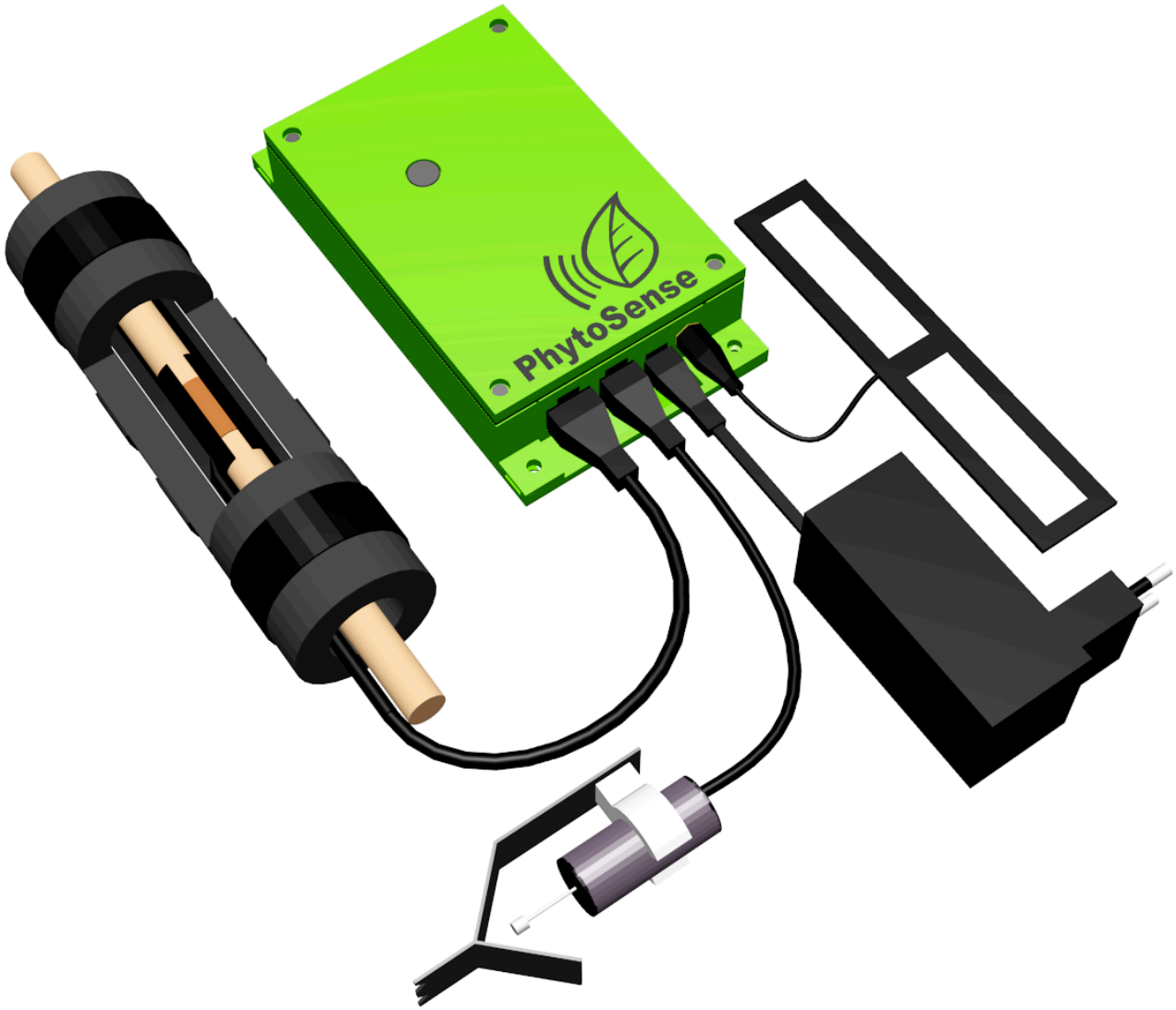
PhytoStem User Guide

Powered by PhytoSense



Phyto-IT

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Overview

Product description

The PhytoStem plant monitoring system allows measuring sap flow and stem diameter variations of plants with stem diameters ranging from 8 - 19 mm.

The sensors show plant responses to changes in the environment (irrigation, lighting, temperature changes,...) or plant manipulation (pruning, harvesting,...).

The system is suitable for herbaceous (tomato, cucumber, capsicum,...) or woody (grapevine,...) stems.

What you'll find in the box

Please keep the system stored in the box when it is not being used.

PhytoStem data logger

Diameter variation sensor

- Solartron stem diameter variation sensor
- Sensor holder
- Rubber bands
- Spare parts canister

Sap flow sensor

- Dynagage sap flow sensor
- Extension cable
- Electrically insulating compound
- Velcro strip
- Waterproof, breathable fabric
- Pipe insulation material (3 parts)
- Two-layer bubble foil

Power adapter

Antenna

Not included (but needed during installation)

Transparent kitchen foil (for sap flow sensor installation)

Aluminium foil (for sap flow sensor installation)

Cable ties (for mounting the datalogger and for sap flow sensor installation)

General usage

Optimal operating environment

Temperature: 10 - 50 °C

Relative humidity: 10 - 90 % (non-condensing)

Altitude: less than 2000 m

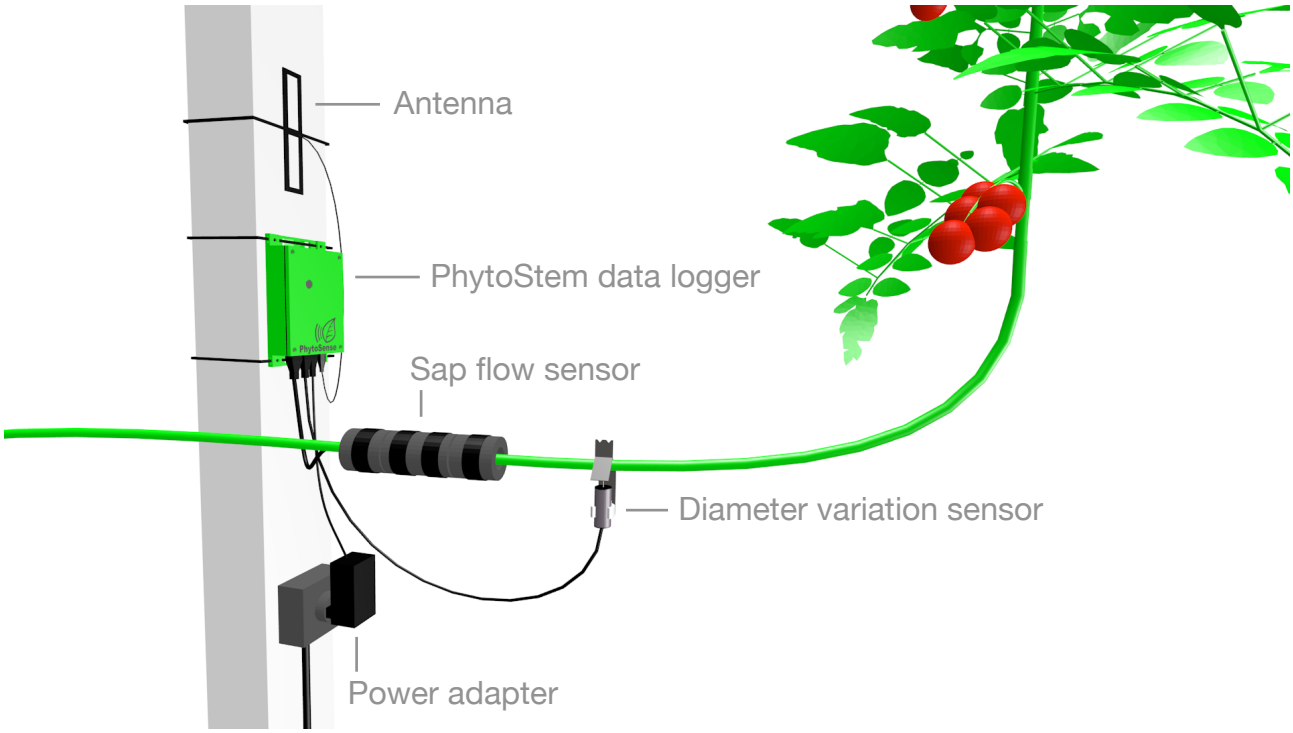
Inside use

Ventilation: no special ventilation is required

The manufacturer cannot be held accountable when the equipment is operated outside these ranges.

Typical installation

(see “Sensor installation instructions” and “Mounting instructions” for more details)



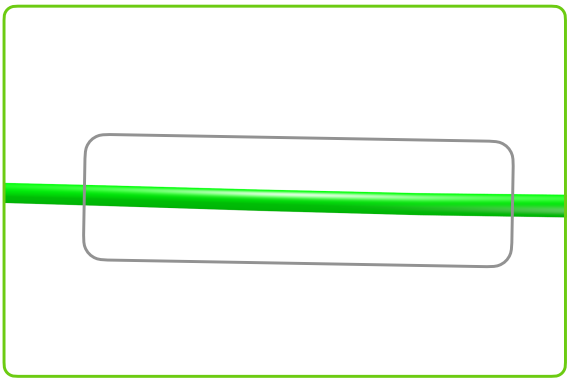
Since the equipment consists of sensitive electronics and sensors, care should be taken to protect the equipment from direct sunlight and water exposure. Additional measures should be taken to avoid these conditions as they may negatively impact the measurements.

If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

Sensor installation instructions

Sap flow sensor installation

1



Find a suitable stem segment to install the sensor. Preferably with a smooth and circular circumference.

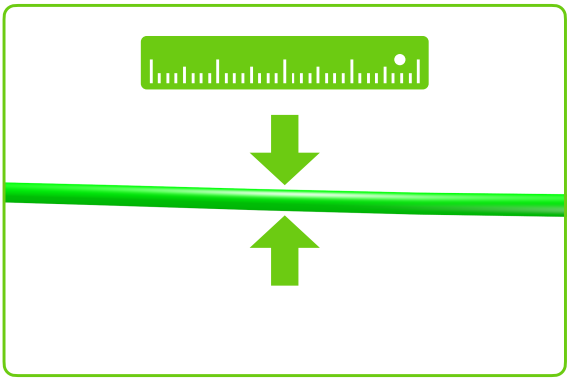
If possible, select a horizontal stem piece as this will be better to install the diameter variation sensor later on.

Roughly 30 cm of free stem should be available.

If needed, some leaves or branches can be pruned. Always prune leaves or branches with sharp blades to obtain a clean cut and minimise the possibility of infection.

If pruning is not desired, one can opt to use less insulation material (see below). In this case, 10 cm of free stem is sufficient to install the sensor. Note, however, that this might compromise measurement accuracy.

2

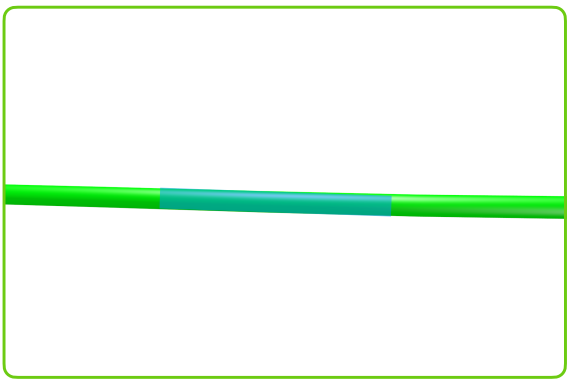


Measure and note down the stem diameter where the sensor will be installed. Take several measurements in different directions when the stem is not completely circular.

Note down the sensor resistance (in Ohm). This can be found on the white label of the sap flow sensor.

Sensor installation instructions

3



Apply a thin layer of electrically insulating compound (white gel) to the stem segment which will make contact with the sensor. Approximately 5 cm in length.

Wrap the stem segment with one layer of transparent kitchen foil. This is to prevent root growth. Try to remove as much air bubbles and wrinkles as

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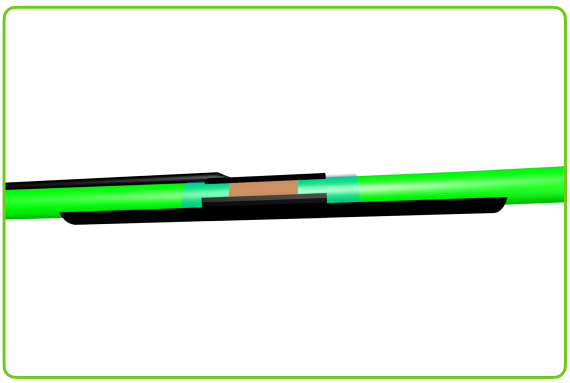

Coat the inside of the sensor with a small amount of electrically insulating compound. This is to prevent short-circuits between the thermocouples.

Fold out the loose part of the sensor heater.

Position the sensor on the stem (and the foil) according to the 'Flow' indication on the white label of the sensor. Make sure the thermocouples on the inside of the sensor (above and below the heater, at the back of the sensor) make good contact with the stem.

Fold the loose part of the heater back inside the sensor onto the stem.

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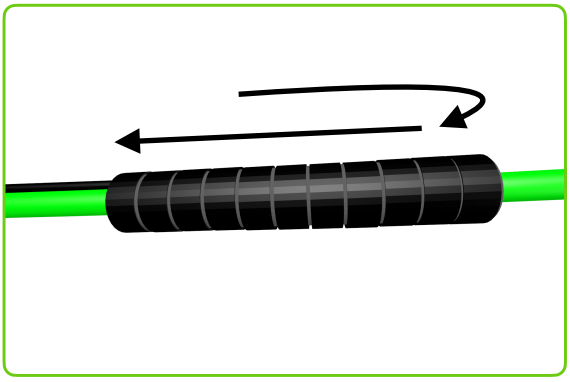


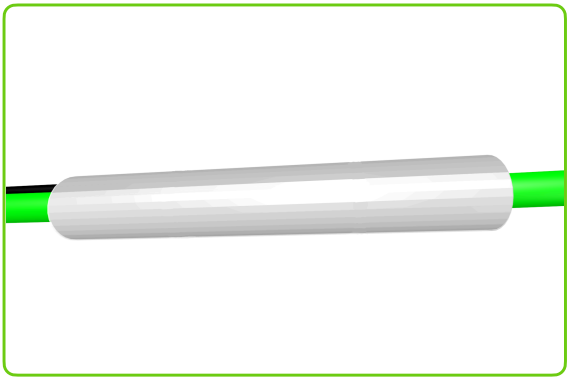
Wrap the velcro strip around the sensor. Start at one side of the sensor and continue wrapping to the other side. The velcro strip should be wrapped tightly around the sensor. Good contact between the sensor thermocouples and the stem is crucial for proper measurements.

After wrapping, you should not be able to rotate the sensor with your hand without rotating the stem. If this is the case, the velcro strip is not tightened enough.

If much stem growth is expected, it might be necessary to loosen the velcro strip mid-growing season to prevent the sensor from constricting the stem.

Sensor installation instructions

6

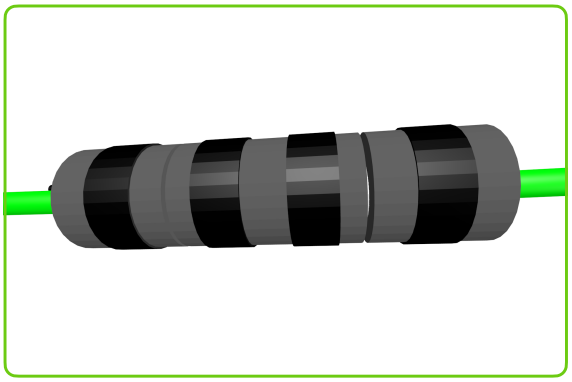


Wrap the water repellent cloth around the sensor. The rough and bright white side should be on the outside.

If the cloth cannot be made to stay in place it can be secured with cable ties. However, this might restrict the growth of the plant.

This cloth with allow any moisture inside the sensor to get out but no moisture to get in the sensor.

7



Install the black pipe insulation material. The large piece should be in the middle, the small pieces on the sides.

If the free stem length was limited, one can opt to use less insulation material. The large piece of insulation should be seen as the absolute minimum. Less insulation might compromise measurement accuracy.

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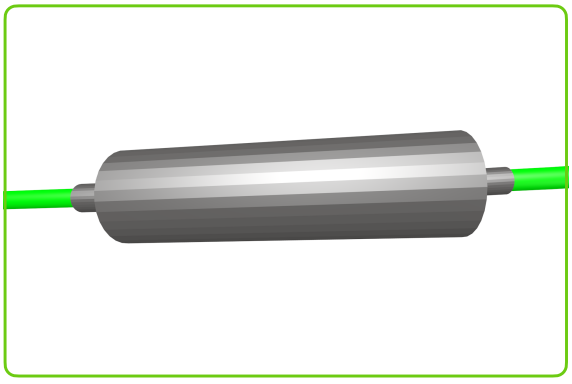
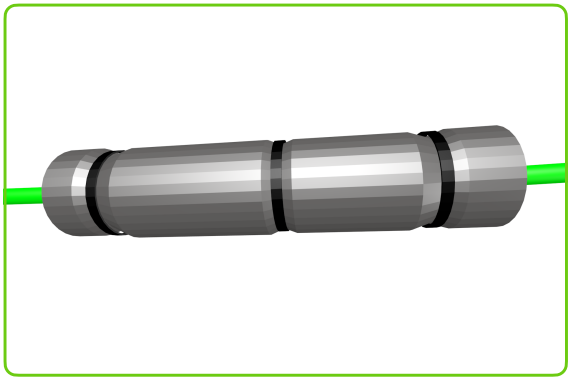


Wrap one layer of aluminium foil around the insulation material and seal it well on the stem. This is to prevent water seeping into the sensor from the side.

One can also opt to leave one side of the sensor open to allow any water building up in the sensor to escape more easily.

9



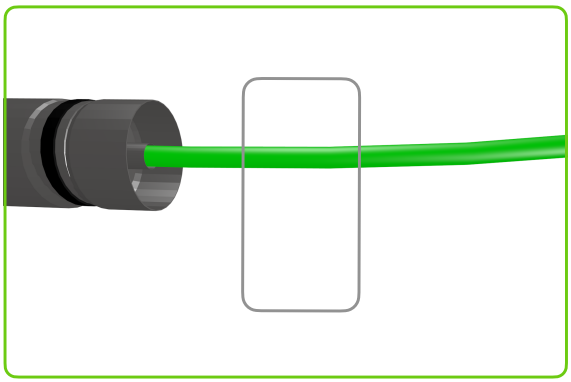
Wrap the thick bubble foil around the sensor. This is to prevent any direct sunlight to affect the measurements.

Secure with cable-ties.

Sensor installation instructions

Diameter variation sensor installation

1

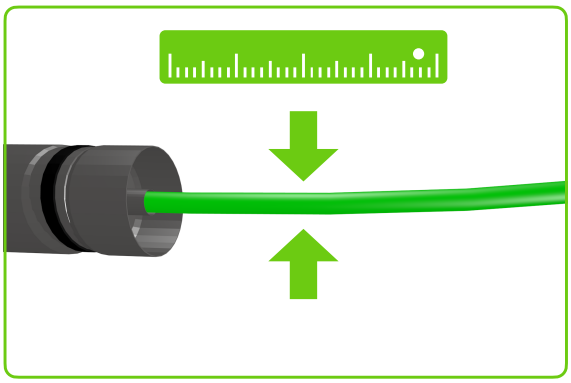


Find an appropriate place for the diameter variation sensor.

Roughly 5 cm of free stem should be available.

If possible, select a horizontal stem piece. This will ensure the sensor is pulled down by gravity and is less likely to be disturbed.

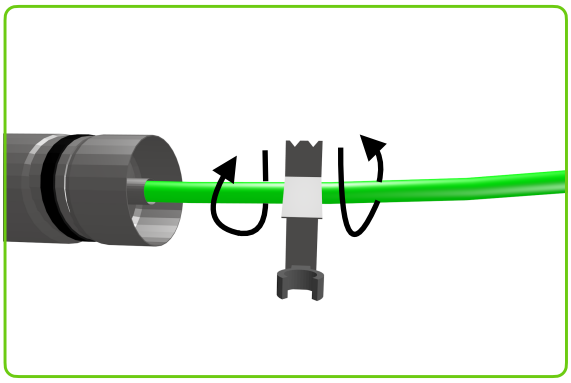
2

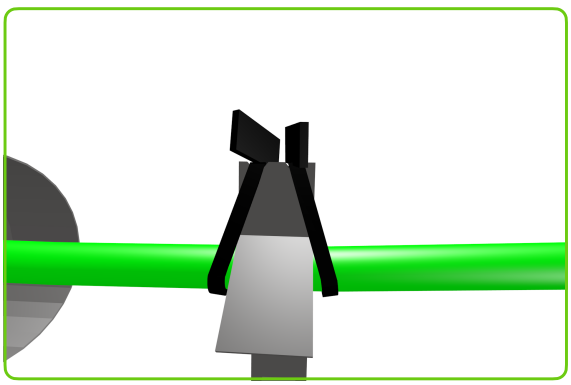


Measure and note down the diameter of the stem at the location where the sensor will be installed.

This value will be used as the starting point of the diameter variations.

3





Position the holder (without the sensor) on the stem segment.

One can also opt to leave the sensor in the holder. In this case, slide the sensor completely down in the holder such that enough space is available to put the holder (with sensor) on the stem.

Secure the holder on the stem segment with two durable elastic bands: hook the elastic band on the holder and pull it around the stem and secure it on the same location on the holder. Repeat this for the second elastic band.

The holder should be perpendicular to the stem. If required, the orientation of the holder can still be slightly adjusted once it is attached to the stem with the rubber bands.

Sensor installation instructions

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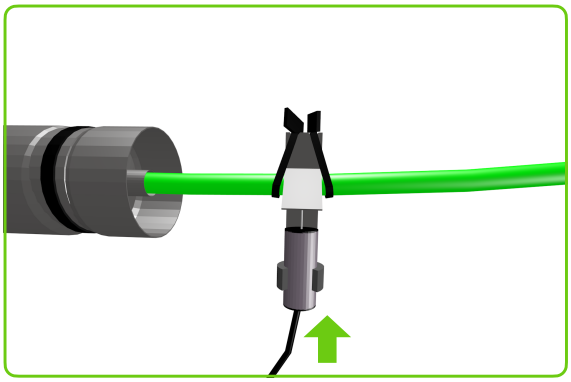

Slide the sensor in the holder from the bottom.

Make sure the sensor head is perpendicular to the stem and makes contact with the stem. If required, slide the sensor slightly in and out of the holder such that the **spring of the sensor head is only pressed in slightly**.

The raw value of the sensor measurement should be somewhere between -2800 and -2200 mV (this should be checked in PhytoSense)

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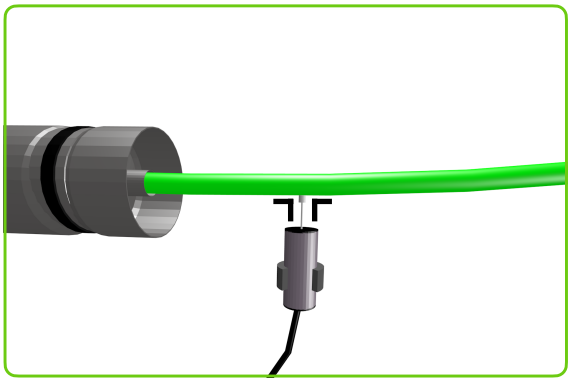


Make sure the sensor head is perpendicular to the stem in all directions.

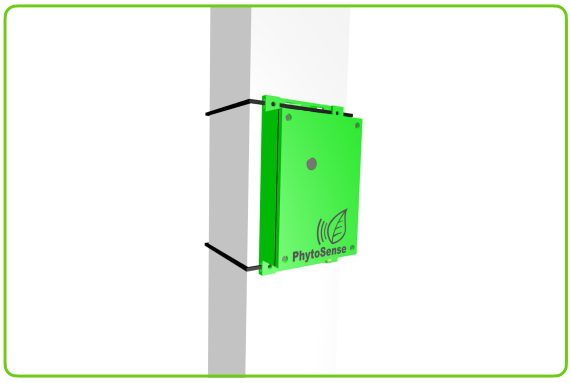
It might also be of interest to look at the anatomy of the stem of the species under investigation. Positioning the sensor head on a location where vascular tissue (xylem) is most present, might improve the detection of changes in water relations.

Installation on tomato

Installation on pepper / eggplant

Mounting instructions

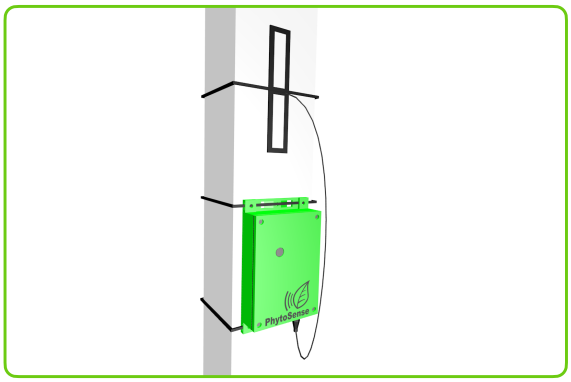
1



Firmly secure the PhytoStem data logger to the greenhouse structure. E.g. using cable ties going through the holes in the enclosure.

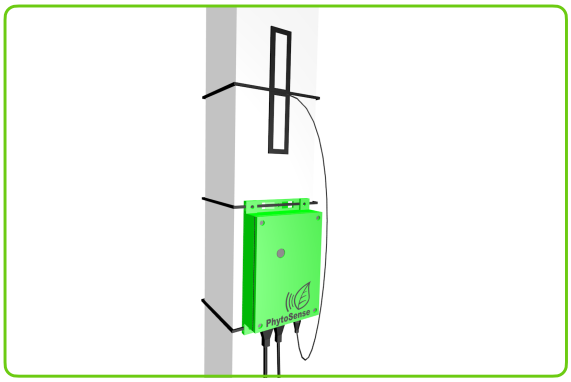
The data logger needs to be installed as shown on the figure with the connectors pointing down. This is to minimise the chance of water entering the data logger.

2



Connect the antenna to the data logger. If cellular reception is poor at the installation location, the antenna should be moved higher up the greenhouse (e.g. above the canopy) or be moved away from metal objects which might interfere with the cellular reception.

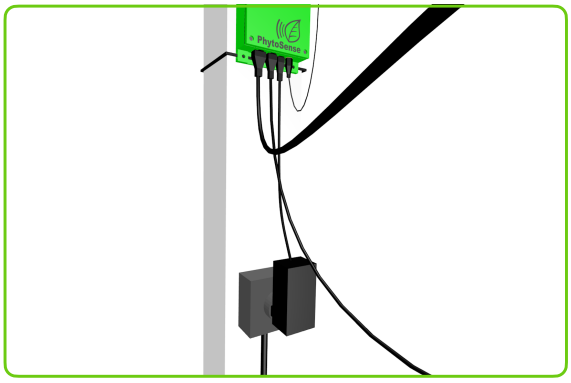
3



Connect the sensor cables to the data logger.

The sap flow sensor extension cable should also be connected to the sap flow sensor.

4



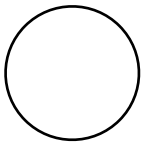
Plug in the power adapter.

Only plug in the power adapter in an appropriate and safe power socket. The power socket should be easily accessible in case of an emergency.

Operating instructions

Data logger startup sequence

Once the data logger is powered up, the indicator LED will turn on. Different colours indicate different parts of the boot sequence:



Color:	White
State:	Not blinking
Duration:	A few seconds
Meaning:	Startup

Color:	Green
State:	Blinking
Duration:	Several seconds to minutes
Meaning:	Looking for the cellular network

Color:	Cyan
State:	Blinking rapidly
Duration:	Several seconds
Meaning:	Connecting to internet

Color:	Cyan
State:	Breathing. Slowly alternating between on and off.
Duration:	Continuous
Meaning:	The data logger is connected and working normally. Data should appear in PhytoSense after about 5 minutes.

In rare circumstances the LED might turn magenta during power-up or normal operation.

Color:	Magenta
State:	Blinking
Duration:	About 1 minute
Meaning:	The data logger is performing a firmware update. **DO NOT SWITCH OFF THE LOGGER DURING THIS PROCESS.**

For other LED colors, see the ‘Troubleshooting’ section below.

Removal and maintenance

Please follow these instructions in order to ensure an optimal lifetime of you PhytoStem system.

Opening the PhytoStem datalogger is only allowed by Phyto-IT or an authorised service provider.

Maintenance during operation

Once installed, the PhytoStem system required little or no maintenance. For most crops, the sensors can remain on the same part of the stem during the entire growing season.

If stem growth is larger than > 5 mm, it might be required to slightly pull back the diameter variation sensor in order to bring its raw signals between -2800 and -2200 mV and release some of the tension on the spring of the sensor head.

In very rare cases, fast and strong growing stems (diameter increase of > 1cm) might get constricted by the sap flow sensor and potentially cause damage to the plant. If this is the case for your crop, it might be necessary to re-install the sap flow sensor during mid-season.

Disconnecting the data logger

1. Unplug the power adapter from the power socket and disconnect the power cable from the data logger.
2. Unplug the sensor cables from the data logger.
3. Unscrew the antenna connector from the data logger.
4. Remove the data logger from the greenhouse structure.
5. If required, the data logger can be cleaned with a wet cloth and some detergent.

Sap flow sensor removal

1. Make sure the sensor has been disconnected from the data logger.
2. Remove all the different insulation layers from the sensor. The aluminium foil and the kitchen foil on the stem can be disposed.
3. Before storage: **make sure all the parts of the sensor are dry**. Preferably let them dry to the air for a few days.

Removal and maintenance

Diameter variation sensor removal

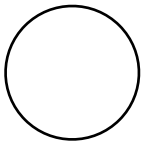
1. Make sure the sensor has been disconnected from the data logger.
2. Slide the sensor out of the sensor holder. Be careful not to lose the sensor head and spring.
3. Remove the sensor holder from the stem. Make sure to keep the two black elastic bands.
4. Slide the sensor back in the holder making sure the sensor head touches the sensor holder.

Disinfection

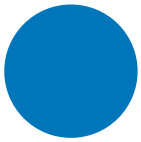
It is allowed and advisable to disinfect the sensors after each use. This can be done using standard disinfectants (e.g. isopropyl alcohol).

Troubleshooting

In case **no data** is being received by PhytoSense please check for following failure conditions.



Color:	No light
Meaning:	The data logger is not getting power. Please check if the power adapter is plugged in the data logger and the power socket. Also check if the power socket has power.



Color:	Dark blue
State:	Blinking
Duration:	Continuously.
Meaning:	There is a problem with the SIM card. Try to reboot the unit and/or contact support.

Color:	Red
State:	Blinking
Duration:	Continuously or in combination with other LED colours.
Meaning:	There is a problem with the cellular module. Try to reboot the unit and/or contact support.

Color:	Green
State:	Blinking
Duration:	Continuously for more than 5 minutes.
Meaning:	The data logger is unable to connector to the cellular network. If possible, reposition the antenna. Preferably moving it above the canopy.

Color:	Cyan
State:	Blinking rapidly
Duration:	Continuously for more than 5 minutes.
Meaning:	The data logger has problems connecting to internet. If possible, reposition the antenna. Preferably moving it above the canopy.

In case **bad data** is being received by PhytoSense please check if all the sensor cables are properly connected to the sensors and the data logger.

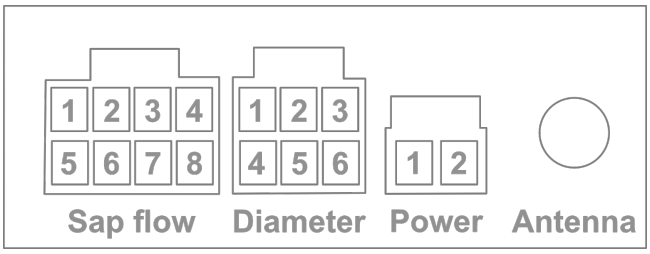
Technical specifications

PhytoStem data logger

Manufacturer	Phyto-IT
Model	PhytoStem Model 1
Input voltage	9 VDC
Power consumption	0.75 W (min), 1.4 W (max) 0.79 W (average of 1.4 W during 10 seconds, 0.75 W during 140 seconds) (good cellular reception, measuring at 2.5 minute intervals with sensors)
Operating temperature	10 - 50 °C
Operating relative humidity	10 - 90 % (non-condensing)
Weight	278 g
Dimensions	170 mm x 35 mm x 100 mm

Connectors

Sap flow	1	Heater VDD (+, 4.5 V)
	2	Heater measurement (+)
	3	Signal (Ch)
	4	Signal (Reference)
	5	Heater VSS (-)
	6	Heater measurement (-)
	7	Signal (Ah)
	8	Signal (Bh)



Diameter	1	Diameter signal 1
	2	Diameter signal 2
	3	VDD (+, 10 V, diameter sensor)
	4	NTC signal (currently not used)
	5	VSS (-)
	6	VDD (+, 3 V, NTC)

Power	1	VSS (-)
	2	VDD (+, 9 V)

Cellular or Wi-Fi module (indicated on the logger)

Manufacturer	Particle
Model	Electron (Cellular) or Photon (Wi-Fi)
Data sheets	http://www.phyto-it.com/downloads/documents/datasheets/Particle_Electron.pdf http://www.phyto-it.com/downloads/documents/datasheets/Particle_Photon.pdf
Certification	FCC, IC, CE, TELEC, RoHS, PTCRB, GCF, UL https://docs.particle.io/datasheets/certifications/certification/

Technical specifications

Power adapter

Manufacturer	XP Power
Model	VER18US090-JA
Input voltage	90 ~ 264 VAC 50/60 Hz
Output power	18 W (max)
Output voltage	9 V
Output current	2 A
Operating temperature	0 - 60 °C
Cable length	1.5 m
Weight	80.29 g
Dimensions	90.0 mm x 43.0 mm x 42.7 mm
Data sheet	http://www.phyto-it.com/downloads/documents/datasheets/XPPower_SFVER18.pdf

Antenna

Manufacturer	Siretta
Model	ALPHA40/5M/SMAM/S/S/29
Impedance	50 ± 5 Ohm
Gain	0.5 (700-824 MHz) / 1 (1710-2170 MHz) / 2 (2300-2700 MHz) dBi
Operating temperature	-30 - 60 °C
Cable length	5 m
Dimensions	155 mm x 30 mm x 4.5 mm
Weight	88 g
Data sheet	http://www.phyto-it.com/downloads/documents/datasheets/Siretta_Alpha40.pdf

Diameter variation sensor

Manufacturer	Solartron Metrology
Model	DF5
Operating temperature	-5 - 70 °C
Voltage	10 VDC
Current	13 mA
Cable length	3 m
Weight (sensor)	30 g
Weight (sensor holder)	26 g
Dimensions (sensor)	19 mm (diameter) x 45 mm (length)
Dimensions (sensor holder)	20 mm x 45 mm x 90 mm
Data sheet	http://www.phyto-it.com/downloads/documents/datasheets/SolartronMetrology_SMMDDFSeries.pdf

Technical specifications

Sap flow sensor

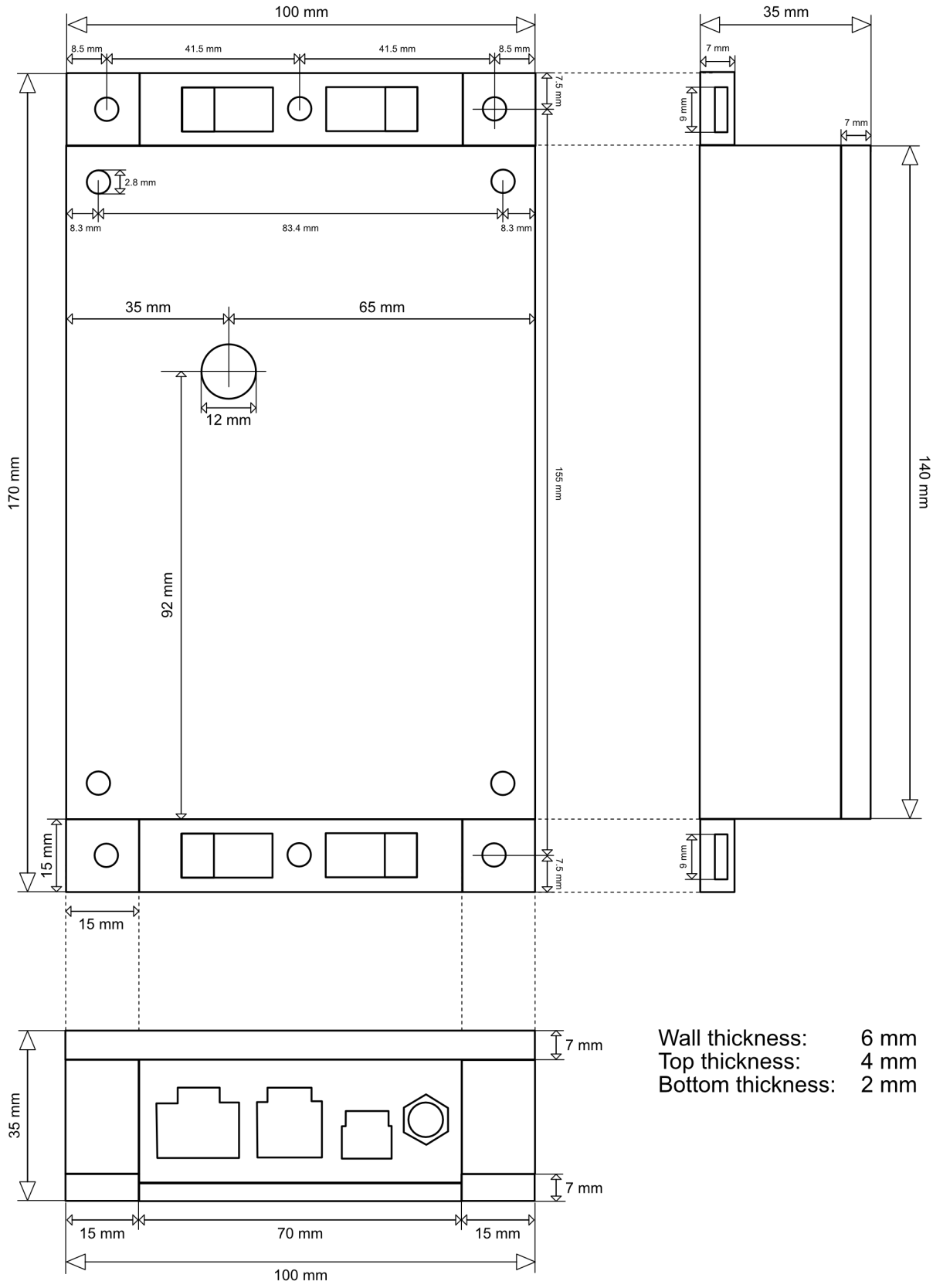
Manufacturer	Dynamax
Models	EXO-Skin SGEX-9 - SGEX-16
Operating temperature	0 - 50 °C
Weight (sensor + insulation)	110 g
Extension cable length	3 m

	SGEX-9	SGEX-10	SGEX-13	SGEX-16
Heater (Ohm)	120	140	120	100
Voltage (VDC)	4.0	4.5	4.5	4.5
Power (W)	0.13	0.15	0.17	0.20
Typical stem diameter (mm)	9	10	13	16
Min. stem diameter (mm)	8	9.5	12	15
Max. stem diameter (mm)	10	13	16	19
Installation length (mm)	150-350	170-360	190-380	210-400

Minimum and maximum stem diameters are as provided by the manufacturer. Each sensor could be installed on slightly smaller or larger stems. However, doing so might compromise the proper working and accuracy of the sensor.

Data sheet http://www.phyto-it.com/downloads/documents/datasheets/Dynamax_EXO-Skin.pdf

Mechanical drawing



Wall thickness:	6 mm
Top thickness:	4 mm
Bottom thickness:	2 mm

Additional information

CE certification

PhytoStem is CE certified and was evaluated according to the standard ETSI EN 301 489-7 V1.3.1 referring to ETSI EN 301 489-1 V2.2.0 (EMC) and EN 61010-1:2010 (LVD)

Electromagnetic compatibility report (EMC)
http://www.phyto-it.com/downloads/documents/certification/PhytoStem_EMC_Report.pdf

Low voltage directive report (LVD)
http://www.phyto-it.com/downloads/documents/certification/PhytoStem_LVD_Report.pdf

The cellular modules used in PhytoStem are FCC, IC, CE, TELEC, RoHS, PTCRB, GCF, UL certified. For reports see:
https://docs.particle.io/datasheets/certifications/certification/

Designed and manufactured by Phyto-IT in Belgium

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http://www.phyto-it.com
http://www.phytosense.net