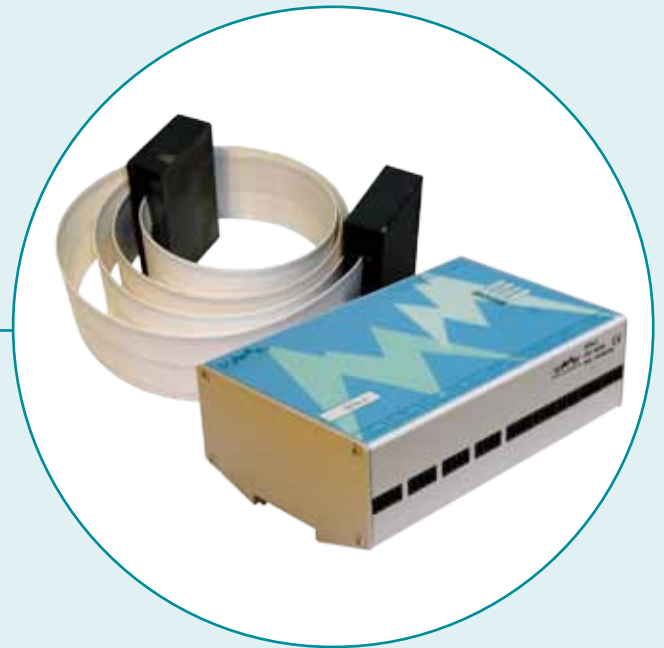
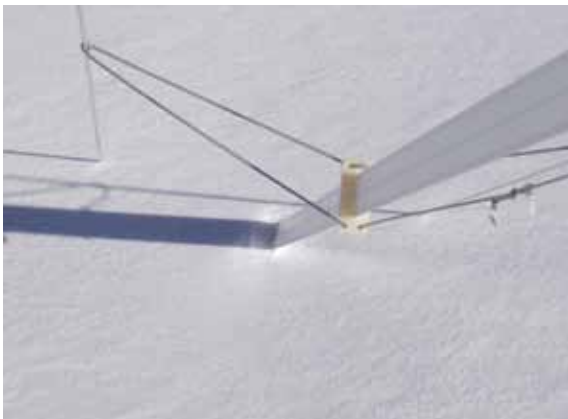


# SPA-2

The **SnowPackAnalyser** measures the volumetric contents of ice, water and air together with the snow depth and calculates the SWE and the snow density.



## Features and advantages

- ✓ Recording of the snow parameters
  - snow depth
  - snow water equivalent (SWE)
  - snow density
  - liquid water content
  - ice content
- ✓ Sensor integration via RS 485 or SDI-12 interface
- ✓ Energy-saving sensor operation
  - sleep mode between the measuring intervals
  - ideal for solar-powered stations
- ✓ Comfortable parametrisation
- ✓ Information about SWE, snow density, liquid water and ice content
  - of the whole snow pack
  - of specific snow layers

## Introduction

### Automatic and continuous measurement

To measure certain snow parameters can be a challenging task. Therefore, several different variables have to be measured to be able to provide reliable information about the whole snow pack. In addition, snow has a considerable variability in space and time. Until now, only punctual measurements for certain values were possible. With its strap sensors and different system assembly versions the Snow-Pack-Analyser System (SPA) now constitutes a revolutionary innovation for an automatic, continuous, and most

importantly areal measurement of the parameters snow depth, snow water equivalent (SWE), snow density, and the contents of liquid water and ice. For this reason the significance and reliability of the data about the snow pack's state can be increased substantially. The SPA enables a modern, up-to-date data recording with a high resolution over time. Moreover, the system helps to reduce the often dangerous and expensive employment of staff in wintry terrain.

### Measuring principle

#### Snow depth

The measurement principle is based on the travel time measurement of an ultrasonic pulse between the sensor and the snow surface. The influence of the temperature is compensated automatically.

#### Measuring the dielectric constant

Snow consists of the three components ice, water and air. Using different measurement frequencies, these components show different dielectric constants. Measuring the complex impedance along a flat strap sensor (SPA sensor) at two different frequencies allows to determine the volume contents of the individual components.

### Installation of the system

The SPA-system can be integrated simply and conveniently into new or existing weather stations. The snow depth sensor is fixed on a mast with a beam. The SPA sensors are attached to this same mast as well, whereas the second end is connected to a frame on the ground and stretched by a special suspension. A further

#### Snow water equivalent, snow density, liquid water and ice content

The SPA sensor measures the specific volume contents of liquid water and ice in the snow pack. Based on these information it then calculates the snow density and consequently, in combination with the snow depth, the snow water equivalent.

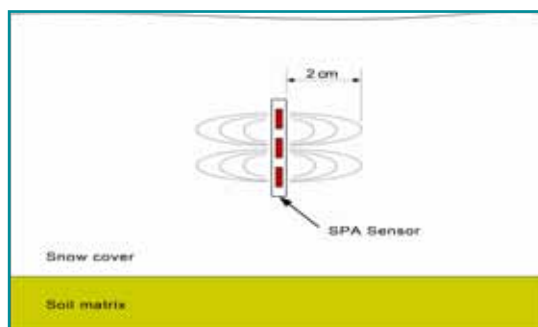


Fig. 1: Measuring principle of the SPA sensor

### Good results despite ice layers

It is a very common situation that ice layers in the snow pack cause for distortions of the measurement values when measuring the snow water equivalent. However,

core part of the SPA-system is the SPA-analyser that is integrated in a switch box. It analyses the data inputs and transfers the measurement results to a data logger via an RS 485 or SDI-12 interface. It is also possible to connect up to four analogue sensors (e.g. temperature measurements) to the SPA-analyser.

using the SPA-system ice layers have no influence on the measurements. Hence, a large source of errors can be eliminated.

## Individual system assembly

The SPA-system can be operated with up to four SPA sensors. Their quantity and system assembly depends on the different and individual measurement tasks. The SPA is installed on the ground resulting in the sensors to be stretched horizontally or slopingly in the snow

pack. The sloping sensor strap is employed at a snow depth of 30 cm at the minimum and it reaches up to 2.5 meters (version 1), respectively 5 meters (version 2) of snow depth at the maximum. The horizontal straps are installed at a height of 10, 30, and 50.

### Combination (horizontal/sloping)

This version combines a sloping with a horizontal SPA sensor. The sloping one determines the parameters SWE, snow density and the liquid water and ice content across the whole snow pack.

The horizontal sensor strap provides important data about the snow pack near to the ground, for example the snow density and the liquid water content. These parameters are used for the run-off prediction during the snow melting period.

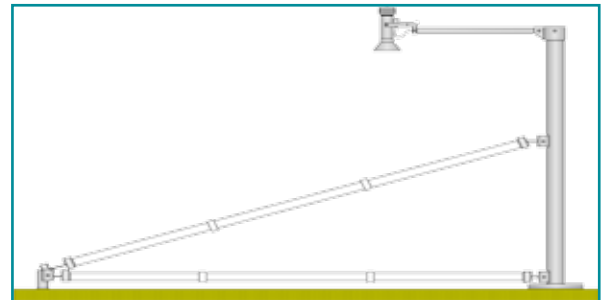


Fig. 2: Illustration of the system assembly Combination

### Profile

The SPA sensors are installed horizontally at increasing levels and therefore provide data about the snow density, liquid water content and ice content at specific snow depths. With this assembly it is possible to generate a density or moistness profile of the snow pack.



Fig. 3: Illustration of the system assembly Profile

## Fields of application and example

Water supply and management, hydropower plants, flood prevention authorities	Run-off predictions and expected water quantity during snowmelt
Agriculture, mining	Expected infiltration of melting water into ground or underground
Hydrology	Point of saturation and snowmelt discharge
Alpine communities, skiing resorts	Snow density and liquid water content for risk assessment of wet snow avalanches
Research facilities	Snow depth, snow density, snow water equivalent, contents of liquid water and ice

The SPA-system provides high resolution data of the parameters snow depth, snow water equivalent, snow density, and liquid water and ice content of the snow pack. The most interesting period of the year is during springtime when the snowmelt begins. At first a decrease of the snow depth can be noticed (grey line, A) followed by a rise of the liquid water content (green line, B). Several days later also the snow water equivalent drops (blue line, C) what marks the saturation point. No more water can be stored in the snow pack and the run-off starts.

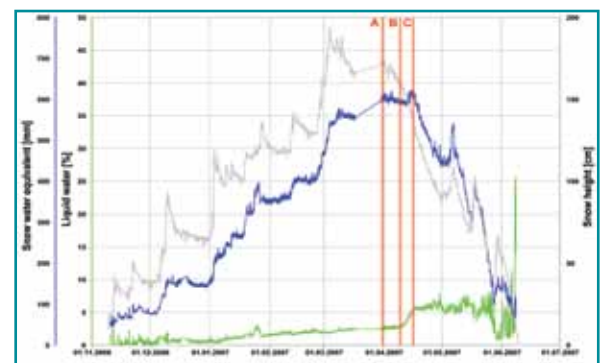


Figure 4: Measuring values of the SPA-system November until July

## Technical Data

General	
Dimensions framework	6360 mm x 1100 mm x 3700 mm (L x W x H)
Power supply	supply voltage: 9 ... 15 VDC reverse voltage protection, overvoltage protection
Power consumption	active: 65 mA (sleep-mode: 1 mA)
Operating temperature	-35 ... 60°C

SPA-sensor	
Material	weatherproof, UV resistant sensor strap, reinforced with Kevlar cords
Length	horizontal strap: 4.8 m   sloping strap: 4.8 m (standard), resp. 6.7 m
Width	60 mm
Measuring principle	measurement and analysis of the complex impedance along the SPA sensors depth of penetration: 4 cm on both sides

SPA-analyser	
Inputs	up to four SPA sensors
Analogue inputs (4 x)	1 x ultrasonic snow depth sensor with integrated temperature compensation 3 x for integration of further sensors (e.g. temperature measurements of snow, ground, snow surface) - optional
Outputs	RS 485 / SDI-12; various ASCII formats

Measurement range		
Snow depth accuracy 2cm	0 ... 2.5 m	0 ... 5 m
SWE (mm of water) accuracy +/-5% (FS*)	0 ... 1000 mm H2O	0 ... 3000 mm H2O
Density accuracy 5% (FS*)	0 ... 1000 kg/m <sup>3</sup>	
Volumetric water content accuracy 2% (FS*)	0 ... 100 %	
Volumetric ice content accuracy 2% (FS*)	0 ... 100 %	
FS*	Accuracy measured in laboratory environment	

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