PiCUS : TreeTronic

Electric Resistance Tomograph

Version 3

Hardware Manual

Refers to PiCUS : Treetronic 3 Version:

TreeTronic 3 - Hardware:	3
TreeTronic 3 - Software:	1
PiCUS PC Program:	Q73.2-Q74.2
Manual version:	May 12, 2017
Author:	Lothar Göcke

argus electronic gmbh
Erich-Schlesinger-Straße 49d
18059 Rostock
Germany
www.argus-electronic.de

1 Contents

2 Abbreviations

A	Ampere
BT	Bluetooth
ERT	Electric resistance tomograph of tomogram
MP	Measuring point. Each nail that used for the sonic or resistivity scan is a measuring point.
m/s	Unit of the speed in “meter per second”
Ω	Ohm
PRHD	PiCUS Radio Hammer with Display. Works only with PiCUS 3.
SoT	Sonic tomogram or tomography
U	Electric voltage
I	Electric current
USB	Universal Serial Bus.
UTC	Universal Time Coordinated. This time is delivered by the GPS signal. For most common purposes, UTC is synonymous with Greenwich Mean Time (GMT).
V	Volt
Windows ®	- Is a trademark of the Microsoft Corporation (USA)

3 Field of application / disclaimer

The PiCUS : Treetronic® electric resistance tomograph was developed to examine living trees. Using the device inappropriately can lead to damage, to the unit, the operator and to the tree itself.

Although every effort has been undertaken to present the results of measurements as comprehensibly as possible, interpretations of readings do require qualified technical expertise. The user bears the sole responsibility for all conclusions made about the status of any tree examined. Neither the manufacturer nor the distributor of the PiCUS : Treetronic® can be held liable for any decisions made based on measurements made with the instrument.

We strongly recommend attending a training course conducted by the distributor or by a certified institution in your country. A list of such institutions can be found at the argus electronic web site.

The PiCUS : Treetronic® shows the apparent electric resistivity of the wood. It cannot always identify the specific reasons for such differences. This means the instrument is not able to identify the exact type of damage: it may be decay, hollowness, cracks, or something else.

Before taking any action or deciding to fell a tree, please be sure to identify the underlying reason for the defect you see in the tomogram.

All technical information are subject to change without notice.

4 Introduction into ERT

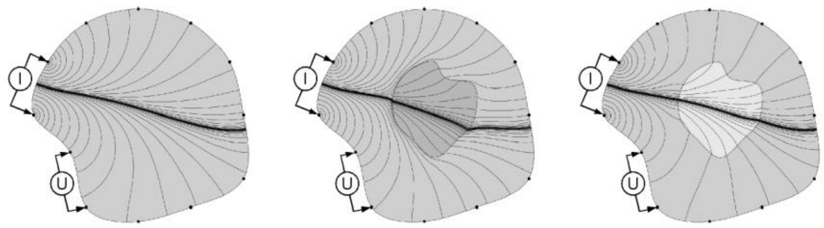
4.1 Electrical resistance tomography on trees

Electric Resistance Tomography (ERT) is an inspection method originally developed in the field of geophysics. It uses electric voltage and current, supplied by electrodes placed on the surface of the earth or in bore holes, to locate anomalies in resistance due to underground water, etc. ERT methods were first applied to trees in 1998 by two geophysics, Just and Jacobs. The PiCUS : Treetronic® Tomograph uses the working principles of ERT to inspect the resistance of wood in trees. Resistance is influenced by water content, cell structure, ion concentration, and other factors in wood.

4.2 Theory of operational

The electrical resistance and its reciprocal, electrical conductivity, are physical properties that allow you to make conclusions about the structure of objects. Electrical resistance tomography is used to determine the spatial resistance distribution in a non-destructive manner. Low resistance can indicate increased moisture content, whereas hollowed structures cause increased levels of resistance. However, in order to appraise the health and stability of trees based on resistance, you need to have a lot of experience.

The measurements rely on point-like electrodes (nails) placed around the boundary of an object. A current is injected into the object with two of these electrodes. The resulting electric field depends on the resistance distribution and is measured in pairs by the other electrodes in order to obtain a voltage. The following figure shows the electric potential for homogeneous conductivity distribution in normal wood (left). In cases where there is an increased anomaly (centre), the potential lines are moved outwards and we observe increased voltage around the periphery. If the anomaly is more conductive than the background (right), the potential lines are attracted and we see lower resistance[1].



“I” – current is applied and measured, “U” – Voltage is measured

The colours in the ER Tomograms represent values in the unit [Ohm * meter].

4.3 Why is the ERT Method needed for tree inspections?

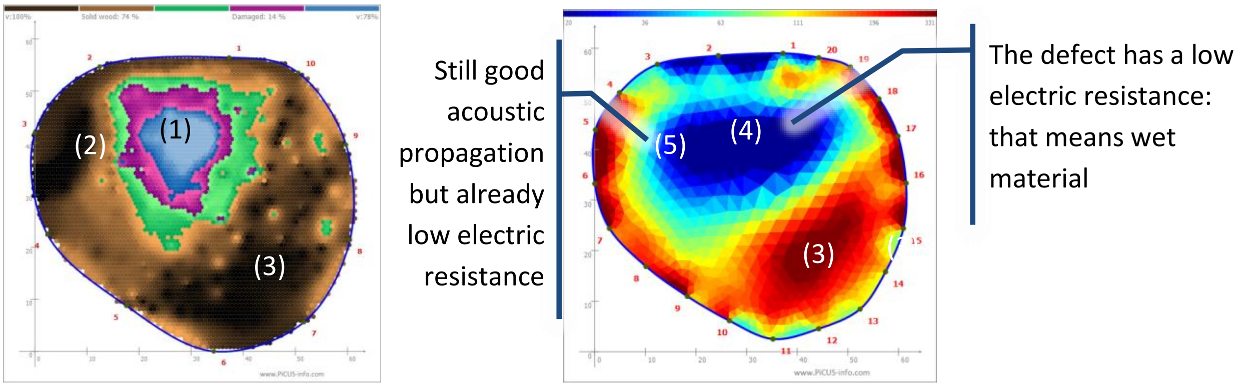
Our first tomography instrument - the PiCUS Sonic Tomograph - gives information about how the wood in a certain tree transmits sonic waves. It measures the sonic velocity, which is determined by the relation between the modulus of elasticity (MOE) and wood density. Because both MOE and density correlate strongly with the soundness of the wood, sonic velocity is a good indicator of internal problems in trees. Yet sonic tomography (SoT) cannot always answer all questions about the quality of the wood at the tomography level. In some situations the sonic investigation is altered by the internal structure of the wood. This makes it necessary to consider using an additional inspection method which relies on other aspects. By combining SoT and ERT, which are based on different working principles, we gain two different types of information about wood. The ERT adds information about chemical properties of the wood, most of all

[1] Graphic by Dr. T. Günther and Dr. C. Rücker

about the moisture content. Using both sonic and resistance information enables you to make a more thorough analysis of a tree because the nature of the defect can be diagnosed: is it a crack, cavity or decay.

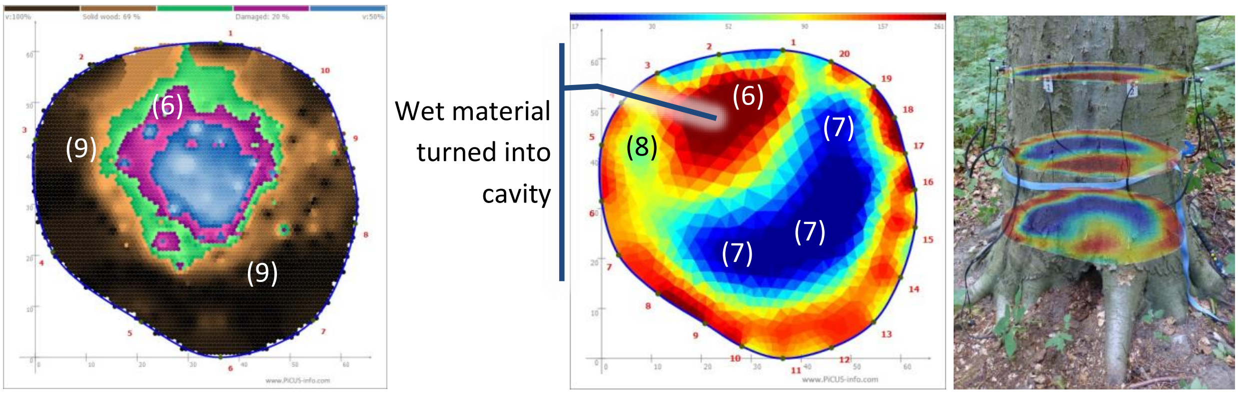
In particular when investigating trees with decay, the ERT is a **foresight, the look ahead into the future**: The TreeTronic tomograms even show very early stages of the infection. Those early infections are not yet visible in the SoT since they do not affect the MOE as much.

The example below shows how a fungi inside a beech develops over the course of the years from 2007 to 2015. The SoT recorded in 2007 shows the defect (1). The defect is clearly visible in the ERT (4). The combination of slow acoustic wave propagation and low electric resistance means that a wet fungi is present. The ERT shows at (5), that the affected area is larger than shown in the SoT at (2). Thus, this part is affected by an early stage of the fungi, that has no big influence on the sonic wave propagation. We can expect that the area at (5) will be degraded in the future. The best wood can be found near (3).



2007: SoT ERT

The scan recorded in 2015 shows: The defect has grown in size! The „composition“ of the defect has changed: Formerly “wet” areas (at 4) are now „dry“ (at 6). That means the wet decay has turned into a dry cavity. The prognosis of the 2007 scan came true! The ERT-scan of 2015 also shows, that the infection has occupied almost the entire cross section (7). The slight decrease of the resistance in the ERT (at 8) is to be considered as an early infection too. Since acoustic wave propagation is still relatively good (SoT at 9) we can expect to find a relatively firm wood structure – at least so far.



2015: SoT ERT

Data like this helps to learn about the speed of growth of fungi in trees and thus, we get an orientation for re-scheduling the next scan.

5 Get started

5.1 General hints

The TreeTronic 3 can be operated with or without a Windows - PC. Chapter “TreeTronic 3 operation ” describes how to use the TreeTronic 3 in stand-alone mode. Chapter ”TreeTronic 3 operation with PC” describes how to control the TreeTronic 3 using the PiCUS Q74.2 Windows PC program.

The functionality of the device in both PC - and stand-alone mode is very similar. The main difference is that the TreeTronic 3 CANNOT calculate the electric resistance tomogram stand-alone mode.

Previous versions of the PiCUS PC program (before Q73.1) do not work with the Treetronic 3 hardware!

5.2 Safety information

Before taking measurements with the Treetronic, **remove all sonic sensors from the nails**! **The voltage of the Treetronic can destroy the sonic sensors**.

Attention: do not touch the clamps, nails or the tree during the ERT scan. The voltage applied is up to 80 Volts and may cause injuries! Furthermore the measuring result may be corrupted.

Do not connect the clamps/electrodes with one another.

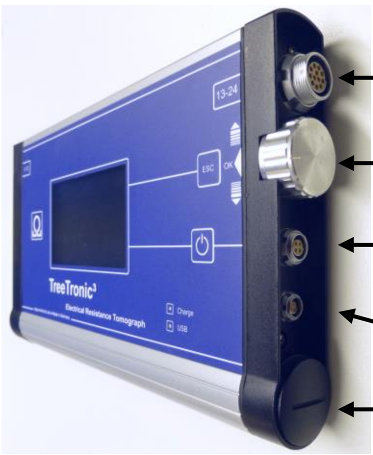
Do not mount more than one clamp/electrode to each nail.

5.3 Hardware

5.3.1 TreeTronic 3 – Main control unit

Socket (A) for cable loom clamps 1 to 12

Socket (C) - cable connection to PiCUS 3



Socket (B) for cable loom clamps 13 to 24

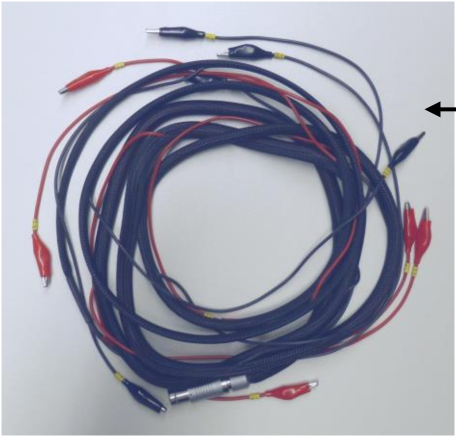
Twist and Push button (S)

Socket (E) for charger

Socket (D) for USB cable (Connection to PC)

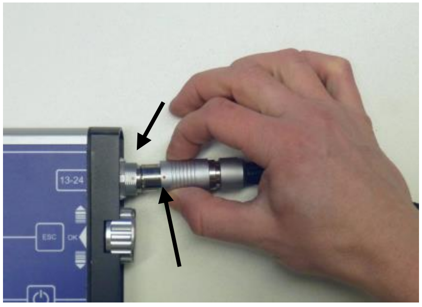
Battery compartment (do not open)

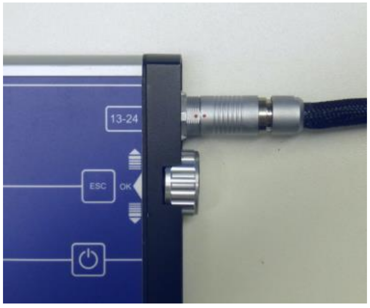
5.3.2 Cable loom



Cable loom with 12 clamps

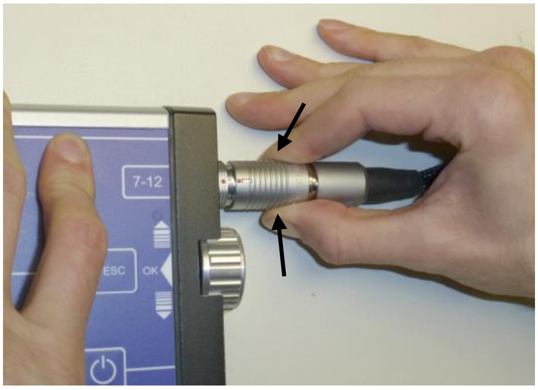
How to connect the cable looms to the main control unit.

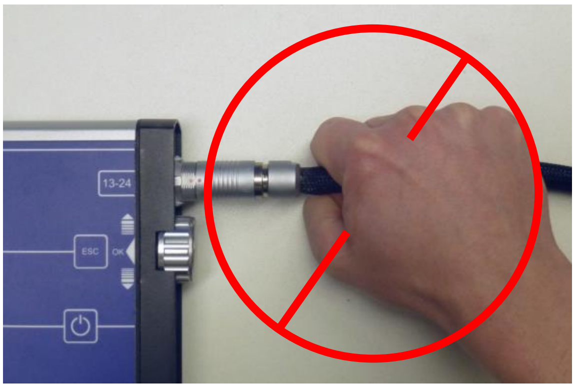




Red dot need to meet red dot.   Cable loom 13-24 correctly plugged in socket (B)

How to disconnect sensor cable looms





Always handle the connector at the grip! This is important to unlock the connector.

NEVER pull the cable loom on the cable itself!

5.4 User Controls

The TreeTronic 3 is equipped with three buttons that are used for navigation through the menu and typing in data.

“OK” Button: Push the “twist and push” button. Used to go into a (sub) menu or confirm a value.

“ESC” Button: Used to leave a menu when all settings are done.

“+/-“ Twist wheel: Used to scroll through menus and alter values.

“ON/OFF” Button: Hold the button pressed for 3 seconds to turn the TreeTronic 3 ON or OFF.

5.5 General settings

The following setting should be done before using the TreeTronic 3.

1. **Set language**. Languages English, German and French are available.

   TreeTronic 3 main menu → ” Settings” → “Language”

2. **Set display Brightness**. Adjust to your requirements. Bear in mind: less brightness – less power consumption.

   TreeTronic 3 main menu → ” Settings” → “Display Brightness”

3. **Set PiCUS calliper Bluetooth address**. Each calliper has a unique Bluetooth address. This address can be found when in the Bluetooth manager of the PC when the PiCUS calliper is connected to that PC.

   TreeTronic 3 main menu → ” Settings” → “Calliper Address”

4. **Set Bluetooth address of the TreeTronic 3 in the PiCUS 3**. Tree data such as height, geometry of the measuring level etc. can be sent from the PiCUS 3 to TreeTronic 3 via Bluetooth or USB. In order to use the BT connection the PiCUS 3 needs to know the BT address of the TreeTronic. The BT address of the TreeTronic 3 is shown in the menu:

   TreeTronic 3 main menu → ”Settings” → “updates”

5. **Set power off time**. The TreeTronic 3 will turn off after the specified time to safe power.

   TreeTronic 3 main menu → ” Settings” → “Auto Power OFF”

6. **GPS Timezone.** This setting is used to adjust to the local time in relation the GPS time obtained from the integrated GPS receiver.

   TreeTronic 3 main menu → ” Settings” → “GPS Time Zone”

7. Download your individual “**Treenames**” file to the TreeTronic 3. For details see chapter: “Download tree names list to TreeTronic 3”

6 TreeTronic 3 operation

6.1 General hints

In many situations the combination of TreeTronic and PiCUS Sonic Tomograph is recommended to yield best results. Both instruments can be used with a PC or autarkic. When operated without the PC the instruments can share tree related data such as geometry information in order to avoid typing in those information twice.

Before the actual ERT scan can start the tree needs to be carefully visually inspected to locate possible defects and the level of tomography. The list below describes the main steps to follow:

1. Visual inspection to decide at which level the tomogram needs to be taken.
2. Selecting the positions of all MPs and tapping in all nails at those points.
3. Enter tree data. There are two options:
    a. Recording the geometry of the measuring level (positions of all MP). Enter tree name, number, height of measuring level etc. Measure tree height using the semi-automatic tree height functions of the TreeTronic 3.
    b. Import tree data from PiCUS 3.
4. Installing the TreeTronic 3 on the tree.
5. Run the U-I measurement, also called resistivity scan.
6. Save the data on the internal SD-card of the TreeTronic 3.
7. Dismantling of the Treetronic 3, removing nails.
8. Upload data files to PC.

The next chapters describe the operation of the TreeTronic 3 in both PC-operation and autarkic mode.

TreeTronic 3 installation

6.2 U-I data Scan with the TreeTronic 3

There are two options to enter geometry of the measuring level and other tree data (height etc.) into the TreeTronic. If the PiCUS 3 (Sonic Tomograph) was used prior to the ERT then the data will be available in the PiCUS 3. The data can be transferred to the TreeTronic 3 using a BT connection.

Alternatively the geometry can be recorded in the TreeTronic itself. This chapter describes both methods.

6.2.1 Import tree data from PiCUS 3

When a sonic tomogram has been recorded prior to the ERT scan the tree data (geometry etc) of the PiCUS 3 can be sent directly to the TreeTronic 3. To do so proceed as follows.

1. Prepare the TreeTronic 3 for receiving data:

   TreeTronic 3 Main menu → "*Data connections*".

   The TreeTronic 3 now waits for the serial connection (either BT or USB) to the PC or PiCUS 3.
2. Start the PiCUS 3

   PiCUS 3 Main Menu → "*Data connections*" → *"to TreeTronic"*

3. When the geometry data has been received the ERT scan can start. However, in many situations it is recommended to use more MP in the ERT scan than for the SoT. MPs can be added one by one using the menu:
   TreeTronic 3 Main Menu → "ERT" → *"Geo Circle"* → "Add MP"
   The number of MP can also be doubled if the PiCUS 3 has send a geometry with 12 MP or less.
   TreeTronic 3 Main Menu → "ERT" → *"Geo Circle"* → "Double MP"

6.2.2 Recording the geometry of the measuring level

There are two ways to record and enter the positions of the MPs:

- Assuming the tree circumference is a circle and entering the distances of all MP along the circumference
- Use triangulation method to measure positions of all MP accurately on any shape of trees

For more or less circular cross sections the measuring level can be depictured as a circle. However, in most cases the triangulation method ("Free Shapes") yields better results.

6.2.3 Circular geometries

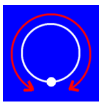
In the "ERT" menu of the TreeTronic 3 select the menu

"Geo circle" The sub menus configure the circle and positions of MP along the circumference.

"Number of MP"

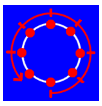
Enter the number of MP here. The number of MP is the number of nails in the tree. Only even numbers can be used. Minimum is 8, maximum is 24.

"Tree circumference"



Enter the circumference in the unit millimetre [mm]. Wrap the measuring tap anti-clockwise around the measuring level. The zero mark is at MP 1.

"MP-Distances"



Wrap the measuring tap anti-clockwise around the measuring level. The zero mark is at MP 1. Enter the position of each MP along the circumference. Example: nail 2 is at 25,7 cm. Type in line "MP1 -> MP2 [mm]": 257.

"ESC" button: quit that menu.

6.2.4 Free shapes geometry with calliper

In the "ERT" menu of the TreeTronic 3 select the menu

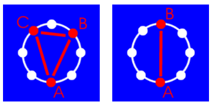
"Free Shape"

The sub menus configure the free shape measuring.

"Number of MP"

Enter the number of MP here. The number of MP is the number of nails in the tree. Only even numbers can be used. Minimum is 8, maximum is 24.

"Base Points"



Enter the number of base points (two or three) first. Select the base points afterwards.

"Free Shapes Calliper"

Mechanical callipers or the PiCUS calliper can be used for the triangulation measurements. To work with a standard calliper (mechanical) choose menu

"Using NO Callipers"

In order to work with the PiCUS Calliper turn on the Calliper now. Follow the instructions on the Calliper. When the Calliper is in the Bluetooth mode select menu:

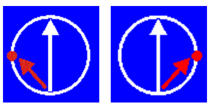
"Calliper is ON"

The TreeTronic 3 starts to connect with the calliper. Once the connection is established the measuring commands are being sent to the calliper screen. The TreeTronic 3 unit can be carried during the geometry measurement to avoid BT radio shadow of the tree.

If the BT connection is interrupted – because of large diameter tree - and the calliper screen is frozen, then bring calliper and PiCUS in direct view and push "Enter" button on the TreeTronic 3 to re-send the lost command to the calliper.

Once all distances are measured by the calliper or typed in manually the outline of the tree is drawn. Click "Geometry OK" or "Revise" to accept or change geometry.

"MP1->MP7 [mm]: 0"



Example: distances to measure with either PiCUS electronic calliper or with a different tool. The distance can be entered by hand (use the twist-button 'C') or via BT from calliper. If the distance was entered by hand in some cases the orientation is also required. Twist button 'C' to change orientation and OK to enter.

"Geometry OK" Confirm geometry.

Note: this function quits the geometry measurement. If the Geometry function is called again all distances entered before are set to 0. Thus, all distances need to be entered again.

"Revise" Alter all distances.

Note: If a value needs to be measured again (because a wrong value was taken or the BT connection was interrupted) set the value on the screen to "0" and push "OK" to re-send the command to the calliper.

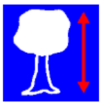
6.2.5 Tree Data

"Tree Data" Menu is used to enter tree details.

"Tree Species"

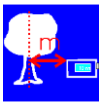
Choose botanical tree name from a list of 27 trees that have been downloaded from the PC. If the tree species is not in the list choose "_Not specified" or alter the list.

"Tree Height"

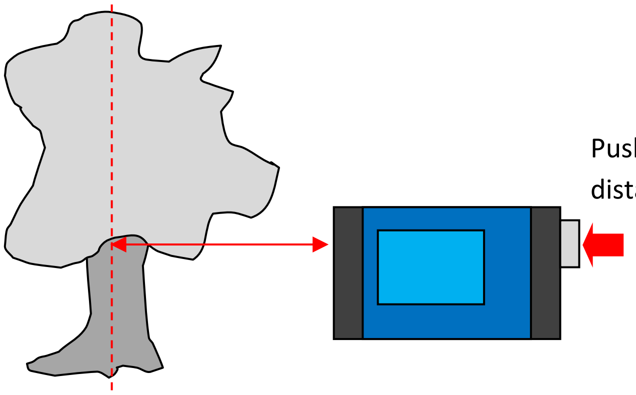


The tree height can be typed in when the height was measured with a different device. The TreeTronic 3 has a semi-automatic function to measure tree height. Click on: "Measure height" to activate the measuring.

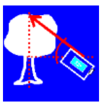
"Distance to Tree"



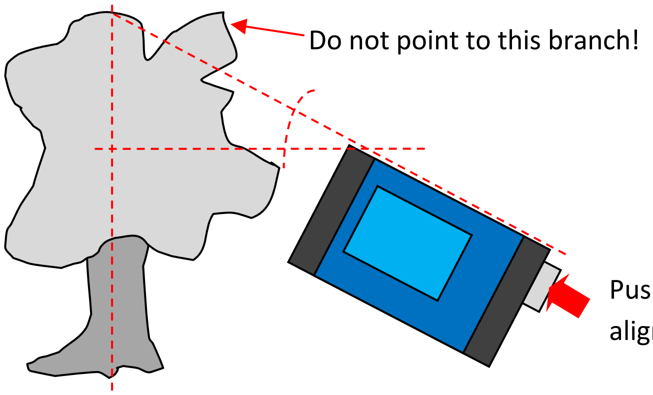
Enter distance of your location to the tree in meter [m]. Typically the distance should be 10 to 30 meter.



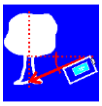
"Angle Tree Top"

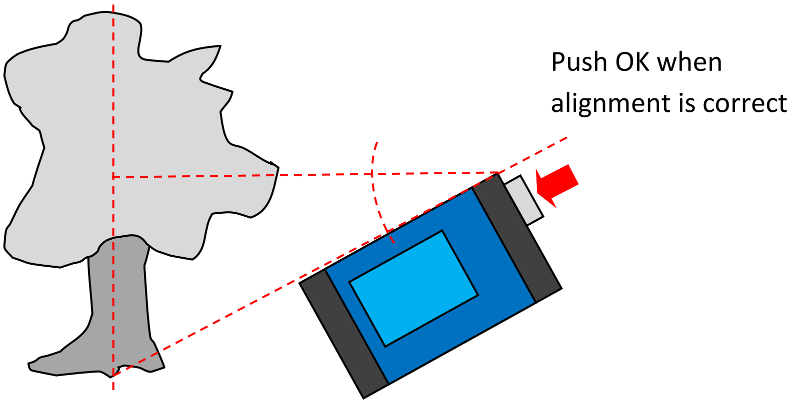


measures the angle to the treetop**. Attention: do NOT aim to the outer branches. Try to point to the axis of the tree**.

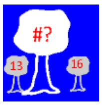


"Angle Tree Base" measure the angle to the tree base.



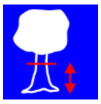


"Number" Enter the number of the tree according to your numbering system



"N/E/S/W" Alignment" Enter North-alignment of the MPs. Standard: MP 1 at North.

"Height of Meas. Level" Enter height of measuring level in [cm].



6.2.6 Installing the TreeTronic 3 on the tree

When all data is entered the sensors and TreeTronic 3 main unit need to be mounted to the tree. Use the blue strap to hold main unit and cable looms if the measuring level is higher than 30 cm. Put the number plates on all MP to have a good reference in the photos.

1. Place the TreeTronic 3 main unit in-between MP 12 and 13.
2. Plug in the left sensor cable loom - clamps one to 12 - to the left socket A, named “1-12”.
   If needed, plug in the right sensor cable loom - sensors 13 to 24 - to the right socket B, named “13-24”.
3. Connect clamps to the nails. Make sure the numbers are in the correct order, the red-black-red sequence of the cables helps to avoid errors. In all cases an incorrect cable order will result in incorrect data.
4. **Attention:** Do not connect the electrodes with one another. Also, do not mount more than one electrode to a nail. Take acoustic sensors (PiCUS sonic tomograph) off the nail! The high voltage of the Treetronic could damage the acoustic sensors.


Only ONE clamp per nail!


Remove acoustic sensors before the ERT scan!

6.2.7 Resistivity measurement

Before the actual scan can start make sure that all clamps are placed correctly on the nails. Stain and rust on the nails will interfere with the measurement.

Select

1. *“ERT”* → *“Measurement”* to start the resistivity (U and I) measurement. The measurement screen is shown.
2. Press OK to start the measurement. The scan will take 10 to 60 seconds, depending on number of MP and conductivity of the wood.
3. **Attention: do not touch the clamps, nails or the tree during the ERT scan. The voltage applied may reach 80 Volts any cause injuries!** Furthermore the measuring result may be corrupted.
4. The Treetronic will report error messages if too much or too low current occurs. Check clamps and nail contact to wood if that happens.
5. Check data quality by watching the bar graphs on the display. The yellow bars show the current “I” that is pushed into the tree.

6. Press “ESC” to return to the “ERT” menu. In here the file can be saved:
7. “*File*” → *“Save all data to File”* to save the data.

6.2.8 Calculation of the tomogram

The Treetronic 3 cannot calculate the final ERT. The data must be uploaded to the PC to see the tomogram.

6.2.9 Saving data to the internal SD card of the TreeTronic 3

The TreeTronic 3 can save up to 120 files. When 100 files are on the SD card a warning is shown. Files can still be saved.

To save data recorded go to file menu.

"ERT" → *"File"* → *"Save all Data to File"* and push "OK" button.

The filename is created automatically using UTC time and date (from GPS unit). When the files are loaded to the PC the local time, derived from PC Clock and the regional PC settings, and date are added to the filename.

Other functions in the file menu:

"*Clear U/I*"	Deletes all U and I data of the scan. All other data such as geometry, tree species, height etc. are not changed. This function can be used when a second scan of the same measuring (unchanged geometry) level needs to be done.
"*Clear all Data*"	Deletes all data: U, I, geometry and tree information.
"*Load/Delete Files*"	Access to the file load and delete functions.
"*Load File*"	Shows the content of the internal SD card. "Number of files" is the number of stored files. Scroll through the menu to select the file to load and push "OK" when done to load the file.
	Attention: loading a file overwrites the current data (U, I, geometry and tree data)!
"*Delete Files*"	Shows number of files on the SD card and offers to delete all of them at once. Push "OK", enter "13" and push "OK" again to delete ALL files. **Deleted files CANNOT be restored**.

6.2.10 Upload data files to PC

To download data files from the SD card of the TreeTronic 3 to the PC proceed as follows:

1. Prepare the TreeTronic 3 for data files upload by going to menu:

   Main menu *"Data connections"*.

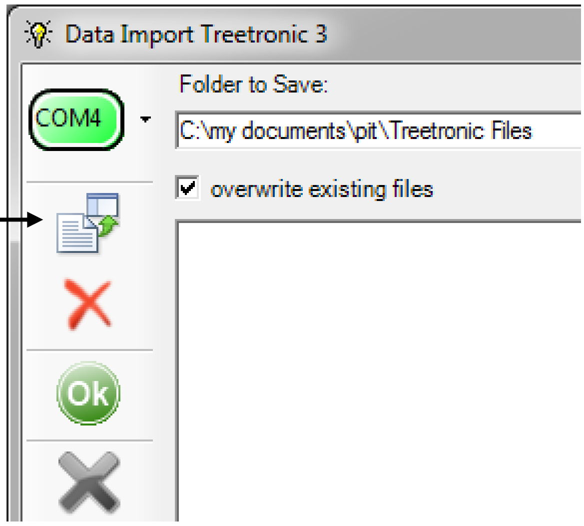
   The TreeTronic 3 now waits for the serial connection (either BT or USB) to the PC or PiCUS 3.
2. Start the PiCUS Q74 program on the PC. Make sure that the Q74 program is configured for TreeTronic 3 operation.

   PC program *"Configuration" → "Select Hardware" → "TreeTronic 3"*
3. Make sure the COM port is selected correctly (BT or USB) in menu

   PC program *"Configuration" → "Select COM port" → Tab "Port TreeTronic"*
4. Go to:

   PC program *"TreeTronic 3" → "Data Import"*.

   The download window will open
5. PC program Open the COM port in the download window and select a valid path on the PC.
6. PC program Click "Import" button to start the data file download.
7. After downloading all files you are being asked to delete all files on the TreeTronic 3. If you press yes then all files on the SD card of the TreeTronic 3 are being deleted. Attention: deleted files cannot be restored!



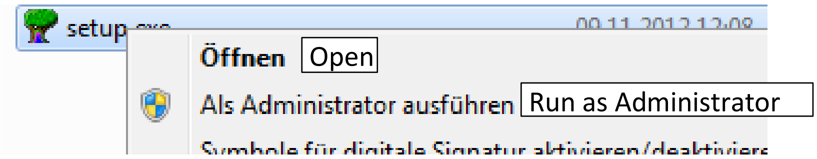
Note: The files downloaded are renamed according to the local settings of the PC. The TreeTronic 3 derives the filenames from the GPS time and date. GPS time and date are always given UTC. The local time and date will differ from UTC. In order to keep track of files the PiCUS PC program calculates local time and date of the measuring file and adds this information (prefix "LT" – local time) to the filename. The local time information is derived from the time settings on the PC the program is running at.

6.3 TreeTronic 3 operation with PC

This chapter shows how to record electric resistivity data (U and I) of a tree using the PiCUS PC Q74 software. This function is only available in PiCUS Q73.2 or higher versions.

6.3.1 Installation of the PiCUS PC software

To install the Q74 program the setup.exe must be executed in "Run as Administrator" mode. Right click the icon and choose from the drop down menu.



6.3.2 Configuration of the software

Two main settings must be completed before the PiCUS PC program and Treetronic 3 can work together: version of the TreeTronic and COM port number.

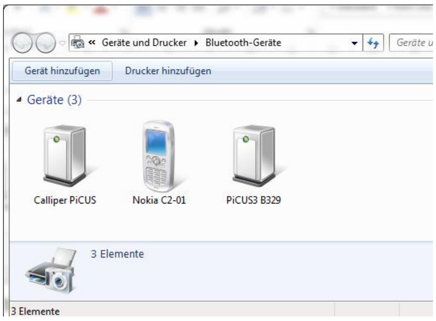
The Treetronic can be connected to the PC via Bluetooth or USB. The USB driver is installed during the installation of the PiCUS PC software. A new USB-COM port to the Treetronic is ONLY created when the instrument is connected to the PC using the USB cable provided.

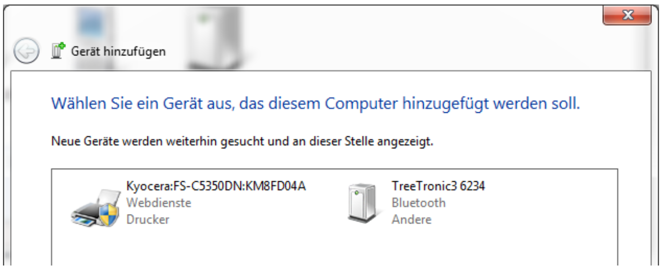
6.3.3 Installing Bluetooth COM ports

The communication between the PC and the Treetronic via Bluetooth requires a Bluetooth COM port on the PC. The BT installation procedure depends on the operating system of the PC and the BT driver. On Windows 7® systems the procedure is shown here:

1. Activate the TreeTronic 3 menu: *"Data connections"*
2. Turn on the BT system of the computer, the BT icon should appear in the task bar.

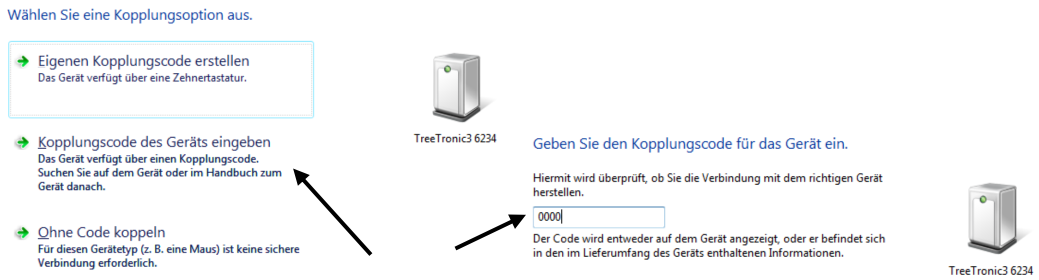
3. Right click on the BT icon and select "*Show BT devices*". The folder "Devices and printers" is shown.





4. PC – BT Manager: "*Add Device*"
5. Select the TreeTronic and press continue.

6. Select “Enter the pairing code” (2ed option)

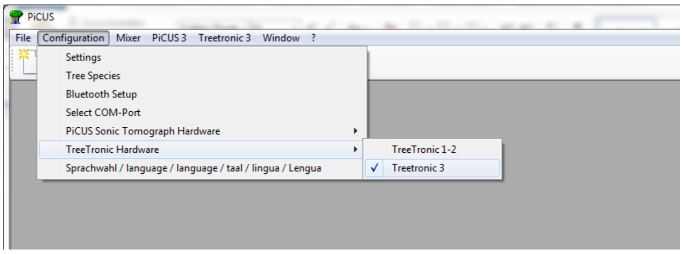


7. The pairing code is “0000”. Click continue and watch the COM port being created. Write down COM port number. Enter the COM port in the COM configuration window of the PiCUS program.

6.3.4 Connecting PC and Treetronic

1. Configuration of the PiCUS PC Program

   PC program *“Configuration” → “TreeTronic Hardware” → “TreeTronic 3”*



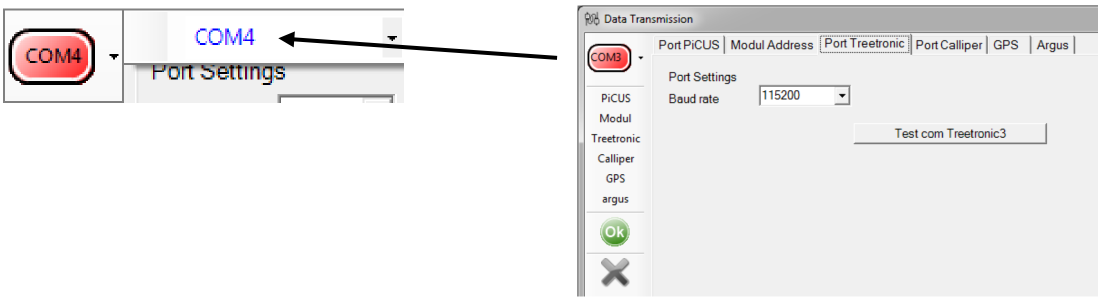
   This setting will only affect the measuring process, the file format and the ERT calculation. However, files of all TreeTronic versions can be calculated using the “TreeTronic 3” setting.

2. Enter “TreeTronic 3” COM port

   PC program *“Configuration” → “Select COM port” → Tab “Port TreeTronic”*

   Set TreeTronic COM port, either USB or Bluetooth. Set Baud rate to 115200. Press “OK” to save the settings.

   Note: Install the USB cable between TreeTronic 3 and PC **BEFORE** you open this dialog. The USB COM port is only visible when the TreeTronic is connected to the PC **prior** to opening this window. The USB port of the TreeTronic is shown in blue characters in the drop down menu.



Attention: Every time the COM port is changed, for instance when the connection is changed (Bluetooth to USB), the port setting in this window needs to be updated.

3. Test COM connection

   In order to check the COM connection between TreeTronic 3 and PC turn on the TreeTronic 3. Go to menu:

   TreeTronic 3 *"Data connections"*

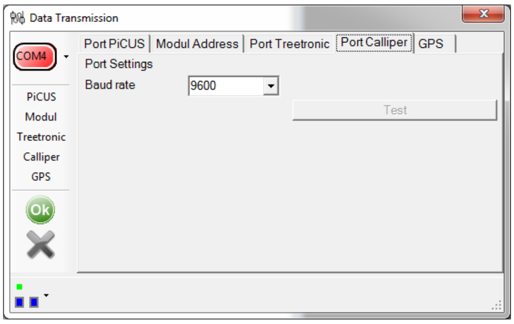
   The TreeTronic 3 screen shows "Searching for PC (BT – USB)…"

   PC program *"Configuration" → "Select COM port" → Tab "Port TreeTronic"*

   PC program Click  to open the COM port. The icon should turn green.

   Click "Test TreeTronic 3" button. If the connection works properly the PC program shows the message "TreeTronic 3 ok". The TreeTronic 3 screen shows "USB <-> PC: ok" or "BT <-> PC: Ok".

4. Set Calliper and PiCUS Tomograph COM port



Enter the PiCUS Calliper BT COM port accordingly.

Enter PiCUS Sonic Tomograph port – if applicable - accordingly.

Close window with OK to save settings.

"GPS" settings are only important if an external GPS receiver is connected to the PC. The TreeTronic 3 has an in-built GPS module whose information can be read in the Q74 measuring window. See chapter: "Read GPS position from TreeTronic 3".

6.3.5 Resistivity measurement with PiCUS PC program

The workflow for a tomogram scan using Q74 software and the TreeTronic 3 is very similar to the previous software and hardware. This description will show the main steps needed to perform the U/I (resistivity) scan.

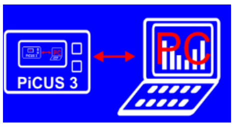
In the Q74 PiCUS PC program follow the following procedure:

1. PC program — Open a new file: *"File"* → *"New"* and follow the wizard.
2. PC program — Enter tree data in menu: *"Edit"* → *"Tree Data"*
3. PC program — Enter geometry. (See chapters "Geometry" in PiCUS PC Software Q74 manual)
4. PC program — Open ERT scan window:

   "*Measurement*" → "*Electric Resistance Measurement*" or click icon: 
5. TreeTronic 3 — *"ERT (PC)"* → *"Connect PC"*

   The TreeTronic 3 screen shows

   "Searching for PC (USB – BT) …"

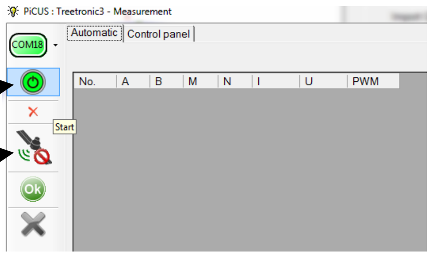
   

   The TreeTronic 3 will also find either USB or Bluetooth connection to the PC automatically. Once the PC connection is made the system is ready for the ERT scan.
6. PC program — Clicking  to open port. The button should change to  .

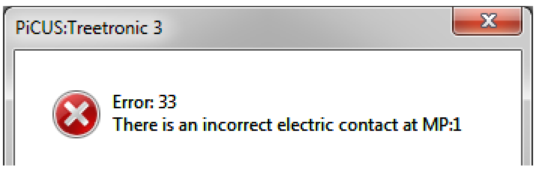
   Attention: Every time the COM port is changed, for instance from Bluetooth to USB, the port setting needs to be updated. The COM Port number can also be changed in the ERT scan window but changes are not saved.
7. PC program — Click on Start Measurement. The scan will take 10 to 60 seconds, depending on number of MP and wood conditions.

   Start scan

   Get GPS

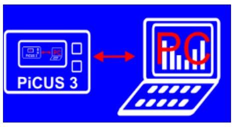
8. **Attention: do not touch the clamps, nails or the tree during the ERT scan. The voltage applied may reach 80 Volts any cause injuries!** Furthermore the measuring result may be corrupted.
9. The TreeTronic 3 sends all data at once to the PC when the scan is completed.
10. Error messages help to identify disconnected wires. The example shows that at MP 1 no electric contact could be made. In that case the connection of the wires to MP 1 and 2 needs to be checked.

11. GPS coordinates can be collected from the TreeTronic using the GPS button.

6.3.6 Read GPS position from TreeTronic 3

The TreeTronic 3 has an in-built GPS receiver that is turned automatically on when the TreeTronic is turned on. In stand-alone mode the GPS coordinates are automatically saved to the file when the save function is called. In PC guided modus the GPS signal can be transmitted to the PC through the "Measure electric resistance" window of the Q74 software. Proceed as follow:



1. Turn on TreeTronic 3 and bring it to PC modus or "Data connection".

   TreeTronic 3 *"ERT (PC)" → "Connect PC" or "Data connection"*

2. PC program "Measurement" → "Electric Resistance Measurement" or click icon: 
3. PC program Clicking  to open the COM port. The button should change to .
   The screen of the TreeTronic 3 should show "PC <-> USB ok" (or BT ok)
4. TreeTronic 3 Wait until the GPS letters in the top right corner of the Treetronic 3 display turns green to indicate that GPS data is available.

5. PC program Click the satellite icon  to start reading GPS data. The icon changes to: 

   The readings take a few seconds. The function is turned off automatically. If GPS signals are available the bottom line shows both UTC and coordinates.

   GPS Mode UTC 7:45:23 AM 54.074697°N 12.116655°E

Depending on signal quality the signal acquisition may take up to 5 minutes. The longer the GPS module can read the signal the better is the quality of the coordinates.

Therefore it is a good strategy to do the electric scan and get GPS coordinates afterwards. The GPS coordinates are saved to the Treetronic data file and can be found in the tree data window.

6.4 Charging TreeTronic 3

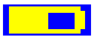
Connect main unit and charger as shown on the photo to charge the equipment.

On the TreeTronic 3 the “charge” LED will show light until charging is done.

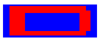
Note: Do not expose the unit to sunlight when charging! The sun will warm up the device and interfere with the charging temperature control. Charging temperature range is 15° - 25°C.

The battery symbol in the top right corner of the TreeTronic 3 screen shows battery status. Meaning:

Battery full. After charging the battery display shows a voltage larger than 11 Volt.



Battery below 10.0 Volt, TreeTronic 3 will work for another 1-3 more hours (depending on usage, temperature, display brightness etc)



Battery below 9.3 Volt, TreeTronic 3 will work for some more minutes. Finish work as soon as possible and save the data.

7 ERT functions of the Q74 PiCUS software

7.1 Download tree names list to TreeTronic 3

The list of tree names that can be loaded into the TreeTronic 3 may have 27 entries maximum. The list can be configured on the PC. Proceed as follows:

1. PC program *“Configuration”* → *“Tree species”*

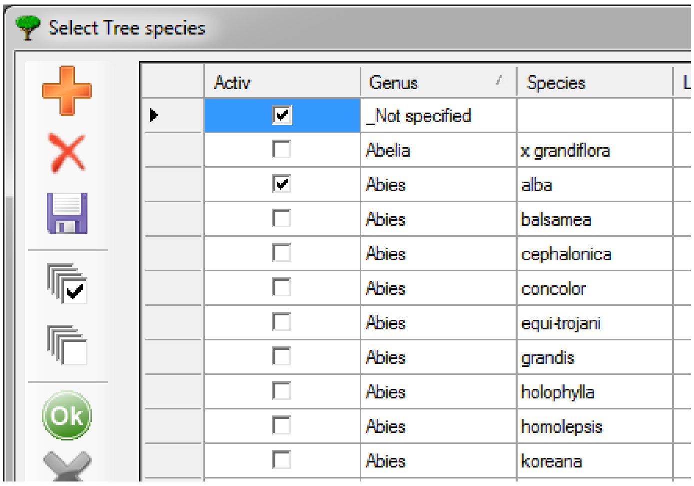
Add tree species to the list.

Remove tree species from the list.

Save list to PC disk.

Select/un-select all

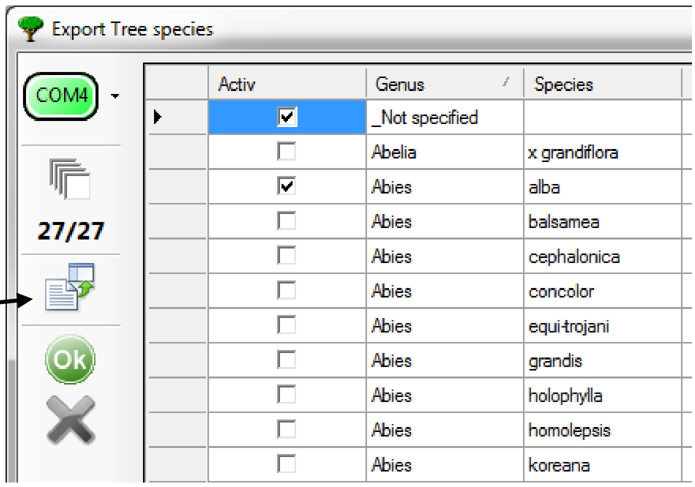
Close that window.



2. PC program Select the species you want to see in the “tree data” window of the PiCUS Q74 PC program in that list. For this window the number of trees selected is not limited. This list is also the base of the list that can be downloaded to the TreeTronic 3. The TreeTronic 3 download list can have 27 entries.
3. PC program Close the window using “OK” button.
4. TreeTronic 3 *“Data to PC”*
   The TreeTronic 3 now waiting for BT or USB connection to the PC.
5. PC program “TreeTronic 3” → *“Tree species Export”*

Number of selected names.

Download to TreeTronic 3 button.



6. PC program Push button ”*Send tree species*” to download the list to TreeTronic 3.
   The TreeTronic 3 confirms the receiving of the file.

7.2 Calculation options for ERT

To access the calculation options for *.trt files click on

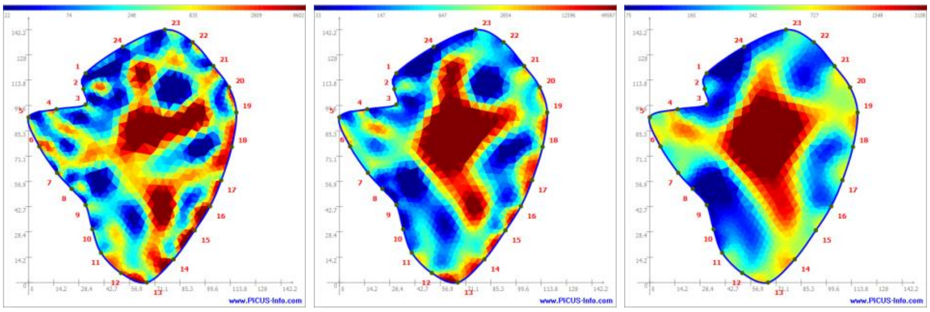
PC program *Configuration → Settings → Calculation*

The options are *smoothing*, *mesh fineness* and *colours*. Both *smoothing* and *mesh fineness* do affect the resistivity values calculated. Thus, when comparing tomograms, all files must be calculated using the same settings.

7.2.1 Smoothness

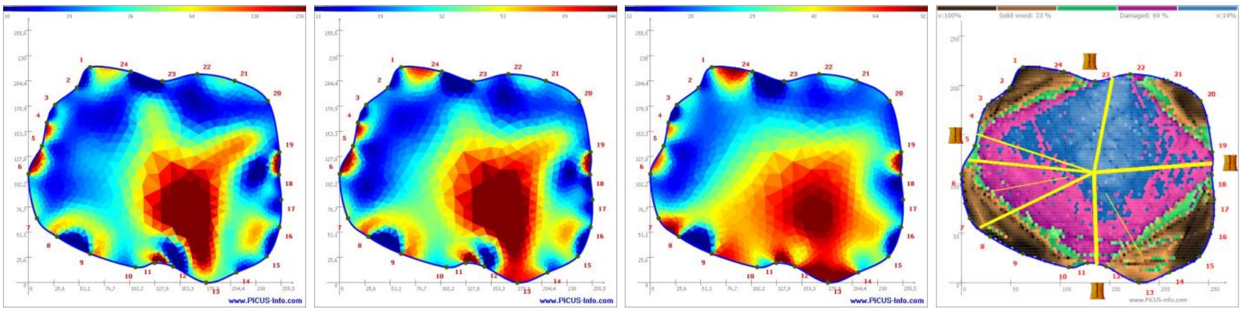
The smoothness level determines how many details are shown in the ERT. Low smoothness values (1, 3, 10) will display more details than larger values (100), but they may also suffer more from measuring errors. Smoothness level 10 or 20 (the default) is a well-balanced value.

The tomogram must be re-calculated before any changing of the smoothness value takes effect. The example below shows the results of different smoothing parameters. The Smoothing-10-ERT is best to understand.



Smoothness 3 Smoothness 10 Smoothness 100

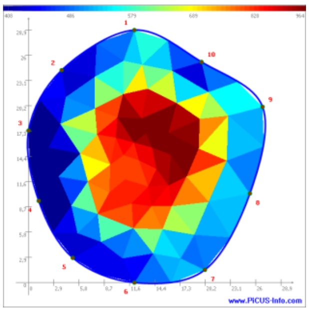
The next example is recorded on a Sequoia Giganteum, circumference at the measuring level is 810 cm. The sonic data (SoT) raised the suspicion that there could be significant cracks. The ERT calculated with smoothing 1 (meaning very sharp interpretation of data) shows the likely positions of the cracks most clearly. These positions coincide with those calculated in the SoT, indicated by yellow lines.



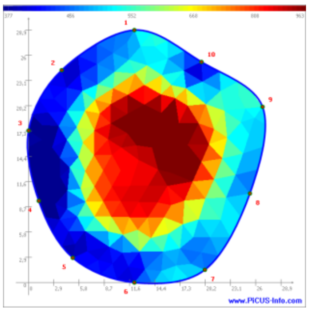
Smoothness 1 Smoothness 3 Smoothness 20 SoT

7.2.2 Mesh fineness

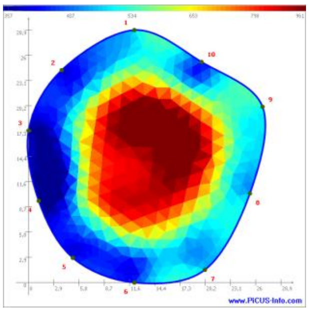
The cross-section of the tree is displayed in the ERT with a network of small triangles. “Mesh fineness” specifies the number of triangles between two MP along the circumference. Calculation time increases with rising mesh fineness. The standard value is 4. The tomogram must be re-calculated before any changes of the mesh fineness takes effect. The drop down menu limits the values from 1 to 8. Values larger than 8 may be typed in using the keyboard. However, too high values do not to improve ERT quality.



Mesh 2



Mesh 4



Mesh 8

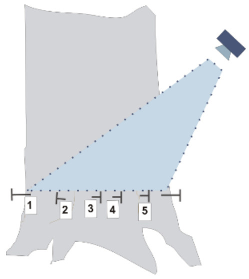
7.2.3 Colour scale

There are two ways of using colour in the ERT:

1. “Automatic” is checked: the colours scale is stretched between the lowest and highest resistance of the file calculated: Dark reds are assigned to the highest resistance levels, dark blues are assigned to lowest resistance calculated. Sound trees of certain species may have a small variation in resistance across the cross-section, for instance only 30 Ω * meter. With the “Automatic” option, even these tomograms will show the full colour scale from red to blue.
2. “Automatic” is un-checked: Dark red colours are assigned to the “maximal resistor” value. Dark blues are assigned to the “minimal resistor” value. Resistance larger than the “maximal resistor” value will also be drawn in dark red; resistance lower than the “minimal resistor” will be shown in dark blue.

7.3 3D Graphics of ERTs

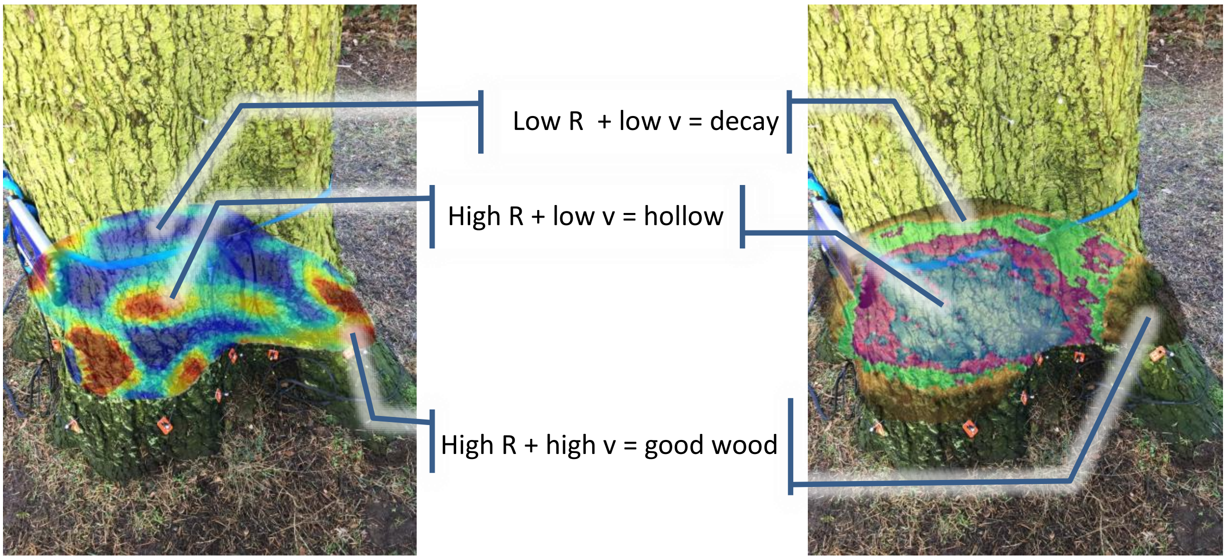
One or more SoT or TreeTronic tomograms can be displayed in 3D views.



Q74 also offers the option to merge the perspective tomograms into photos of the tree.

The photo should be taken from above like shown in the sketch in order to have a better view on the actual test result. Otherwise the tomogram must be tilted and details are not as good visible.

The ERT tomogram (left) and SoT (Right) are easy to see because the photo was taken from a higher position.



ERT **SoT**

Tomograms and Photo of an *Abis grandis* tree with cavity and decay.

Procedure

1. *Main menu → "File" → „New" or use the new icon to start the wizard*.
2. Select sonic tomogram SoT (or ERT) and check „3D view".
3. 3D window will open.
4. Click „+" to add at least one file.
5. Optional: Click „load left picture" in order to load a photo in which the tomogram shall be merged.
6. Click the „Tomogram" icon to re-calculate the tomogram.
7. Click the „3D" icon to start the 3D view in the 3D window.
8. When only one file is used the 3D window may appear empty. This is because the camera position is exactly at the tomogram level. To change the camera angle hit the "k" key. More camera option are given help window – hit "F1".

The twisting tomogram can be moved around and transferred into the photo using the „← ↑ → ↓" keys. Let the computer work for a second before you hit a key again.

Options

These options are available in the active 3D window. Hit F1 to see the min an extra window.

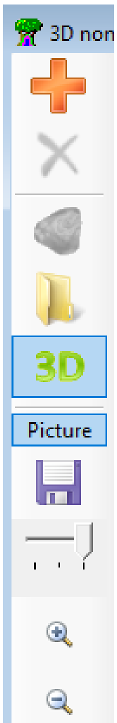
g/t	- Distance camera tomogram
i, k	- Change vertical angle of the camera
q	- Rotate the tomogram horizontally by 90°
← ↑ → ↓	- Shift position of the tomogram (camera)

p - Copy current graphic into the right site of the 3D main window (in the back).
s - Stop/start rotation of the tomogram
a - save the rotation as animated Gif

Hint: In case the tomogram requires special calculation options then these settings can be done like normal in the settings window. Select the file in the list before by left-clicking. Re-run the calculation.

Meaning of the icons in the 3D window

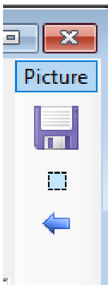
Left menu



1. Add files to the list
2. Remove files from the list
3. Calculate tomogram(se)
4. Load photo of the tree in which the tomogram is to be merged.
5. Start 3D Graphic. (Terminate 3D calculation with ESC-key)
6. Switch between Photo – Tomogram at the left side. Is available after a photo was loaded.
7. Save left image.
8. Change transparency of the tomogram laying over the photo. Available after running the 3D function.
9. Re-size (larger – smaller) the merged tomogram. Is available after the 3D window was closed.

Transparency level: 0% 50% 70%

Right menu



1. Toggle between cut-view and 3D view of the tomograms. Hit “p” before to copy the 3D vies as an image into the right side of the window..
2. Save image on the right as *jpg.
3. Select a rectangular selection in the right image.
4. Transfer the right image, or the selected part of it, into the photo on the left side.

Hint: In order to calculate 3D ERT graphics of a tree, the measurements at each level need to be calculated using identical calculation options. Proceed as follows:

1. Open an ERT file.
2. Select calculation options for the ERT calculation

   PC program *Configuration → Settings → Calculation*

   Example: Smoothness = 4, Mesh = 6, Colour scale = “Automatic”

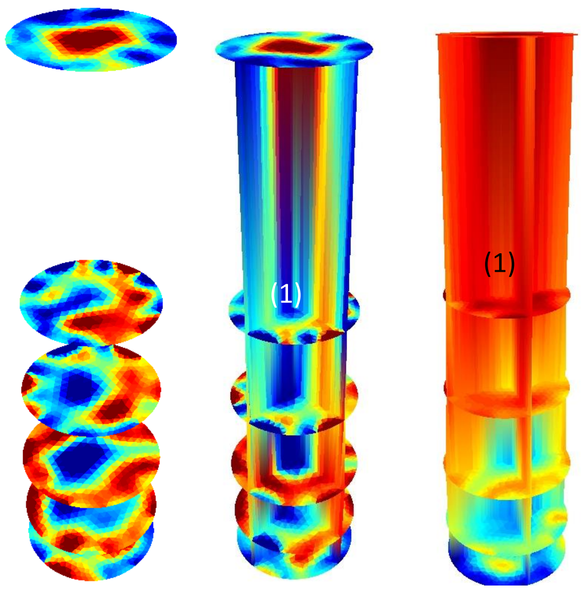
3. Open all files recorded on the tree and run the calculations.
4. Write down the minimum and maximum resistance recorded, shown in the legend of each ERT.

   Example:
   20 cm scan: minimal resistance = 23 Ωm; maximal resistance = 318 Ωm
   60 cm scan: minimal resistance = 46 Ωm; maximal resistance = 290 Ωm
   60 cm scan: minimal resistance = 39 Ωm; maximal resistance = 450 Ωm

5. Identify the minimum and maximum resistance levels of all files. In our example it is:

   Minimum: 23 Ωm; Maximum = 450 Ωm

6. Click on each file opened, un-check the “Automatic” option in the colour scale, and type in these boundary values. When the “Automatic” option is selected, all tomograms will use a different scale.
7. Re-calculate all files.
8. Save each file in order to store the calculated ERTs in the files.
9. Start the 3D window



ERT 1 ERT 2 ERT 3

ERT 1+2 was calculated in “Autoscale” colour mode. All tomograms use an independent full colour scale from dark blue to dark red.

ERT 3 were calculated using the same resistance range: variations between levels become visible (1).

To save the images, proceed as follows.

1. Push “s” to stop the motion.
2. Push “p” to copy the current screen into the 3-D project window. Close the 3-D window.
3. “Right click” in the right window to open an on-screen menu. Select “save” to save the image.

Alternatively the “alt” + “print” keys can be used to copy the current screen into the window clipboard. From here it can be pasted into other image-processing programs.

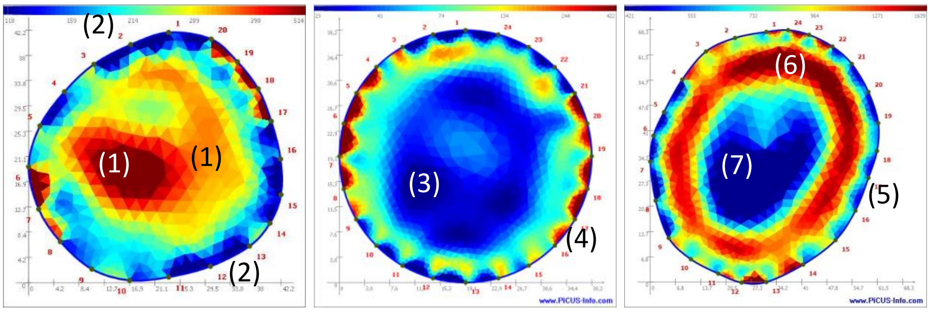
8 Interpretation of ERT

8.1 How to read resistance tomograms

The main aspect of interpreting ERTs is the distribution of high and low conductive areas. You are looking to see where high resistance is and where low resistance is. This information needs to be compared with the normal resistance distribution in sound trees of this particular species.

The actual value of the resistance given in a tomogram is less important and less accurate, due to the ambiguity of the measuring method.

So far we have identified three types of typical resistivity distributions in trees which we simply call ERT Type 1, 2 and 3.



ERT Type 1 Type 2 Type 3

8.1.1 ERT Type 1

Low resistance (high conductivity = blue colours) on the outside and **high resistance** (lower conductivity = red colours) towards the inside of the tree. This ERT shows the normal resistance distribution of a sound beech tree. The heartwood (1) of beech trees is less conductive (**higher resistance**) than the edge of the tree. The blue the ring on the outside (2) shows the bark/sapwood for water transportation.

Many tree species, in particular most of the European tree species, belong to this group:

*Acer (*Maple*), Asculus (*Chestnut*), Betula (*Birch*), Castanea sativa (Sweeet chestnut), Cedrela odorata* (Spanish cedar), Cinnamomum camphora (camphor tree) , many *Eucalyptus* (Eukalypt), *Elaeis guineensis (Oilpalm)*, *Fagus (*Beech*), Fraxinus (*Ash*), Larix (*Larch*), Pinus (Pine), Picea (Spruce), Populus (*Poplar*), Mimosoideae (Acazia), Salix* (Willow)*, Sorbus (*Whitebeam, mountain-ash*), Swietenia macrophylla* (Mahagoni), *Tilia (*Linden tree*), Ulmus* (Elm) and others.

Species like *Asculus* or *Populus* often develop internal wet wood even when they are young. The wet wood changes the resistivity of the heartwood. Early stages of the wet wood do not pose a risk for the stem breaking stability.

8.1.2 ERT Type 2

High resistance (low conductivity – red colours) **on the outside** and **low resistance** (high conductivity – blue colours) towards **the inside** of the tree. The example above is an ERT of a sound sequoia giganteum tree shows low resistance in the centre (3) - blue colours). The bark/sap-wood has higher resistivity (4) - red colours than the heartwood. That does not (!) mean the sapwood is dry! The absolute values of the sapwood indicate that the wood is conductive – because of the moisture content, it is not dry – but it is less resistance is higher than the resistance of the heartwood.

Examples are: *Sequoiadendron giganteum, Casuarina (Horse tail tree), Samanea saman (Rain tree), Tectona Grandis* (Teak)

8.1.3 ERT Type 3

Type 3 ERTs show a ring – like R distribution. The example was taken on *Quercus robur*.

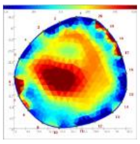
In the ERT the blue ring (5) - low resistance- on the outside represents bark/sapwood. The blue low resistance centre (6) of that *Quercus robur* is caused by high concentration of several ions. These tomograms are typical for sound *Quercus robur* trees.

8.2 Combined analysis of ERT and SoT

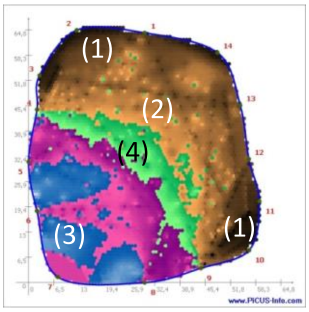
In order to interpret SoT and ERT in combination the following decision tables can be used.

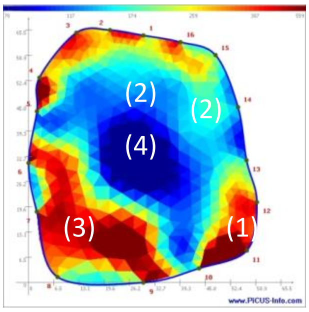
8.2.1 ERT type 1 decision table

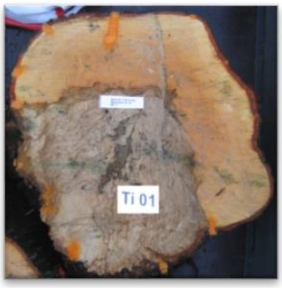
SoT – Sonic Velocity [m/s]	**ERT Resistivity [Ω * m]**	**Wood status**	**# in Tomogram**
High (brown)	High (red)	Sound wood	(1)
High (brown)	Low (blue)	Still safe, but early decay	(2)
Low (blue/purple)	High (red)	Cavity / crack / dead decay	(3)
Low (blue/purple)	Low (blue)	Decay	(4)



The example shows a *Tilia* tree with different stages of decay.



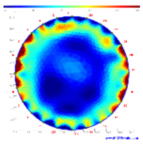




SoT ERT Photo

8.2.2 ERT type 2 decision table

SoT – Sonic Velocity [m/s]	**ERT Resistivity [Ω * m]**	**Wood status**
High (brown)	Low (blue)	Sound wood. Ambiguous, eventually early dceay
High (brown)	High (red)	Ambiguous, may be dry hard fungi
Low (blue/violet)	High (red)	Cavity / crack / dead decay
Low (blue/violet)	Low (blue)	Decay



8.3 Limitations of the method

The ERT data measured are ambiguous; several resistance distributions in a tree can cause the same readings at the circumference. Therefore, the electric resistance measurements may not show the correct results in the following situations:

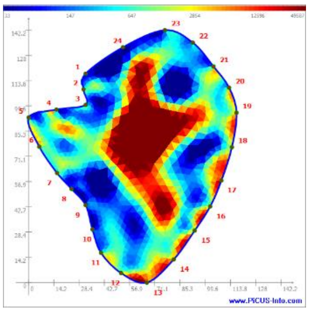
1. Measurements close to ground level. The ERT calculation assumes the (infinite) extension of the tree above and below the measuring level. This condition cannot be fulfilled when measuring close to the ground because the cylindrical cross-section of the trunk develops into the root system beneath ground level. However, particularly in highly conductive wood near/under ground level (such as can be found in trees with a fungus infection), this will be shown correctly.

2. Hollow trees. The remaining ring of wood is very conductive compared to the hollow centre of the tree. The calculation may not be able to identify the cavity correctly (the cavity should have high resistance) if the distance between the measuring points is too large.

Example1:	Tree diameter:	1 meter
	Remaining wall thickness:	~10 cm
	Distance between MP:	**30 cm**
	Result: an ERT may fail to show the high resistance of the cavity correctly.	

Example 2:	Tree diameter:	1 meter
	Remaining wall thickness:	~10 cm
	Distance between MP:	**5-10 cm**
	Result: the ERT will show the high resistance of the cavity.	

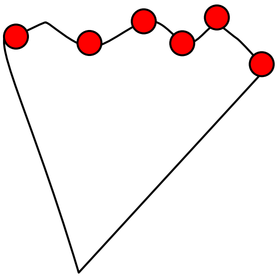
3. Water-filled cavities. A cavity filled with water could be shown with blue colours (high conductive) in the ERT.
4. Multiple damages. The ERT of trees having multiple damages such as cavities, decay, cracks, bark inclusions in the level of tomography will be not as accurate as a tree having just one of those damages.
5. Apparently wrong colours for sound wood. The ERT is showing the relative resistivity of the wood. In case the tree has a large cavity (dry and empty) then this cavity will determine the upper end of the resistivity range and will be shown with red colours. In relation to this very high-R area the remaining sound wood is always "wet". Thus, the remaining wood will be shown with blue colours (low R). The image to the right shows an example: The red area in the centre is a cavity and cracks. Most of the blue parts around it are the "normal" wood. The "normal" wood is naturally more "wet" than the cavity is.

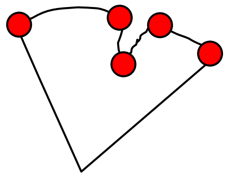


8.4 Trouble shooting

8.4.1 Mesh creator

The mesh (or net) generator calculates the net of triangles. In rare cases the calculation of the net can fail. This is due to misplacement of sensors. The distance between MPx and MPy is too small and the distance between MPx and the centre (of the tree) is very different to the distance between MPy and the centre.

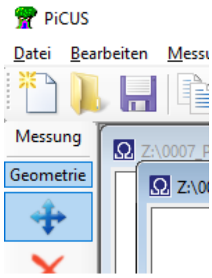




Left sketch: Net generator works well. The distance between the MP is small and the adjacent MP have approximately the same distance to the centre of the tree.

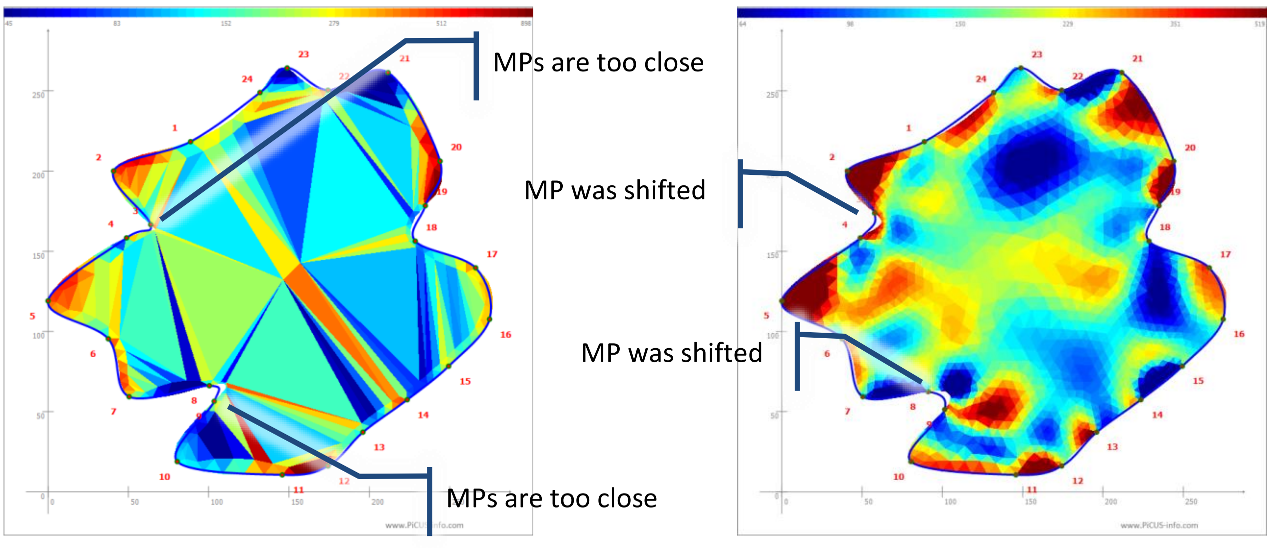
Right sketch: Net generator might fail. The distance between the MP is small and the adjacent MP have very different distances to the centre of the tree.

8.4.2 Mesh creator failure example



The left ERT in the example below is the original geometry recorded using the calliper. However, the net-creator failed due to the close distance in-between MP 3-4 and MP 8-9.

The tomogram on the right is calculated correctly because the distances in-between those points were increased by using the MP-shift function of the Q74 PC software. In the right ERT points were shifted to increase the distance in-between.



Mesh = 6

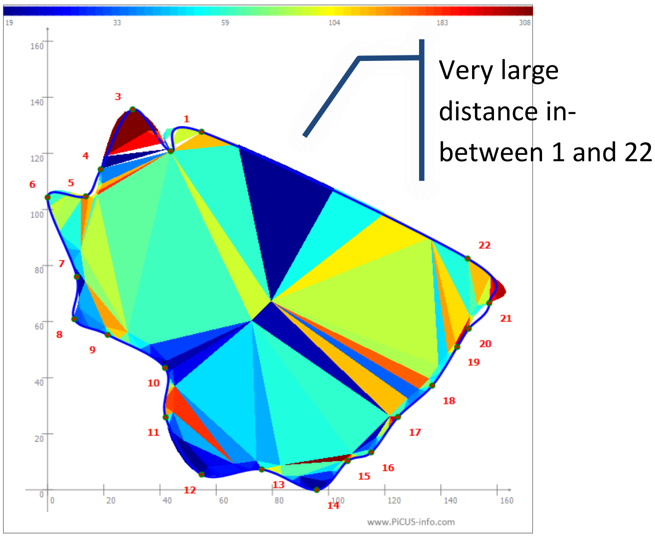
Mesh = 8, Position of MP 3 and 8 changed

In some cases the problem can be solved by using a higher "mesh" number.

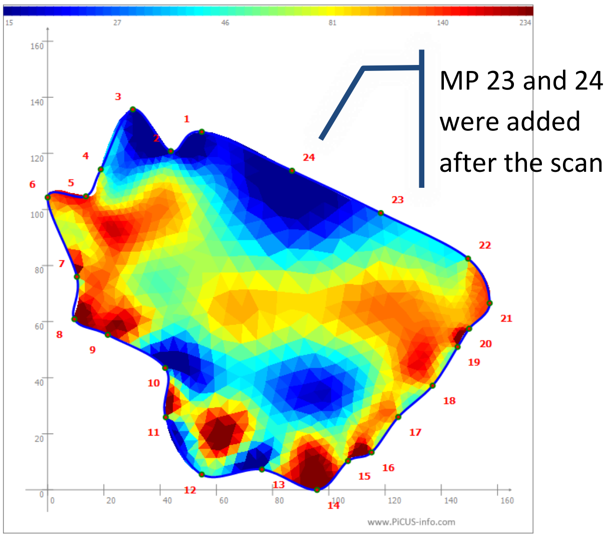
8.4.3 Trees with large open cavities

The net-creator works best if the measuring points are distributed around the circumference with approximately similar distances. Trees with large open cavities may not allow to do so.

The left ERT shows a *Tilia* tree with large open cavity at ground level. No MP could be set in-between MP 1 and 22. The net creator fails because it cannot handle the large variation MP-distances.



Incorrect triangles



Correct ERT

In order to obviate this problem proceed like this:

1. Create a copy of the original ERT data file.
2. Open the ERT file and add two more MP in-between MP 1 an 22:

   PiCUS PC program: Main menu → "Measurement" → *"Geometry"* → *"Add 2 MP"*

   Select the MPs in-between which the extra points need to be located. In the example it is MP 22 and 1. No extra measuring U-I data is needed to do so. The extra points MP 23 and 24 only supply additional geometry information.
3. Re-run the calculation.

The ERT above on the right shows the result. Please mind that the calculated R values in the area of the opening, where the new points have been added, are not necessarily accurate. The low R value near MP 24 – where the opening is – are incorrect.

9 Firmware updates of the TreeTronic 3

The TreeTronic 3 system contains of several µControllers. The software for these µControllers is called "*firmware*". "In electronic systems and computing, firmware is the combination of persistent memory and program code and data stored in it..."(Wikipedia).

9.1 How to check the firmware version of the TreeTronic 3

The versions of the firmware can be checked in the "update" menu of the TreeTronic 3.

TreeTronic 3 *" Configuration"* → *"Updates"*

When this menu is called the following information is given (example):

"Display SW Vers.: 1.0"	- The firmware version of the display (screen of the TreeTronic 3) is "1.0"
"HW Vers. 10"	- The TreeTronic 3 hardware (the PCB) is "10". The hardware cannot be updated.
"SW Vers. 10"	- The firmware version of the TreeTronic 3 is "10".

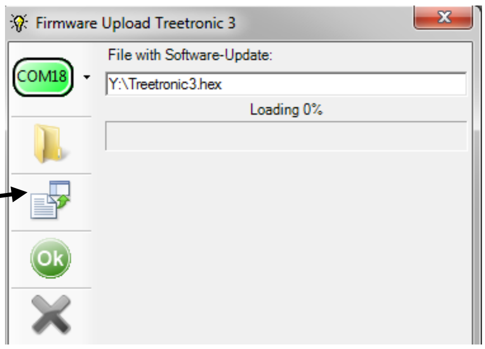
From time to time an update of some or all firmware versions may become necessary.

9.2 Update of the firmware of the Treetronic 3 main µController

This is the procedure to update the TreeTronic 3 firmware. Read the entire list before you start the update.

1. Turn TreeTronic 3 OFF.
2. Start PiCUS PC program.
3. Connect the TreeTronic 3 to the PC using the serial cable. Wait for the COM port to be created in case it is the first time this connection is made. Get the COM port number (Device manager). In the example the COM port number is 18.
4. PiCUS program Select "Configuration" → *"Firmware updates"* → *"TreeTronic 3"*
5. PiCUS program Select correct COM port, path and name of the update-file.
6. PiCUS program Open COM port.

Download to TreeTronic



7. PiCUS program Click download button
8. TreeTronic 3 Press ON button and **keep it pressed** until download is complete.

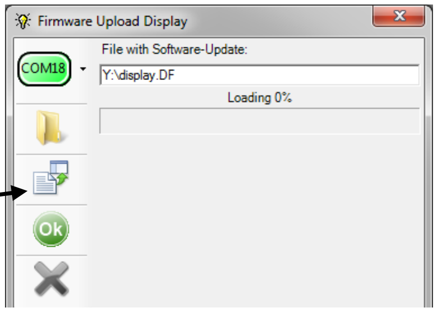
9.3 Update of the firmware of the Treetronic 3 display

This is the procedure to update the TreeTronic 3 display firmware. **Read the entire** list before you start the update.

The update process of the Treetronic display must not be interrupted. Interrupting or cancelling the update will result in a malfunction. The Treetronic must be returned to argus electronic if that happens. It is recommended to terminate all other program (email clients, Windows ® updates etc) on the PC while the display update is done.

1. TreeTronic 3 — Turn TreeTronic 3 ON.
2. TreeTronic 3 — *“Settings”* → *“Firmware updates”* → *“display”.*
Display shows *“Waiting for connection”*
3. Connect the TreeTronic 3 to the PC using the serial cable. Wait for the COM port to be created in case it is the first time this connection is made. Get the COM port number (Device manager). In the example the COM port number is 18.
4. PC program — Select “Configuration” → *“Firmware updates”* → *“display”*
5. PC program — Select correct COM port, path and name of the update-file.
6. PC program — Open COM port.

Download to TreeTronic



7. PC program — Click download button and wait for the update to finish. **DO NOT interfere with download**. When the download fails the Treetronic needs to be send to argus electronic for service.
8. Turn Treetronic OFF and ON to complete the update.

10 Technical specifications

Number channels	24
Number of measuring points for ERT scans	8 to 24
Length of sensor-cable loom	3,5 m
Maximal outgoing current	20 mA
Maximal outgoing voltage	80 V
Accuracy of GPS receiver	0 to 20 meter, depending on environment
Battery capacity of re-chargeable NiMH Battery	2000 mAh
Nominal battery voltage	10V
Charging time	approx. 4 hours
Charging power specification	100/240 VAC, 50/60 Hz
Time of operation at 20°C, 12 sensors (during setup / ERT scan)	up to 12 / 4 h, depending on usage
Dimensions of the measuring case	55 x 42 x 13 cm
Over-all weight (case, Treetronic, tools, nails)	9 kg
Over-all weight (case, Treetronic, **PiCUS Calliper 3**, tools, nails)	10,5 kg
Weight of measuring case	4,8 kg

10.1 Accessories

In general all galvanic pins can be used attach the clamps to the outer wet rings of the tree. However, the use of noncorrosive material is recommended. Pin diameter is 0,5 mm to 3 mm.

10.2 Spare parts

10.2.1 Battery

The internal Treetronic battery is supplied by argus electronic gmbh. Please do not use other batteries. In case the capacity of the battery goes down send the unit to our laboratories for inspection and battery replacement. Skilled technicians can swap the battery by themselves.

Treetronic 3 battery pack

10.2.2 Spare parts item numbers

Number plates TreeTronic 3 Cables (left/right)

#	Item number	Item name
1	901000010	Treetronic 3 battery
2	900100001	Number plates, numbers 1 to 24
3	100201010	Treetronic 3 cables for left socket (red connector), Channel 1 to 12
4	100201011	Treetronic 3 cables for right socket (blue connector), Channel 13 to 24

11 Contact information

argus electronic gmbh
Erich-Schlesinger-Straße 49d
18059 Rostock
Germany

Tel.: +49 (0) 381 / 49 68 14 4-0
email.: info@argus-electronic.de
home: www.argus-electronic.de

Author of the manual: Lothar Göcke