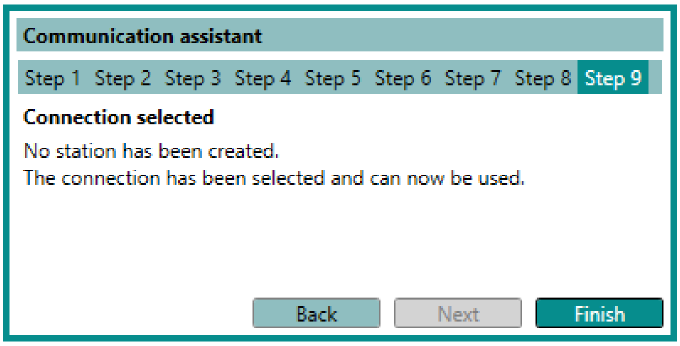


If more than one COM ports are listed and you are not sure which one to select, open the Windows Device Manager (press and type *device manager*) and expand the menu *Ports (COM & LPT)*. By unplugging and re-plugging your USB/RS-232 converter you can identify the number of the desired port.

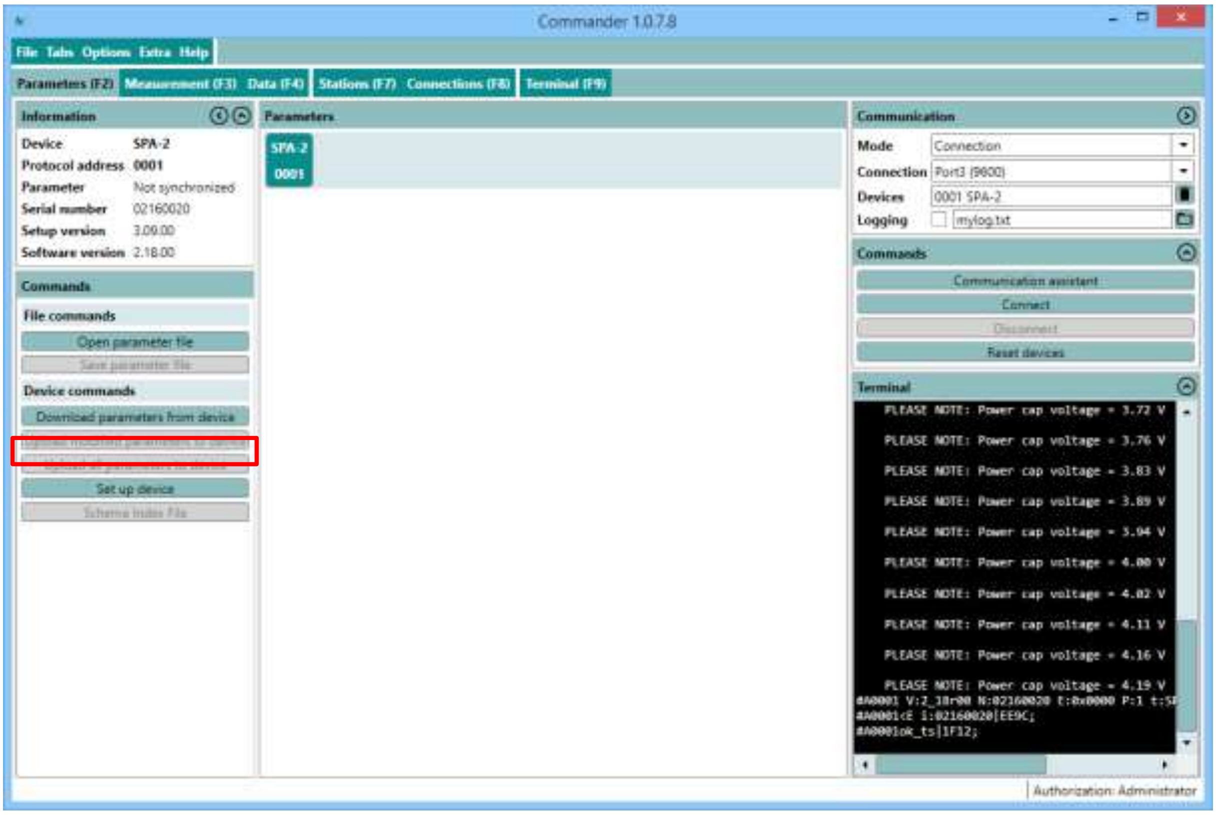
10. The Commander now searches for connected devices. This may take a few minutes. Upon completion, press *No* to the question "*Do you want to save the station?*".



11. Click *Finish*. Upon completion, the newly created connection is displayed in the *Communication* section of the Commander.



12. Open the *Parameters (F2)* tab and click *Download parameters from device*.



7.3 Connection to a data logger

7.3.1 RS-485

The SMA-2 can be connected to a data logger via RS-485 according to *Figure 5*.

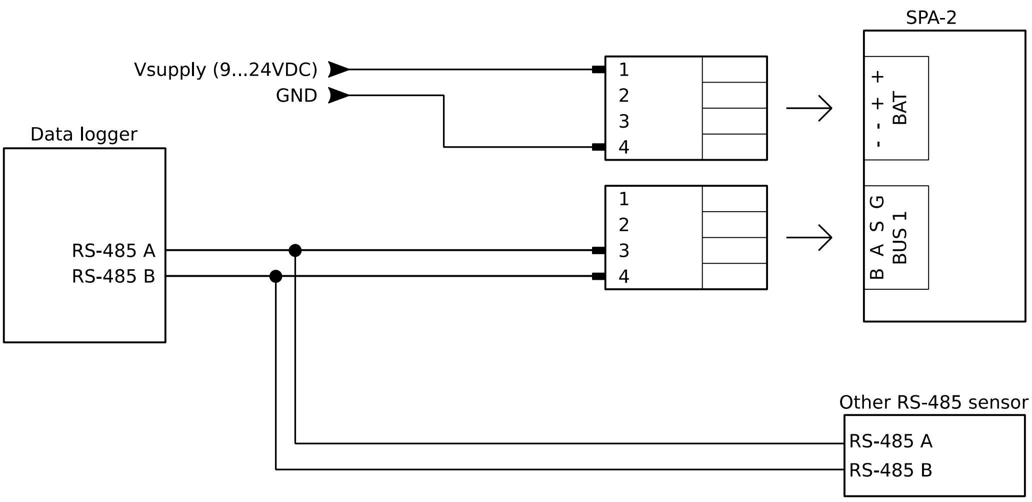


Figure 5: Wiring of the SMA-2 with a data logger via RS-485

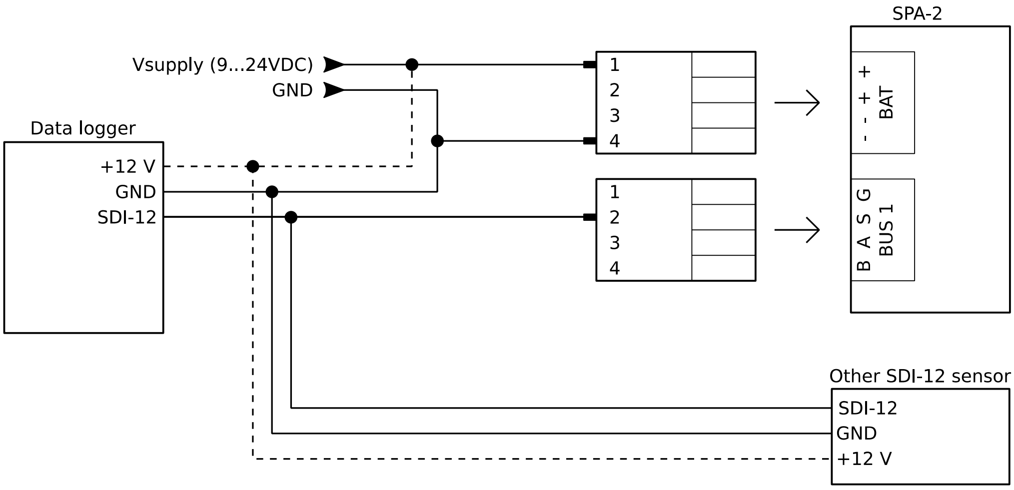


Figure 6: Wiring of the SMA-2 with a data logger via SDI-12

7.3.2 SDI-12

The SMA-2 can be connected to a data logger via SDI-12 according to *Figure 6*. SDI-12 uses a shared bus with a ground wire, a data wire (indicated as SDI-12) and an optional +12 V wire.

⚠ **Attention**	The connection with the 12 V power supply is optional and depends on the connected SDI-12 master device (typically a data logger).

7.4 Connection to Modbus

The SMA-2 sensor is connected to Modbus according to *Table 5*.

Modbus	Terminal	Description
Common	BUS-1 G	GND
D1 - B/B	BUS-1 B	RS-485 A
D0 - A/A	BUS-1 A	RS-485 B

Table 5: Connection to a Modbus

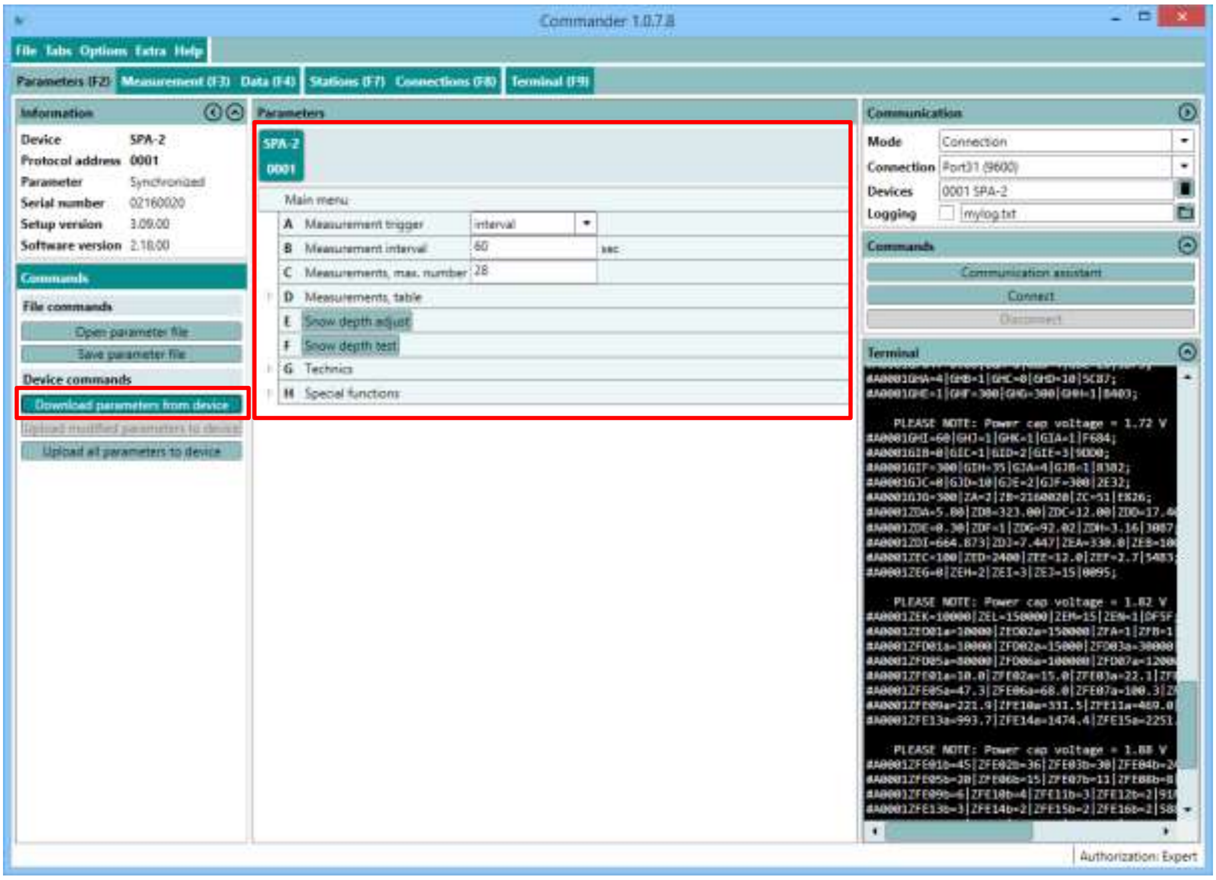
The SMA-2 does not have termination resistors and does not need BUS polarization resistors. Therefore, only a RS-485 BUS termination has to be implemented externally.

8 Configuration

8.1 Setup using Commander

A simple and comfortable way to configure the SMA-2 is the PC software Commander by Sommer.

After establishing a connection as described in Section 7.2 the sensor settings can be accessed by selecting the tab *Parameters (F2)* and clicking *Download parameters from device*. The complete parameter list is transferred from the sensor to your PC and displayed in the *Parameters (F2)* window. Now, the settings can be modified, saved in a parameter file on your PC and uploaded again to the SMA-2. See Section 9 for a complete list of sensor settings.



⚠	**Attention**	During the first communication with a new sensor the parameter schema of the sensor has to be transferred to the local PC. Only then the menu structure is available in the Commander. This may take several seconds.

Besides the sensor configuration utility the Commander provides a terminal to check data transfer and to access the sensor settings menu directly.

☝	**Hint**	A detailed description of the Commander and its utilities can be found in the Commander manual.

8.2 Setup using a terminal program

The Commander software ships with an integrated terminal program. However, communication with a SMA-2 can be performed with any terminal program.

Perform the following steps to access the setup menu of the SMA-2 using a terminal program:

1. After establishing a connection with the SMA-2 as described in Section *7.2* open the preferred terminal program on your PC.
2. Select the COM port assigned to the USB/RS-485 converter and adjust the communication settings as described in Section *7.2*.
3. After successful connection the setup menu can be accessed by entering three question marks (`???`) in quick succession.

Hint	As an unwanted switching into the menu mode has to be avoided the timing of the three question marks `???` is very restrictive and must never be finished with *Return/Enter*. This is especially important for command line tools, which may automatically send a closing carriage return.

The menu items can be selected by entering the letter assigned to each item. Upon selection a sub-menu is opened or the selected parameter is displayed with its unit. Changes to values are confirmed with *Return/Enter* or can be discarded with *Esc*. Menus are closed with *X*. After closing the main menu the sensor performs an initialization.

If the SMA-2 is re-powered a boot message containing the sensors firmware version and address in the RS-485 bus is displayed in the terminal window.

8.3 General settings

When first setting-up an SMA-2 at a measurement site the following general configurations may need to be adapted:

Language (*E-A*)

The menu language.

Decimal character (*E-B*)

The character used as decimal separator in the values of the settings and in serial data strings.

Measurement trigger (*A*)

Measurements of the SMA-2 can be triggered in the following ways:

- Internal measurement interval (selection *interval*): Measurements are initiated by the SMA-2 in the interval specified in *Measurement Interval*.
- External command (selection *SDI-12/RS-485*): Measurements are triggered by commands received via the RS-485 or SDI-12 interface.
- External trigger (selection *TRIG-1 input*): Measurements are triggered by a DC-voltage applied to the TRIG-1 input.
- All options (selection *all allowed*): Measurements are triggered by all of the above options.

Attention	Measurement results are returned independently of ongoing measurements. The time when results shall be returned can be modified in *OP, measurement output*.

Measurement interval (*B*)

A measurement interval between 20 sec and 3 hours can be selected.

8.4 Calibration of SMA-ribbon-sensor

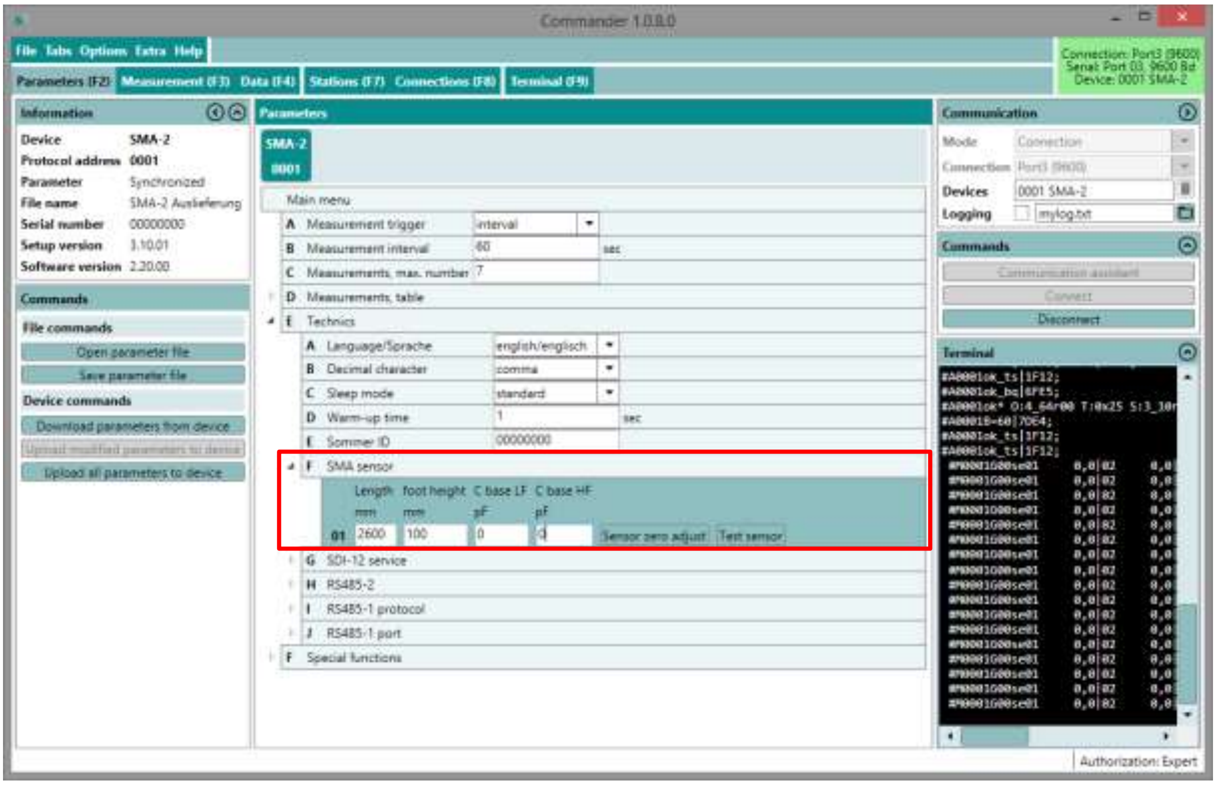
The SMA-ribbon-sensors are calibrated by measuring the complex capacities in dry air (zero) and with an attached reference plate that simulates a certain water content (span). Sommer Messtechnik only ships calibrated SMA ribbon-sensors and generally, a regular zero-check of the sensors is sufficient. If required, the reference plate can be obtained from Sommer Messtechnik.

⚠ **Attention**	During calibration the SMA-ribbon-sensor must be dry and free of snow and ice! All sensors must be connected and active during calibration!

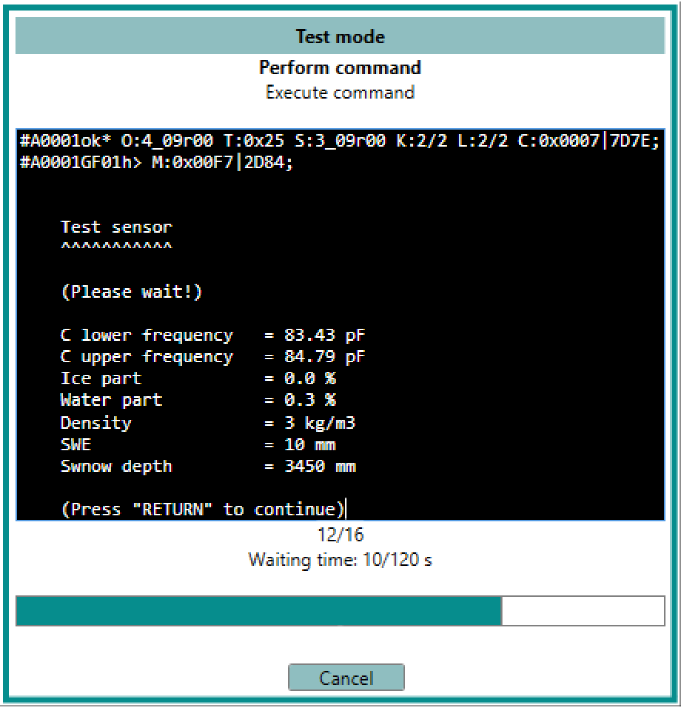
8.4.1 Zero test and adjustment

Follow the instructions below to perform a zero-test and -adjustment:

1. Install the SMA-2 as described in Section *6*.
2. Connect the SMA-2 controller to your PC and a power-supply with the specified rating.
3. Open the Commander software and establish a connection to the SMA-2 as described in Section *7.2*.
4. Download the parameter list and open *SMA, sensor table* in the *Technics* menu.



5. For each sensor click *Test sensor*. The SMA-2 performs a measurement and displays the results in a pup-up window.



The C-values at both frequencies should be 83 ±5 pF. The fractions of ice and water as well as the density should be zero. If the C-values are within these limit, no calibration needs to be performed. If the C-values are outside the limits specified above, perform a zero-adjustment by clicking *Sensor zero adjust*. After the adjustment, test the sensors again.

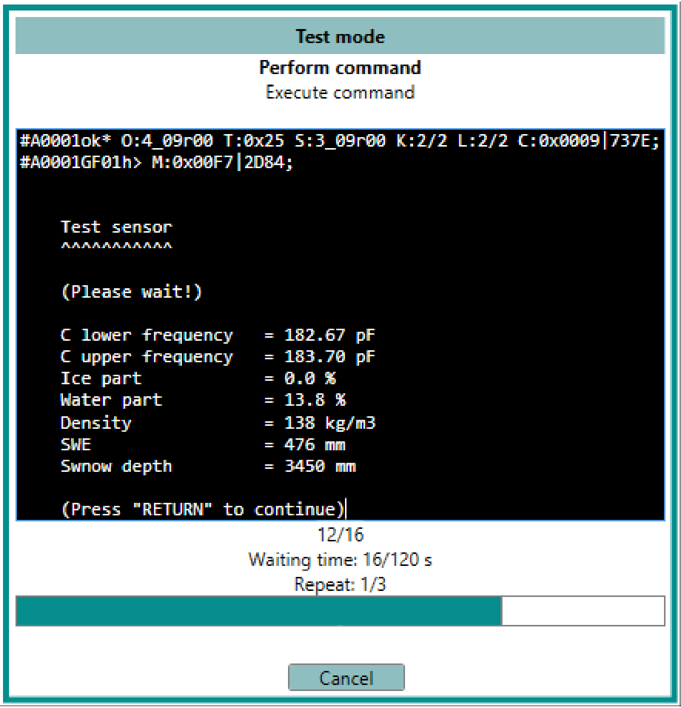
8.4.2 Span test and adjustment

Follow the instructions below to perform a span-test for each SMA ribbon-sensor:

1. Mount the reference plate to the SMA ribbon-sensor as shown in Figure 7. Loosen the knurled bolts and attach the plates to the ribbon. Make sure the thickened edges of the SMA-ribbon are aligned along the grooves of the reference plate. Fasten the bolts by hand.

Figure 7: Reference plate

2. In the Commander open *SMA, sensor table* in the *Technics* menu.
3. Click *Test sensor*. The SMA-2 performs a measurement and displays the results in a pup-up window.



The C-values at both frequencies should increase by 100 ±10 pF, i.e. reach 183 pF. The fraction of water must remain at 0%!

If the C-values are outside these limits, perform a zero-adjustment and repeat the measurement with the reference plate. Should the C-values still deviate too much please contact Sommer Messtechnik.

8.5 Serial data output

The SMA-2 includes a RS-485 and a SDI-12 interface for communication and data output. The measurement values returned by one of these ports are arranged in a fixed sequence and are identified by the index in *Measurements, table*. By default the following variables are recorded by the SMA-2:

Index	Variable	Unit	Description
01	ice content	%	Ice content
02	water content	%	Water content
03	density	kg/m^3	Density
04	Analog 1	as defined	Quantity acquired by analog input 1
05	Analog 2	as defined	Quantity acquired by analog input 2
06	C_LF	pF	Capacity of SMA ribbon-sensor at low frequency
07	C_HF	pF	Capacity of SMA ribbon-sensor 1 at high frequency

Table 6: Measurement table

Attention Erroneous and exceptional data are marked by the values listed in *Appendix A*.

The number of variables recorded by the SMA-2 as well as their names and configuration can be altered by adjusting *Measurements, max. number* and modifying the entries in *Measurements, table*. See the descriptions in *Measurements, table* for the available options. After any change make sure the modified parameters are uploaded to the SMA-2 controller.

Hint For future reference, save the parameter file before any modifications!

8.6 RS-485 interface

The format and timing of data output via RS-485 can be configured in the menu *RS 485-1 protocol*.

8.6.1 System key and device number

The system key and the device number are used to identify a SMA-2 sensor in a bus system. This is essential if multiple devices (SMA-2 sensors and data loggers) are operated within the same system.

System key (*E-I-B*)

The system key separates different conceptual bus systems. This may be necessary if the remote radio coverage of two measurement systems overlap. In general, the system key should be set to 00.

Device number (*E-I-A*)

The device number is a unique number that identifies a device in a bus system.

8.6.2 Output time

The serial data output can be triggered in different ways, selectable under *OP, measurement output*:

Just per command

The serial data output is triggered by commands via the RS-485 interface.

After measurement

The serial data output is performed automatically right after each measurement.

Pos. TRIG slope

The output is triggered by a positive edge of a control signal applied to the trigger input (TRIG 1).

8.6.3 Operation modes

The selected combination of measurement trigger and output time determines the following operation modes:

Pushing mode

This is the default operation mode: The measurements are triggered internally by the SMA-2 and the data are returned automatically after each measurement. No external trigger is required. Set *Measurement trigger* to *interval* and *OP, measurement output* to *after measurement*.

Polling mode

A connected data logger triggers the measurements and the data output. Set *Measurement trigger* to *TRIG input* or *SDI-12/RS485* and *OP, measurement output* to *just per command*.

Apparent polling

A connected data logger triggers only the measurements. The data output is performed automatically after each measurement. Set *Measurement trigger* to *TRIG input* or *SDI-12/RS485* and *OP, measurement output* to *after measurement*.

8.6.4 Waking-up of a connected data logger

The SMA-2 supports wake-up of connected data loggers. Generally, this feature is only used in pushing mode and can be set under *OP, wake-up sequence*.

Sync sequence

The sync sequence is the string `UU~?~?` and is sent directly before a command. It is used to synchronize the receiving UART.

Prefix

The prefix is an arbitrary character; the SMA-2 uses a blank. The character is sent prior to any communication. Then the time of the *OP, prefix holdback* is waited and the command is sent afterwards. With this procedure the receiving device has time to wake-up.

8.6.5 Output protocols

For measurement data output via RS-485 different protocols are available which can be selected under *Output protocol (OP)*.

8.6.5.1 *Sommer* protocol

The data string of the *Sommer* protocol contains the system key, device number, a string number, the measurement values with their corresponding index according to Section 8.5 and a closing sequence. Details of the format are described in Appendix B.1.1.

Recorded values are returned as in the following example:

```
#M0001G00se01     39.5|02      6.2|03      371|04           |05           |06
281|07      94|3762;
```

`#M0001G00se`	Header with system key `00`, device number `01` and string number `00`
`01      39.5|`	Ice content
`02       6.2|`	Water content
`03       371|`	Density
`04          |`	Analog 1
`05          |`	Analog 2
`06       281|`	C_LF
`07       94|`	C_HF
`3762;`	Closing sequence

Table 7: Measurement values returned by Sommer protocol

8.6.5.2 *Standard* protocol

The *Standard* protocol is similar to the *Sommer* protocol with a simpler output for easier reading. Details of the format are described in Appendix B.1.2.

Recorded values are returned as in the following example:

```
M00_0001      39.5       6.2       371                          281
94
```

M00_0001	Header with identifier for measurement values
39.5	Ice content
6.2	Water content
371	Density
	Analog 1
	Analog 2
281	C_LF
94	C_HF

Table 8: Measurement values returned by Standard protocol

8.6.5.3 Modbus

Measurement values can also be acquired via the Modbus protocol by a Modbus master. Details are described in *Appendix D* and Technical Note *Changing data output to Modbus and back to Sommer protocol*.

8.6.6 Commands

Commands can be sent to the SMA-2 to start measurements, request complete measurement strings, request single values and to configure the SMA-2. A more detailed description is provided in Appendix *B.2*.

Command types

If a command contains the identifier `W` the receiving SMA-2 returns a confirmation on receipt. This command type demands a closing sequence with a valid CRC-16.

If a command contains the identifier `S` the receiving SMA-2 does not acknowledge the receipt of the command. This command type demands no closing sequence and therefore no CRC-16.

If a command contains the identifier `R` the receiving SMA-2 returns the requested measurement value or parameter. This command type demands a closing sequence with a valid CRC-16.

Triggering a measurement

The command `$mt` triggers a complete measurement sequence as in the following example:

`#W0001$mt|BE85;` Answer: `#A0001ok$mt|4FA9;`

Requesting a complete data string

The command `$pt` requests a data string as in the following example:

`#S0001$pt|` Answer: the data string

Requesting a single measurement value

The reading command `R` with the index of the requested measurement returns a single measurement value. In the following example the ice content (index 01) is requested:

#R0001_010cv|EA62; Answer: #A0001ok_010cv0.1 |29CB;

8.7 SDI-12 interface

SDI-12 (Serial Data Interface at 1200 Baud) is a serial data communication standard for interfacing multiple sensors with a single data recorder. For a detailed description on SDI-12 communication please refer to *Appendix C* or www.sdi-12.org.

The SMA-2 listens to standard SDI-12 commands as listed in the SDI-12 specifications of version 1.3, e.g., `0M!` to trigger a measurement. Additionally, a set of extended SDI-12 commands is implemented in all SOMMER sensors for instrument configuration, e.g., `0XRB|!` to set the measurement interval.

8.7.1 SDI-12 address (*E-G-A*)

The SMA-2 is identified with a unique address in the SDI-12 bus system. The default address is 0.

8.7.2 Measurement commands

To acquire a measurement from a sensor two individual SDI-12 commands – trigger a measurement and request measurement values – need to be sent.

Triggering a measurement

The command `aM!` with sensor address `a` triggers a measurement as in the following example:

`0M!` Answer: `00129<CR><LF>`

The response states that the measurement will take 1 second and will return 29 measurement values. After completion of the measurement the sensor will return an additional `a<CR><LF>`, with `a` the sensor address.

Requesting measurement values

The command `aD0!` with sensor address `a` returns up to 9 measurement values. If more than 9 values need to be read, or if the values are returned in groups, the commands `aD1!`, `aD2!`,… may need to be issued after `aD0!`. For example, if a measurement returns 8 values in two groups of 4, the commands `aD0!` and `aD1!` need to be issued to receive all values.

The following command sequence has to be sent to the SMA-2 to read all measurement values:

`0M!` Answer: `00129<CR><LF>` (triggers the measurement)

`0D0!` Answer `0+39.5+6.2+371+0+0+281+94<CR><LF>`

The leading `0` in the response is the sensor address.

8.7.3 Sensor configuration commands

An SMA-2 configuration can be set and read with the extended SDI-12 commands `aXWpp!` and `aXRpp!`, with `a` the sensor address and `pp` the parameter identifier as indicated in Section *9*.

To configure the primary settings of a SMA-2 via SDI-12 send the following commands to the sensor (replace the sensor address `0` if required):

1. Set *Measurement trigger* (*A*) to SDI-12/RS485

   `0XWA=3|!` Answer `0A=3|<CR><LF>`

2. Set *Measurement Interval* (*B*), e.g., 60 sec

   `0XWB=60|!` Answer `0B=60|<CR><LF>`

3. Adopt the new settings

   `0XW_ts|!` Answer `0ok_ts<CR><LF>`

8.8 Modbus communication

Measurement values can be read via the Modbus protocol by a Modbus master. Please refer to *Appendix D* for a list of supported Modbus functions and register assignments.

To enable Modbus communication please follow the instructions given in Technical Note *Changing data output to Modbus and back to Sommer protocol*.

8.9 Analog input

The SMA-2 controller has four 0 … 2.5 V, 16 bit analog input ports available. These ports may be used for temperature profile or other measurements. Any auxiliary sensor can be powered by one of the switched power output ports OUT 2 … 4.

A scaling factor and an offset can be entered when configuring the analog sensor in *Measurements, table*. To enable scaling make sure to set *Decimals* to another value than *as S*.

9 Parameter definition

The settings of the SMA-2 can be read and changed with the PC software Commander (see Section *8.1*).

Main menu			
A	Measurement trigger	interval	
B	Measurement Interval	60	sec
C	Measurements, max. number	7	
D	Measurements, table		
E	Technics		
F	Special functions		

The parameters are arranged in a main menu with submenus. In the terminal program menu items are selected by entering the letter left to the label. Submenus are opened or the selected parameter is displayed with its unit. Changes are confirmed with *Enter* or discarded with *Esc*. Menus are closed with X.

A Measurement trigger

Measurements are initiated by one of the following options:

Parameter	Description
Interval (default)	Measurements are initiated in a specified interval.
TRIG input	Measurements are triggered by the positive edge of a DC-voltage signal applied to the TRIG input.
SDI-12/RS-485	Measurements are externally triggered by commands via the RS-485 or SDI-12 port.
all allowed	Measurement is triggered by all options mentioned above.

The commands to trigger measurements via RS-485 and SDI-12 ports are described in Sections *8.6.6* and *Appendix C*, respectively.

Measured data are either returned directly after the measurement or can be requested by commands via the RS-485 or SDI-12 interface. The format of the returned data can be configured in the submenu Output protocol (OP).

B Measurement Interval

An internal measurement interval can be set for the SMA-2. If selected in menu item *Measurement trigger* measurements are performed in the defined interval. However, a measurement is always completed before a new one is initiated.

Unit	sec	seconds
Value range	20…10'800	60 sec (default)

C Measurements, max. number

The number of variables the SMA-2 records. Up to 50 variables can be recorded, depending on the user's needs. They are selected in *Measurements, table*.

Value range	Default	Unit
1 … 50	**28**	**-**

D Measurements, table

In the measurement table the recorded variables are selected. By default, the measurement table contains the following variables:

	Identifier	Unit	Dec.	Scale	Offset	S-Typ	S-Num	S-MEA
01	ice content	%	as S		0	SMA-S	1	ice
02	water content	%	as S		0	SMA-S	1	water
03	density	kg/m^3	as S		0	SMA-S	1	density
04	Analog 1		as S		0	off		
05	Analog 2		as S		0	off		
06	C_LF	pF	as S		0	SMA-S	1	C-LF
07	C_HF	pF	as S		0	SMA-S	1	C-HF

The measurement table can have up to 50 entries. Each entry is configured by the parameters described below:

Identifier

User defined variable name.

Unit

The unit of the selected variable.

Decimals

The number of decimal places assigned to the selected variable. The following options are available:

Decimals	Description
1…5	number of decimal places assigned to the selected variable
none	no decimal places
as S	the number of decimal places of the source is adopted (see *S-TYP*)

Scale

The slope applied to the selected variable. Only available if *Decimals* is set to `1…5` or `none`. If *Decimals* is set `as S` (as source), any scaling of the data source or sensor is adopted.

Offset

The offset applied to the selected variable.

Correction

A measurement of the selected variable is triggered and the result displayed in the terminal window. If the measured value deviates from the correct value, the correct value can be entered. This adjusts the value in *Offset*. The factor in *Scale* is not affected by this correction.

Test

A measurement of the selected variable is triggered and the result displayed in the terminal window.

S-TYP

One of the following sensor (or source) types:

S-TYP	Description and S-MEA options
off	No source (deactivated)
SMA-S	Variables of one of the SMA ribbon-sensors `SWE` Snow water equivalent (only for SMA-2) `Density` Snow density `Ice` Fraction of ice (by volume) `Water` Fraction of water (by volume) `S-Temp` Sensor temperature (only for SMA-2) `C-LF` Capacity at low frequency `C-HF` Capacity at high frequency `Ph-LF` Phase at low frequency `Ph-HF` Phase at high frequency
AIN	Analog input `AN1` Analog input 1 `AN2` Analog input 2 `AN3` Analog input 3 `AN4` Analog input 4
SDI12	SDI-12 input The sensor address is set in *S-NUM*, and the position of the measurement value within the output string is assigned in *S-MEA*. Example: SDI-12 sensor with an output string `0.0 + 6.5 + 4.3 + 2.1 +` … To retrieve the value `6.5`, *S-MEA* must be set to `1` and to retrieve the value `4.3`, *S-MEA* must be set to `2`.
SBP	SOMMER sensor that supports the SBP-protocol (via RS-485) The sensor address is set in *S-NUM*, and the position of the measurement value within the output string is assigned in *S-MEA*.
MIO	SOMMER sensor that supports the MIO-protocol (via RS-485) The sensor address is set in *S-NUM*, and the position of the measurement value within the output string is assigned in *S-MEA*.

SYS	System variable `supply` Supply voltage `error` Error code (internal) `st-func` Status of *Fatal error* (4^{th} LED on SMA-2 controller) `cap-beg` Charging voltage of ultracapacitors before measurement `cap-end` Charging voltage of ultracapacitors after measurement `SWE-sum` Sum of SWE-values of horizontal ribbons in the snowpack (only applicable for SPA-2) `SWE-mva` Average of SWE-values of horizontal ribbons in the snowpack (only applicable for SPA-2)
RECYC	"Recycled" variable The number of a referenced variable is set in *S-NUM*. Example: Variable nr. `03` is set to analogue input 1 (`AIN1`) and represents the raw value. Variable nr. `12` is set to RECYC and its *S-NUM* to `03` to process the raw value. If setting *Scale* to `0.5`, variable nr. `12` returns half of the raw measurement value.

S-NUM

The number of the selected SDI-12 or SMA-S sensor, e.g. `3`.

S-MEA

The name of the SMA-S sensor variable or an internal system variable, the connection port of the selected analog sensor, or the position of the measurement value within the string returned by a connected SDI-12 sensor. See *S-TYP* for the available options.

S-ADD

Contains additional commands which are sent with a standard request to a sensor (or source), or which provide additional options for controlling measurements and handling results. The available commands depend on the settings in *S-TYP*:

S-TYP	S-ADD	Description
SDI12	`_Cn`	Concurrent measurement command for measurement cycle n
	`CCn`	Concurrent measurement command with CRC for measurement cycle n
	`_Mn`	Measurement command for measurement cycle n
	`MCn`	Measurement command with CRC for measurement cycle n
	`_Rm`	Read command for data m
	`RCm`	Read command with CRC for data m
	`n`	Number of SDI-12 measurement cycle
	`m`	Number of SDI-12 output line
SBP, MIO	`TD`	Trigger data of a SBP or MIO device
MIO	`TF`	Trigger fake

E Technics

Technics			
A	Language/Sprache	english/englisch	
B	Decimal character	dot	
C	Sleep mode	standard	
D	Warm-up time	1	sec
E	Sommer ID		
F	SMA sensor		
G	SDI-12 service		
H	RS 485-2		
I	RS 485-1 protocol		
J	RS 485-1 port		

E-A Language/Sprache

The following languages can be selected:

Parameter	Description
german/deutsch	German language
english/englisch (default)	English language

E-B Decimal character

One of the following decimal characters can be selected (this affects measurement values and parameters):

Parameter	Description
comma	-
dot (default)	-

E-C Sleep mode

This parameter defines the behavior of the SMA-2 between two measurements, provided the measurement interval is longer than the time of the measurement itself. The following options are available:

Parameter	Description
MODBUS, fast	For MODBUS applications. The SMA-2 stays in normal mode. This option permits high data transmission rates, but increases power consumption.
MODBUS, slow	For MODBUS applications. The SMA-2 goes into idle mode and can be woken up by a command via the RS-485 interface. This option reduces power consumption at lower data transmission rates.

Standard (default)	The SMA-2 goes into sleep mode and can be woken up by a command via the RS-485 interface only with a time delay. Option with the lowest power consumption.

Hint For MODBUS applications run *MODBUS, set default* to get the appropriate communication settings.

E-D Warm-up time

The between power-up of the sensor and the first measurement.

Unit	sec	Seconds
Value range	0…255	1 (default)

E-E Sommer ID

The Sommer ID is used to define stations within the Commander software. The ID is preset in the device and corresponds to its serial number. For more information please consult the Commander manual.

By default the Sommer ID is set to the device's serial number.

E-F SMA sensor

The installation settings for the installed SMA ribbon-sensor. By default, the sensor is configured as follows:

	Length [mm]	Foot height [mm]	C base LF [pF]	C base HF [pF]
01	2600	100	0	0

Sensor length

Length of SMA ribbon-sensor.

Foot height

Mounting height of the SMA ribbon-sensor.

C base LF

Sensor adjustment value.

C base HF

Sensor adjustment value.

Sensor zero adjust

Function to perform a zero adjustment of the sensor (see Section *8.4* for details).

Test sensor

Function to perform a test measurement of the selected SMA-sensor.

E-G SDI-12 service

SDI-12 service			
A	SDI-1 sensor address	0	
B	SDI-1 ,’M‘ response (> 9 v.)	M1, M2, M3 split	
C	SDI-2 maximal duration	20	sec
D	SDI-2 sensor search		
E	SDI-2 change sensor address		
F	SDI-2 ask for a sensor address		

E-G-A SDI-1 sensor address

The unique identifier of the SMA-2 within a SDI-12 bus system.

Value Range	0…9, a…z, A…Z	0 (default)

E-G-B SDI-1 ,’M‘ response (> 9 v.)

Defines how an SDI-12 `M`-command received by the SMA-2 is answered if the requested number of measurement values exceeds 9. The following options are available:

Parameter	**Description**
expand address	This option should only be used with SDI-12 standard V1.0. The measurement values can be requested with the commands `aD0!`, `aD1!`,…, with `a` the sensor address. Max. 9 values are returned for each command.
just expand output	The `M`-request received by the SMA-2 is answered according to SDI-12 standard V1.3, which supports transmitting more than 9 measurement values per answer.
as at ‘C’ request	The `M`-request received by the SMA-2 is answered as if several `C`-requests were sent.
M1, M2, M3 split (default)	The `M`-request received by the SMA-2 is answered as if several `Mk`-commands were sent, with `k` depending on the number of measurement values to be transmitted (M1 returns the first 9 measurement values, M2 the second nine values, etc).

E-G-C SDI-2 maximal duration

The timeout for commands sent to SDI-12 devices connected to the SMA-2. If a SDI-12 device does not respond to a command within this time the device returns an error code (see Appendix *A.1*).

Unit	sec	Seconds
Value range	0 … 255	20 (default)

E-G-D SDI-2 sensor search

Only available in terminal mode. Searches for connected SDI-12 sensors and lists their identification and sensor address in the terminal window.

E-G-E SDI-2 change sensor address

Only available in terminal mode. Changes the SDI-12 address of a connected sensor.

E-G-F SDI-2 ask for a sensor address

Only available in terminal mode. Reads the SDI-12 address and its identification of a single SDI-12 sensor connected to the SMA-2.

E-H RS 485-2

RS 485-2			
A	Baud rate	9600	
B	Parity, stop bits	no par., 1 stop	
C	Minimum response time	0	ms
D	Transmitter warm-up time	10	ms
E	Flow control	off	
F	Sending window	300	ms
G	Receiving window	300	ms
H	Trig, polling	off	
I	Trig, timeout	60	sec
J	Trig, sleep while timeout	off	
K	Network scan extension	off	
L	Polling delay	2	sec
M	Transparency to RS485-2		

E-H-A Baud rate

Baud rate for the RS-485 interface.

Unit	-	-
Value range	1'200 … 115'200	9'600 (default)

E-H-B Parity, stop bits

The following combinations of parity and stop bits can be selected:

Parameter	Description
no par, 1 stop (default)	No parity and 1 stop bit
no par, 2 stop	No parity and 2 stop bits
even par, 1 stop	Even parity and 1 stop bit
odd par, 1 stop	Odd parity and 1 stop bit

E-H-C Minimum response time

Setting of this parameter avoids interference of communication at the RS-485 interface. For this purpose the response to a command is delayed by the selected time.

Unit	ms	Milliseconds
Value range	0 … 2'000	0 (default)

E-H-D Transmitter warm-up time

The time between the RS-485 interface is switched on and the first data package of a message is sent.

Unit	ms	Milliseconds
Value range	0 … 2'000	10 (default)

E-H-E Flow control

Flow control of the RS-485 interface.

Setting	Description
Off (default)	no flow control
XOFF-XON blocking	XOFF-XON flow control, especially adapted for half-duplex systems

E-H-F Sending window

If XON-XOFF flow control is activated data are transmitted in blocks with the defined length.

Unit	ms	Milliseconds
Value range	50 … 5'000	300 (default)

E-H-G Receiving window

If XON-XOFF flow control is activated data are sent and received in alternation in the specified interval.

Unit	ms	Milliseconds
Value range	50 … 5'000	300 (default)

E-H-H Trig, polling

Sets the polling of connected digital sensors.

Setting	Description
off (default)	Continuous polling is inactive.
on	Continuous polling is active.

E-H-I Trig, timeout

The time the SMA-2 is waiting until expected commands/answers are received via the RS485-2 interface.

Unit	sec	Seconds
Value range	3 … 250	60 (default)

E-H-J Trig, sleep while timeout

To reduce power consumption the MRL-7 can switch to a sleep mode between measurements.

Setting	Description
off (default)	SMA-2 remains activated during measurements, i.e. *Trig, timeout*
on	SMA-2 is inactive between initialization of measurement and reception of measurement data. The connected sensor must send a *Prefix* command to wake up the SMA-2 for data transmission.

E-H-K Network scan extension

Optional detection of connected SOMMER sensors with the Commander software.

Setting	Description
off (default)	Detection of SOMMER devices connected to RS485-2 is deactivated.
on	Detection of SOMMER devices connected to RS485-2 is activated.

E-H-L Polling delay

Time by which polling of multiple digital sensors is delayed. Used to poll sensors in sequence to avoid communication conflicts.

Value range	Default	Unit
0 … 20	**2**	**sec**

E-H-M Transparency to RS485-2

Only available in terminal mode. After activation, direct communication with a connected sensor is enabled, i.e. commands and theirs answers are exchanged over the RS485-2 interface of the SMA-2. With this mode the settings of a connected digital sensor can be read or changed.

In this submenu the data output via the RS-485 interface is defined.

E-I RS 485-1 protocol

RS 485-1 protocol			
A	Device number	1	
B	System key	0	
C	Output protocol (OP)	Sommer	
D	OP, measurement output	after measurement	
E	OP, wake-up sequence	prefix	
F	OP, prefix holdback	300	ms
G	MODBUS, set default		
H	MODBUS, device address	35	

E-I-A Device number

The device number is used for the unique identification of the device in a bus system.

Value range	0…98	1 (default)

E-I-B System key

The system key defines the bus system of the device. Thus, different conceptual bus systems can be separated. Interfering bus systems occur if the remote radio coverage of two measurement systems overlap. In general, the system key should be set to 00.

Value range	0…99	0 (default)

E-I-C Output protocol (OP)

The following serial output protocols can be set. See Section *8.6.5* for a detailed description.

Parameter	Description
Sommer (default)	Sommer protocol; data values are returned with an index starting at 1
standard	Standard protocol; data values are returned without an index
MODBUS	Modbus protocol

Hint For MODBUS applications run *MODBUS, set default* to get the appropriate communication settings.

E-I-D OP, measurement output

Specifies the timing of the serial data output.

Parameter	Description
just per command	The output is only requested by commands via the RS-485 or SDI-12 interface.
after measurement (default)	The serial data output is performed automatically right after each measurement.
pos. TRIG slope	The output is triggered by a positive edge of a control signal applied to the trigger input (TRIG 1).

E-I-E OP, wake-up sequence

Serial data can be transmitted to a recording device automatically without a request. However, many devices demand a wake-up sequence before they can receive and process data. The SMA-2 has the option to send a sync sequence and a prefix before data are transmitted (see Section *0*). The following options are available:

Parameter	Description
off	No wake-up sequence
sync	The sync sequence `UU~?~?` is sent before the output string.
prefix (default)	A blank with a time delay is sent before the output string.
prefix & sync	A blank with a time delay and the sync sequence `UU~?~?` is sent before the output string.

E-I-F OP, prefix holdback

The hold-back time defines the time delay between the prefix and the data string.

Unit	ms	Milliseconds
Value range	0...5'000	300 (default)

E-I-G MODBUS, set default

Only available in terminal mode. The Modbus protocol demands a defined setting, including multiple parameters. This command sets all these parameters automatically (see Appendix *D.1*).

E-I-H MODBUS, device address

Unique device address for the Modbus protocol.

Value range	1...247	35 (default)

E-J RS 485-1 port

RS 485-1 port			
A	Baud rate	9600	
B	Parity, stop bits	no par., 1 stop	
C	Minimum response time	30	ms
D	Transmitter warm-up time	10	ms
E	Flow control	off	
F	Sending window	300	ms
G	Receiving window	300	ms

E-J-A Baud rate

The following transmission rates in bps (baud) can be selected:

Parameter		
1'200	9'600 (default)	57'600
2'400	19'200	115'200
4'800	38'400	

E-J-B Parity, stop bits

The following combinations of parity and stop bits can be selected:

Parameter	**Description**
no par, 1 stop (default)	No parity and 1 stop bit
no par, 2 stop	No parity and 2 stop bits
even par, 1 stop	Even parity and 1 stop bit
odd par, 1 stop	Odd parity and 1 stop bit

E-J-C Minimum response time

Setting of this parameter avoids interference of communication at the RS-485 interface. For this purpose the response to a command is delayed by the selected time. Additionally, the response is kept compact.

Unit	ms	Milliseconds
Value range	0...2'000	30 (default)

E-J-D Transmitter warm-up time

The transmitter warm-up time defines the time before data is sent.

Unit	ms	Milliseconds
Value range	0...2'000	10 (default)

E-J-E Flow control

The XOFF-XON flow control can be activated with this setting.

Parameter	Description
Off (default)	no flow control
XOFF-XON blocking	XOFF-XON flow control, especially adapted for half-duplex systems

E-J-F Sending window

If XON-XOFF flow control is activated data are transmitted in blocks with the defined length.

Unit	ms	Milliseconds
Value range	200...5'000	300 (default)

E-J-G Receiving window

If XON-XOFF flow control is activated transmission of blocks is delayed by the specified time.

Unit	ms	Milliseconds
Value range	200...5'000	300 (default)

F Special functions

Special functions	
A	Device status
B	View setup
C	Set factory default
D	Temp. load factory default
E	Relaunch program

F-A Device status

Displays information about the sensor and the software version.

F-B View setup

All parameters of the SMA-2 are listed in the terminal window.

F-C Set factory default

All parameters are reset to factory defaults. Only available in terminal-mode.

F-D Temp. load factory default

Loads factory default values temporarily. Only available in terminal mode.

F-E Relaunch program

The device is restarted. Powering the sensor off and on again is equivalent.

Appendix A Measurement values

A.1 Error and exception values

Measurement data may be returned with the following values:

Value	Description
99999999	Positive overflow
99999998	Initialization error
99999997	Measurement error
99999996	Conversion error
99999995	Setup error
99999990	No sensor response (SDI-12 and SBP)
−9999999	Negative overflow

Table 9: Exceptional and error values

Appendix B RS-485 interface

B.1 Protocols

B.1.1 *Sommer* protocol

The data string of the *Sommer* protocol has the following format:

```
#M0001G00se01     39.5|02      6.2|03      371|04          |05          |06
281|07      94|3762;
```

Header

The header (#M0001G00se) identifies the data by system key, device number and string number.

Parameter	Format	Description
Start character	#	
Identifier	M	M identifies an output string
System key	dd	
Device number	dd	
Command ID	G	G defines an output string with string number
String number	dd	00 string containing variables 01…08 01 string containing variables 09…16 …
Command	se	se identifies automatically sent values

Table 10: Header of the *Sommer* protocol

Measurement value

A measurement value (02   1.2|) has a length of 8 digits and is returned together with its index. If the measurement value is a decimal number one digit is reserved for the decimal character. Values are returned right-aligned, so blanks may occur between index and value.

Parameter	Format	Description
Index	dd	2 digits
Value	xxxxxxxx	8 characters, right-aligned
Separator	|	

Table 11: Values in *Sommer* protocol

End sequence

The data string is terminated with a CRC-16 in hex format (3762) followed by an end character and <CR><LF>. The CRC-16 is described in Appendix *B.4*.

Parameter	Format	Description
CRC-16	Hhhh	4-digit hex number
End character	;	
Control characters	<CR><LF>	Carriage return and Line feed

Table 12: End sequence of the *Sommer* protocol

B.1.2 *Standard* protocol

The data string of the *Standard* protocol has the following format:

```
M00_0001      39.5       6.2       371                          281
94
```

Header

The header (M00_0001) identifies the data by system key and device number.

Parameter	Format	Description
Identifier	M	M identifies measurement values
String number	dd_	00_ string containing variables 01…08 01_ string containing variables 09…16 …
System key	dd	
Device number	dd	

Table 13: Header of the *Standard* protocol

Measurement values

Measurement values are returned in sequence and are separated by a blank. A measurement value has a length of 8 digits. If the measurement value is a decimal number one digit is reserved for the decimal character. Values are returned right-aligned, so additional blanks may be returned between values.

Parameter	Format	Description
Separator	[blank]	blank
Value	xxxxxxxx	8 characters, right-aligned

Table 14: Values in *Standard* protocol

End sequence

The data string is terminated with <CR><LF>.

B.2 Commands and answers

The structure of serial commands and answers (#W0001$mt|BE85;) is described in the following table:

Parameter	Format	Description
Start character	#	
Identifier	X	W Write a setting and receive a confirmation T Write a volatile setting and receive a confirmation S Write a volatile setting without confirmation R Read a setting, value or other information A Answer of device to read or write command
System key	dd	
Device number	dd	
Command	xxx	See *Table 16*
Separator	|	
CRC-16	hhhh	4-digit hex number
End character	;	

Table 15: Structure of commands and answers

Commands

The following commands can be used with the SMA-2:

Command	Description
$mt	Trigger a measurement
$pt	Return measurement values
_dd0cv	Return a single measurement value with index dd (see Section *8.5*)
XX	Read a parameter of the sensor menu with identifier XX
XX=xxxx	Write a parameter with identifier XX and the value xxx to the sensor menu

Table 16: List of commands

Examples

Trigger a measurement:

`#W0001$mt|BE85;` Answer: `#A0001ok$mt|4FA9;`

Return measurement values:

`#S0001$pt|` Answer: the data string

Read ice content (Index 01):

`#R0001_010cv|EA62;` Answer: `#A0001ok_010cv39.5 |29CB;`

Read measurement interval (menu item B):

`#R0001B|228E;` Answer: `#A0001B=20|3D60;`

Write measurement interval (menu item B):

`#W0001B=60|C09B;` Answer: `#A0001B=60|7DE4;`

B.3 Error codes

During communication via RS-485 interface the following errors can occur. The error code is bit-coded and returned in hex format. If multiple errors are present the error codes are summed up.

Error number	Description
0x0001	PLEASE NOTE: Parameter conflict (view manual)!
0x0002	PLEASE NOTE: Parameter conflict (view manual)!
0x0004	Mistake: Please just enter valid values!
0x0008	Mistake: Please, just enter menu choice characters!
0x0010	Cancel!
0x0020	Testmode canceled!
0x0040	Error: CRC failure!
0x0080	Denied, due to temporarily loaded menu!
0x0100	Testmode finished!
0x0200	Timeout!
0x0400	PLEASE NOTE: Maybe difficult interpretation of archive data!
0x0800	Action currently not available. Please try again later!
0x1000	DIRECTIVE: Please don't forget to change the serial counterpart too!
0x2000	PLEASE NOTE: An old archive pointer has been replaced!
0x4000	PLEASE NOTE: Sorry, job site!

Table 17: Error codes

B.4 Sommer CRC-16

The CRC-16 (cyclic redundancy check) used in data transmission of Sommer devices is based on the ZMODEM protocol. When data are exchanged between two devices the receiving device calculates the CRC-value. This value is compared to the CRC value sent by the other device to check if the data were transmitted correctly. Please refer to technical literature or contact Sommer for calculation of CRC-16 values.

Appendix C SDI-12 interface

This manual covers the main aspects of SDI-12 communication. Detailed information can be found at http://www.sdi-12.org.

SOMMER devices with SDI-12 communication listen to standard commands as listed in the SDI-12 specifications of version 1.3. Additionally, for instrument configuration a set of extended SDI-12 commands is implemented in all SOMMER sensors.

C.1 Standard SDI-12 commands

A standard SDI-12 command starts with the sensor address and ends with an exclamation mark, e.g., `0M!`.

The answer from the SDI-12 device is a string containing the sensor address, the requested data and a terminating carriage return/line feed, e.g., `0+2591+706+25.53+0<CR><LF>`.

C.1.1 Sensor identification

The identification of a SDI-12 device is requested with the command `aI!`, with `a` the sensor address.

Example:

`0I!` Answer: `013Sommer  USH  140r90 USH-9    <CR><LF>`

The answer contains the following information:

`0`	SDI-12 address
`1`	SDI-12 version number leading the decimal point
`3`	SDI-12 version number after the decimal point
`Sommer`	Description of the company (6 characters and 2 blanks)
`USH`	Description of the firmware (5 characters and 2 blanks)
`140r90`	Firmware version (6 characters and 2 blanks)
`USH-9`	Device designation (max. 13 characters)

C.1.2 Triggering a measurement

Measurements can be triggered with the commands `aM!` And `aC!`, with `a` the sensor address.

Example:

`0M!` Answer `00084<CR><LF>` and `0<CR><LF>` after 8 seconds

The answer contains the following information:

`0`	SDI-12 address
`008`	Duration of the measurement in seconds
`4`	Number of measurement values

C.1.3 Requesting measurement values

After each measurement, results are requested with the command `aDn!`, with `a` the sensor address and `n` the index of the returned data string.

Generally, the command aD0! is sufficient to request up to 9 measurement values. If more than 9 values need to be read, or if the values are returned in groups, the commands aD1!, aD2!,… may need to be issued after aD0!. For example, if a measurement returns 8 values in two groups of 4, the commands aD0! and aD1! need to be issued to receive all values.

Example:

0M! Answer 00084<CR><LF> and 0<CR><LF> after 8 seconds

0D0! Answer 0+2591+706+25.53+0<CR><LF>

The first value in the response to the aDn! command is the sensor address. If more than 9 values need to be read, or if the values are returned in groups, the commands aD1!, aD2!,… may need to be issued after aD0!. For example, if a measurement returns 8 values in two groups of 4, the commands aD0! and aD1! need to be issued to receive all values.

C.1.4 Requesting continuous measurements

If the SDI-12 device is operating in continuous measurement mode (not polled by SDI-12), the command aR0! will request and return the current reading of the sensor. The values within the data string follow the order as listed in Section *8.5*. The first value in the response to the aRn! command is the sensor address.

Example:

0R0! Answer: 0+2591+706+25.53+0<CR><LF>

If more than 9 values need to be read, or if the values are returned in groups, the commands aR1!, aR2!,… may need to be issued after aR0!. For example, if a measurement returns 8 values in two groups of 4, the commands aR0! and aR1! need to be issued to receive all values.

C.2 Extended SDI-12 commands

Extended SDI-12 commands are non-standard commands implemented by SOMMER to enable device configuration via SDI-12.

Attention After any changes, the settings have to be adopted with the command aXW_ts|!, with a the sensor address.

C.2.1 Reading and writing sensor configurations

The configuration parameters of a SOMMER sensor are read with the command aXRpp! and written with the command aXWpp=vvv!, with a the sensor address, pp the parameter identifier and vvv the value of the parameter.

Example:

Reading of measurement interval (menu item B)

0XRB|! Answer: 0B=300|<CR><LF>

Setting of measurement interval to 60 s (menu item B)

0XWB=60|! Answer: 0B=60|<CR><LF>

Reading and writing a configuration with multiple options:

Changing the measurement trigger (menu item A) from *interval* to *SDI-12/RS485*

`0XRA|!` Answer `0A=1|<CR><LF>`

`0XWA=3|!` Answer `0A=3|<CR><LF>`

Reading and writing a configuration value within a table

Some SOMMER sensors are equipped with multiple transducers and their settings are listed in a table (see example below). A value within such a table is addressed by its row-index (01, 02 …) and column-index (A, B …). A corresponding SDI-command has the following format:

`0XWDDE01B=-1.4|!` Answer `0DDE01b=-1.4|<CR><LF>`

In this example the value in row `01` and column `B` of the parameter D-D-E is changed to -1.4.

	Identifier	offset zero kg	gain	zero default kg	gain default
01	Load Cell 1	-1.4	0,997787	0,000	0,997787
02	Load Cell 2	0,000	0,997787	0,000	0,997787
03	Load Cell 3	0,000	0,997787	0,000	0,997787
04	Load Cell 4	0,000	0,997787	0,000	0,997787

C.2.2 Adoption of settings

USH-9 settings are adopted with the command `aXW_ts|!`, with `a` the sensor address.

Example:

`0XW_ts|!` Answer: `0ok_ts|<CR><LF>`

Appendix D Modbus

D.1 Modbus default settings

The default settings are configured by the command MODBUS, set default:

Baud rate	19'200
Data bits	8
Parity	even
Stop bits	1
Flow control	none

Table 18: Default Modbus settings

D.2 Modbus Configuration

Function 06: Write single registers and Function 03: Read holding registers

<table>
<tr><th></th><th>Register address</th><th>Variable</th><th>Range</th><th>Bytes</th><th>Format</th></tr>
<tr><td rowspan="4">Config values</td><td>0</td><td>Modbus default[1]</td><td>0 - 1…read
1…write</td><td rowspan="4">2</td><td rowspan="4">unsigned int</td></tr>
<tr><td>1</td><td>Modbus device address</td><td>1 to 247</td></tr>
<tr><td>2</td><td>RS-485 baud rate</td><td>1…1200 baud
2…2400 baud
3…4800 baud
4…9600 baud
5…19200 baud
6…38400 baud
7…57600 baud
8…115200 baud</td></tr>
<tr><td>3</td><td>RS-485 parity/ stop bits</td><td>1…no parity, 1 stop bit
2…no parity, 2 stop bits
3…even parity, 1 stop bit
4…odd parity, 1 stop bit</td></tr>
</table>

Table 19: Function 06 and Function 03 to read and write configuration values

[1] Writing "1" sets the Modbus default settings (see Appendix D.1).

Function 04: Read input registers (read only)

The measurement values are stored in the same sequence as listed in Section *8.5*.

	Index	Register address	Variable	Unit / value	Bytes	Format
Test value		0	Hardcoded test value	2.7519…	4	float
Main values	01	2	ice content	%	4	float
	02	4	water content	%		
	03	6	density	kg/m^3		
	04	8	Analog 1	-		
	05	10	Analog 2	-		
	06	12	C_LF	pF		
	07	14	C_HF	pF		
Device info	-	65533	Device type and configuration	3701	2	unsigned int
	-	65534	Software version	XYYZZ	2	
	-	65535	Modbus version	10100	2	

Table 20: Function 04 Read input registers

Function 17: Report slave ID (read only)

In the table below, the response of function code 17 is explained by means of the following example (report is transmitted in hex format):

```
23 11 26 53 FF 27 74 20 53 6F 6D 6D 65 72 20 20 52 47 2D 33 30 20 20
20 32 5F 37 31 72 30 31 20 34 35 31 35 31 38 32 31 00 BB D4
```

	Content	Length (Bytes)	Example	
			HEX-value	**Decimal, ASCII**
PDU[2] response	Slave address	1	23	35
	Function code	1	11	17
	Byte count (incl. address 0)	1	26	38
	Slave ID	1	53	"S"
	Run indicator status	1	FF	255
	Modbus implementation version	2	27 74	10100
	Separator	1	20	" "
	Vendor string	7	53 6F 6D 6D 65 72 20	"Sommer "
	Separator	1	20	" "
	Device configuration	7	52 47 2D 33 30 20 20	“RG-30 “
	Separator	1	20	" "
	Software version	7	32 5F 37 31 72 30 31	2_71r01
	Separator	1	20	" "
	Serial number	8	34 35 31 35 31 38 32 31	45151821
	NUL	1	00	
	CRC	2	BB D4	

Table 21: Function 17 to report slave ID

[2] Protocol Data Unit