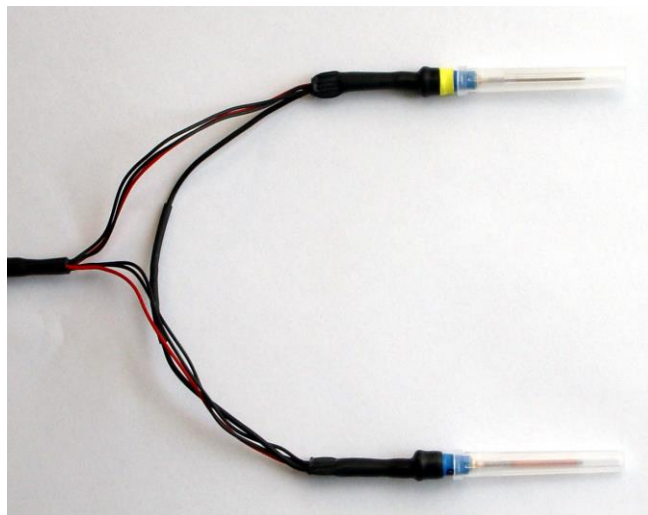


Sap Flow Sensor

Sap Flow Sensor

Type SF-G



User Manual

2003

Sap Flow Sensor (Type SF-G)

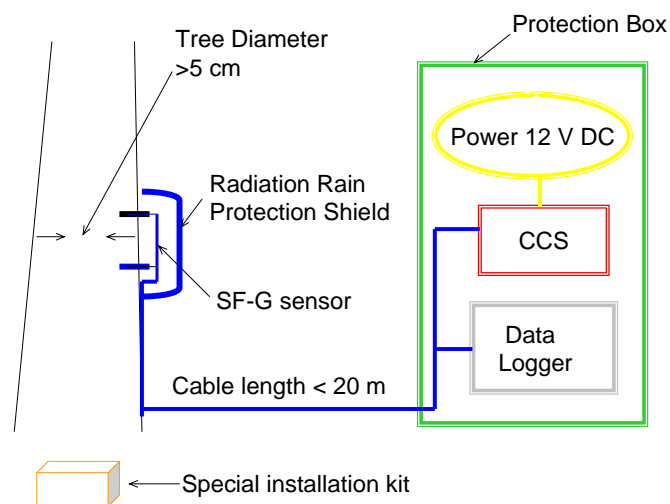
1. Introduction

Thank you for purchasing an Ecomatik sap flow sensor type SF-G.

The SF-G is the well-known thermal dissipation probe (TDP) developed by Granier (1985) for measuring sap flow in trees. The sensor consists of two identical manufactured needles with copper-constantan thermocouples and a special heating wire. The two needles are inserted into the sapwood, one above the other 15 cm apart directly below. The top needle is heated with constant energy supply (=constant current source). The temperature difference between two needles ΔT resulted from the above heated and blow unheated needles is the output signal of the sensor.

The SF-G is a sensor component of the sap flow measuring system. This means that SF-G must be installed into a tree and connected to a special power supply unit and a data logger. The diagram below gives you an overview of the whole sap flow measuring setup for outdoor purposes. All indicated components are available at ECOMATIK.

Please note that the tree diameter at the level of installation must be bigger than 5 cm.



A Setup of SF-G sap flow measuring system

- Blue: SF-G sap flow sensor
- Red: Constant current source (CCS)
- Gray: Data logger, >12 bits
- Yellow: Power supply, 12 V DC, at least 100 mA permanent current
- Green: Protection box for data logger, CCS, power source in outdoor condition
- Orange: Special installation kit
- Black: Tree for investigation, its diameter at level of measurement >5 cm

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2. Product Description

SF-G Sensor



Sap Flow Sensor Type SF-G

The sensor consists of:

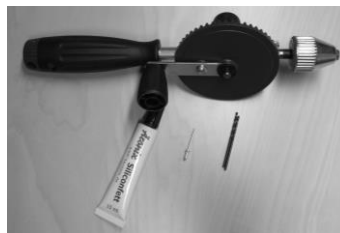
- 1 SF-G sensor with 2 needles supplied with 0.7-m standard cable extendable to 20 m
- 1 radiation protection shield (60 cm x 60 cm)
- 1 tube of silicon paste for sealing the top of protection shield
- 2 aluminum tubes
- 1 adhesive tape for fixing the radiation protection shield on the tree

Constant current source (CCS)



Constant current source for supplying up to 3 SF-G sensors

Installation kit



Installation kit

Installation kit consists of:

- 1 hand drill
- 2 drill bits with 2 mm diameter for drilling the holes for the needles into the wood

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- 1 special needle for inserting the aluminum tubes into the tree
- 1 tube silicon-fat for improving heat dissipation from the needles into the wood

Contact your dealer incase any of the above items is missing.

3. Safety Information

The needles are fragile, please handle with care.

Never supply the sensor with power before it is installed into the tree. For test purposes, please put the needles in water so that heat the can be dissipated.

Pay attention to wiring instructions. Wrong connection could destroy the sensor.

4. Installation

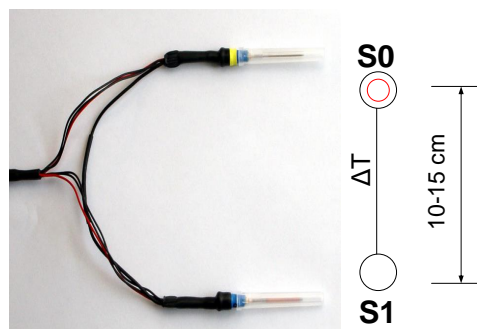
4.1 Preparation

Cable extension: Unless specified in the order, the standard cable length of the sensor is 0.7 m. This can be extended up to 20 m. Use 4-wire cable (Cross- sectional area of at least 0.25 mm²).

Power supply: Irrespective of whether 1, 2 or 3 SL-G sensors are connected, the constant current source consumes about 100 mA. In case you use a car battery as power source, e.g. a 50-Ampere-Hour battery may last 10 days.

4.2 Sensor

In order to avoid thermal effects the sensors should be installed higher than 1.5 m from the ground and on the north facing aspect of the tree.



Installation scheme of the SF-G sensor: The sensor consists of 2 needles: S0 heated and marked with a yellow ring and S1. The temperature difference between S0 and S1 provides the value ΔT .

Following the schematic diagram above, drill two holes of 2 mm diameter and about 23 mm depth into the wood. This depth does not include bark thickness. Use the 8 mm drill bit to isolate the bark. Also, if more than one needle set have to be installed deeper into the sapwood, i.e. incase of larger trees, then progressive holes of 23 mm depths into the sapwood are necessary.

Carefully insert the small aluminum tubes into the holes by using the special needle supplied in the installation kit. Ensure the tubes are tightly fitted and completely immersed into the wood (Extensions of the aluminum tube outside the tree trunk can cause erroneous results). Dip the

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sensor needle S0 into silicon-fat and insert the needle into the aluminum tube. For the needle S1 is silicon-fat not necessary. Ensure that the labels on the needles correctly correspond to the above scheme.

4.3 Cable installation

Once the above installation is correctly carried out, fix the cable onto the tree stem so that the needles are protected from any accidental pull/ drag on the entire cable length. This can be done using a rope or cable straps. Ensure the suspension rope/strap is not so tight as to interfere with normal tree growth and expansion during the entire measurement period. Also, there should be no tension between the sensor and cable.

4.4 Protection shield

Corresponding to the tree diameter prepare a radiation protection shield such as one shown in the picture below.



Prepared protection shield

Install the prepared radiation-protection shield around the sensors using adhesive tape. Take care that the shield does not touch the needles. Seal off the top of the shield with silicon paste to protect the sensor from dripping rainwater.

4.5 Wiring

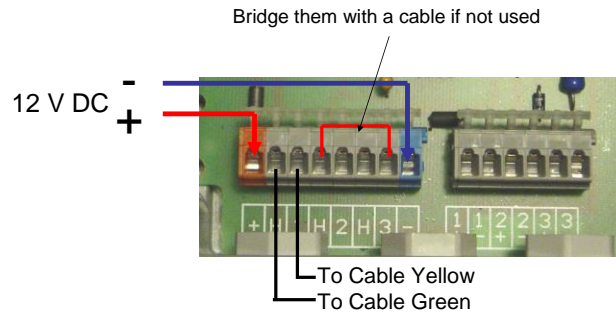
The SF-G sensor requires constant power supply (CCS) and provides three signals. Wiring should be done as shown in the table.

Wiring description

Use	Wire color	Connected to
Heating +	Green	CCS +
Heating -	Yellow	CCS -
Signal S0	White	Signal +
Signal S1	Brown	Signal -

Connect the heater wires to the CCS as shown in the picture below. One CCS can supply three SF-G sensors. If only one or two SF-G sensors are used, the open sockets must be bridged. Press the trigger from top with a small screwdriver to open the clamps and to insert or remove the wires.

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Connection of CCS

4.6 Logger configuration

The SF-G sensor signal output in channel two (S0-S1) range from +100 to +800 μV DC. All loggers with voltage resolution $<10 \mu\text{V}$ can be used for SF-G sensors. Please specify the channels for SF-G sensor so that it can measure voltage in the required range i.e. from +100 to 1000 μV DC.

Some loggers directly convert the voltage values into temperature. In this case, the expected outputs are from 2.5 to 20°C.

5. Data processing

5.1 Sap flow density

Sap flux density is calculated after the formula (1) by Granier (1985). Please use the software for the data processing.

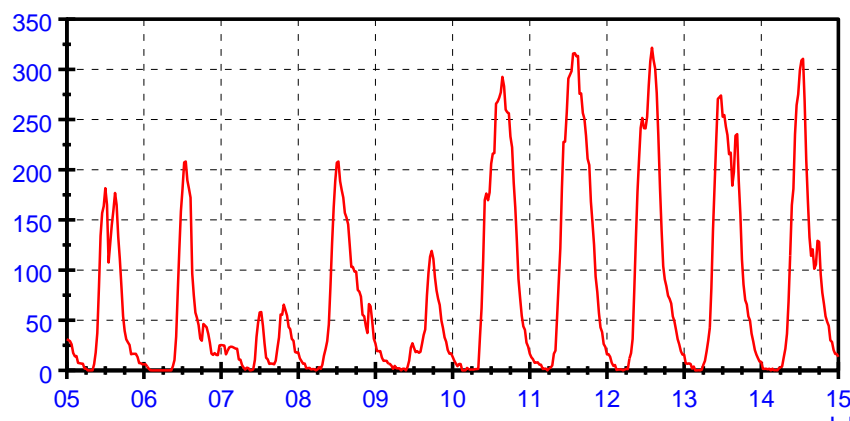
$$U = 0.714 \times \left(\frac{\Delta T_{\max} - \Delta T}{\Delta T} \right)^{1.231} \quad (1)$$

U is sap flux density ($\text{ml}/\text{cm}^2/\text{minute}$)

ΔT is temperature difference between two needles.

ΔT_{\max} is max. value of ΔT every night

After this formula the sap flow density goes back to zero every night. Fig.1 show an example measured by a spruce tree.



Sap flow density measured with Granier sensor.
The Granier sensor shows zero sap flow every night

5.2 Sap flow of the tree

The sap flow of the tree is given by the formula (2)

$$F = u \times SA \quad (2)$$

Where

F is Sap flow in ml/min.

u is sap flow density in ml/(cm²×min), calculated after formula (1).

SA is sap wood area of the tree in cm².

6. Technical Specification

Sensor	
Sensor composition	2 needles
Needle size	33 mm length, 1.5 mm diameter
Heating zone	20 mm from top of the needle
Cable length	0.7 m, extendable to 20 m
tree size	Diameter > 5 cm
Power consumption	0.2 W +/- 5%, 84 mA DC, stabilized
Output	100 µV to 800 µV DC
Logger requirement	1 differential channels
Power supply	
Input	12 V DC
Output	84 mA stabilized, suitable for 1 to 3 SF-G sensors

7. Literature

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