EMS Brno

Data Acquisition Environment

Hardware – Software – Cloud application

www.emsbrno.cz

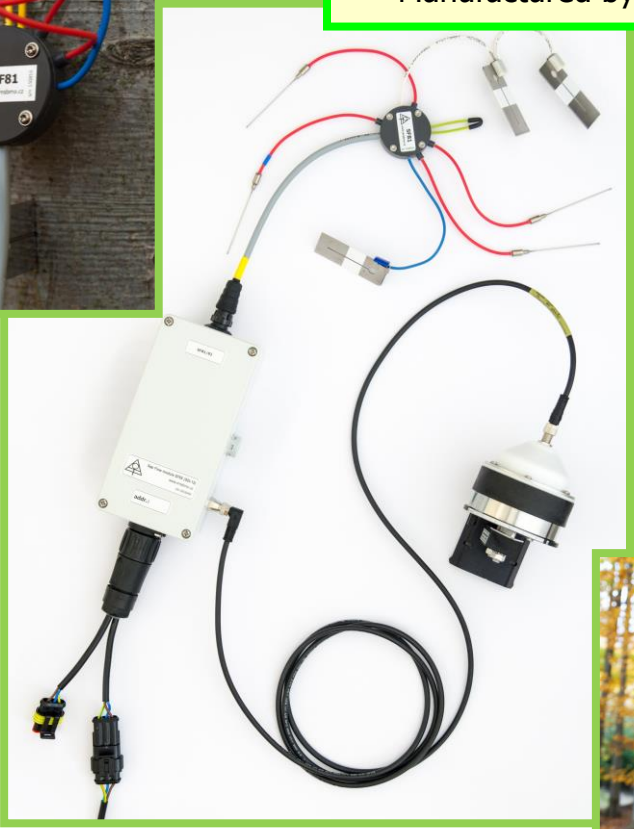
Sap flow system EMS 81

based on SF 8X (SDI-12) module for connection to SDI-12 network

Main features:

- Tissue heat balance method with variable power and constant dT
- Input for stem increment sensor
- SDI-12 ver 1.3 compatible
- No overheating of stem tissues
- Power requirements proportional to sap flow rate – fits to solar powering
- Battery operated with extremely high efficiency > low energy consumption
- Manufactured by EMS







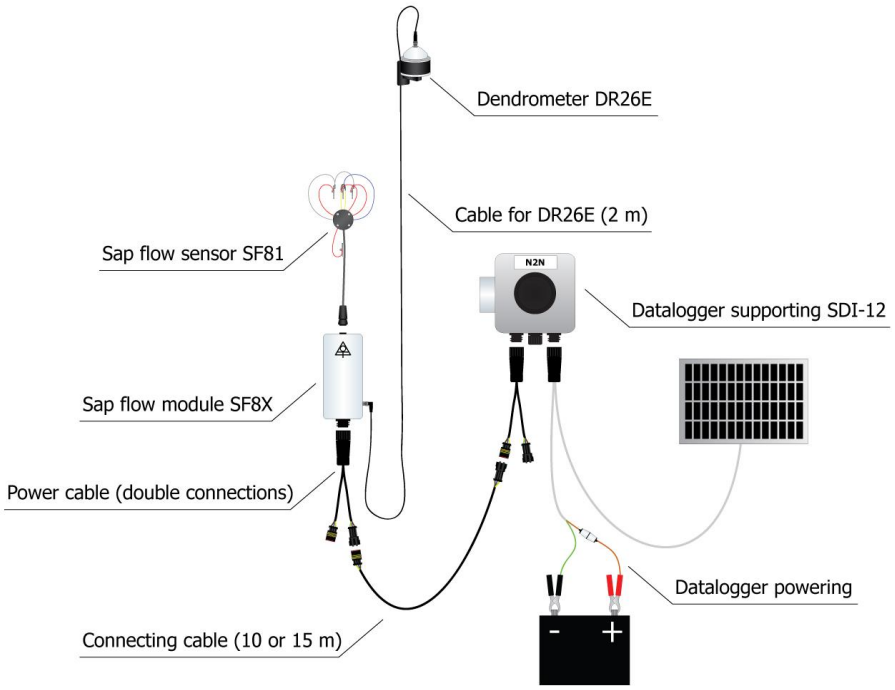


Specification:

- Minimal stem diameter at cambium level 12 cm
- Constant temperature difference adjustable to 1, 2 or 3 K
- Average power consumption 0.3 – 0.4 W @ dT=1 K

System description

Measuring system consists of the SF8X (SDI-12) module with SDI-12 output, sap flow sensor SF 81, set of stainless electrodes, weather shields and connecting cables. System can be equipped with stem increment sensor DR26E. System is ready to be connected to the datalogger supporting SDI-12 communication protocol.

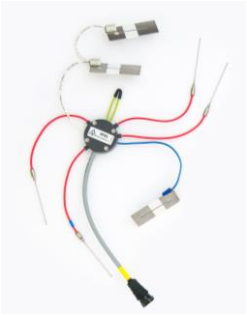


System components



Module SF8X (SDI-12)

Electronic unit is controlling the measurement and transfers the data to the datalogger by SDI-12 communication protocol. When the module is activated by the magnetic head of communication cable, beeps indicate the address of the module. Short beep indicates one unit, longer beep five units. The sum of units gives the ordinal number of the address. If there is a problem with the sensor operation, the error status is indicated by number of short beeps following a short jingle.



Sap flow sensor SF81

Sensor intended for continuous measurement of volumetric sap flow in tree trunks larger than 12 cm (at cambium level). The stainless electrodes (terminals) are hammered into the stem and thermosensor needles are inserted into the geometrical center of the part of electrode inside xylem. Highly conductive steel equalizes radial differences in temperature of the sapwood and allows measurement of mean xylem temperature. Therefore, measured values are nearly independent on the radial profile of sap flow density.

Dendrometer DR26E



Sensor designed for long-term measurement of tree trunk circumference increment by stainless tape that encircles the tree trunk. Tape length variations are measured with a rotary position sensor. The sensor is connected to the module SF8X (SDI-12), that collects and transfers measured values.

Weather protection set

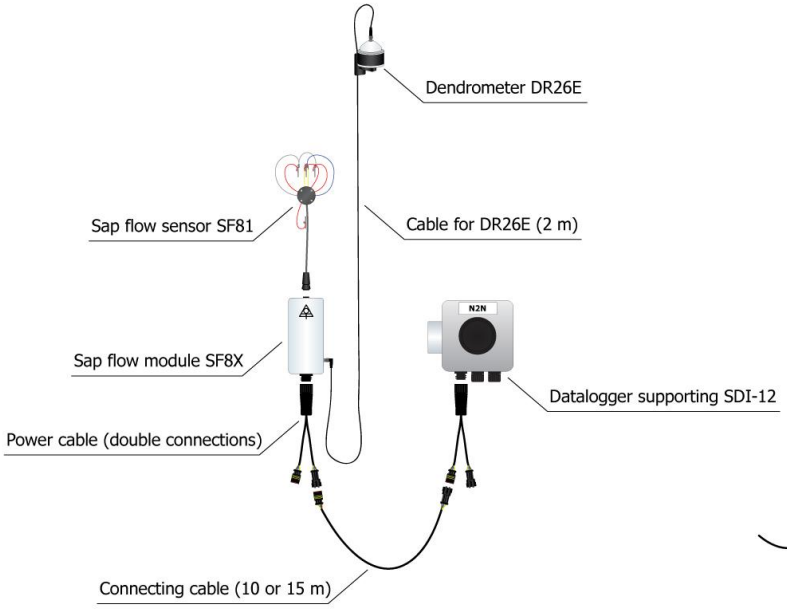


The measuring point at the tree is protected against ambient factors, mainly against direct sun irradiation by means of reflective insulating weather shields. It reflects the sunshine and reduces the effect of the ambient temperature on the heat field. It also protects sensor against heavy rain and wind although a little wetness on the stem does not affect measurements.

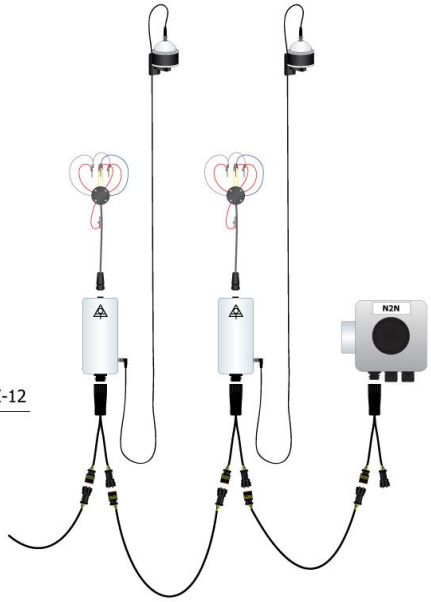
Powering and data transfer

Powering and the data transfer are managed by the datalogger. In terms of measurement layout there are two possibilities of modules connection – parallel or serial.

Individual connection:



Network connection:



Compatible dataloggers

RailBox RBXX	optional number of SDI-12 ports (up to 3), voltage channels (up to 64) and counters (up to 8)
GreyBox N2N	**3P** - three separately powered SDI-12 ports **3PL** - three separately powered SDI-12 ports; internal battery **6P** - six SDI-12 ports powered in pairs (1+4, 2+5, 3+6) **6PL** - six SDI-12 ports powered in pairs (1+4, 2+5, 3+6); internal battery

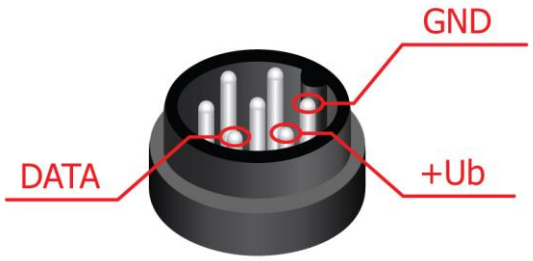
Accessories



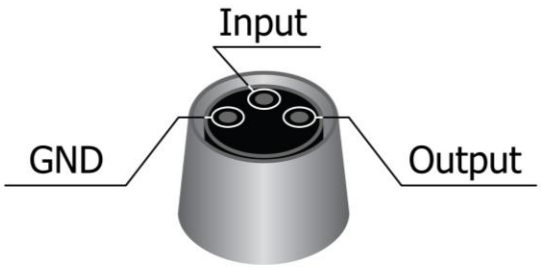
Installation tools

The set of installation tools are designed to ensure efficient and precise installation of sap flow sensor SF81. In portable case you will find all the necessary tools for measuring the bark and phloem thickness, hammering of electrodes, cleaning slots in electrodes and extraction of needles and electrodes.

Sap flow module SF 8X (SDI-12)
- Amphenol C016 male connector wiring



Sap flow measuring unit MicroSet 8X
- female connector for DR26E wiring



Standard M8 male connector cable wiring



Brown - Output
Black - Input
Blue - GND

Specification:

Sap Flow module SF8X (SDI-12)

Output	SDI-12 ver 1.3
Heating method	direct heating of stem tissues by passing of electrical AC current
Sap flow values	mW/K
Preset temperature difference	1, 2 or 3 K
Sap flow range (dT=1K)	0 to 0.375 kg/h per cm;
Sap flow range (dT=2K)	0 to 0.187 kg/h per cm;
Sap flow range (dT=3K)	0 to 0.125 kg/h per cm;
Range of xylem resistance	300 Ohm to 35 kOhm
Power voltage for increment sensor	at least 7 V DC
Starting voltage	11.7 V DC
Nominal voltage	12 V DC
Turn off voltage	10 V DC
Wide operating voltage range	10 – 16 V DC
Absolute maximum voltage	± 30 V DC
Maximum current consumption	ca 400 mA
Maximum heating power	2.4 W (limited)
Average efficiency	better than 85 %
Heating voltage	AC 1 kHz, non-sinusoidal, max 150 V_{ef} @25 kΩ
Average current consumption	Approx. 20 mA to 50 mA daily average (according to the sap flow rate)
Controlled temperature	average of all three electrodes
Dimensions	160 x 80 x 60 mm; 500 g
Operating environment	-20 to 50 °C; 0 to 100% RH
Sap flow sensor connection	6-pin Switchcraft EN3 P6 connector female
Increment sensor connection	3-pin M8 connector female
Module output connection	Amphenol C016 connector male

Sap flow sensor SF81

Terminals/electrodes	three stainless plates 25 x 1 mm, 60, 70 or 80 mm long
Distance between electrodes	20 mm
Temperature sensors	four thermocouples in stainless needles (T-type)
Thermocouple needles diameter	1 mm
Thermosensor arrangement	three needles placed in the middle of electrodes, one reference

EMS81 sensor with SDI-12 interface.

The sensor matches the SDI-12 standard, version 1.3, as it is described here: http://sdi-12.org/archives.php except of commands for continuous measurement (aR0 – aR9 ev. aRC0 – aRC9).
Supported commands:
Commands are marked in bold. Each sensor replay ends with <CR><LF>

Command: INFO – aI!
For instance:
1I! 113EMSBrno SF8X 2.1Sn#1234567890

Parameter	Length	Description
1I!	3	Request for reading of information of sensor on the address #1
1	1	Sensor address - here 1
13	2	SDI version – here 1.3
EMSBrno	8	Manufacturer – completed with space char. 0x20
SF8X	6	Model - completed with space char. 0x20
2.1	3	Sensor FW version – here 2.1
Sn#1234567890	13	Sensor serial number

Command: Acknowledgement – a!
For instance:
2! 2

Parameter	Length	Description
2!	2	Check of sensor availability
2	1	Sensor answer with its address - here 2

Command: Address change – aAb!
For instance:
1A2! 2

Parameter	Length	Description
1A2!	4	Request for the change of address on the address #1 to the address #2
2	1	New sensor address - here 2

Command: Measurement, mod 0 – aM!
For instance:
1M! 10034

Parameter	Length	Description
1M!	3	Measurement request on the address #1
1	1	Sensor address – here 1
003	3	Time when the measured values are ready in seconds – here 3. If the data are ready earlier, the sensor will send the address ended with <CR><LF> - service request.
4	1	Number of returned variables – here 4

Command: Measurement, mod 1 – aM1!
For instance:
1M1! 10035

Parameter	Length	Description
1M1!	4	Measurement request on the address #1
1	1	Sensor address – here 1
003	3	Time when the measured values are ready in seconds – here 3. If the data are ready earlier, the sensor will send the address ended with <CR><LF> - service request.
5	1	Number of returned variables – here 5

Command: Measurement, mod 0 with CRC - aMC!
For instance:
1MC! 10034

Parameter	Length	Description
1MC!	4	Sensor measurement request at address 1 with CRC data control
1	1	Sensor address here 1
003	3	Time after which the measured data will be available in seconds - here 3. If the data is available earlier, the sensor sends the address terminated by the <CR> <LF> - service request.
4	1	Number of variables returned - here 4

Command: Concurrent Measurement, mod 0 - aC!
For instance:
1C! 100304

Parameter	Length	Description
1C!	3	Sensor measurement request at address 1 with CRC
1	1	Sensor address here 1
003	3	Time after which the measured data will be available in seconds - here 3
04	2	Number of variables returned - here 4

Command: Concurrent Measurement, mod 0 with CRC - aCC!
For instance:
1CC! 100304

Parameter	Length	Description
1CC!	4	Sensor measurement request at address 1 with CRC data control
1	1	Sensor address here 1
003	3	Time after which the measured data will be available in seconds - here 3
04	2	Number of variables returned - here 4

Command: Concurrent Measurement, mod 1 – aC1!
For instance:
1C1! 100305

Parameter	Length	Description
1C1!	4	Sensor measurement request at address 1 with CRC
1	1	Sensor address here 1
003	3	Time after which the measured data will be available in seconds - here 3
05	2	Number of variables returned - here 5

Command: Concurrent Measurement, mod 1 with CRC – aCC1!
For instance:
1CC1! 100305

Parameter	Length	Description
1CC1!	5	Sensor measurement request at address 1 with CRC data control
1	1	Sensor address, here 1
003	3	Time after which the measured data will be available in seconds - here 3
05	2	Number of variables returned - here 5

Command: Data, mod 0 – aD0!
For instance:
1D0! 1+120.1+25.1+20.233+4XYZ

Parameter	Length	Description
1D0!	4	Data request from the address #1
1	1	Sensor address - here 1
+120.1	Variable	Sap flow (raw P/dT) [mW/K]
+25.1	Variable	Increment [mm]
+20.233	Variable	Temperature [deg.C.]
4	Variable	Error code
XYZ	3	16-bit CRC - added only if aMC! or aCC! commands were requested for the measurement

Command: Data, mod 1 – aD0!
For instance:
1D0! 1+28.2+1.2+0.8+1+0XYZ

Parameter	Length	Description
1D0!	4	Data request from the address #1
1	1	Sensor address - here 1
+28.2	Variable	AC resistance between electrodes [kOhm]
+1.2	Variable	dT of left electrode [deg. C]
+0.8	Variable	dT of central electrode [deg. C]
+1	Variable	dT of right electrode [deg. C]
0	Variable	Error code

XYZ	3	16-bit CRC - added only if aMC1! or aCC1! commands were requested for the measurement

Command: Read address – ?! **Warning: only one sensor on the line is allowed!**
For instance:
?! 2

Parameter	Length	Description
?!	2	Read sensor address
2	1	Sensor address - here 2

Command: Verify – aV!
For instance:
1V! 10034

Parameter	Length	Description
1V!	3	Verify request on the address #1
1	1	Sensor address - here 1
003	3	Time when the measured values are ready in seconds – here 3
4	1	Number of returned variables – here 4

Command: Settings dT – aX00x! **– x – only character 1, 2, 3 or O are allowed. Numbers 1, 2, 3 represent the dT value. Letter "O" causes turning the heating off. Another characters are ignored and the sensor does not respond to them.**
For instance:
2X001! 2

Parameter	Length	Description
2X001!	6	Request for the sensor for the change of dT on the address #2 - here 1
2	1	Sensor answer with its actual address - here 2.