SLF SNOW SENSOR – USER MANUAL

OVERVIEW

1) Graphical Display (102x64 with Backlight)
2) Abort Button
3) Enter Button
4) Navigation Buttons
5) Power Button
6) Connection to Sensor or Computer (USB)
7) Battery Compartment (back side)
8) Sensing area (back side)
9) Connection to Control Unit

SPECIFICATION

Parameter	Value	Unit
Snow density range	*0..917*	kg / m³
Snow moisture range	0..20	vol. %
Meas. Frequency	20	MHz
Battery run time	>10	hrs
Temperature range	-25 to +60	°C
Memory size	280	samples
Battery	3 x 1,5V	AAA cells*
Data download	via USB	
Display	102 x 64 px with backlight	
Measurement volume	ca. 45 x 95 x 17 mm	

* We strongly recommend using Energizer Ultimate Lithium or Varta Litium batteries for best performance at low temperatures.
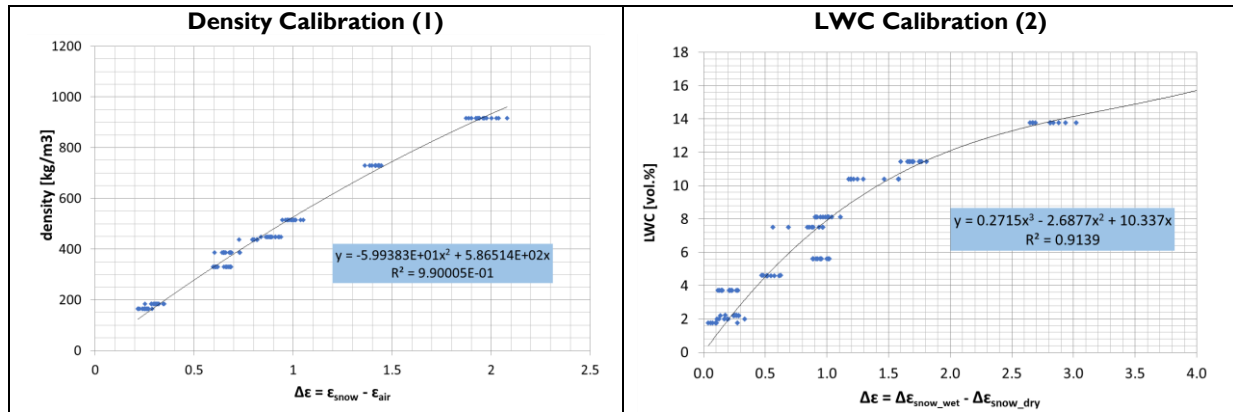
WORKING PRINCIPLE

The SLF Snow Sensor device measures the density (ρ) or the liquid water content (LWC) of snow with a capacitive sensor, which generates an electrical field permeating the snow. Depending on the fractions of ice, air and water within the permeated snow volume, the measured capacitance changes, as ice, air and water have different dielectric properties. For dry snow (absence of liquid water) the snow density can be directly deduced. To determine the LWC, the ice fraction (dry density) of the snow must be known. Rather by a density measurement before the snow has started to melt or by approximation (e.g for machine made snow).
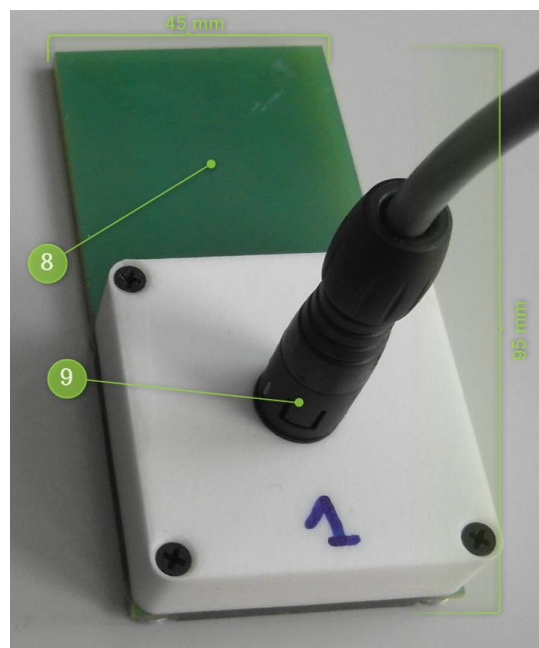
The capacitive sensor forms an oscillator together with a quartz crystal. A change of the capacitance forces a frequency change in the oscillator. Measurements on materials with known dielectric properties (air, PTFE) provides the linear ε – Δf relation represented by the calibration factor k. Reference measurements (weighted volumes, LWC dilution method) on snow with varying densities and wetness give the ρ – ε relation function (Eq. 1) as well the LWC – Δε relation function (Eq. 2) expressing the increase of ε by liquid water within snow of a certain density.

$$\rho \text{ (kg/m}^3) = -5.99\Delta\varepsilon^2 + 58.65\Delta\varepsilon \qquad (1)$$

$$\text{LWC (vol\%)} = 0.2715\Delta\varepsilon^3 - 2.69\Delta\varepsilon^2 + 10.34\Delta\varepsilon \qquad (2)$$

Density Calibration (1)

$y = -5.99383E+01x^2 + 5.86514E+02x$
$R^2 = 9.90005E-01$

LWC Calibration (2)

$y = 0.2715x^3 - 2.6877x^2 + 10.337x$
$R^2 = 0.9139$

DENSITY MEASUREMENT

0) Verify the absence of liquid water in the snow ($T_{snow} < 0\ °C$). The density measurement works only for dry snow.

FOLLOW THE DENSITY MEASUREMENT MENU:

1) Start "Density Meas" menu

2) Air measurement: Make sure the sensor is clean of water droplets or snow and is not hold at the capacitors area. Start the measurement by pressing the ENTER button.

3) Snow measurement: Use a scrapper like tool to flatten uneven snow surfaces. Put (don't press) the sensor on a flat snow surface and start the measurement by pressing the ENTER button. Due to the inherent variability of the snow density but also due to imperfections of the snow surface preparation, at least 3 to 5 repetitions are recommended.

4) Save measurement: After snow measurement is confirmed, the density value is immediately calculated based on ρ – ε relation that is stored in each snow sensor. Each measurement is assigned to a constantly increased measurement number that is stored in memory and can be transferred over USB to the computer. For consecutive measurements the device uses the same air value until the density measurement menu is left. Pressing the repeat button, the snow measurement will be repeatetd and overwritten.

MOISTURE MEASUREMENT

0) Verify the existence of liquid water in the snow (T_{snow} = 0 °C).

FOLLOW THE MOISTURE MEASUREMENT MENU:

1) Start "Moisture Meas" menu

2) To calculate the LWC value it is required to know the snow density also called in this manual as the "dry snow" value. Therefore, the first step is to determine the snow density, by entering the "Meas dry snow" menu. The workflow provides 10 measurement locations (0 to 9) that store the corresponding snow density and are later referred to when measuring wet snow and calculating LWC. The dry snow value can be either derived by
   a. performing a measurement forehand (e.g. early morning) if T_{snow} < 0 °C Select menu "Meas Air" and refer to the density measurement description above.
   b. manually entering a value for the density that can be an estimate or from reported values for typical snow types in the literature [e.g. Fierz et al., 2009; Wolfsperger et al., 2018].
   c. or calculated based on measuring the weight of a well-defined snow volume. This will introduce a small error since measuring the weight also includes the weight of the water. Since the ε of water (~90) is much larger than that of ice (~3), measured LWC is largely dominated by water content rather than snow density. E.g. at LWC = 14% snow density is overestimated by 30% resulting in ε_{snow_dry} increase of just 0.3. Optionally, the obtained LWC value can be used to manually calculate the mass of water and in multiple iterations an accurate density estimation can be obtained.

3) Once the snow density is stored, the wet snow measurement can be performed after the corresponding measurement location must be selected.

4) Follow the on-screen guidance to measure the air and snow values. Use a scrapper like tool to flatten uneven snow surfaces. Put (do not press) the sensor on a flat snow surface and start the measurement by pressing the ENTER button. Variability of the snow's density itself but also due to imperfections of the snow surface preparation, at least 3 to 5 repetitions are recommended. Prevent the sensor of heating up causing additional melting while in contact with the snow. The LWC value is immediately calculated based on LWC – Δε relation that is stored in each snow sensor using the density related to the selected measurement location.

CONFIGURATION MENU

Show Info

Displays information regarding control unit and snow sensor:

1) Software version of control unit
2) (Firmware-) FPGA version of snow sensor
3) Serial number of snow sensor
4) EPS calibration value (derived from PTFE measurement)

Enter Mess Nr

Allows to set the continuously increase measurement number to any value

Service

Service menu to set calibration constants of snow sensor and LWC- / density relation functions. Only accessible with password.

TX Over USB

See below

DATA TRANSFER TO COMPUTER

1) Disconnect snow sensor

2) Go to Config Menu and start "TX over USB"

3) Connect USB adapter cable between computer and control unit.

4) On Windows Computer:
   a. Windows should recognize "STMicroelectronics Virtual COM Port" and start installing driver if not already present.
   b. Open Terminal Window (e.g. Tera Term) and connect to virtual COM port.
   c. Press "Start TX" Button.

5) On Apple Computer:
   a. MacOSX recognizes virtual COM port without any extra driver.
   b. Open terminal application.
   c. Check if the device is visible to your computer. The name is always "usbmodem???".

      $ ls -l /dev/.usb**

      crw-rw-rw- 1 root wheel 21, 11 Oct 23 09:24 /dev/cu.usbmodemFD131

      crw-rw-rw- 1 root wheel 21, 10 Oct 23 09:24 /dev/tty.usbmodemFD131
   d. Now open the "tty" device for the transfer.

      $ screen /dev/tty.usbmodemFD131
   e. Press "Start TX" Button
   f. The data are transferred now and shown on the terminal.

6) Copy and paste comma delimited data to spreadsheet (e.g. Excel).
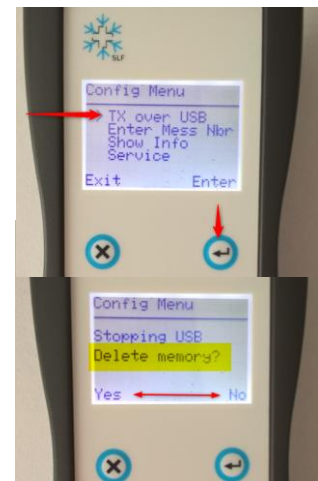
7) After USB download memory can be deleted if desired and measurement index set back to zero.
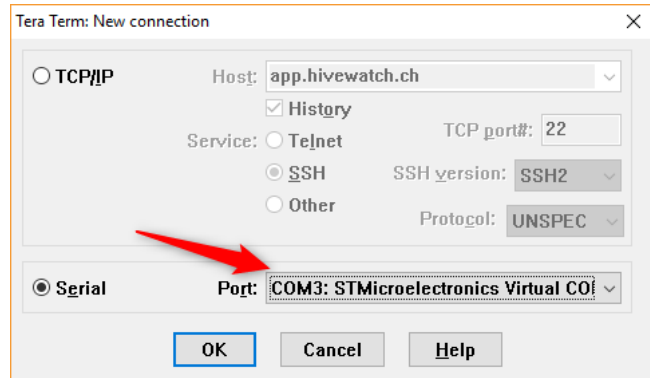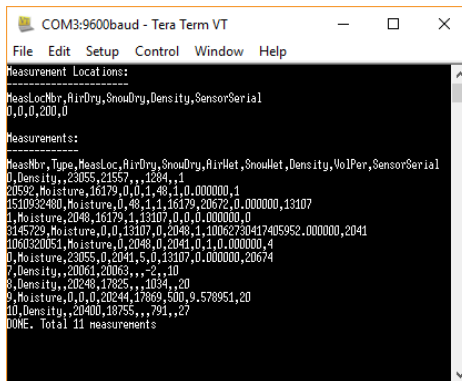
LITERATURE

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SUPPORT

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