SPA

Snow Pack Analyzer

Document version: 2012-Jan

Software version: 3.33

User Manual

Sommer **M**easurement **S**ystem **T**echnology.

Contents

Safety Information

Please read this entire manual before setting up or operating this equipment. The non-compliance of this manual could result in damage to the equipment. Also in the case of non-compliance injuries of individuals cannot be excluded totally.

To make sure that the protection provided of and by this equipment is not impaired, do not use or install this equipment in any manner other than that specified in this manual.

1.General information

Snow has an enormous variability in space and time. Up to now mainly punctual measurements are available for the relevant parameters. The Snow Pack Analysing System (SPA) constitutes an innovation in snow measurement. It is a system for automatic and continuous measurement of all relevant snow parameters like snow depth, snow density, snow water equivalent and contents of liquid water and ice. There are several possibilities to install the system, depending on demand.

1.1. Principle of measurement

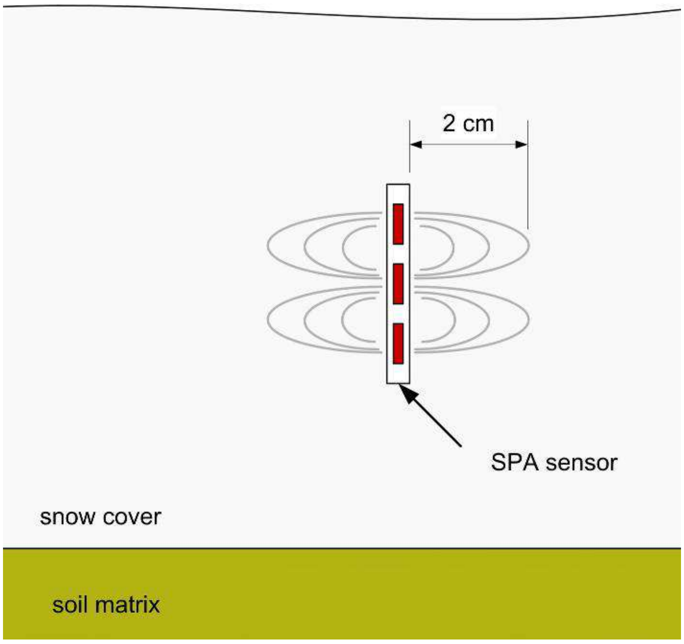


Fig. 1: Principle of measurement of the SPA-sensor

Snow consists of the three components ice, water and air. Referring to different measurement frequencies, these components show different dielectric constants. Measuring the complex impedance along a flat ribbon sensor (SPA-sensor) with at least two frequencies allows to estimate the volume contents of the individual components. These specific volume contents equate the liquid water, ice and air in the snow pack, which result in the snow density and the snow water equivalent.

1.2. Measurement parameters

Snow density

The SPA calculates the snow density of the snow surrounding the SPA-sensor.

Snow water equivalent SWE

The SWE corresponds to the water column in mm resulting from the melting of the complete snow cover on a defined area. It is calculated from the snow density of sloping sensors with respect to the snow depth.

Contents of liquid water and ice in snow pack

The volumetric contents of ice and liquid water in the snow are output in %.

Snow depth

The snow depth is measured by an ultra sonic sensor. It is necessary to determine the SWE.

2. Hardware

Fig. 2: SPA-sensor

Fig. 3: IASP control unit

2.1. SPA-sensors

The SPA-sensor is a 6 cm wide flat ribbon sensor including three copper wires. The length varies between 3 and 10 m. Its ends are terminated by boxes including mounting rings. The connection cable is led out of one box.

2.2. Correction length sensor (potentiometer)

The deforming of sloping sensors due to the snow pack can be corrected by measuring the additional length of the sensor rope at the suspension. The sensor measures the rotation of the suspension roll and converts the values into length. The correction is automatically included in the calculation.

2.3. Snow depth sensor

The snow depth sensor USH-8 is based on transit-time measurements of an ultrasonic pulse between the sensor and the snow surface. It is mounted with an extension arm on a mast and is directly connected to the control unit.

The snow depth is an essential parameter to calculate the snow pack parameters of sloping sensors. On one hand the length of the sensor in snow is determined and on the other hand the total SWE is calculated using the actual snow depth.

2.4. Control unit IASP

The control unit IASP performs all measurements, switches between sensors and calculates the snow parameters with respect to snow depth, length correction and geometric parameters. The data is output via a RS-232 interface.

The analogue input F2-1 (#1) is preadjusted for the length correction. The analogue input F3-3 (#6) is preadjusted for the USH-8 snow depth sensor.

Connector	Pins	Function
COM		RS-232 interface for communication with the data logger
BAT	+ / -	voltage supply 10.5 to 15 VDC
	S+ / S-	switched supply output for economic sensor operation
I1 … I4		connections for sensor band 1 … 4 respectively
IO		not useable, leave unconnected
F1		not useable, leave unconnected
F2	1	analog inputs for the snow scale (analogue input #1)
	2 and 3	analog inputs 0 … 2.5 V (#2 and #3)
	4	analog ground (AGND)
F3	1 and 2	analog inputs 0 … 2.5 V (#4 and #5)
	3	analog input for the USH-8 snow depth sensor (analogue input #6)
	4	analog ground (AGND)

Tab. 1: Connector assignment for Fig. 3;
the analogue input F3-3 (#6) is reserved for the USH-8 snow depth sensor

2.5. Framework

The framework enables the installation of one sloping and up to three horizontal sensors and secures a tight and upright positioning of the sensors. It includes the basement framework, a mast for the installation of the sloping sensor, the snow depth sensor and the housing and suspension equipment for the SPA sensors consisting of springs, levers and stretching devices.

3. Installation

3.1. Measurement site

A representative measurement site is horizontal and is not located in a basin or on a ridge. It is free of influences from trees or rocks and is not exposed to intensive winds. An undisturbed accumulation of the snow pack has to be guaranteed.

3.2. Framework

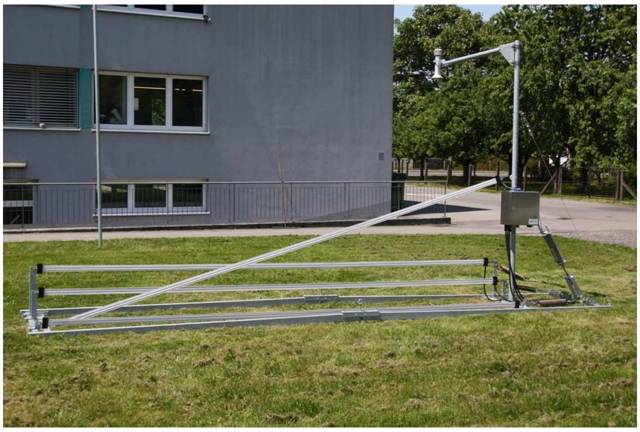


Fig. 4: SPA framework

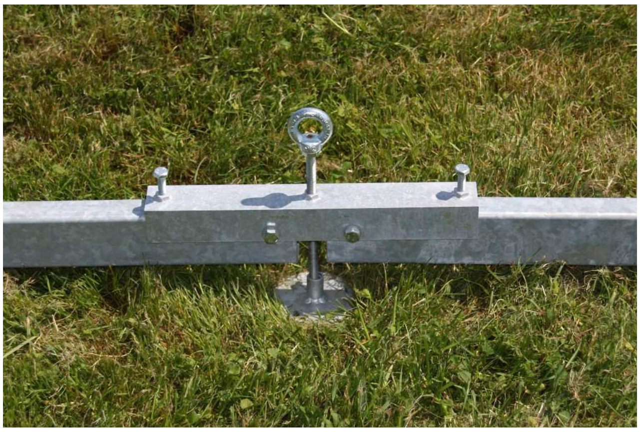


Fig. 5: Connection construction with foot

First the basement framework is placed on the ground. It is delivered separated in two parts each with about two 3 m long beams connected with cross-beams. The side with the two round cross-beams is for the installation of the mast and the fixation of the suspension, the side with the rectangle cross-beam is used for fixing the sensors. The inner L-shaped cross-beam can be located at three position, depending on the installation height of the sloping sensor of 1.5, 2 or 2.5 m.

The two parts of the framework are connected with a connection construction consisting of a u-profile, screws and a foot. It is important to install the framework with an initial tension to resist the forces of the spanned sensors. This is achieved by connecting the two parts of the framework in a small angle, support it with the foot and fix it with the screws. The height of the foot should be at least 10 cm.

After the installation of the basement the mast is installed on the inner cross-beam. The mast holds the snow depth sensor, the rolls for the sloping SPA-sensor and the housing for the measurement and communication devices. It is recommended to install the snow depth sensor before erecting the mast. The mast is supported with two steel wires to be spanned to the near edges of the basement.

3.3. Snow depth sensor

The snow sensor is an ultra sonic sensors using transit time measurement. It is installed on the top of the mast using the extension arm. The installation height has to be 1 m above the expected maximal snow depth. The extension arm should be orientated on one side of the framework to guarantee a snow measurement free of influences. Ensure that the area of the snow depth measurement is free of constructions, sensors or cables and that it will be undisturbed during the complete winter season. Use barrier tapes to prevent accidental entering of the area.

3.4. Sloping SPA-sensor

At the skew SPA the bend of the sensor which is also with strong tension not preventable at snow cover has to be considered.

Without snow cover the sensor has, caused by the tension, a straight course.

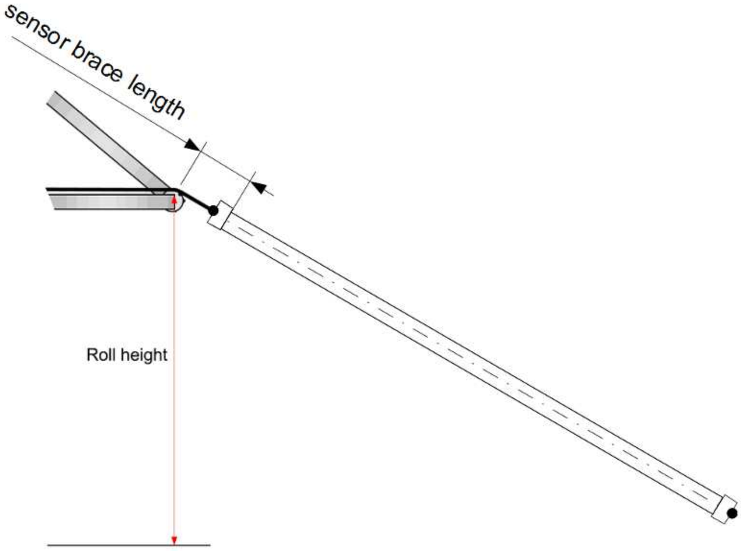


Fig. 6: Sketch of the sloping sensor, the tensioner part differs for simplicity from reality

With snow cover it is possible that the sensor has at the air / snow boun-dary a slight bend.

The sensor is not stretchable but nevertheless the bend leads to an extension of the fractional part of the sensor which is covered by snow.

This increase can be determined over the length change in the sensor brace length.

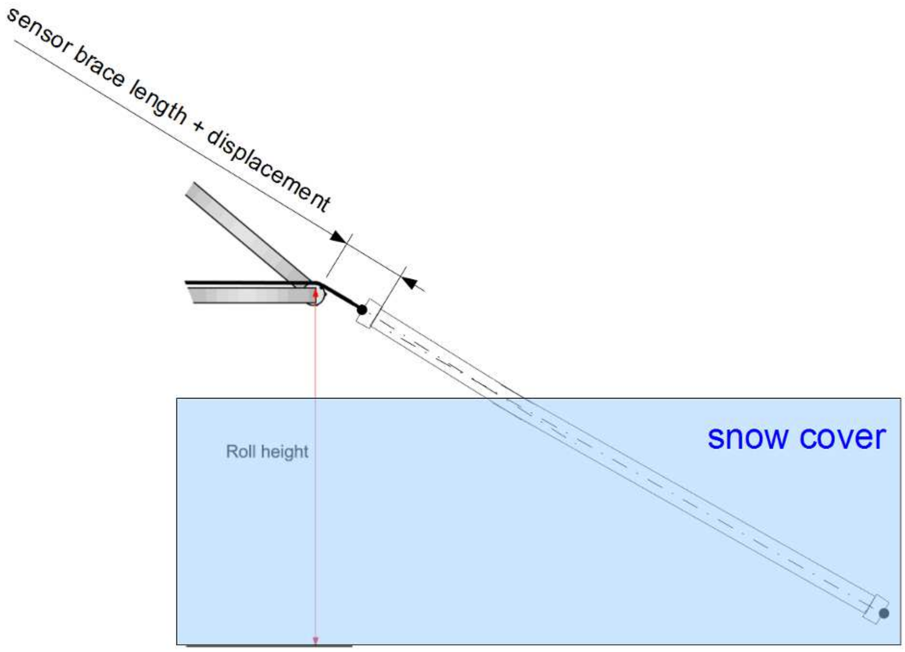


Fig. 7: Sketch of the sloping band with a snow cover; the slight bend in the sensor is best noticeable at the symmetry lines

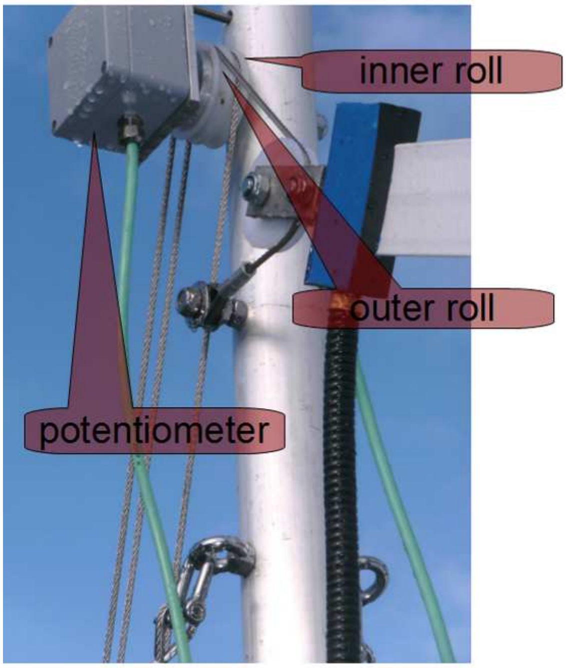


Fig. 8: Upper end of the sloping sensor with the upper part of the tensioner; consider that the potentiometer is not included at every SPA

⚠ **Attention:** The inner and outer roll rotate at a length displacement with different extent. The rotation is only measured at the outer roll. So it is very important that the ropes are not interchanged during the assembling.

Fig. 9: Upper end of the sloping sensor with the upper part of the tensioner from different views


Fig. 10: Suspension at top of the spring with the pulley sytem (overview and detail)

The installation height of the sloping SPA-sensor should be higher than the maximum expected snow depth. On the mast are three predrilled positions at heights of about 1.5, 2 and 2.5 m. Depending on the selected height the L-shaped cross-beam is installed at the predefined positions at the far end of the framework. The higher the sensor is spanned, the nearer the cross-beam is located, where the bottom end of the SPA-sensor is fixed.

To span the sensor a spring and pulley system is used, that is spanned by a stretching device. The stretching device is fixed at the near end of the framework and connected to the spring. The small bar with the lower roll of the pulley system is connected to the opposite side of the spring. The rope of the pulley system is fixed at the top screw of the bar connected to the spring. Then it is guided to the inner roll fixed on the mast, back to the roll on the pulley system, up to the outer roll on the mast and through the roll of the sensor. Finally it is connected to the screw located bellow the rolls on the mast. Then the sensor is spanned using the stretching device.

3.5. Correction length sensor

If a correction length sensor (potentiometer) is used for the sloping sensor, it is installed at the deflector roll located on the mast (Fig. 8). The bolt of the sensor has two rotary stop positions. Make sure that the bolt is in the correct position to react to extensions of the suspension rope.

3.6. Horizontal SPA-sensors

Fig. 11: Spring connection for horizontal sensor

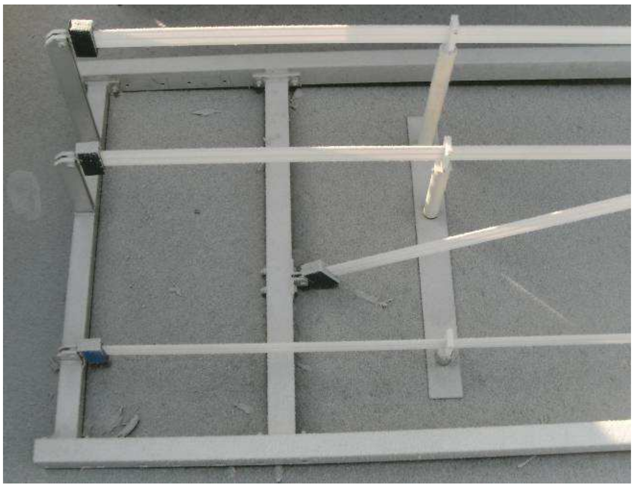


Fig. 12: Far end of framework

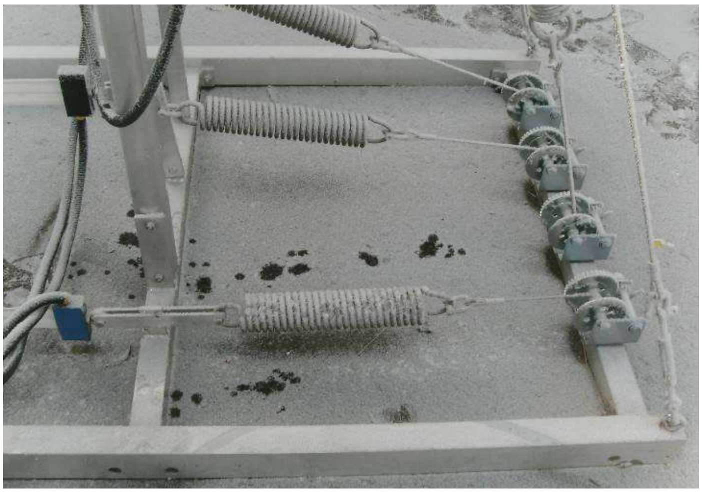


Fig. 13: Same as Fig. 11 but from the other side

The horizontal SPA-sensors are installed at predefined levels on the installation rack. The far end of the sensors are connected at the far end of the framework. Then they are connected to the levers located on the crossbeam of the mast. The stretching devices are fixed to the round cross-beam at the other end of the framework. The springs are positioned directly at the levers and connected to the wires of the stretching devices. Afterwards the sensors are spanned using the stretching devices until the spring has elongated by about 100 mm and the sensor is 5000 mm long. The horizontal sensors are supported with about 5 forks to ensure an upright and stable position.

3.7. Housing

Mount the housing on the mast and connect the cables of the SPA-sensors, the snow depth sensor and the correction length sensor at the marked inputs.

3.8. Power supply

The supply voltage of the complete system is 10,5 to 15 VDC.

3.9. Summary

- Install framework with an initial tension.
- Locate snow depth sensor 1 m above the maximal expected snow depth.
- Install the sloping SPA-sensor higher than the maximal expected snow depth.
- Span the sensor using the stretching device.
- Install correction length sensor and set rotary bolt to correct position.
- Install and Span horizontal sensors by elongating the spring by about 100 mm.

4. Parameterization

4.1. Connection establishment via terminal

4.1.1. Local communication

The parameterization of the IASP can be performed by directly connecting the serial interface with a PC or laptop. Any communication program can be used.

Until *Windows XP* the terminal program *HyperTerminal* was included in the Windows operating systems under ***Start → Programs → Accessories → Communications → HyperTerminal***.

The connection cable is a serial data cable with a 1:1 connection (not crossed).

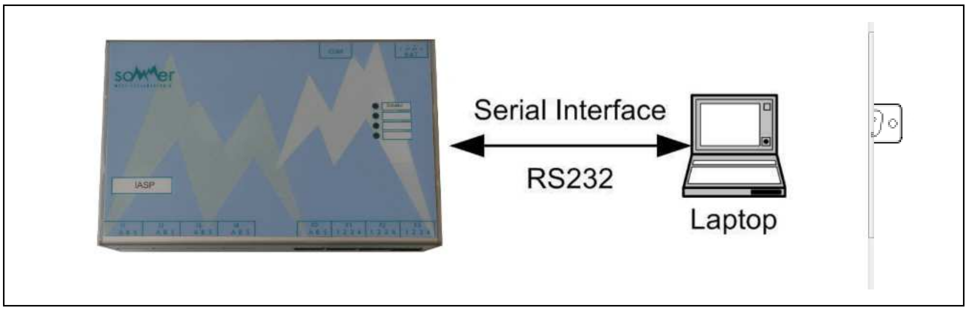


Fig. 14: Connection of the IASP via serial interface

To communicate with the sensor in delivery state the following settings are required:

Baud rate:	9600
Data bits:	8
Parity:	none
Stop bits:	1
Flow control:	none

Tab. 2: Parameter settings for serial connection

4.1.2. Connection affirmation

If a connection is established and the sensor is switched on, a connection affirmation is sent.

```
IA-SPA
(c)2006-2012 Sommer GmbH&CoKG
Software version :   wdV3.33r01
```

4.2. Main Menu

The main menu is opened by quickly entering **three question marks ???** in the terminal program.

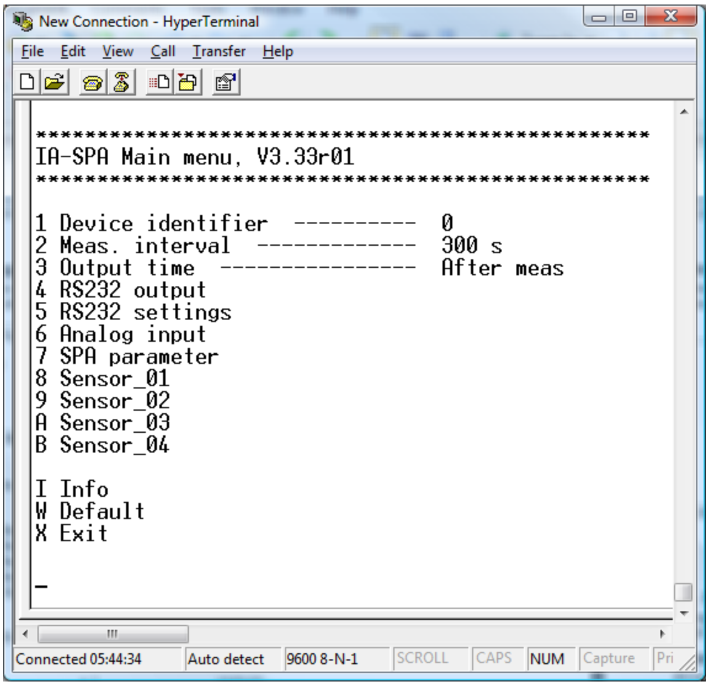


Fig. 1: Main menu

The menu items are accessed by entering the menu key display left of the menu item. Either sub menus are opened or the specific parameter is displayed with the corresponding unit. Changes are verified with **Enter**, editing is aborted with **Esc**. Sub menus are closed with **X**. The menu is not case sensitive. If the main menu is closed, the sensor starts the measurement mode and returns the message *Run!* .

5.Necessary parameter adjustments after assembly

5.1. Snow depth

The actual snow depth offset is adjusted in ***Main menu → Analog input → Snow depth adjustment***.

5.2. Displacement offset / Length correction

This step applies only for SPA's which include a potentiometer.

Fig. 15: SPA with potentiometer

Fig. 16: SPA without potentiometer

ⓘ A sloping SPA-sensor is installed with a spring to ensure a tight spanning and to prevent the sensor from damages due to compression of the snow pack. This non static installation may cause changes in the sensor position, that can be corrected by measuring the extension length of the sensor suspension.

In delivery state the length measurement for SPA-sensor 1 is connected to the analog input 1. This analogue input (channel) is defined for the SPA-sensor in
Main menu → Sensor_01 → Input length corr .

Horizontal sensors are operated without length correction by setting the value of the ***Input length corr.*** to "0".

It is then necessary to adjust the potentiometer which measures the length displacement. Instantly after the assembling process there is no snow cover on the sensors. Therefor the right offset adjustment is zero:

Main menu → Analog input → Target value adjustment input_01 → 0

The actual value is checked with ***Main menu → 8 Sensor_01 → 6 Input check***

5.3. Geometric parameters

The correct calculation of the snow parameters demands the geometric situation of all included sensors. Especially for the sloping SPA-sensor these settings are used to determine the length of the sensor in the snow and to correct a smooth inclination of the measurement site.

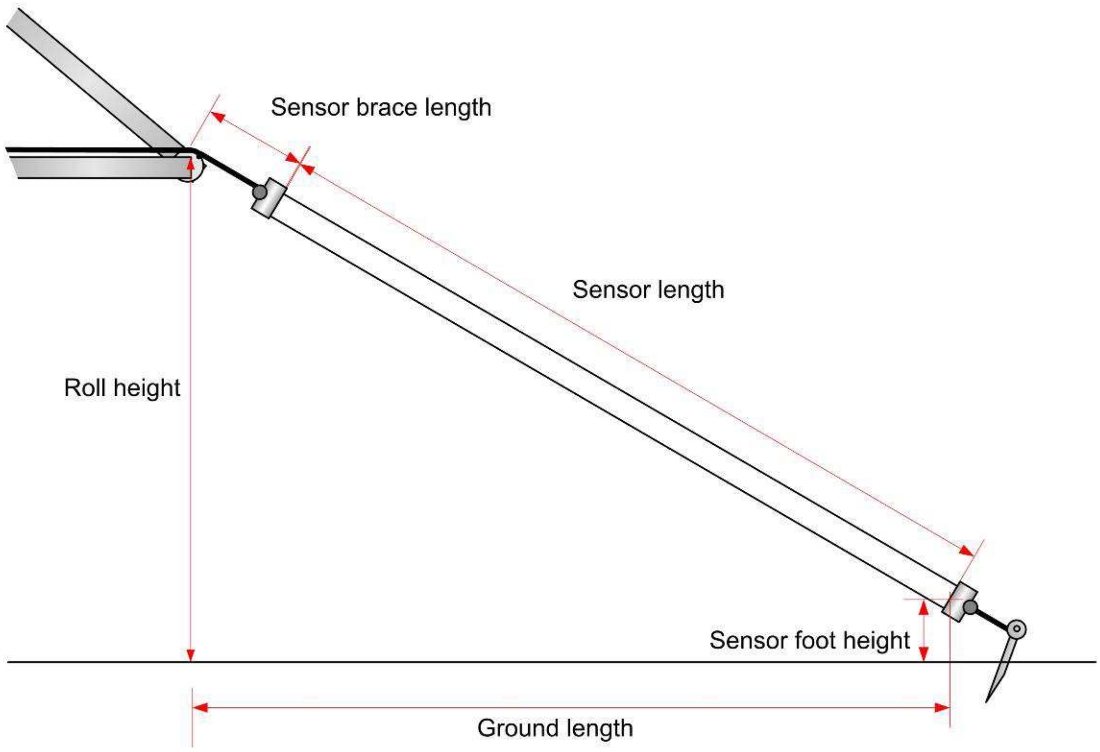


Abb. 2: Geometric parameter of SPA-sensor

Numbering of the sensors

The four in different position mounted sensors are indicated with numbers from 1 to 4. For the standard SPA the assignment is as following:

- diagonal/slope sensor = sensor 1
- horizontal, at the lowest level height (100 mm) sensor = sensor 2
- horizontal, medium level height (300 mm) sensor = sensor 3
- horizontal, at the highest level (500 mm) sensor = sensor 4

Adjustment

The following geometric parameters are necessary:

- Sensor length: Length of the sensor from one box to the other.
- Roll height: Plumb line height of the top of the roll and the ground
- Foot height: Plumb line height of the middle of the sensor at the lower box and the ground
- Brace length: Distance between the middle of the roll and the sensor at the upper top box.
- Ground length: Distance on the ground between plumb line of roll and plumb line of sensor foot.

For horizontal sensors the roll height and the foot height have to be equal. The brace length is set to "0" and the ground length is equal to the sensor length.

The geometric parameters are measured with a measuring tape and should be of about 1 cm accuracy. The geometric parameters are entered into

Main menu → Sensor_01

Main menu → Sensor_02

Main menu → Sensor_03

Main menu → Sensor_04

5.4. Actual Snow depth

The snow depth measurement offset has to be adjusted in the control unit IASP by entering the actual value in ***Main menu → 6 Analog input → 7 Snow depth adjustment***

A test measurement of the snow depth is performed with ***Main menu → 6 Analog input → Snow depth***

5.5. Measurement interval

The minimum recommended interval is 5 minutes (= 300 s) (***Main menu → 2 Meas. interval***)

⚠ **Attention:** If the interval is adjusted to a lower value eventually temporary problems in the meausurement process can occur.

The adjusted default interval is 10 minutes.

⚠ **Attention:**

Approximately the first 7 minutes after connecting the SPA to the power supply the measured values are not reliable if the SPA was disconnected for more than a moment.

During this startup time invalid measurements are indicated with a value of 9999 pF for the measured low frequency capacity and 0000 pF for the measured high frequency capacity.

example extened MIO protocol output:

I000000000000000000000409;

I0100-999-008-9990000043F;

I0200**99990000**-9999999046B;

The 7 minutes is the time the internal high capacity electrolytic capacitors need to load. These capacitors deliver the power for the measurement.

6. Description of the parameters

1 Device identifier

The device identifier is included in the output protocol to identify the data values. The first output string is assigned with the device identifier. For every following string the device identifier is increased by 1 (*see chapter 7*). It is recommended to set the device identifier to **0**.

Value range: 0 to 9999 (default: 0)

Example:

- if Device identifier is adjusted as 0:

```
I000000000000000000000409;
I0100-999000002510000042A;
I020000100013-862-8860430;
```

- if Device identifier is adjusted as 3:

```
I030000000000000000000040C;
I0400-999000002510000042D;
I050000100013-862-8860433;
```

More details regarding the output strings you can find in chapter *7*.

2 Meas. Interval

The measurement interval controls the time for the measurements. For permanent monitoring it is important, not to set a to short interval. The measurements are performed using a measurement battery. A to short measurement interval will prevent the battery from charging and the measurement will be invalid. The recommended interval is 10 minutes (600 s).

Unit: [s]

Value range: 5 to 13980

(default: 600; values greater than 240 are rounded to multiples of 60)

3 Output time

The output of the data is either performed directly after the measurement or the data strings are requested by a exclamation mark sent via the RS-232 interface.

Values:

- After meas = 1 (default) push operation of data output → after every measurement the data is output
- Per '!' over RS232 = 2 pull operation of data output → use the '!' for data output/request

4 RS232 output

In this submenu the parameter for the output protocol of the RS-232 interface are listed.

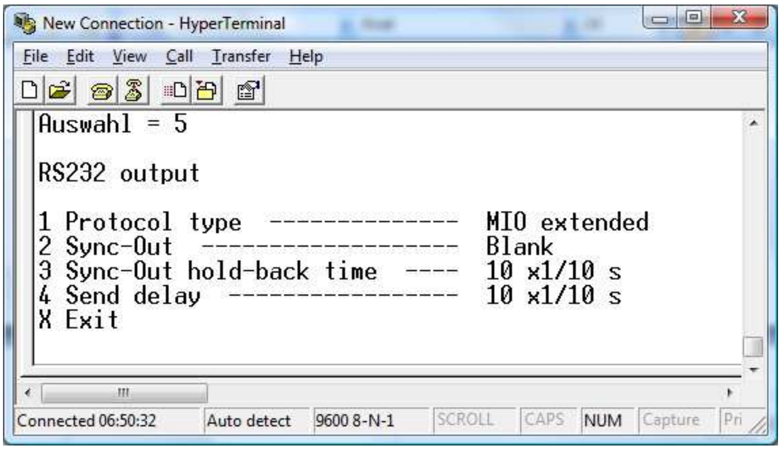


Fig. 3: Submenu: RS232 output

1 Protocol type

The protocol type for the data output via the RS-232 is selected. For a description of the protocol see chapter 7. Basic protocols do not include the capacitances and phases, only the extended protocols do.

- Off = 1
- Standard basic = 2
- MIO basic = 3
- Standard extended = 4
- MIO extended = 5 (default)

2 Sync-Out

The parameter is used for waking up connected data logger. Either a blank is sent prior to the output strings, or the RTS control line is switched on.

- Off = 1
- RTS method = 2
- Blank = 3 (default)

3 Sync-Out hold-back time

The holdback-time defines the time span between the Sync-Out signal (blank or RTS) and the transmission of the output string.

Unit: [1/10 s]

Value range: 3 to 20 (default: 10)

4 Send delay

The sending delay defines the time span between the strings of the protocol.

Unit: [1/10 s]

Value range: 3 to 100 (default: 10)

5 RS232 settings

In this submenu the parameters of the RS-232 interface are listed. Changes will cause a reboot of the IS-SP. A new parameterization of the interface at the PC may be necessary too.

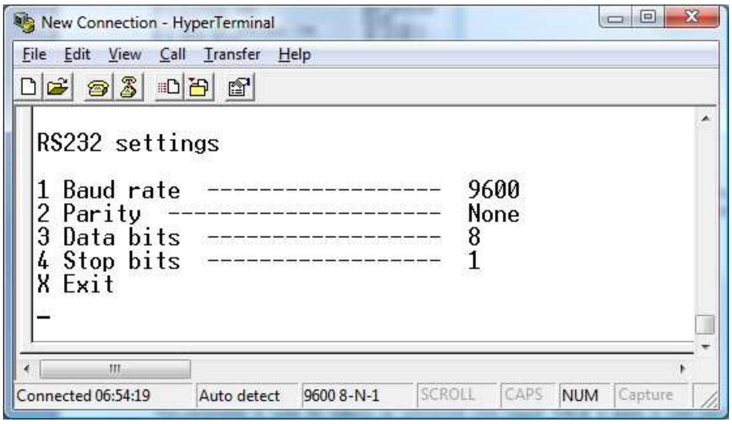


Fig. 4: Submenu: RS-232 settings

1 Baud rate

The baud rate of the RS-232 interface is selected.

- 1200 Baud = 1
- 2400 Baud = 2
- 4800 Baud = 3
- 9600 Baud = 4 (default)
- 19200 Baud = 5

2 Parity

The parity of the RS-232 interface is set.

- none = 1 (default)
- even = 2
- odd = 3

3 Data bits

The number of data bits for the RS-232 interface is set.

- 7 Data bits = 1
- 8 Data bits = 2 (default)
-

4 Stop bits

The number of stop bits for the RS-232 interface is set.

- 1 Stop bit = 1 (default)
- 2 Stop bits = 2

6 Analog input

In this menu the measurement values (offsets) of the snow depth and the analog inputs can be adjusted. Measurements can be performed and the measurement values are displayed.

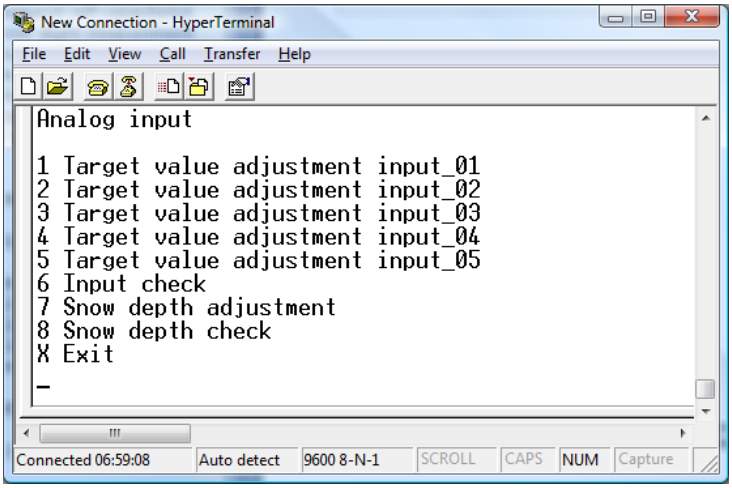


Fig. 5: Submenu: Analog input

Assignment:

Target value adjustment input_01	displacement sensor
Target value adjustment input_02	for analogue input #2
Target value adjustment input_03	for analogue input #3
Target value adjustment input_04	for analogue input #4
Target value adjustment input_05	for analogue input #5
Snow depth adjustment	for analogue input #6

1 … 5 Target value adjustment input_0x

A target value for the input can be set. The measurement value is automatically shifted to this value by an offset.

6 Input check

All inputs are measured and the measurement values are displayed.

7 Snow depth adjustment

A target value for the snow depth is entered. The snow depth is automatically set to this value by an internal offset.

8 Snow depth check

A measurement of the snow depth is performed and the measured value is displayed.

7 SPA parameter

In this menu settings for the SPA measurement and calculation are set.

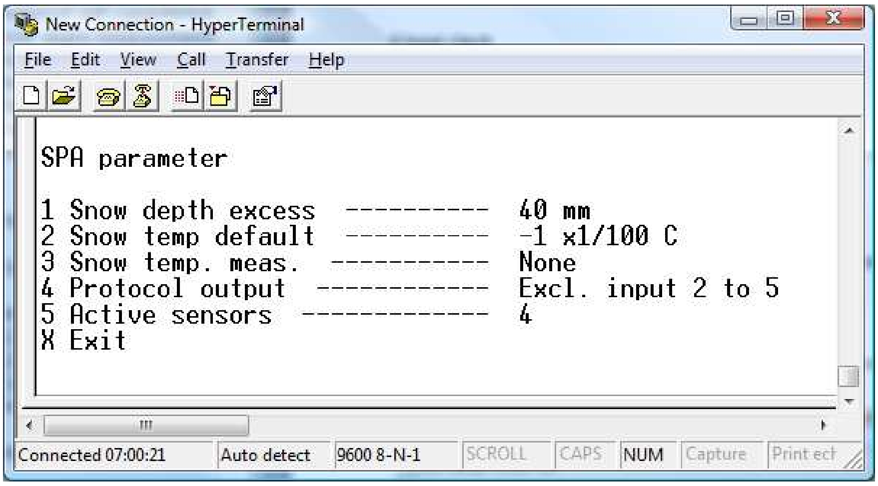


Fig. 6: Submenu: *SPA parameter defaults*

1 Snow depth excess

The snow depth excess defines a layer of snow. SPA calculation for any SPA-sensors is only performed, if the measured snow depth exceeds the foot height of the SPA-sensor by this value.

Unit: [mm]

Value range: 0 to 255 (default: 40)

2 Snow temp default

The SPA calculation is slightly depended on the snow temperature. This value defines the snow temperature for the calculation, if the temperature is not measured.

Unit: [1/100 ℃]

Value range: -5000 to 5000 (default: -100)

3 Snow temp. meas.

The parameter defines, if the snow temperature is measured and which input is the snow temperature.

- None = 1 (default)
- Input 1 = 2
- Input 2 = 3
- Input 3 = 4
- Input 4 = 5
- Input 5 = 6

4 Protocol output

The parameter defines, if the values of the inputs 2 to 5 are included in the protocol output.

- Excl. input 2 to 5= 1 (default)
- Incl. input 2 to 5 = 2

5 Active sensors

The parameter describes the sensors that are measured and output.

- Sensor 1 only = 1
- Sensor 1 and 2 = 2
- Sensor 1 to 3 = 3
- Sensor 1 to 4 = 4 (default)

8 Sensor_

For every SPA sensor connected to the IASP the geometric parameters and specific options have to be set.

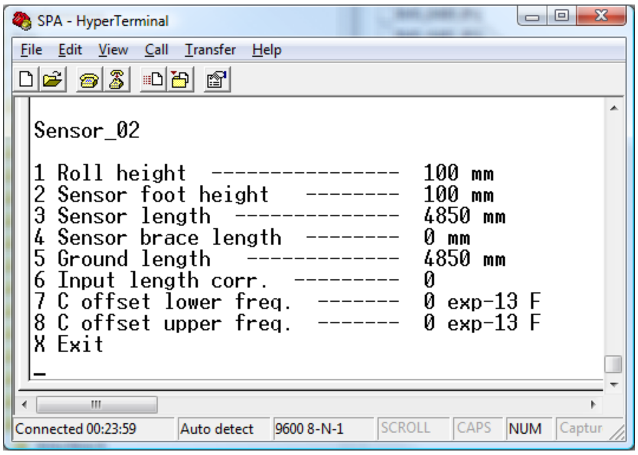


Fig. 7: Submenu: defaults for Sensor_02, the Ground length can also be set to zero for horizontal sensors

1 Roll height

The roll height is the vertical plumb distance from the upper roll of a sloping SPA-sensor to the ground. For horizontal installed SPA-sensors the roll height and foot height have to be identical.

Unit: [mm]

Value range: 0 to 10000

2 Sensor foot height

The foot height is the vertical distance from the middle wire of the SPA-sensor to the ground. For sloping sensors it is measured at the end of the sensor. For horizontal installed SPA-sensors the roll height and foot height have to be identical.

Unit: [mm]

Value range: 0 to 10000

3 Sensor length

The length of the sensor is measured between the two junctions of the sensor and the finishing boxes.

Unit: [mm]

Value range: 0 to 10000 (default: 4850)

4 Sensor brace length

This length is the distance from the upper roll of a sloping SPA-sensor to the junction of sensor and upper box.

Unit: [mm]

Value range: 0 to 10000

5 Ground length

The ground length is the distance at the ground from the plumb lines of the roll and the sensor foot. This value is only considered at a sensor with skew arrangement.

Unit: [mm]

Value range: 0 to 10000 (default: 4850)

6 Input length corr.

To improve the geometric information of the sensor, a distance sensor can be applied at the top of sloping SPA-sensor. The parameter defines the input of this distance sensor, that is used for the geometric correction.

Value range: 0 to 5 (default: 1)

7 C offset lower frequency

The offset value of the SPA sensor. Use this parameter to make a fine adjustment if your system retrieves e.g. a snow water equivalent unlike zero although the sensor is not covered by snow.

Unit: [exp-13 F]

Value range: 0 to 1000 (default: 0)

8 C offset higher frequency

The measured value of the SPA sensor. Use this parameter to make a fine adjustment if your system retrieves e.g. a snow water equivalent unlike zero although the sensor is not covered by snow.

Unit: [exp-13 F]

Value range: 0 to 1000 (default: 0))

I Info

The software version, the serial number of the device and all settings and measurement parameters are listed block wise. To proceed any key has to be pressed.

W Default

The complete parameters are set to the default values. All changes are lost.

X Exit

The main menu is closed and the changed settings are accepted. The IASP automatically performs the defined measurements.

7. Data output

The data is output by the RS-232 interface. The protocol is either the standard protocol or the MIO protocol. Basic protocols do not include the auxiliary values capacitance and phase.

7.1. Protocol values

The output values are separated in blocks of four values (Tab. 3). Every block corresponds to a string in the output protocol and is identified by the string ID. The string ID starts with the Device identifier (*see page 17*).

- The white [ ] shaded strings are output in each case.
- The light gray [ ] shaded strings are output if the extended version of the protocol types is used (***RS232 output → Protocol type***).
- The light green [ ] shaded strings are only output if the sensors are activated (**not reasonable at the SPA system**) in the menu ***SPA parameter → Active sensors***.
- The light orange [ ] shaded string is only output if in the menu SPA parameter → ***Protocol output set***.

sensor 1 … slope sensor
sensor 2 … horizontal sensor in 100 mm height
sensor 3 … horizontal sensor in 300 mm height
sensor 4 … horizontal sensor in 500 mm height

i	String label	Values 1	Values 2	Values 3	Values 4
00	Main results	Sensor 1 ice content	Sensor 1 water content	Sensor 1 snow density	Sensor 1 SWE
01	First auxiliary results	Sensor 2 ice content	Sensor 2 water content	Sensor 2 snow density	Sensor 2 SWE
02	Second auxiliary results	Sensor 3 ice content	Sensor 3 water content	Sensor 3 snow density	Sensor 3 SWE
03	Third auxiliary results	Sensor 4: ice content	Sensor 4 water content	Sensor 4 snow density	Sensor 4 SWE
04	Peripheral results	Snow depth	Analog Input 1	Chip temperature	Length of sensor 1 in snow
05	Aux. peripheral results	Analog Input 2	Analog Input 3	Analog Input 4	Analog Input 5
06	Sensor 1: aux. values	Sensor 1 C (low freq.)	Sensor 1 C (high freq.)	Sensor 1 phase (low freq.)	Sensor 1 phase (high freq.)
07	Sensor 2: aux. values	Sensor 2 C (low freq.)	Sensor 2 C (high freq.)	Sensor 2 phase (low freq.)	Sensor 2 phase (high freq.)
08	Sensor 3: aux. values	Sensor 3 C (low freq.)	Sensor 3 C (high freq.)	Sensor 3 phase (low freq.)	Sensor 3 phase (high freq.)
09	Sensor 4: aux. values	Sensor 4 C (low freq.)	Sensor 4 C (high freq.)	Sensor 4 phase (low freq.)	Sensor 4 phase (high freq.)

Tab. 3: Table of MIO values

String ID = Device identifier + i	i … two digit index

⚠ **Important:** If strings are not transmitted, then the string indices shift. For example if only the strings "Main results", "Peripheral results", and "Sensor 1: aux values" are output (delivery status), then the index assignment would be as following:

i	String label
00	Main results
01	Peripheral results
02	Sensor 1: aux. values

The units and decimal places of the values 1 – 4 and additional information are:

Value	Unit	Decimal Place
Ice content	%	1
Water content	%	1
Snow density	kg/m³	0
SWE	mm	0
Snow depth	cm	1
Length corr. (Analog 1)	mm	0
Chip temperature	°C	1
Capacitance	pF	0
Phase	°	1

Tab. 4: Units and decimal places; consider that at the SPA the values Snow depth and Length corr. do not represent reasonable values

7.2. MIO Protocol

MIO transfer consists of multiple ASCII strings containing four data values. A single string starts with the start ID „I“ followed by the string ID and system number. The four data values are 4 digits long without a decimal separator.

Attention: If a value is negative then the minus sign represents the first of the four digits.

The string finishes with a 4-digit checksum in hex format and the end ID ;

		Digits							
start ID	I								
string ID		2							
placeholder			2						
data value 1				4					
data value 2					4				
data value 3						4			
data value 4							4		
check sum / CRC-16								4 hex	
end ID									;

Tab. 5: MIO string pattern

Example for a an output:

```
I0000099909990999999990409;
I01008000-002024100000428;
I020004880450-894-9420446;
```

The first string represents according to Tab. 3 the string "Main results". The significance is as follows:

	Digits (decimal separator not output)									
cathegory	**1**	**2**	**2**	**4**	**4**	**4**	**4**	**4**	**1**	**meaning**
start ID	I									
string ID		00								
placeholder			00							no meaning
ice content				099.9						99.9% (max. value of range)
water content					099.9					99.9% (max. value of range)
snow density						0999				999 kg/m³ (max. value of range)
SWE							9999			9999 mm water column (max. value of range)
Check sum								0409		check sum
end ID									;	

example string: I 00 00 0999 0999 0999 9999 0409 ;

The second string represents the "SPA sensor: Peripheral results":

	Digits (decimal separator not output)									
cathegory	**1**	**2**	**2**	**4**	**4**	**4**	**4**	**4**	**1**	**meaning**
start ID	I									
string ID		01								
placeholder			00							no meaning
snow depth				8000						8000 mm (max. value of range)
analog input 1					-002					dependent on the adjustment in
chip temperature						024.1				24.1°C
length of sensor 1 in snow							0000			
Check sum								0428		check sum
end ID									;	

example string: I 01 00 8000 -002 0241 0000 0428 ;

The third string represents the "SPA sensor: Aux. values"

	Digits (decimal separator not output)									
cathegory	**1**	**2**	**2**	**4**	**4**	**4**	**4**	**4**	**1**	**meaning**
Start ID	I									
string ID		02								
placeholder			00							no meaning
C (low freq.)				0488						488 pF
C (high freq.)					0450					450 pF
phase (lov freq.)						-89.4				-89.4°
phase (high freq.)							-94.2			-94.2°
Check sum								0446		check sum
end ID									;	

example string: I 02 00 0488 0450 -894 -942 0446 ;

7.3. Standard protocol

The standard protocol is the same as the MIO protocol but with following differences:

- All the values within a string are separated with a blank
- There is no start ID
- There is no placeholder
- There is no end ID

example:

output with the Standard extended protocol:

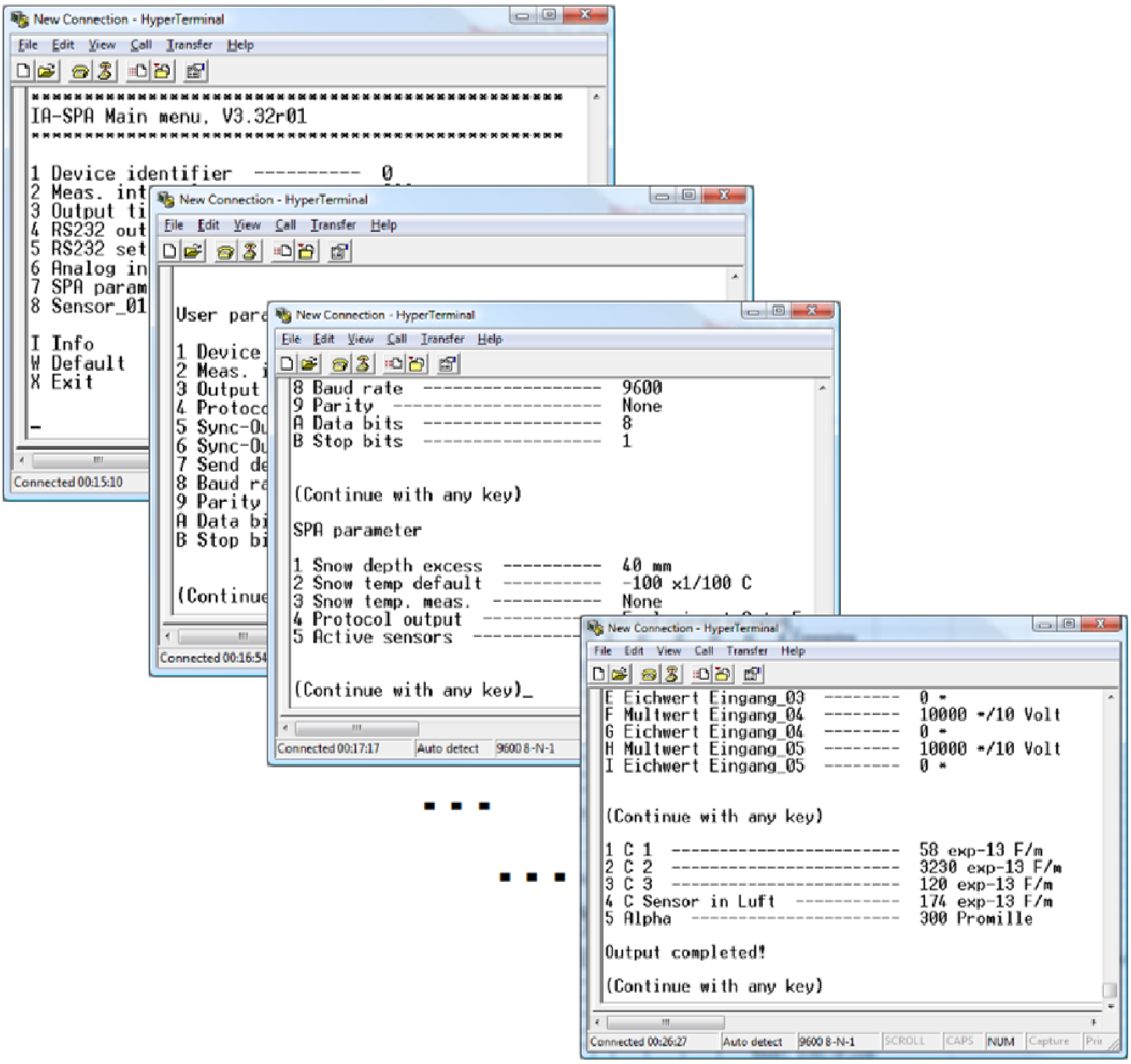
```
00 0000 0000 0000 0000 0400
01 -999 0006 0229 0000 042C
02 0488 0451 -894 -942 043E
```

instanteneous after change to the MIO extended protocol:

```
I000000000000000000000409;
I0100-999000602310000042E;
I020004880451-894-9420447;
```

8. Support

If you need support with the SPA please send us the software version you can see in the main menu. Please depict also the actual adjustments you can display with pressing the slash key **/** in the main menu.



Copy this information into a text file and send it to us.

This helps us very much to give you the optimal help.

9. Base settings and default values

Menu	Parameter description	Default value
1. Device identifier	1. Device identifier	0
2. Meas. interval	2. Meas. interval	600
3. Output time	3. Output time	After meas
4. RS232 output	4.1 Protocol type	MIO extended
	4.2 Sync-Out	Blank
	4.3 Sync-Out hold-back time	10
	4.4 Send delay	10
5. RS232 settings	5.1 Baud rate	9600
	5.2 Parity	None
	5.3 Data bits	8
	5.4 Stop bits	1
7. SPA parameter	7.1 Snow depth excess	40 mm
	7.2 Snow temp default	-100 x1/100 C
	7.3 Snow temp. meas.	None
	7.4 Protocol output	Excl. input 2 to 5
	7.5 Active sensors	Sensor 4
8. Sensor_01	8.1 Roll height	2000 mm
	8.2 Sensor foot height	80 mm
	8.3 Sensor length	4850 mm
	8.4 Sensor brace length	150 mm
	8.5 Ground length	
	8.6 Input length corr.	1
	8.7 C offset lower frequency	0 exp-13 F
	8.8 C offset higher frequency	0 exp-13 F
9. Sensor_02	9.1 Roll height	100 mm
	9.2 Sensor foot height	100 mm
	9.3 Sensor length	4850 mm
	9.4 Sensor brace length	0 mm
	9.5 Ground length	0 mm
	9.6 Input length corr.	0
	9.7 C offset lower frequency	0 exp-13 F
	9.8 C offset higher frequency	0 exp-13 F
A. Sensor_03	A.1 Roll height	300 mm
	A.2 Sensor foot height	300 mm

	A.3 Sensor length	4850 mm
	A.4 Sensor brace length	0 mm
	A.5 Ground length	0 mm
	A.6 Input length corr.	0
	A.7 C offset lower frequency	0 exp-13 F
	A.8 C offset higher frequency	0 exp-13 F
B. Sensor_04	B.1 Roll height	500 mm
	B.2 Sensor foot height	500 mm
	B.3 Sensor length	4850 mm
	B.4 Sensor brace length	0 mm
	B.5 Ground length	0 mm
	B.6 Input length corr.	0
	B.7 C offset lower frequency	844 exp-13 F
	B.8 C offset higher frequency	844 exp-13 F

10. Technical data

Technical changes and errors excepted

IASP = SPA analyzer module

Inputs	4 x SPA sensors 1 x Snow depth: 4..20 mA (USH-8) 1 x SPA sensor length
Output	1 x RS-232: 1200..9600 Baud ASCII protocol
Power supply	Supply voltage: 10,5 to 15 VDC Reverse voltage protection Overvoltage protection
Energy consumption	Active: 50 mA at 5 s measurement time per SPA sensor Sleep: < 2 mA
Measurement range	SWE: 0..9999 mm water column Snow density: 0..999 kg/m³ Ice and water content: 0,0..99,9 % Snow depth: 0..8 m (see USH-8 manual)
Area of application	Operating temperature: -35 °C to +60 °C
Housing	Material: Anodized aluminum Dimensions: 70 x 100 x 55 mm (L x H x W) Installation: Mounting for top hat rail
Protection type	IP 55

SPA Sensor

Coating	Material: PVC Ultraviolet resistant
Conductors	3 copper wires
Connection Cable	Length: 4000 mm Connector: Watertight sealed
Dimension	Width: 60 mm Length: 4850 mm

SPA Framework

Material	Steel
Dimension	Length: 6360 mm Width: 1100 mm Height (mast): 3000 mm (standard)