SFM1x Sap Flow Meter Quick Start Guide

Version 1.0

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1. Quick Start Guide

Note: The SFM1x needles are made of hollow 1.3mm stainless steel tubing. They can easily be damaged if basic care is not taken in handling the instrument.

Please read this entire document before installing your SFM1. If you are unsure about anything regarding your instrument, please contact ICT International before use.

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2. System Requirements

2.1 Hardware

The minimum system required to run ICT Combined Instrument Software (CIS) is :

Intel Atom 1.66 GHz and 1GB RAM or higher.

2.2 Software

ICT Instrument software is compatible with the following Operating Systems:

a. Windows 8 & 8.1
b. Windows 10

2.3 Screen Resolution

ICT Combined Instrument Software works best on computers that have a screen resolution of 1024x 768 or higher.

3. Charging the SFM1x Internal Battery

The SFM1x is a self-contained instrument that incorporates a lithium-ion battery. Before using the instrument, this battery should be charged. ICT International recommends using part number CH24.

A solar panel can be connected to the SFM1x in the field, see Figures 1-3 for more details.

The unique power bus-plug design was developed by ICT International to simplify the electrical wiring process. It minimizes the need for custom tools in the field, requiring only that the outer cable sheath be stripped back to expose the copper wire.

As shown in Figure 1, no other tools are required. Retaining straps ensure the power bus plugs do not separate from the instrument when removed from the power bus during wiring preparation and connection of external power.

3.1 Connecting a Power Supply to the Instrument

Important: Do not connect external power until the final step

1

Remove both ICT Bus plugs from either end of the sensor.

2

Unscrew the end of the plug 1 to 2 turns.

3

Remove the Bus plug sealing cap.

4

Insert either polarity of the external power source cable.

5

Strip a maximum of 15mm from the end of the cable.

6

Pull the cable back so only that the stripped wires protrude from the ICT bus plug.

7

Bend the stripped wires back over the end of the ICT bus plug.

8

Important : Seal the cable against water ingress by tightening the end of the plug.

Repeat for second bus plug

9

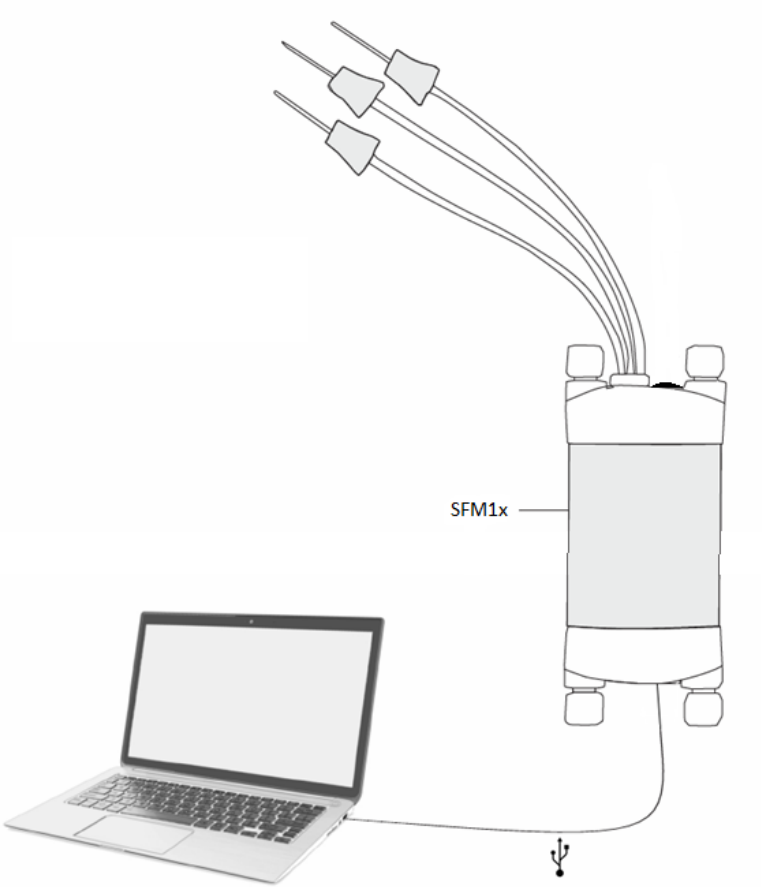
Insert the ICT bus plugs into the endcap of the sensor. The plugs can be inserted in either polarity and will click when seated into position.

10

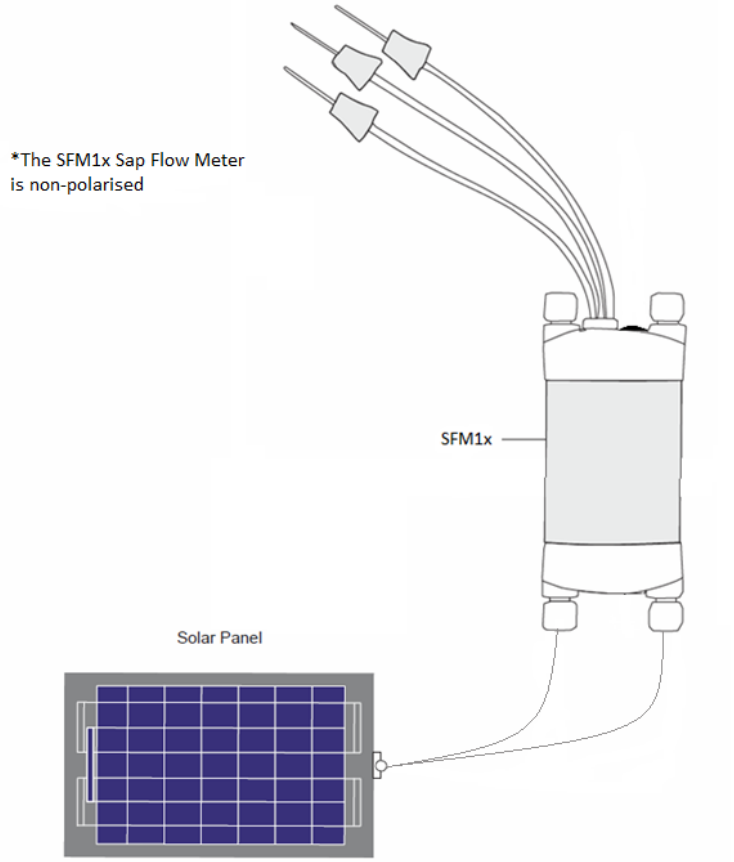
Connect the power cable to the external power source.

Figure 1. Connecting wires to power bus plugs.

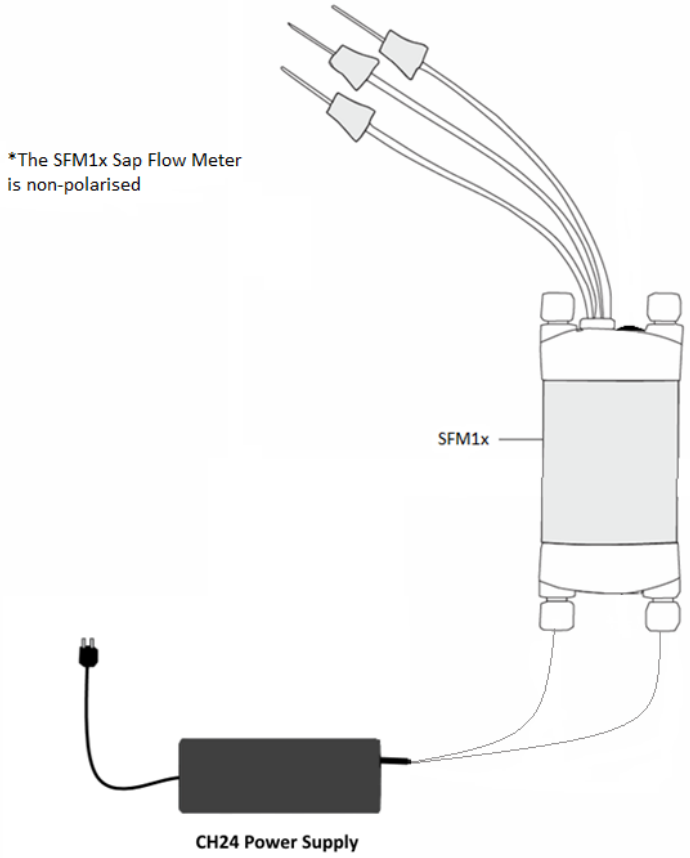
3.1.1 Connecting Power via USB C Cable to a Laptop/PC



3.1.2 Connecting Power Directly via Solar Panel



3.1.3 Connecting Power Directly via CH24

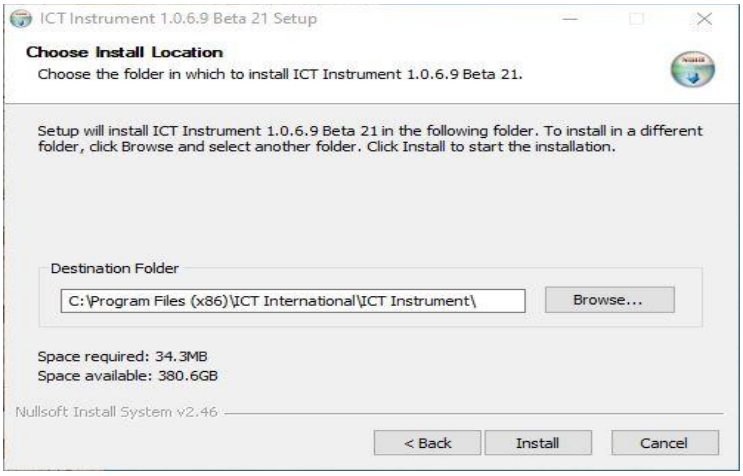


Note: Continuous connection of an external battery or constant power supply (for days to months at a time) is not recommended as this can shorten the life of the internal battery. ICT International recommends using a solar panel directly connected (with no external battery backup in parallel) wherever possible, or a timer switch to turn off external power for 8-12 hours daily to simulate a solar panel during the day and night.

4. Install ICT Combined Instrument Software

Insert the supplied USB drive and run ICT Instrument-1.0.6.9 Beta 21.exe.

Choose Next (a) and then choose the desired installation location (b) and then Install (c).



The most recent versions of all ICT Software are available from: http://www.ictinternational.com/support/software/

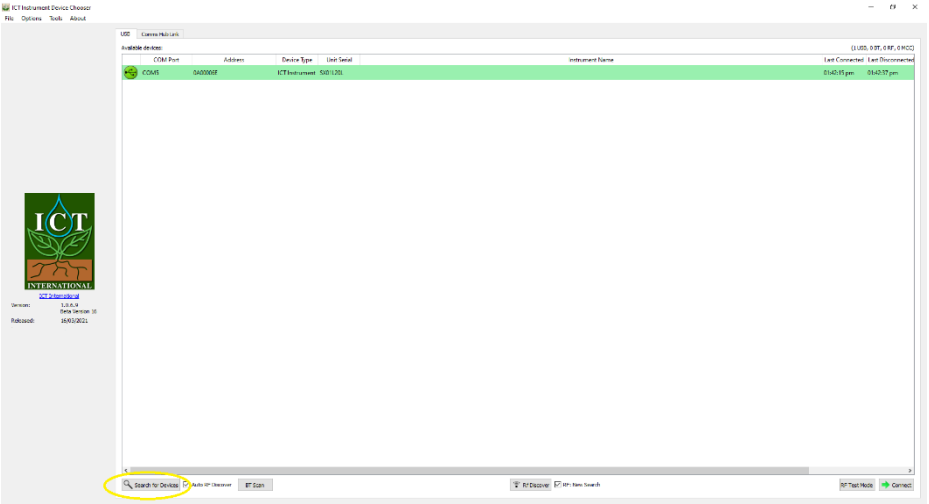
5. Turn the Instrument On

To charge and turn on your SFM1x, connect the instrument to a computer via a USB cable. Alternatively, the SFM1x can either be turned on manually by pressing the power button or automatically by connecting an external power supply.

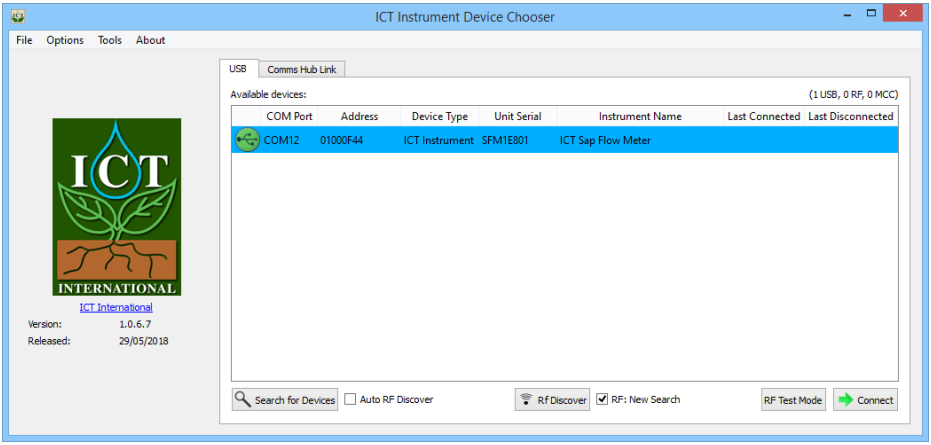
6. Connect to the Instrument

6.1 Connecting via USB

Connect the USB cable to the instrument and the computer. The SFM1x will automatically be detected by the computer, as with any USB device. Open ICT Instrument Software and Search for Devices.



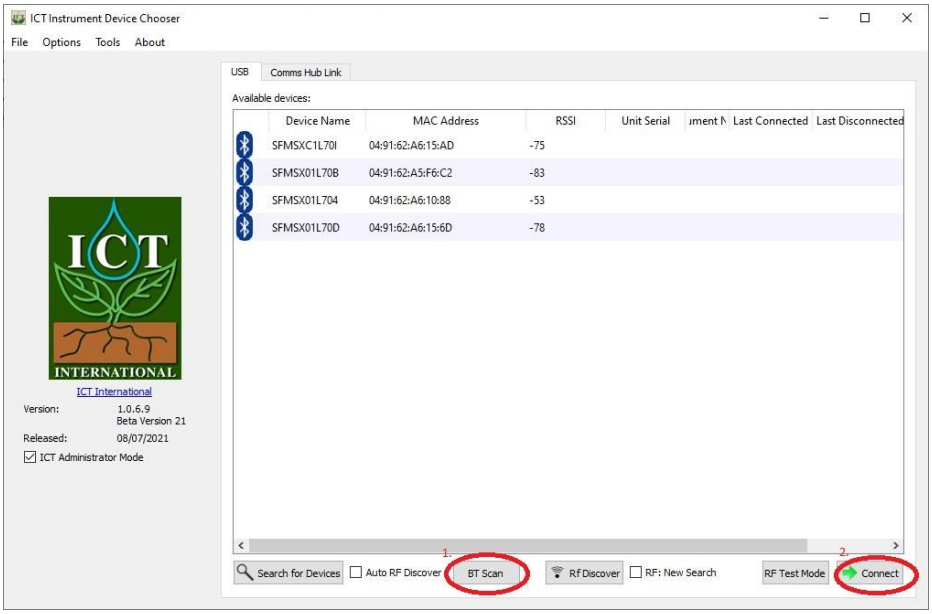
Double-click the instrument in the list to connect to it or select it and click ‘Connect’.



6.2 Connect via Bluetooth

Ensure that the SFM1x is on. Press BT Scan, ICT Instrument Software will then begin scanning for available instruments.

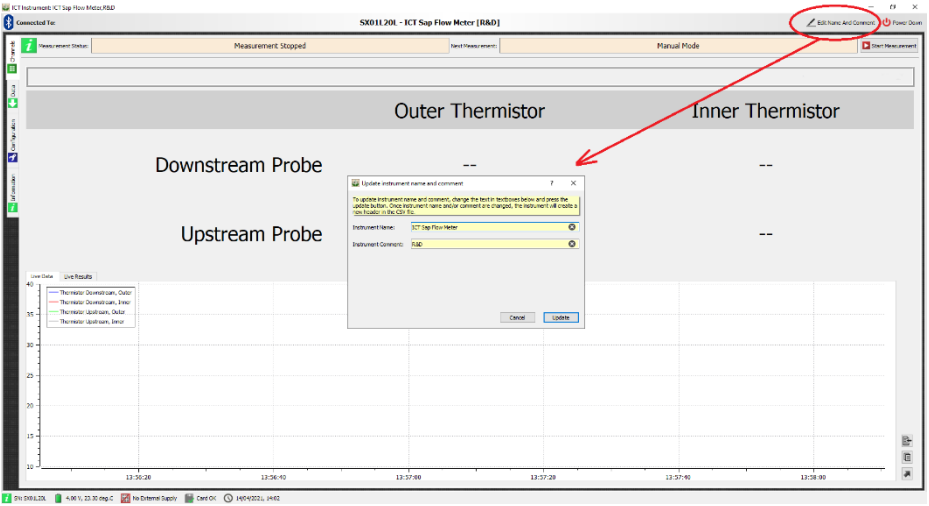
You can double click the instrument, or select it and Connect, as with USB.



7. Instrument Information

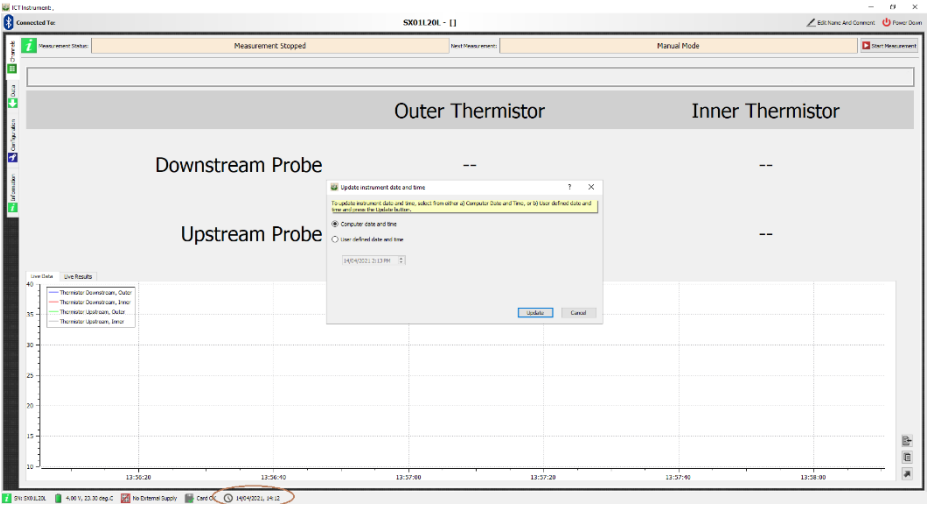
In ICT Instrument Software, fields are given for naming and adding a comment. This naming system can be helpful for experiments, for instance, naming them based on the location or purpose of the SFM1x, and to tell them apart easily.

The Name field is visible in the Device Chooser list, this makes it easier to find the logger you wish to connect to when using multiple SFM1x loggers in the field.



7.1 Set Date and Time

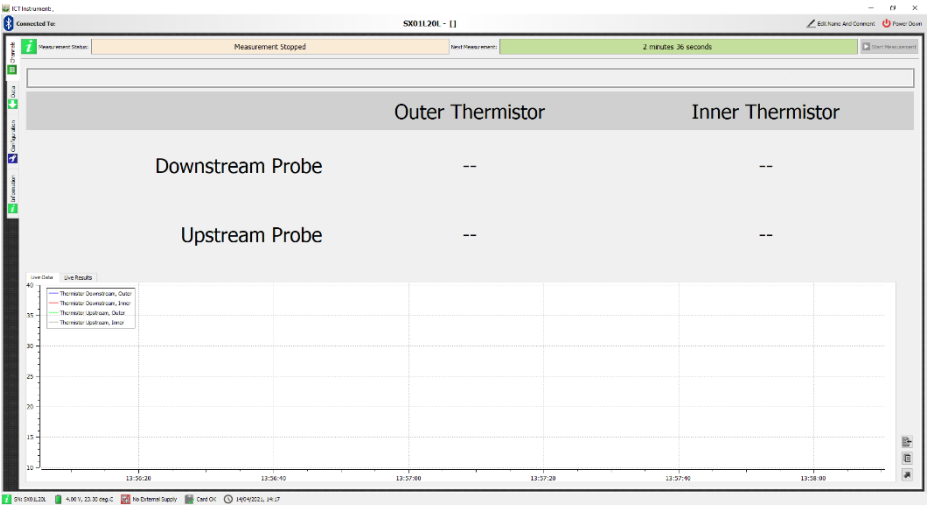
SFM1x instruments are delivered with the clock set to Australian Eastern Time (UTC +11). In case the clock needs to be adjusted to your local time zone, click the Date and Time at the bottom of CIS.



The date and time can be automatically set to the date & time of the computer that the SFM1x is connected to by selecting the option “Computer Date and Time”. An alternative option is provided to update the instrument to a user-defined time.

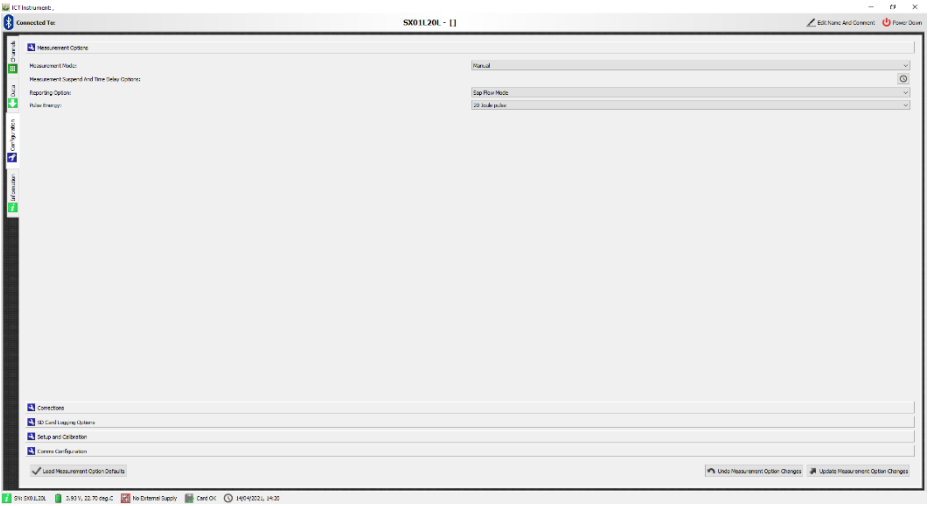
8. Set the Measurement Parameters

When you connect to an instrument, the Channels screen will be displayed. This shows the current measurement status, when the next measurement will take place, instrument serial number/name/comment, battery status, external power status, SD Card Status, and the instrument time and date.



You can also begin a manual measurement from this tab if the SFM1x is in Manual measurement mode.

8.1 Configuration



Measurement Options allow you to select the basic logging settings of the SFM1x.

Measurement Mode allows you to select a measurement interval between 3 minutes and 60 minutes. A good standard measurement interval is 10 or 15 minutes. Refer to the SFM1x Manual for more information about logging intervals.

Measurement Suspend and Time Delay allow you to set a time for the instrument to begin logging. This can be handy for completely setting up an instrument before installation in the field. Logging can be delayed for up to 24 hours (23:59:59), at which point it will begin to log at the set interval.

Reporting Option: Sap Flow Mode produces corrected and uncorrected sap flow values (cm/hr), as well as Sap Flow (kg/hr), temperature differences, ratios, pulse duration, and any other diagnostic information. This is stored on the MicroSD card in .csv format.
Sap Flow Mode should be used for most applications.

Needle Temperature Mode records raw temperature values in .bin format (cannot be opened in Excel/ICT DataView). These files are designed to be

interpreted with Sap Flow Tool. Needle Temperature Mode is generally not recommended.

Pulse Energy allows you to select the joules output during the heat pulse. 20 joules is appropriate for most applications. In delicate plants, you may need to use 10 joules to prevent damage. In plants with exceptionally high sap flow rates, you may need to use a higher value.

8.1.1 Corrections

Corrections are used for pre-processed channels – Corrected Inner and Outer; and Sap Flow (kg/hr). Note that data can be post-corrected in ICT DataView.

Probe Spacing allows you to set the distance between probes. By default, this is set to 5mm. The original HRM principle was developed using 6mm spacing, as such this option is provided, though it is not recommended. The standard drill guide uses 5mm spacing.

Base-line Asymmetry Multiplier and Offset are used to correct for small needle misalignments. See the SFM1x Manual for more information.

Thermal Diffusivity. A default value of 0.0025cm^2 s^{-1} is provided. For greater accuracy, the thermal diffusivity of the fresh (green) sapwood can be measured and entered. See the SFM1x Manual for more information.

Wounding Coefficient is used to correct for the wound response of the tree. This is usually measured after de-installation; however, some example values are provided in the SFM1x Manual.

Vs Factor is a multiplier used to convert corrected Heat Pulse Velocity to Corrected Sap Velocity. See the SFM1x Manual for more information.

Sap Wood Area is the cross-sectional area of conducting sapwood. This can be calculated automatically by entering bark depth, sapwood thickness, and tree diameter at installation/breast height into the SFM Water Usage mode of ICT DataView. Contact ICT International for more information.

8.1.2 SD Card Logging Options

Probe Selection. Inner and Outer is the default option and will record both measurement points. Inner Only and Outer Only are intended to be used in small stems where both measurement points are not within the plant.

Calculated Results. Available parameters are:
Raw Heat Pulse Velocity
Sap Velocity
Sap Flow in kg

All of these are logged by default.

Diagnostic Temperature Data records the max temperature, average temperature rise, and temperature ratios during the heat pulse measurement. This is not enabled by default but can be useful when troubleshooting measurement options.

Power Management. Available parameters are:
Internal Battery
External Supply

These record the status of the internal battery and external power supply. Both are enabled by default, and ICT International strongly recommends logging Internal Battery and External Supply as this is useful for troubleshooting and diagnostic purposes.

Raw Temperature Mode, number of measurements/second and **Raw Temperature Mode, number of measurements after the pulse.** These are used in Needle Temperature Mode. Contact ICT International for more information.

9. Install the Sensor

Care must be taken when installing the sensor to ensure that the needles are parallel. Corrections can be made, but there is no substitute for good preparation and installation. An installation video is available at: https://youtu.be/qj4poHlebD0

9.1 Measure the Plant

Remove any loose bark. Use stem diameter tape to measure the diameter of the plant at installation height. This should be below the first branch of the tree, and where possible, at breast height.

Measure the bark depth using a bark depth gauge or a flathead screwdriver with the tip horizontal to the stem. You should feel a change in resistance when the bark depth gauge/screwdriver reaches the sapwood.

Measure the sapwood thickness using a coring tool. Bore the coring tool into the stem at least halfway through the tree to ensure that the core passes through the sapwood into the heartwood. Remove the sapwood core and stain with an indicator dye.

See the SFM1x Manual for more information on measuring the plant.

9.2 Attach Installation Guide

Attach the installation guide to the tree using the 4 anchor pins. For small diameter stems between 10-25mm in diameter it may be necessary to pack the back of the installation guide with a stick to ensure a stable mounting of the guide on the stem. This should then be held in place with clear adhesive or sticky tape, so the holes of the guide are easily visible.

9.3 Begin Drilling

Commence drilling the three holes into the stem using a 1.3mm drill bit. Use a cordless drill on a high RPM setting to get good clean-cutting action.

Only drill short increments on each pass (2-3mm). The moist sapwood of the tree will build up in the flutes of the drill bit and will require cleaning. Continuing to drill with the flutes full of fiber will burn the hole and result in the installation site becoming unusable.

Note: A Dremel cordless drill is recommended as it does not have a handle with a large battery to act as a counterweight, which may cause difficulty when attempting to drill parallel holes.

9.4 Check the Holes are Parallel

After drilling all three holes, remove the drill guide and check the installation to see if the holes are aligned axially and parallel. This can be done by inserting three drill bits into the holes and visually inspecting them. A piece of 5mm lined notepaper can be a very handy guide.

Note: You should not attempt to drill the holes quickly, the set of three holes will take at least 10 minutes to drill correctly. If the guide slips or a drill bit breaks (and cannot be removed without removing the guide) it is advised that the installation be abandoned, and a new site be found to start a fresh installation.

9.5 Using Spacers

Before installation, you should determine the location of each measurement point in the sapwood. This should be done based on the measured bark depth and sapwood thickness. If the bark is greater than 10mm thick, some bark should be removed to allow the outer measurement point to sit 2.5mm below the cambium in the outer sapwood. If the bark is thinner than 10mm, small spacers can be used to locate the outer measurement point approximately 2.5mm below the cambium in the sapwood. This is useful for small stem installations where you need to ensure that at least one measurement point is in the sapwood.

Spacers can be made from an electrical cable sheath stripped from the figure-8 power cable used for charging the SFM1x. Use a razor blade to cut all three spacers the same length, with square edges on both sides.
If you can, insulate the installation with foam and aluminum foil to prevent ambient environmental conditions from affecting the measurement. Insulation is not normally necessary on installations that do not require spacers.

9.6 Greasing the Needles

Before inserting the needles, use a small amount of silicone vacuum grease to aid the installation and removal of the needles. This helps minimize the cementing action of sap and gums produced by the tree in response to wounding and will help when it comes time for uninstallation.

9.7 Attaching the SFM1x to the Tree and Installing the Needles

Position the instrument so that a gentle curve in the cable of the measurement needles is created to take the strain off the cables. Fasten the plastic mounting bracket in place using a strap, screws, or nails.

Carefully insert the needles into the holes. Do not use a hammer or other object to drive the needles in place, this will damage the needles.

You should only require finger pressure to insert the needles into the holes. If you find that it is too difficult to insert the needles, use the drill to gently ream out the holes and try again.

9.8 Insulating Needles for Small Diameter Stems

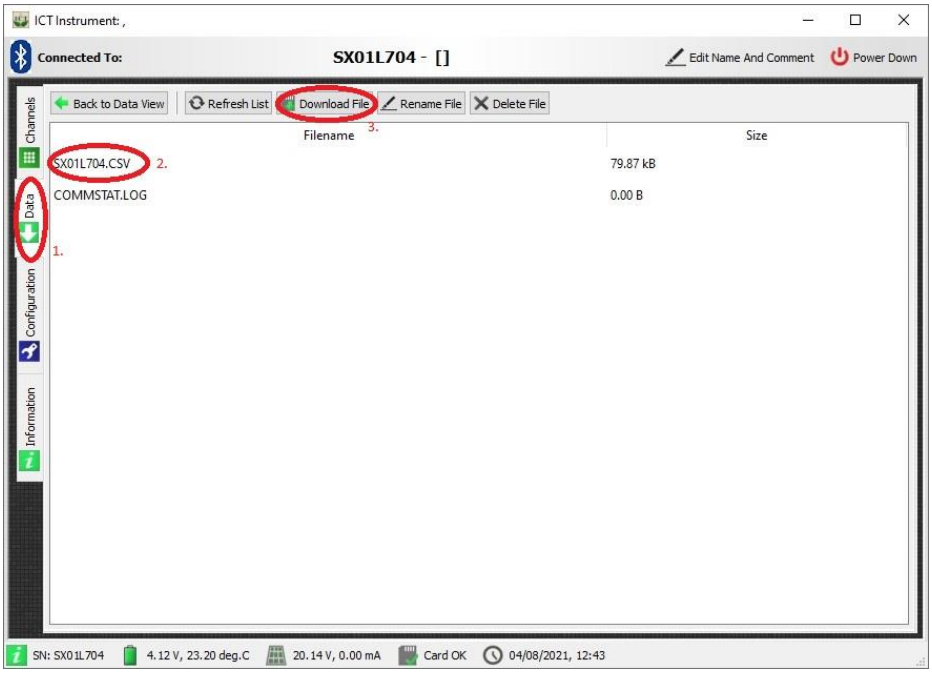
If the needles extend beyond the stem, they should be insulated from direct sunlight, as this will artificially heat the stainless-steel needles. A cable sheath from the figure-8 power cable can be used along with some insulating foam. Cover the full installation with aluminum foil to reflect direct radiation.

9.9 Uninstallation – Removal of the Needles

SFM1x needles can be safely removed from the installation site. A mini-crowbar or lever tool (part number SFM-LT) is required. Grasp the hubs of all three needles and turn them clockwise (~30-40°) and anticlockwise alternately [note: for left-handed, turn anti-clockwise first then clockwise]. This is to loosen the needles from the sapwood tissue (depending on tight the needles are bonded to the sapwood tissue, you might hear a cracking sound). Continue turning the needles [clockwise and anti-clockwise] until the bottom probe emerges from the install site. Use the lever tool with the needle in the slot and gently pry the need out. Do the same for the remaining needle probes.

10 Downloading Data

Data can be downloaded from the instrument in several ways. The simplest is to click Download File from the data tab of ICT Combined Instrument Software. Download can be made via USB or Bluetooth.



You will be prompted for a location to save the data file.

If you would like the SFM1x to begin a new data file, Rename or Delete the existing file.

The included MicroSD card can store many decades of data when recording in Sap Flow Mode, therefore it is not necessary to delete the data file from the MicroSD card. If you rename the data file a new data file will be started by the SFM1x, and the old data file can be retained as a backup.

10.1 Download Data Directly from MicroSD Card

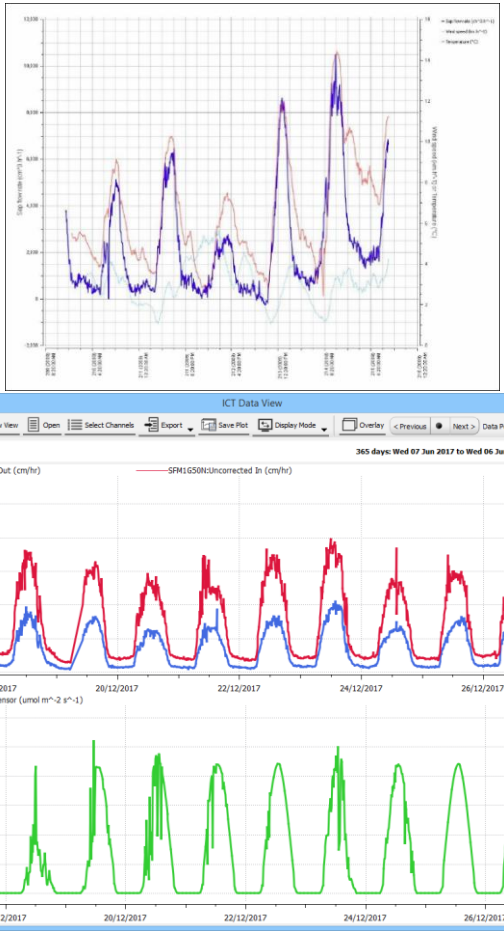
The MicroSD card can be removed from the logger and inserted into a MicroSD card reader. The data file (.csv or .bin) can be copied off onto your device, then simply re-insert the MicroSD card into the SFM1x.

Open the USB port cap to access the MicroSD card. The card is secured with a spring locking mechanism, push the card in slightly to eject it. Forceps or tweezers can be used to remove and insert the card.

11 Analyse Data

Data recorded in Sap Flow Mode is saved in .csv format (Comma Separated Values). Data recorded in Needle Temperature Mode is saved as .bin (binary). Both file types can be opened in Sap Flow Tool (www.sapflowtool.com – 30 day trial available) for post-processing and detailed analysis. .bin files can be processed and exported from Sap Flow Tool as .csv.

.csv files can be opened in ICT DataView for comparison with outer measured parameters, such as stem water potential, solar radiation, VPD, soil moisture, stem circumference, or any range of environmental sensors.



Sap Flow Tool (top), DataView (bottom).

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