# Dendrometer

**ECOMATIK GmbH**
Muenchner Str. 23
D-85221 Dachau/Germany
Tel.: +49 8131 260 738
Fax: +49 8131 260 736
e-mail: info@ecomatik.de
website: www.ecomatik.de

## Circumference Dendrometer (Type DC3)

For measuring changes in the circumference of plant stems


User Manual

**Version 2019**

# 1. Introduction

Thank you for purchasing an Ecomatik Dendrometer type DC3. This is a highly precise sensor for the continuous measurements of changes in the circumference of plant stems, under both indoor and outdoor conditions.

This manual is written to help you install and operate your DC3 Dendrometer without difficulty and for 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 dendrometer is the sensor part of the measuring system. This means that the dendrometer must be installed onto the experimental tree, and connected to a data logger for continuous data recording. The dendrometer is compatible with most data loggers. At Ecomatik a low-cost, specially developed dendrometer data logger DL18 is also available.

# 2. Product Description

As shown blow, a standard version of the DC3 dendrometer consists of:

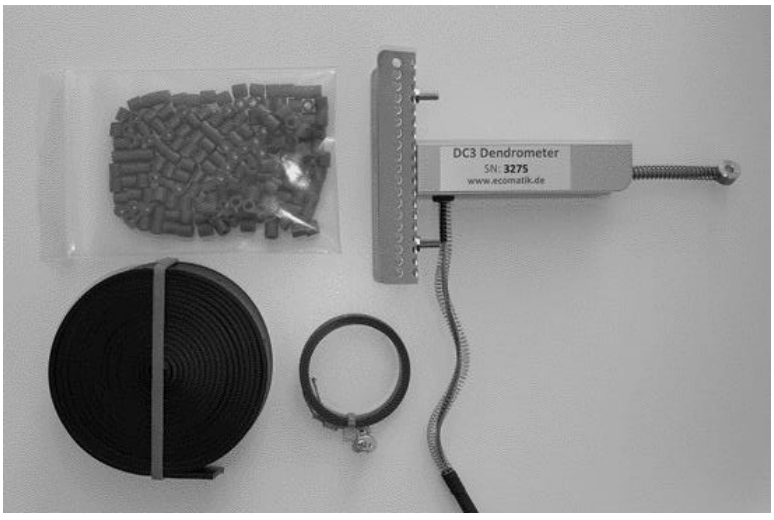
1 Sensor with 5 m cable. The cable length can be extended up to 100 m

1 m special wire for receiving the circumference changes. The wire length can be extended to several meters.

1 special wire rope clamp to fix the stem embracing wire

1 bag of plastic slides for reducing the friction between the steel wire and the measured plant stem.

2 m perforated rubber belt for fixing the sensor onto the tree.




**DC3 Dendrometer**

Please contact us should you miss anything of these items.

The standard cable length is 5 m. if you ordered cable extension, the cable length is the ordered extension + 5 m.

To meet the requirements of different loggers, there are 2 different types of cables: **cable with plug** and **cable without plug**. Cable with plug can only be connected to Dendrometer Logger DL18. Cable without plug can be connected to other loggers.

# 3. Safety Information

The sensor is protected from water droplets, but it is not waterproof, therefore please do not immerse the sensor in water, or install the sensor below a longer lasting snow cover.

For a high degree of measurement accuracy, it is very important to keep the original shape of the wire cable. Please handle it with care and avoid any distortion (turning, bending etc.)

Never pull the cable from the sensor and avoid any tension between the cable and sensor during handling, set up and operation.

Pay attention to connections to data logger. Wrong connections will provide wrong readings.

# 4. Installation

## 4.1 Required tools

Screw driver, measuring tape, a pair of scissors.

## 4.2 Choosing the measuring tree

The data processing of the DC3 dendrometer is based on a tree with a trunk of a circular cross-section. For this reason it is very important, to choose a smoothly circular tree for measurement with DC3 dendrometer.

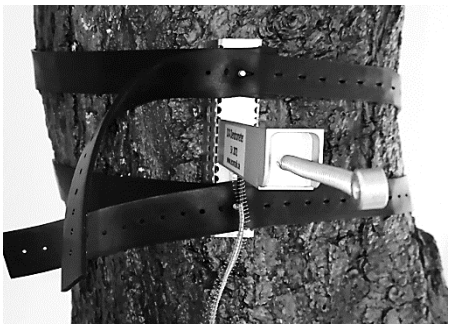
## 4.3 Mounting

4.3.1 Cut two rubber belts as long as the tree circumference.

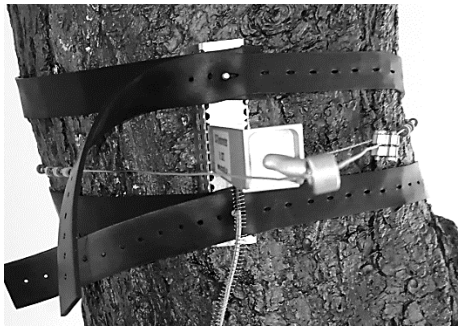
4.3.2 Attach one end of each of the two perforated rubber belts to the fixation bolts at the back-side bar of the dendrometer frame.

4.3.3 Firmly fix the dendrometer at the stem, by tightly wrapping the rubber belts around the stem/branch and locking them again by slipping the desired hole of each belt on the corresponding bolt at the back-side bar (see picture 1).

4.3.4 Unroll the wire from the reel and untighten the wire rope clamp by turning the two screws of the clamp (please do not disassemble the clamp completely). Thread a certain number (dependent on the tree circumference) of the provided plastic slides on the wire. Next insert the end of the wire through the sensor hole. Finally pass the prepared wire around the tree trunk, and pass it through the rope clamp (picture 2).



Picture 1



Picture 2

Pull the wire such, that the sensor rod is pushed in by about 2-3 mm. When the installation is taking place before frost period, the sensor rod should be pushed in by 7 mm. At frosts the stem diameter can shrink considerably. When reached the desired rod position firmly tighten the clamp by fastening the two clamp screws.

4.3.5 Ensure that the wire lies flat around the stem, and move the plastic slides along the wire so that the wire itself does not touch the bark.

4.3.6 Fix the cable onto the tree stem/branch so that the sensor is protected from any accidental pull/ drag of the entire cable length. This can be done using a rope or cable straps. In addition, there should be no tension between the sensor and cable. Ensure that no rain water can run along the cable into the sensor casing.

### 4.4 Collecting the Initial Data

For data processing, after the installation the following initial data should be collected:

$c_0$: Circumference of tree at the height of dendrometer in mm.

## 5. Wiring and Logger Configuration

The dendrometer is compatible with most data loggers. In the following we describe the connection with Dendrometer Logger (DL18), Campbell Logger (CR1000). Please contact us if your logger is not described here.

### Dendrometer Data Logger (DL18)

The DL18 is a battery powered, waterproof logger for connecting 4 dendrometers. It is a very effective data logger for dendrometer measurement under outdoor conditions. For details please see the user manual of the DL18.

### Campbell Data Logger (CR1000)

The dendrometer can be measured both in single-ended voltage as well as differential voltage mode. Differential voltage mode provides better accuracy. But single-ended mode requires half as many channels as differential mode. One CR1000 can include 16 dendrometers in single-ended mode, but only 8 dendrometers in differential mode.

**Single-ended Voltage Mode ( 2 dendrometers)**

| **Connection** | | |
|---|---|---|
| Cable Color | | Input Port |
| 1st dendrometer | Yellow | 1H |
| | Green | Ground |
| | Brown | Vx1 |
| | White | Ground |
| 2nd dendrometer | Yellow | 1L |
| | Green | Ground |
| | Brown | Vx1 |
| | White | Ground |
| **Program Syntax**<br>*ExciteV (Vx1,2500,0)*<br>*VoltSe(SEVolt(),2,mV2500,1,True,0,_50Hz,Mult(),Offs())*<br>If Multiplier=10.16, Offset=0, the results are measured in microns. | | |

**Differential Voltage Mode ( 2 dendrometers)**

| **Connection** | | |
|---|---|---|
| Cable Color | | Input Port |
| 1st dendrometer | Yellow | 1H |
| | Green | 1L |
| | Brown | Vx1 |
| | White | Ground |
| 2nd dendrometer | Yellow | 2H |
| | Green | 2L |
| | Brown | Vx1 |
| | White | Ground |
| **Program Syntax**<br>*ExciteV (Vx1,2500,0)*<br>*VoltDiff(DiffVolt(),2,mV2500,1,True,0,_50Hz,Mult(),Offs())*<br>If Multiplier=10.16, Offset=0, the results are measured in microns. | | |

An interval 0.5-hour for data collection can reveal the diurnal course of diameter changes very well.

## 6. Data Calculation

For calculating the tree circumference $C_i$ ($R_i = C_i/\pi/2$) the following parameters are necessary:

$C_0$ : Circumference of tree at the height of dendrometer in mm at beginning of the measurement $R_0 = C_0/\pi/2$

$V_i$ : Data records of the dendrometer in mm.

$V_0$ : the first valid record of the dendrometer in mm.

The tree circumference $c_i$ is given by:

$$C_i = 2 \times (\pi \times R_0 - R_0 \times arccos(\frac{R_0}{R_0+128-V_0}) + \sqrt{(R_0 + 128 - V_0)^2 - {R_0}^2}$$
$$+ R_{i-1} \times arccos(\frac{R_{i-1}}{R_{i-1} + 128 - V_i}) - \sqrt{(R_{i-1} + 128 - V_i)^2 - {R_{i-1}}^2})$$

arccos: Arccosine in rad.

A simple program in EXCEL for this formula is available. Please contact us for a copy.

## 7. Adjustment and maintenance

Ensure that no falling branches, fruits or snow land on the sensor. The sensor is protected against water droplets but is not waterproof.

When the sensor is correctly installed, it will function under outdoor conditions without the need for further maintenance.

Depending on the growth rate of the tree, the sensor should be reset after some months or years of measurements. When the output approaches 25 mm, the sensor needs to be reset.

Relax the turnbuckle / screw slowly so that the sensor rod is pushed in by about 2-3 mm. When the reset is taking place before frost period, the sensor rod should be pushed in by 8 mm. At frosts the stem diameter can shrink considerably.

## 8. Technical Specifications

| | |
|---|---|
| **Name of the Sensor** | Circumference Dendrometer 3<br>Type DC3 |
| **Use area** | For measuring circumference growth of fast-growing trees |
| **Suitable for plant size** | Diameter: >5 cm |
| **Advantages** | Mechanical pressure on the tree is independent from the tree size, thus good comparability of data between different tree sizes. |
| **Range of the senor** | 25.4 mm, corresponding range for tree size:<br>Tree diameter (cm) / Range of mm: Circumference / Diameter<br>10 / 50 / 16,2<br>50 / 35 / 11,3<br>100 / 28 / 9,0 |
| **Resolution** | The resolution of the sensor itself is infinite. The resolution of readings is determined by connected data logger, e.g.<br>CR1000: 3.3 µm<br>Dendrometer logger (DL18): 0.5 µm |
| **Accuracy** | Dendrometer dependent:<br>Max. ±1.97% of reading (stable offset)<br><br>Dependent on the connected data logger, e.g.:<br>CR1000:±(0.04% of reading+10 µm)<br>Dendrometer logger DL18: ±0.1% |
| **Temperature coefficient of the sensor** | <0.2 µm /°C in the whole range |
| **Temperature coefficient of the wire cable** | $<1.4 \times 10^{-6}$/k |
| **Linearity** | <0,7% |
| **Environment** | Outdoor condition: -25 to 70°C air temperature, 0 to 100% relative air humidity |
| **Weight of the sensor** | 37 g without cable |
| **Power supply** | Stabilized Vex of 0.5 – 10 VDC, power consumption practically zero |
| **Material** | Stainless steel and Aluminium |
| **Cable length** | 5 m, extendable up to 100 m |