EMS Brno

Data Acquisition Environment

Hardware – Software – Cloud application

www.emsbrno.cz

Sap flow system EMS 64

consists of SF 6X (SDI-12) module, SF 64 sensor and datalogger working in SDI-12 network

Main features:

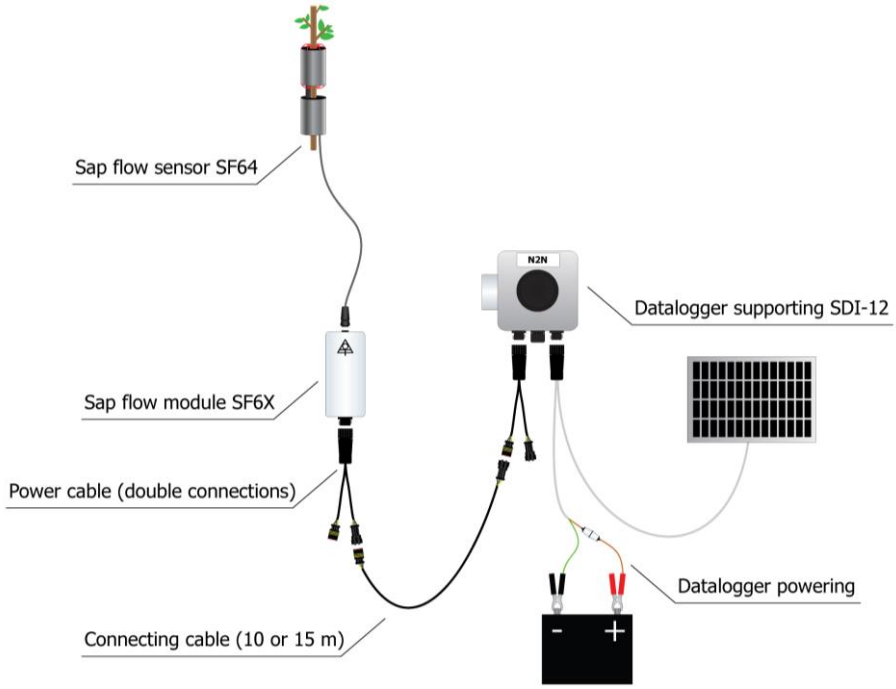
- Tissue heat balance method with variable power and constant dT
- External heating and internal temperature measuring of stem tissue
- No overheating of stem tissues
- Extremely high efficiency > low energy consumption
- Power requirements proportional to sap flow rate – fits to solar powering
- SDI-12 ver. 1.3 compatible
- Manufactured by EMS

Specification:

- Two sensor sizes for diameters 6 to 12 and 10 to 20 mm
- Constant temperature difference adjustable to 2, 4 or 8 K
- Daily power consumption 0.2 to 1.2 Ah (dT=4 K; Ub=12 V) according to sap flow rate

System description

Measuring system consists of the SF 6X (SDI-12) module with SDI-12 output, sap flow sensor SF 64 (6-12 or 10-20 mm), weather shield and connecting cables. System is ready to be connected to the datalogger supporting SDI-12 communication protocol.



System components

Module SF 6X (SDI-12)

Electronic unit is controlling the temperature difference at measuring point at the preset level, calculates sap flow values in terms of kg/h and transfer data 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. If there is a problem with the sensor operation, the error status is indicated by number of short beeps following the address beeps after a short jingle.

Sap flow sensor SF 64

Sensor intended for continuous measurement of volumetric sap flow in stems with diameter between 6 to 20 mm (two dimensions of sap flow sensors according to the stem thickness - 6 to 12 and 10 to 20 mm). The senor consists of two similar cylindrical parts. Each part wraps the stem with insulation foam. One part contains linear heating elements which are gently pressed to the stem by soft foam. A needle thermocouple is inserted to the stem in radial direction at the level of upper edge of heating elements (in direction of water movement). Second cylinder has no heater and it just covers the reference needle thermocouple located with respect to the thermal symmetry. The water passing

along the sensor is warmed and the heating power is controlled in order to keep the temperature difference between needles. Then, the input power is directly proportional to the amount of water passing the sensor in terms of kg/hr.

<u>Weather protection set</u>

The measuring point at the stem is protected against ambient factors, mainly against direct sun irradiation by means of reflective insulating weather shield. 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. Approximately 30 cm of free stem is demanded for proper sensor installation.

<u>Powering and data access:</u>

Sensors are powered from SDI-12 line. The arrangement with EMS datalogger GreyBox N2N is shown here. Notice the way of sensors chaining.

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

<u>Installation tools</u>

The drill is necessary for drilling holes for sensor needles (0.8 mm diameter) in xyloid stems. It is strongly recommended to use a drill with controlled revolutions. The drill should keep revolutions nearly independent to drilling load in order to avoid overheating or burning plant tissues.

Specification:

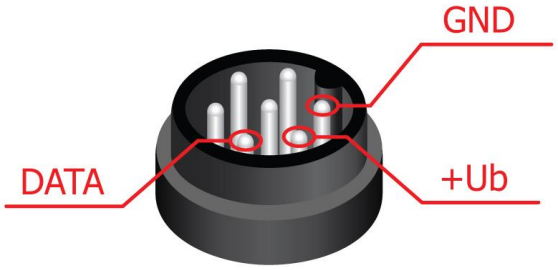
Sap Flow module SF 6X(SDI-12)

Output	SDI-12 ver. 1.3
Heating method	external heating of stem, internal measurement of dT
Sap flow values unit	kg/h
Preset temperature difference	2, 4 or 8 K
Sap flow range (dT=2K)	0 to 1.37 kg/h
Sap flow range (dT=4K)	0 to 0.68 kg/h
Sap flow range (dT=8K)	0 to 0.34 kg/h
Operating voltage range	8.5 – 16.5 V DC
Starting voltage for measurement	11.7 V
Shut-down voltage for measurement	10.5 V
Absolute maximum voltage	30 V DC
Maximum current consumption	ca 400 mA
Maximum heating power	3.2 W (limited)
Average efficiency	better than 85 %
Daily power consumption	0.2 to 1.2 Ah (dT=4 K; Ub=12 V) (according to the sap flow rate)
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
Module output connection	Amphenol C016 connector male

Sap flow sensor SF64

Stem diameter range	6 to 20 mm covered by two sensor types: 6 to 12 mm and 10 to 20 mm
Temperature sensing element	two thermocouples in stainless needles (T-type)
Thermocouple needles diameter	0.8 mm
Thermosensor arrangement	two needles placed in a distance 12 cm, inserted in radial direction into the stem
Sensor heater resistance	100 ohm (± 10%)
Necessary stem length for sensor installation (incl. radiation shield)	30 cm

Sap flow module SF 6X (SDI-12)
- Amphenol C016 male connector wiring



EMS6X 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 SF6X 1.1Sn#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
SF6X	6	Model - completed with space char. 0x20
1.1	3	Sensor FW version – here 1.1
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! 10034

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.
4	1	Number of returned variables – here 4

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! 100304

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
04	2	Number of variables returned - here 4

Command: Concurrent Measurement, mod 1 with CRC – aCC1!

For instance:

1CC1! 100304

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
04	2	Number of variables returned - here 4

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	Diameter [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+2.02+2.00+12.8+1+0XYZ

Parameter	Length	Description
1D0!	4	Data request from the address #1
1	1	Sensor address - here 1
+2.02	Variable	Actual dT1 [°K]
+2.00	Variable	Actual dT2 [°K]
+12.8	Variable	Power supply [V]
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, or 3 are allowed. Numbers 1 represent the dT value 2°K, 2 represent the dT value 4°K and 3 represent the dT value 8°K. Other 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

Command: Settings diameter sensor calibration constant aX40xxx!
For instance:
2X40143! 2

Parameter	Length	Description
2X40143!	Variable	Setting the calibration constant of diameter sensor – here 143
2	1	Sensor answer with its actual address - here 2

Command: Read actual dT – aX31! **Numbers represent the dT value in °K. Value of dT is available after measurement (command M or C) - unavailability of value is answered by 99.**
For instance:
2X31! 2;

Parameter	Length	Description
2X31!	5	Read actual dT
2;2	Variable	Sensor answer with its actual address - here 2; and actual set dT at 2°K.