Temperature

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Tissue Temperature Sensor (T-Tissue)

User Manual

Version 2020

1. Introduction

Thank you for purchasing the Ecomatik temperature sensor for internal tissues (T-Tissue). The T-Tissue is a minimally invasive and highly precise microprobe, for the continuous measurement of internal temperature (e.g. tree cambium, internal fruit temperature, etc.).

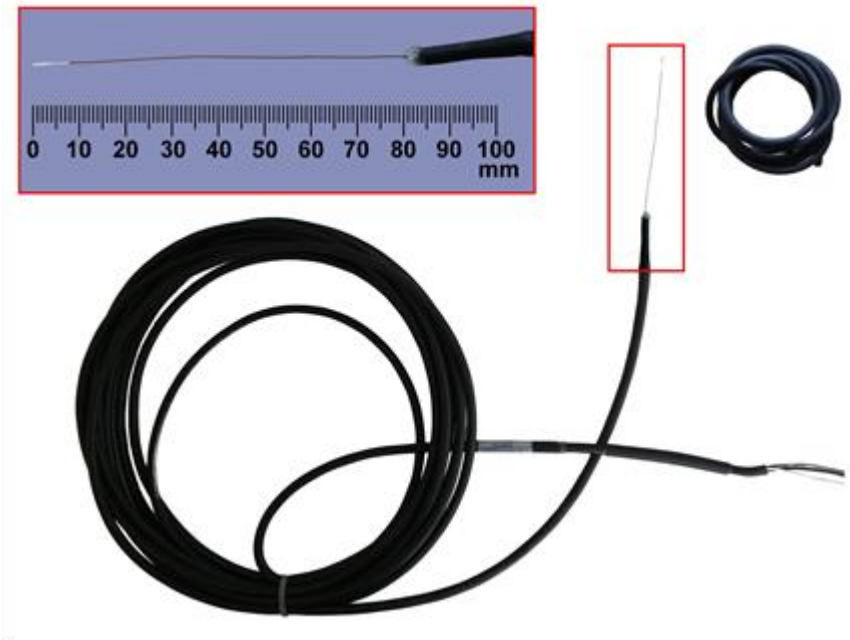
This manual is written to help you install and operate your T-Tissue sensor without difficulty and to achieve the most desirable results. Please read it carefully before installing the sensor, and refer back to it if you should have any difficulty with the sensor in the future.

The T-Tissue is the sensor part of the measuring system. This means that the T-Tissue sensor must be installed into the soil or underwater, and connected to a data logger for continuous data recording. The T-Tissue sensor is compatible with a range of available data loggers.

2. Product Description

As shown below, a standard version of the T-Tissue sensor consists of:

- 1x Sensor with 5 m cable. The cable length can be extended up to max. 50 m.
- 1x piece UV-resistant rubber cord, for pull release fixation of the sensor cable.



T-Tissue sensor

3. Installation & Safety Information

Important!

Please avoid any tension between the sensor, sensor cable and data logger. The installation must be strain relieved on both sides, sensor and data logger. Pay attention to connect the sensor wires correctly to the data logger. Wrong connections will provide wrong readings.

Installation

1. Fix the sensor cable at the measurement object (e.g. stem or branch) by using the included elastic and UV-resistant rubber band.
2. Additionally fix the end of the sensor cable with the sensor head, nearby the desired measurement position by using the included elastic and UV-resistant rubber band.
3. Leave about 30 cm of additional cable slackly hanging between the two above described fixation points, so that the sensor head is free of any pulling force.

T-Tissue sensor non-invasively inserted into an opening bud.

4. In case there should be no non-invasive possibility to insert the microprobe into the desired tissue/measurement depth, drill a small hole with a diameter of 1 mm to the desired measurement depth.
5. In case of a surface-near measurement depth, the installation hole should be drilled at a flat angle to the surface of the object. This way, the internal measuring point is at least a few centimeters away from the opening of the borehole and possible perturbations of measurement can be avoided.
6. Insert the microprobe into the object/tissue until the head of the probe reaches desired measurement depth.
7. In case you drilled an installation hole, seal the installation hole and fix the thin wire of the microprobe by using the included sealing compound. Please note: the surface around the installation hole must be dry and dust-free in order to achieve the best possible adhesion of the sealing compound.
8. Strain relieve the sensor cable leading to the data logger as close as possible to the instrumented measurement object, e.g. on a peg firmly hammered into the ground.

You need further assistance?

In case you need further assistance for installation, please do not hesitate to contact us.

4. Wiring and Logger Configuration

The T-Tissue sensor is compatible with our DL 18 data logger (ordered with stereo plug), as well as with a wide range of other available data loggers, e.g. CR1000 (ordered with bare cable ends). However, note that suitable loggers have to provide a precise and stable, switched (sensor should only be powered 100ms before and during measurements) excitation voltage (V_{ex}) of usually 2500 mV.

Connecting the sensor with bare cable ends, e.g. to a CR1000 logger:

The sensor can be connected either in differential (wiring diagram a), or in single-ended (wiring diagram b) mode.

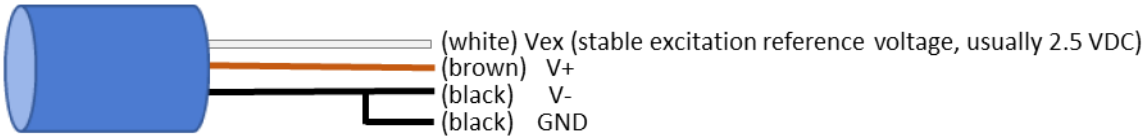


Figure A: Differential wiring

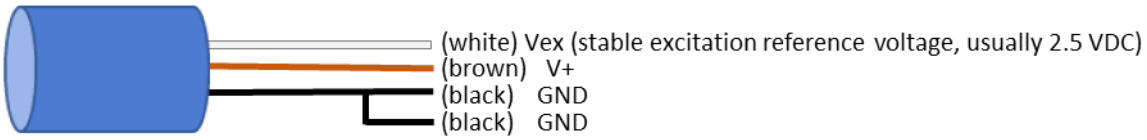


Figure B: Single-ended wiring

Wiring Examples:

Campbell Data Logger (CR1000)

This section describes how to connect the T-Tissue sensor to the widely used Campbell data logger CR1000. If you use another data logger, contact us in case you need further assistance. The T-Tissue sensor can be connected in differential voltage as well

as in single-ended voltage mode, measurement range must be set to 2500 mV. One CR1000 can record up to eight T-Tissue sensors in differential mode, or sixteen T-Tissue sensors in single-ended mode.

Differential Voltage Mode T-Tissue sensor

Connection			
Cable Color			Input Port
1st T-Tissue sensor	$V_{T\text{-}Tissue}$	White	Vx1
		Brown	1H
		Black	1L and Signal Ground
Program Syntax (exemplifying one sensor, with conversion of raw voltage signal in °C) *VoltDiff(T_Soil,1,mV2500,2,True,0,_50Hz,1,0)* *T_Soil=(2500-T_Soil)/T_Air*20000* *T_Soil=1/(0,001130756+0,000233897*LN(T_Soil)+0,000000088*LN(T_Soil)^3)-273.15*			

DL 18 data logger

Ordered with stereo plug connector, the T-Tissue is compatible with our DL 18 data logger. Each T-Tissue sensor requires one of the four channels of the DL 18. For further information on DL 18 configuration for T-Tissue sensors, please refer to our DL18 manual.

Configured correctly, sensor signals will be stored in V. Values in °C can be calculated from stored measurement values as described in the following section (Excel program for data calculation available on request).

5. Manual Data Calculation

In case that the used logger does not support complex conversion procedures of the raw measurement values, stored values have to be converted manually after data download from the logger (e.g. DL 18 logger).

The following function applies to convert the analog output signal of the T-Tissue sensor from V into Ω:

$R_{ntc}=(V_{ex}-V_{out})/V_{out}*20000$

where:

R_{ntc}: NTC sensor resistance in Ω corresponding to the respective mV measurement signal

V_{ex}: excitation Voltage in V (e.g. for DL 18 logger V_{ex} = 2.5 V)

V_{out}: measured sensor output signal in V, ranging between 0 and V_{ex}

The following function applies to convert the analog output signal from Ω into °C:

T (°C)= 1/(a + b(Ln R_{ntc}) + c(Ln R_{ntc})^3)-273.15 (Steinhart-Hart equation)

where:

T: temperature in °C R_{ntc}: sensor resistance in Ω at temperature T

a: coefficient = 1.13075635 E-03

b: coefficient = 2.33896902 E-04

c: coefficient = 8.82996895 E-08

6. Technical Specifications

Name	T-Tissue
Application	Internal (tissue) temperature
Range of the sensor	-40 to 70°C
Accuracy	+/- 0.2 °C
Resolution	Theoretically infinite, depends on data logger
Size and weight	Cylindric, length 3.3 mm, diameter 0.5mm, 5g (only sensor tip without cable)
Output signal type	Within below specified operating conditions: voltage between 333 to 2300 mV, when supplying the sensor with 2500 mV
Power supply	Excitation voltage Vex usually switched 2500 mV, power up 100ms max. Power consumption negligible.
Operating conditions	Temperature: -40 to 70 °C