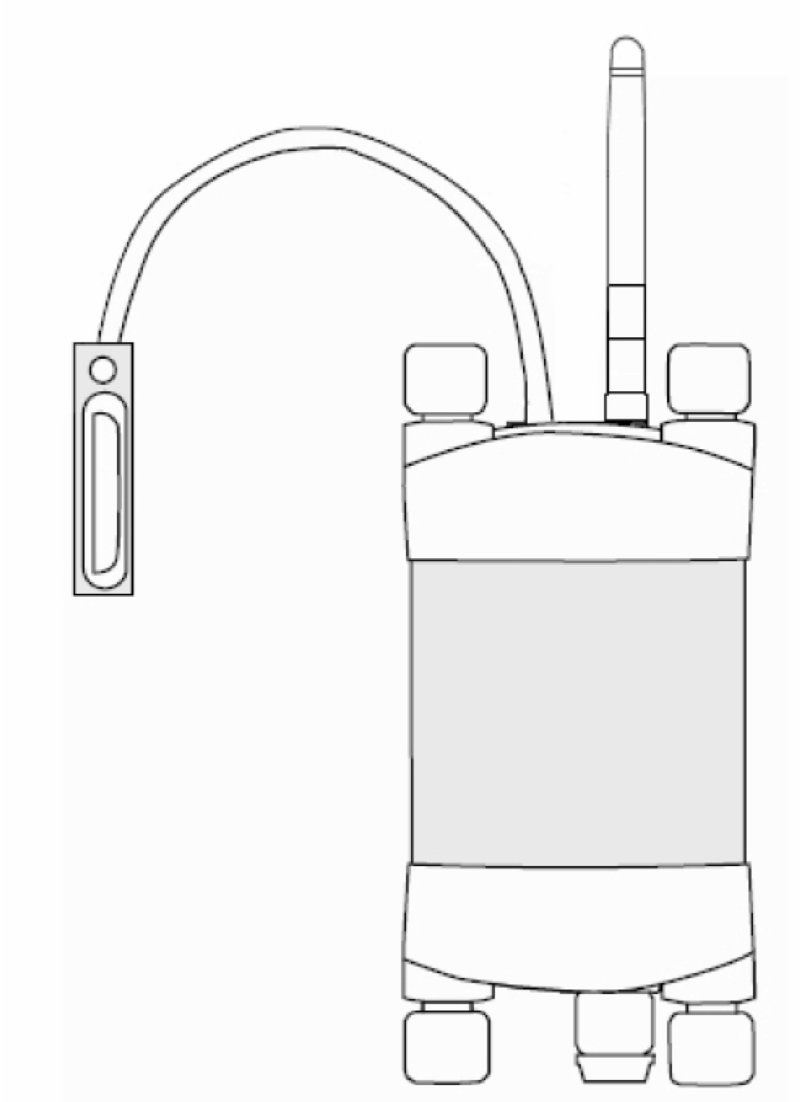
SOM1

Soil Oxygen Meter



April, 2018

Contents

1. Introduction

The SOM1 Soil Oxygen Meter is a complete system for collecting and storing data from up to five ICTO2 soil oxygen sensors. The SOM1 is equipped with an internal battery which provides power to the data logger. ICTO2 sensors are based on a galvanic cell principle and do not require any voltage input.

The SOM1 system is comprised of:

1. The SOM1 data logger
2. Breakout Box for sensor connection
3. ICTO2 Soil Oxygen Sensors

2. System Requirements

2.1 Hardware

The ICT Combined Instrument Software does not require a powerful computer.
Recommended Minimum System Specifications:

Intel Atom 1.66 GHz and 1GB RAM or higher.

2.2 Software

The ICT Instrument software is compatible with the following Operating Systems:

a. Windows 7
b. Windows 8 & 8.1
c. Windows 10
d. Mac OS X

2.3 Screen Resolution

The ICT Combined Instrument Software works best on computers that have screen resolution of 1366 x 768 or larger.

3. Charging the SOM1 Internal Battery

The SOM1 is a self-contained instrument that incorporates a lithium polymer battery. Before using the instrument, this battery should be charged. To choose from a range of charging options see:
Connecting a Power Supply to the Instrument (pages 7 to 11).

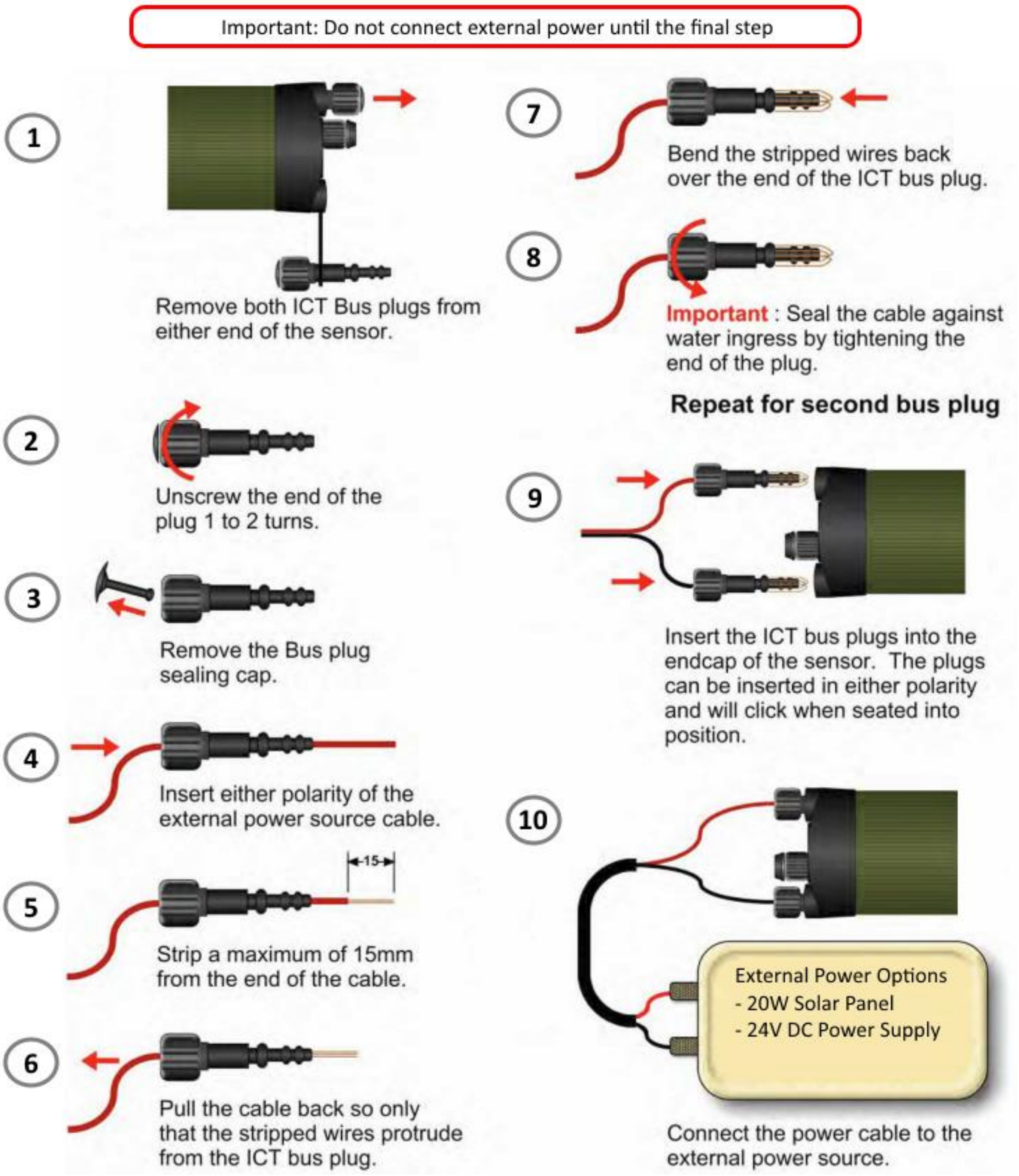
An external power supply should be connected to the SOM1 in the field.
See Connecting a Power Supply to the Instrument (pages 10 & 11) for more details.

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

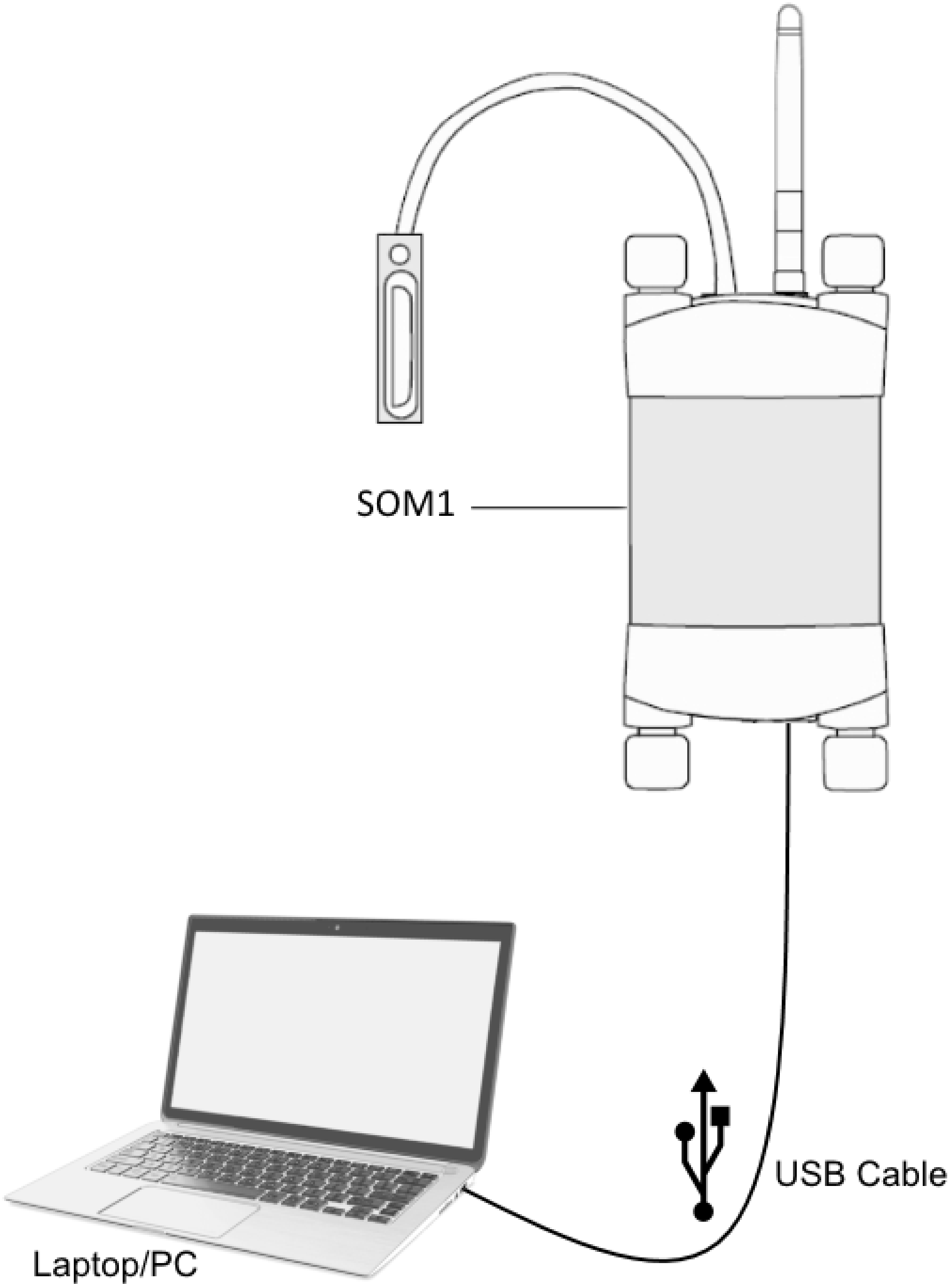
As shown in Connecting a Power Supply to the Instrument (page 7) no other tools are required, with all necessary components and fixings fully incorporated into the instrument design. Retaining straps ensure the power-bus plugs do not separate from the instrument when removed from the power-bus during wiring preparation and connection of external power.

3.1 Connecting a Power Supply to the Instrument

3.1.1 Individual Power Supply Connections



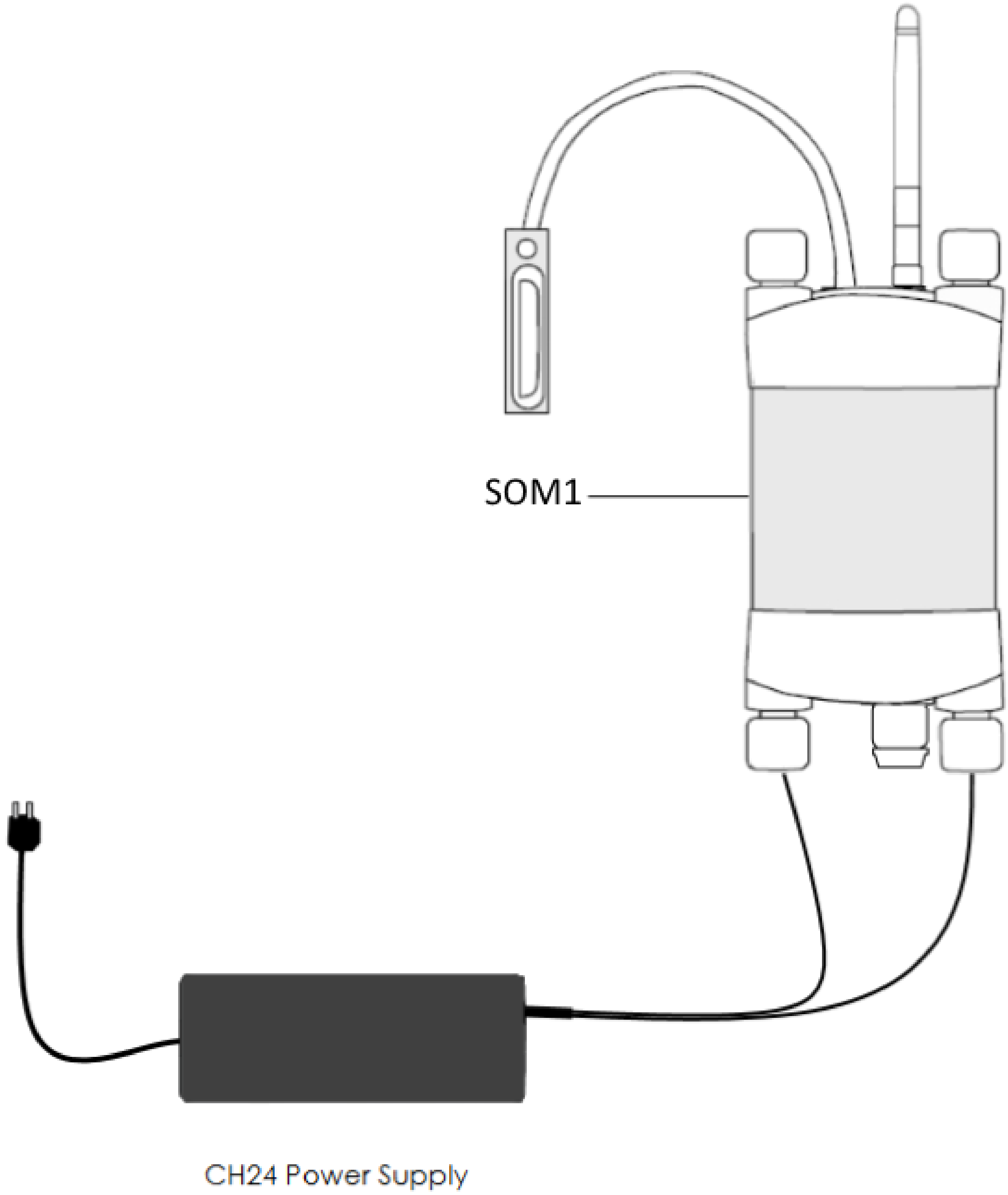
3.1.2 Connecting Power via USB Cable to a Laptop/PC



3.1.3 Connecting Power Directly via CH24 Power Supply

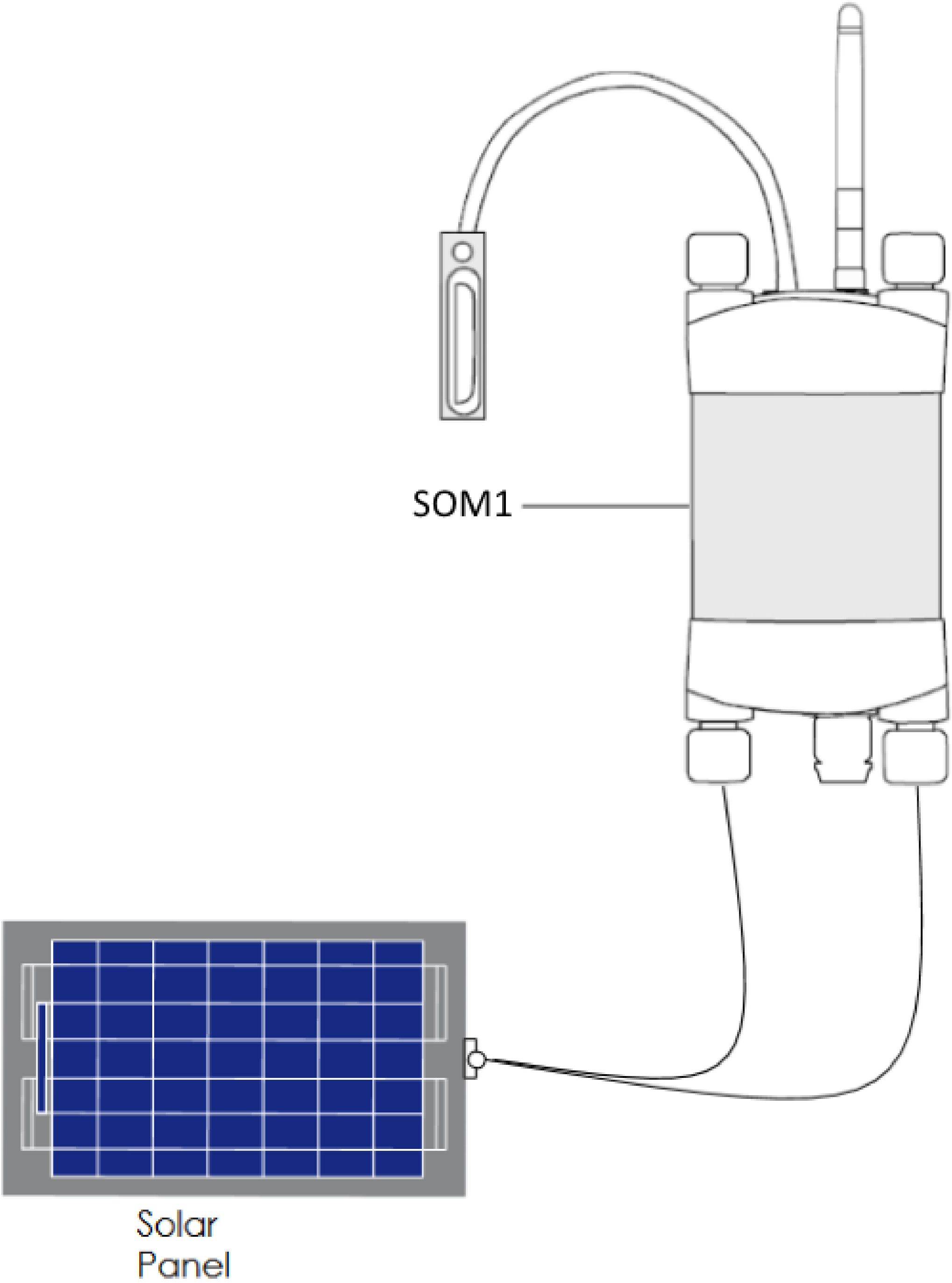
Note: The SOM1 is non-polarised.

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 recommend 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.



3.1.4 Connecting Power Directly via Solar Panel (Field Operation)

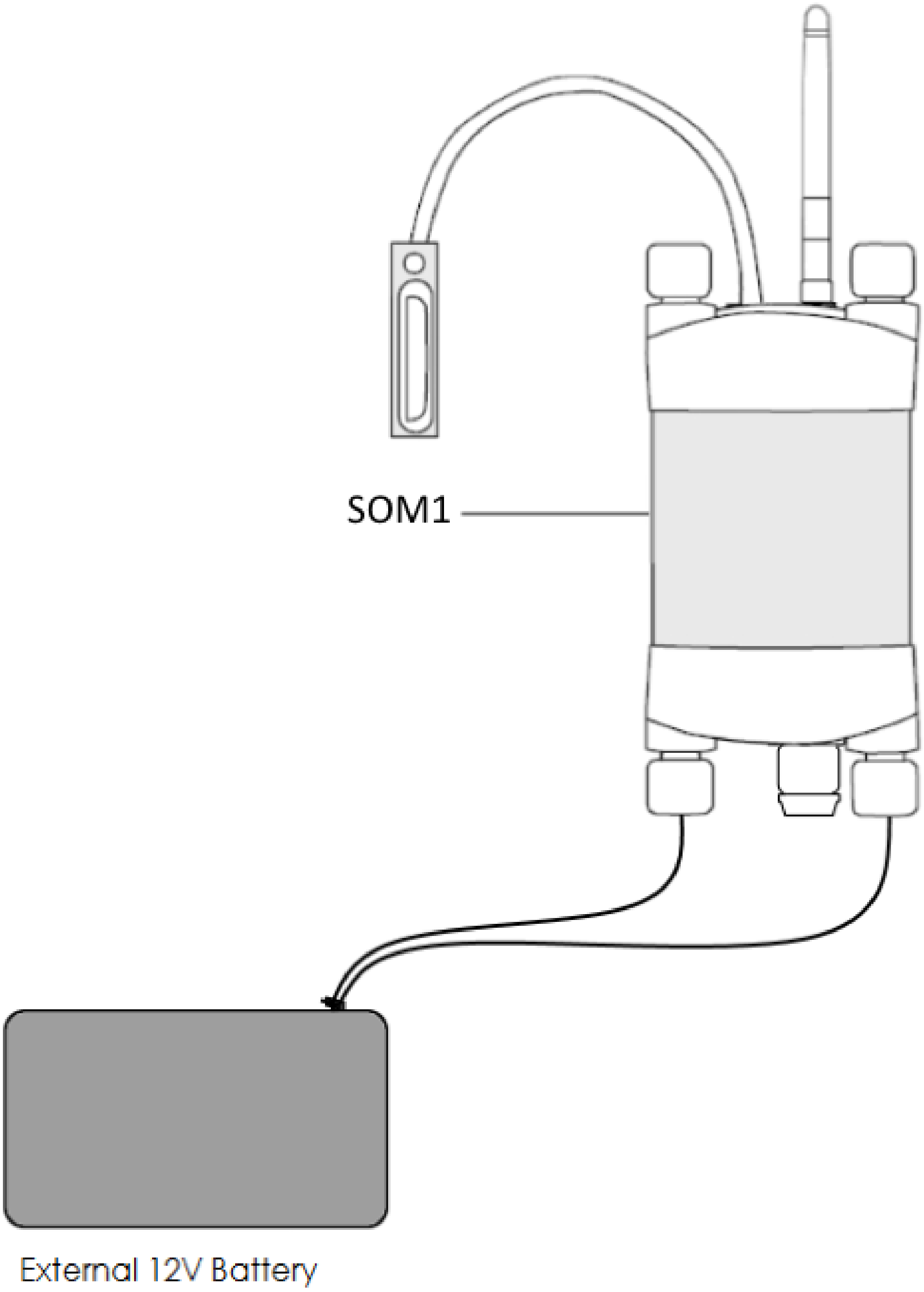
Note: The SOM1 is non-polarised



3.1.5 Connecting Power via External Battery (Field Operation)

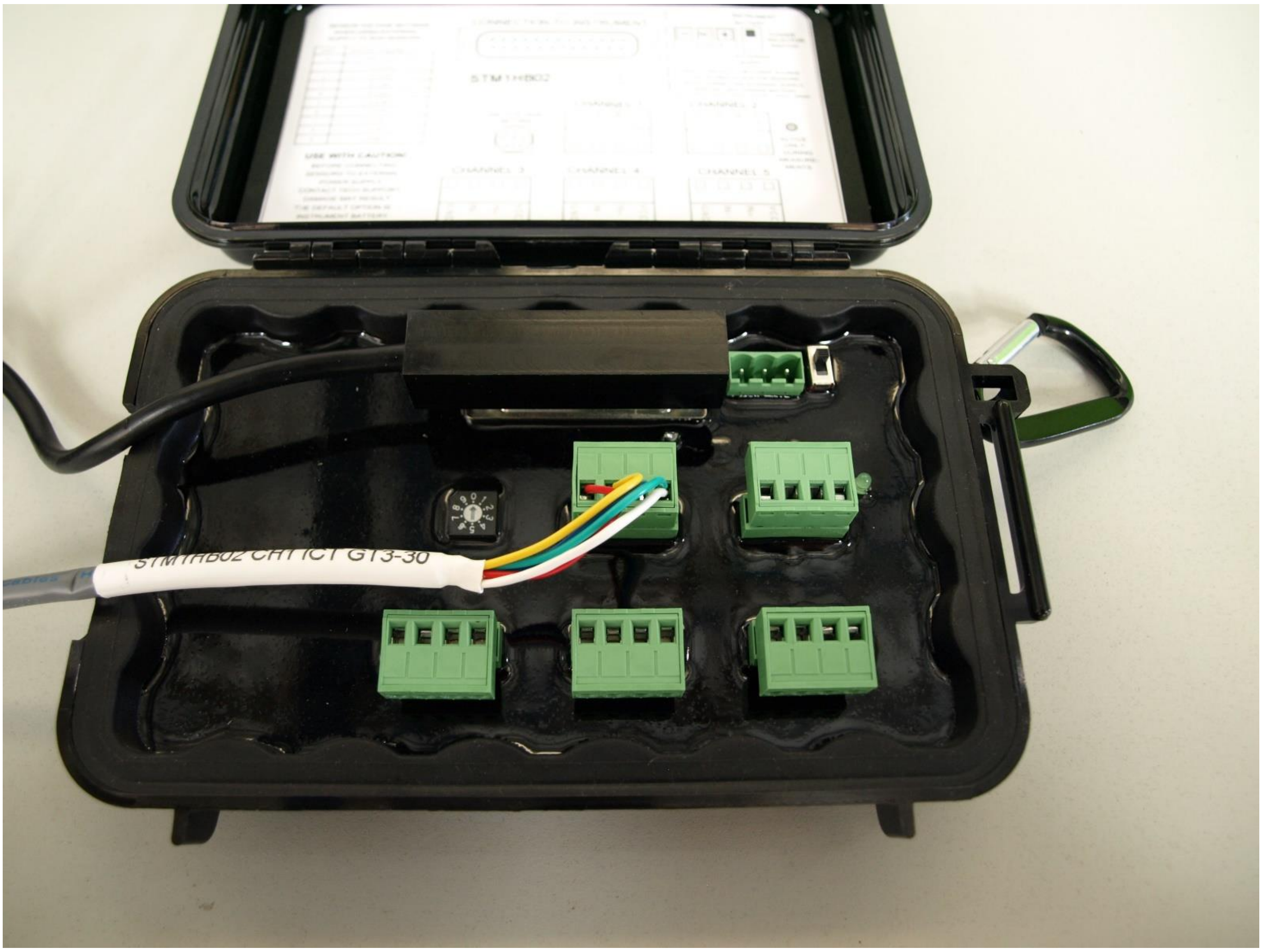
Note: The SOM1 is non-polarised.

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 recommend 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. Connecting Soil Oxygen Sensors to the SOM1

The ICTO2 Soil Oxygen Sensors are connected to the logger by inserting the green connector into the appropriate channel in the break-out box supplied with the system, please note the green connectors are keyed to plug in one way. Sensors purchased as part of the SOM1 package will come with a label stating the Serial Number of the Logger they are paired with, the Channel number it plugs into and make and model of the sensor.



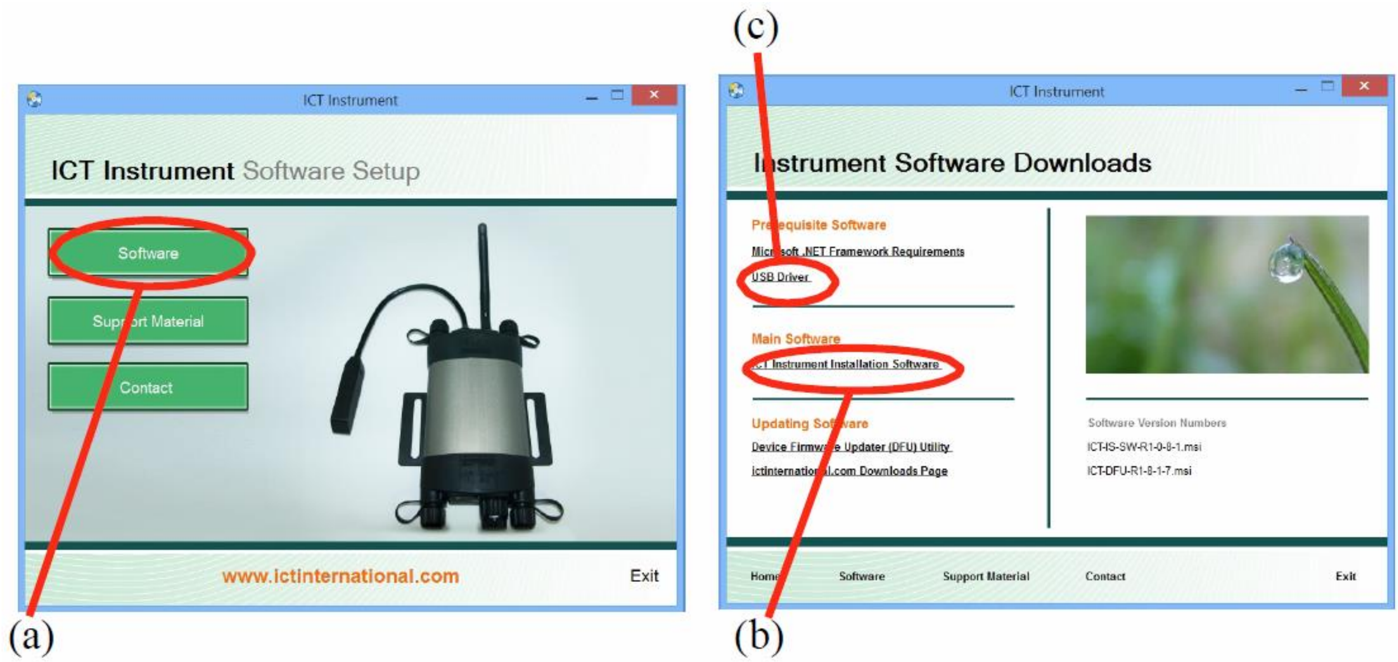
5. Install ICT Combined Instrument Software and USB Driver

Insert the supplied USB drive and run Autorun.exe.

Choose Software (a) then choose ICT Instrument Software (b).

Follow the on-screen prompts until the finished installation screen appears.

To install the USB driver, choose USB Driver (c) and wait for the installation to complete.

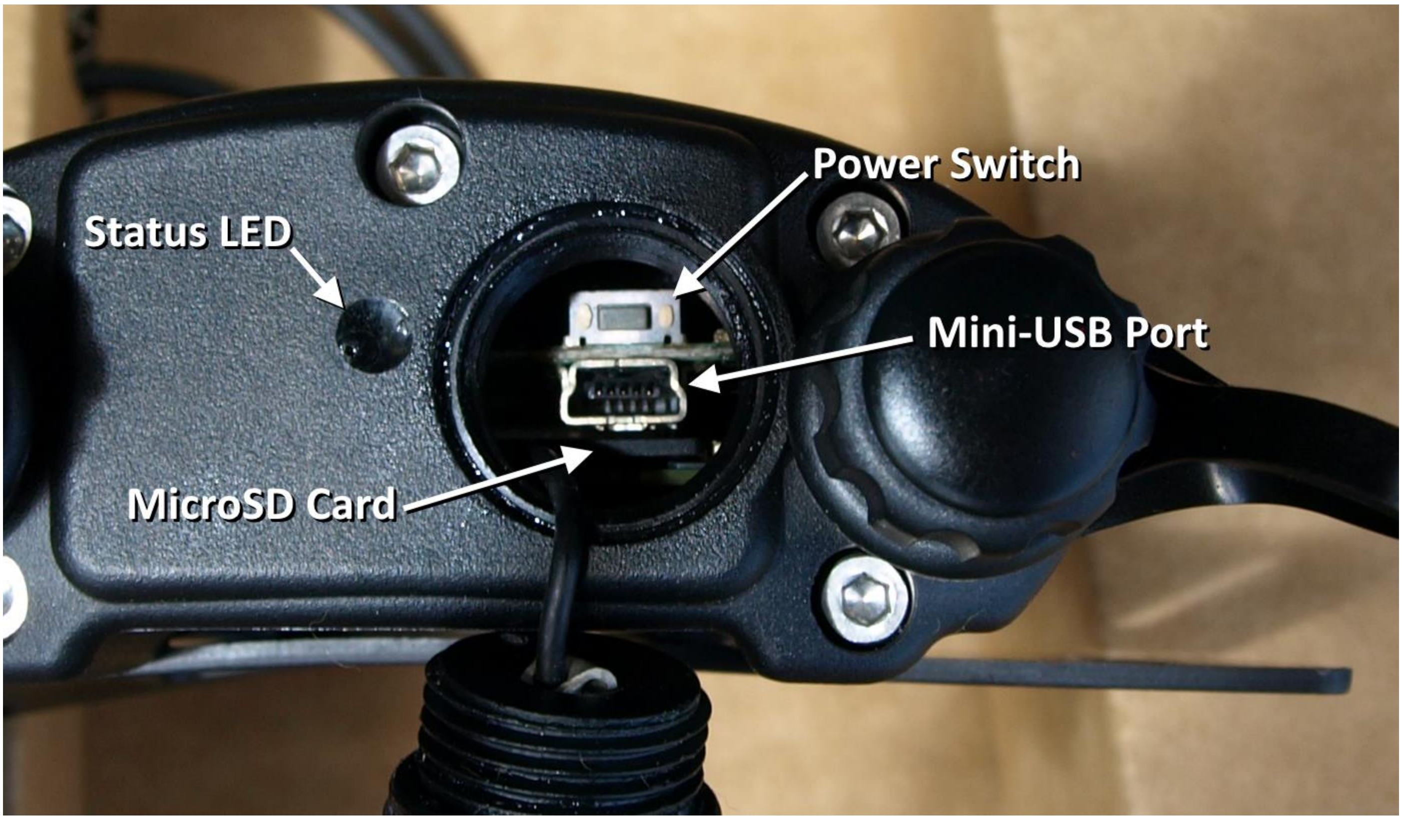


Alternatively, the individual installers (Windows and Mac) are available in the Instrument Software folder.

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

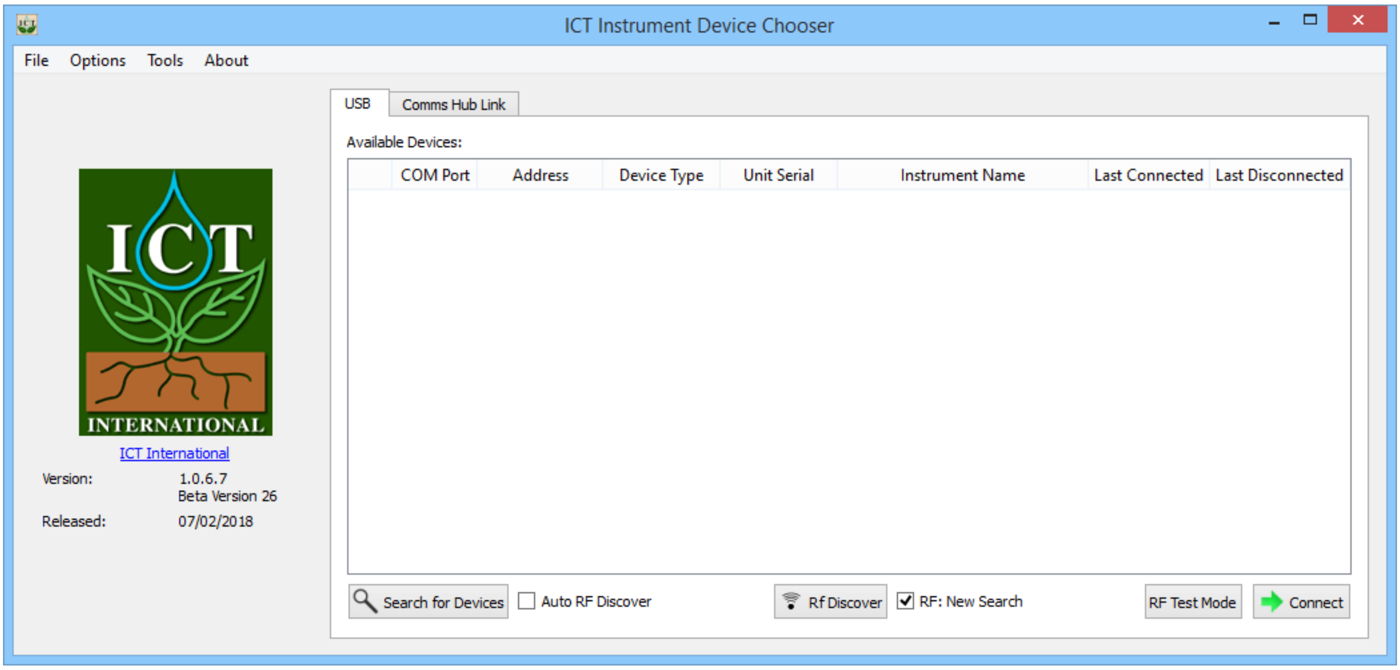
6. Turn the Instrument On

To charge and turn on your SOM1, connect the Instrument to a computer via a USB cable. Alternatively, the SOM1 can either be turned on manually by pressing the power button or automatically by connecting an external power supply.

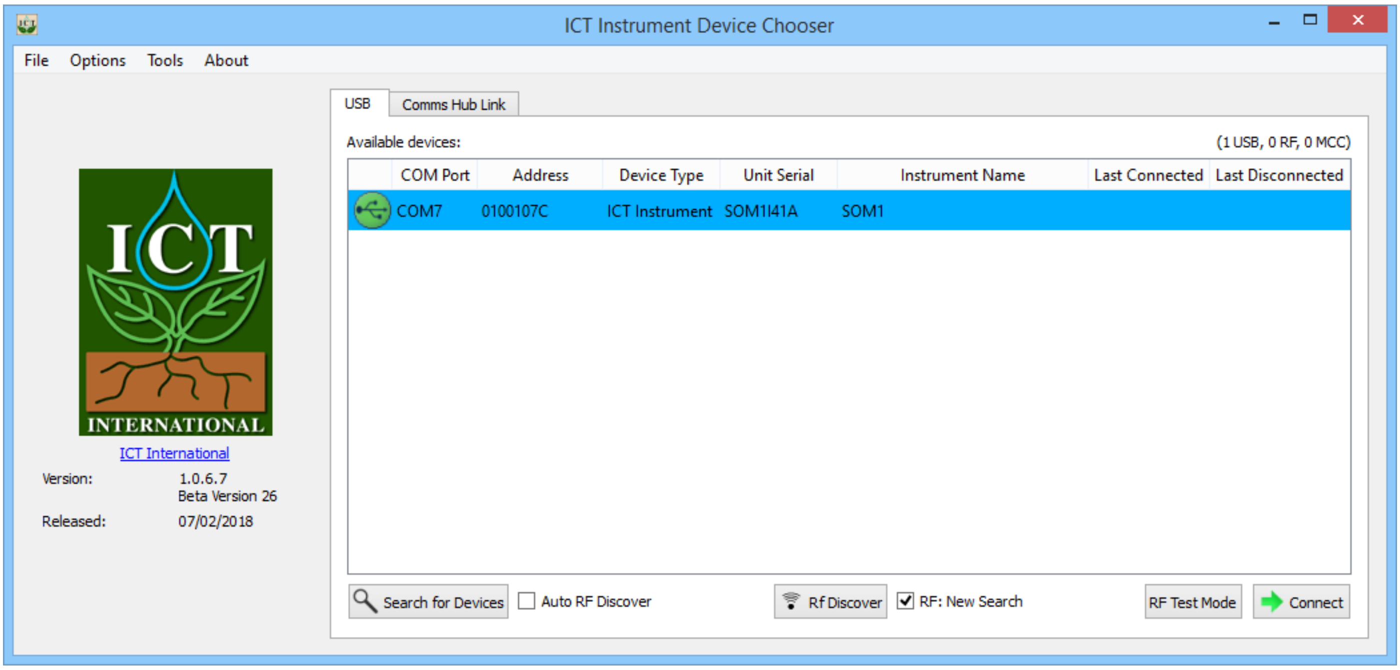


7. Connect to the Instrument

Connect the USB cable to the instrument and the computer. The SOM1 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’.



7.1 Connect via MCC Mini

Ensure that the SOM1 is on. Connect the MCC Mini to your computer, open ICT Combined Instrument software. Tick 'Auto RF Discover' and then Search for Devices.

The MCC Mini should appear on the list, it will then automatically search for nearby ICT Instruments.

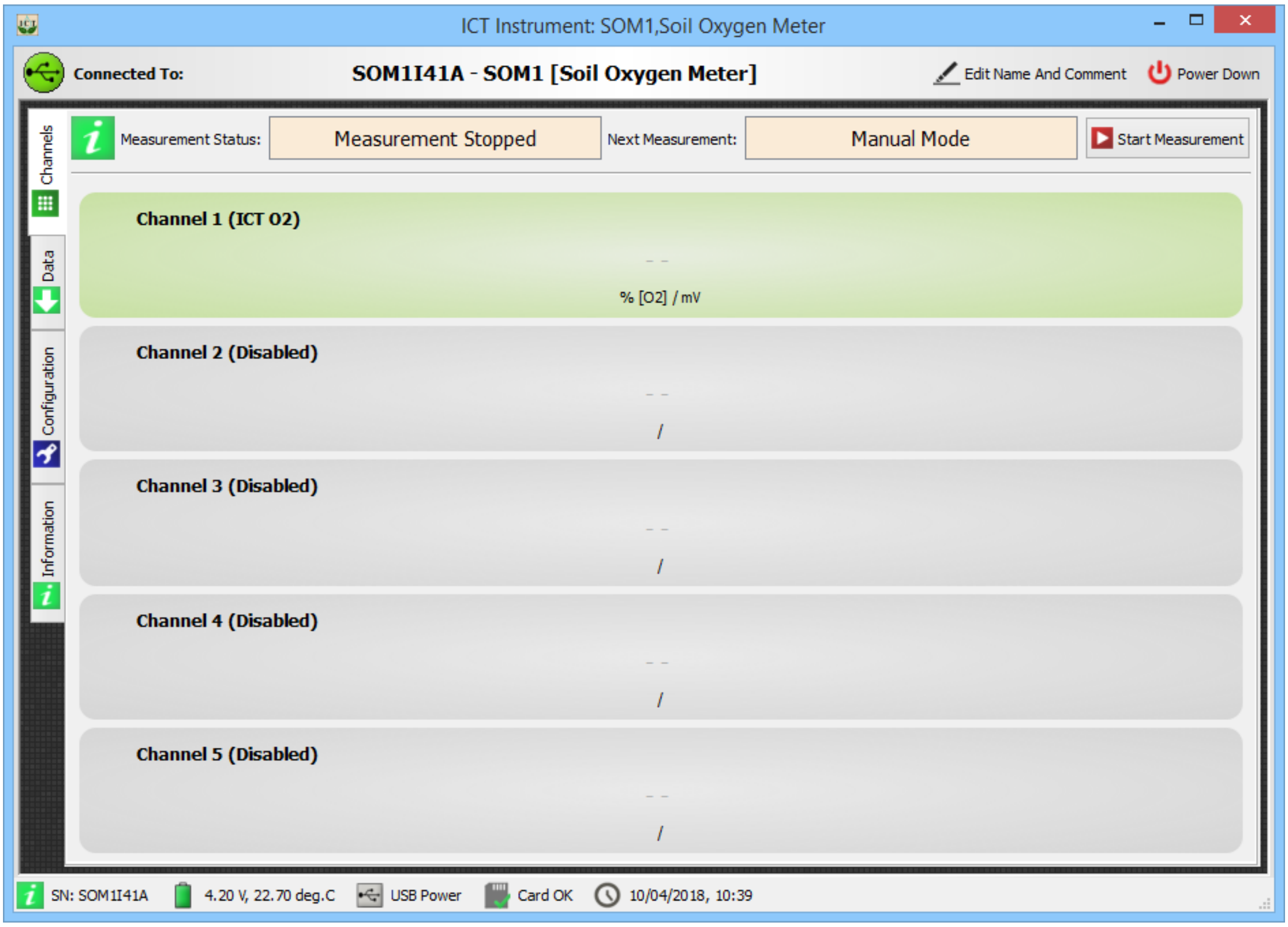
You can double click the instrument, or select it and Connect, as with USB.

You may need to install the MCC Mini USB driver from the ICT International website:

http://www.ictinternational.com/support/software/

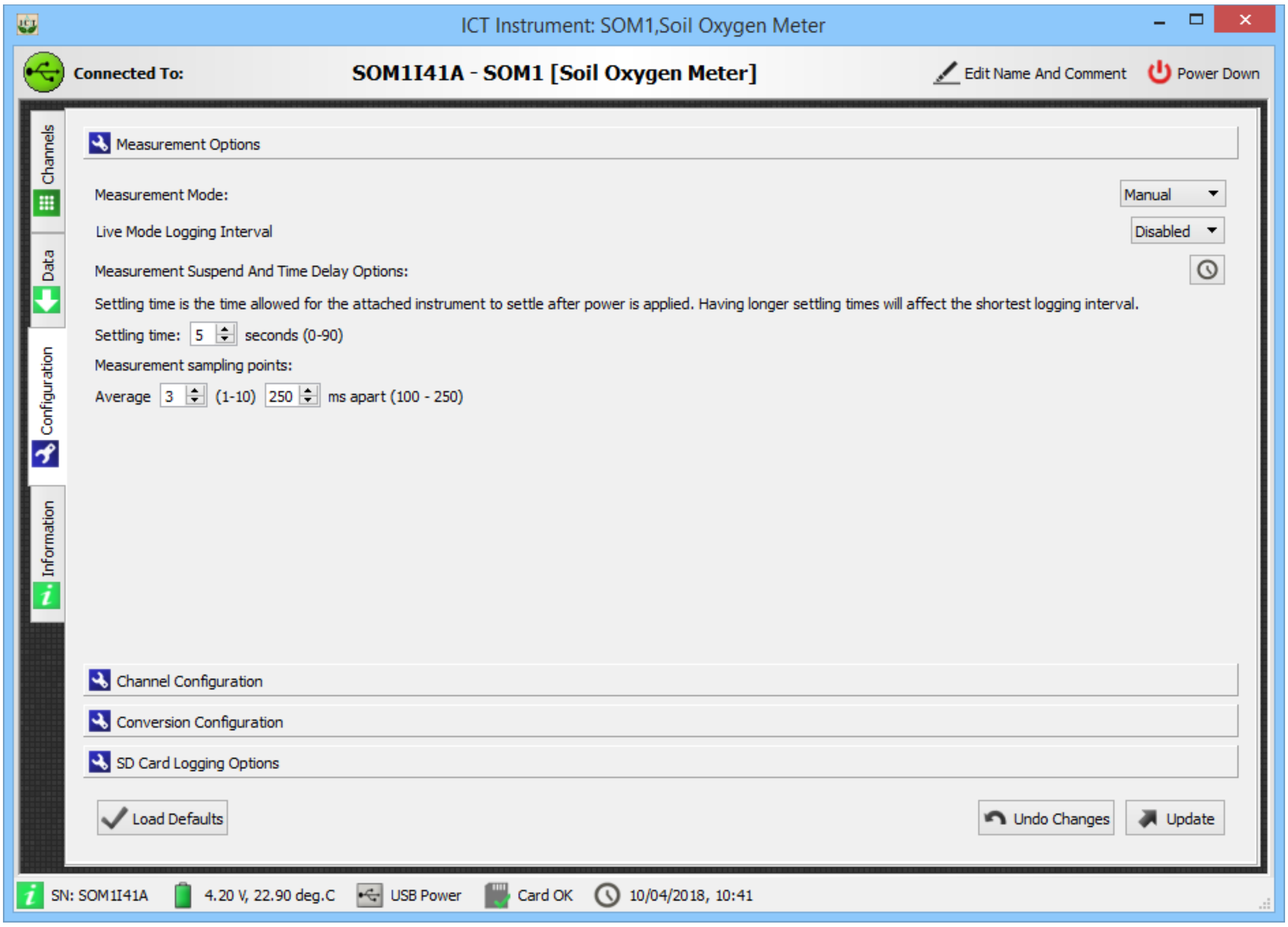
8. Set the Measurement Parameters

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, the currently configured channels, instrument serial number/name/comment, battery status, external power status, SD card status, and the instrument time and date.



8.1 Configuration

Normally, all instruments provided by ICT International come pre-configured, calibrated and tested. All that you need to do is select a logging interval. This is done from the Configuration screen:



Note: Click 'Update' after changing any settings in order to send them to the logger.

A range of standard Measurement Modes are available, from every 1 minute to 60 minutes.

In manual mode a measurement will be taken whenever the Start Measurement button on the Channels screen is clicked.

If the SOM11 is in live mode, measurements can be taken from every 250ms to 60 seconds. ICT recommend connecting the SOM1 to a continuous external power supply (eg: a CH24) when using live mode, as this significantly increases the power usage of the logger.

8.1.1 Settling Time

Settling time is the time required for the output of the attached sensors to stabilise after power is applied. By default, this is set to 5 seconds, ICT International set this to suit the application so this doesn't need to be changed normally. Longer settling times will affect the shortest logging interval. Settling time does not apply to Live Mode.

8.1.2 Measurement Sampling Points

Measurement sampling points are averaged to produce a more stable output. By default, 3 measurements are taken 250ms apart and averaged, ICT International set this to suit the application so this doesn't need to be changed normally. This can be set anywhere from 1 to 10 measurements, 100 to 250ms apart.

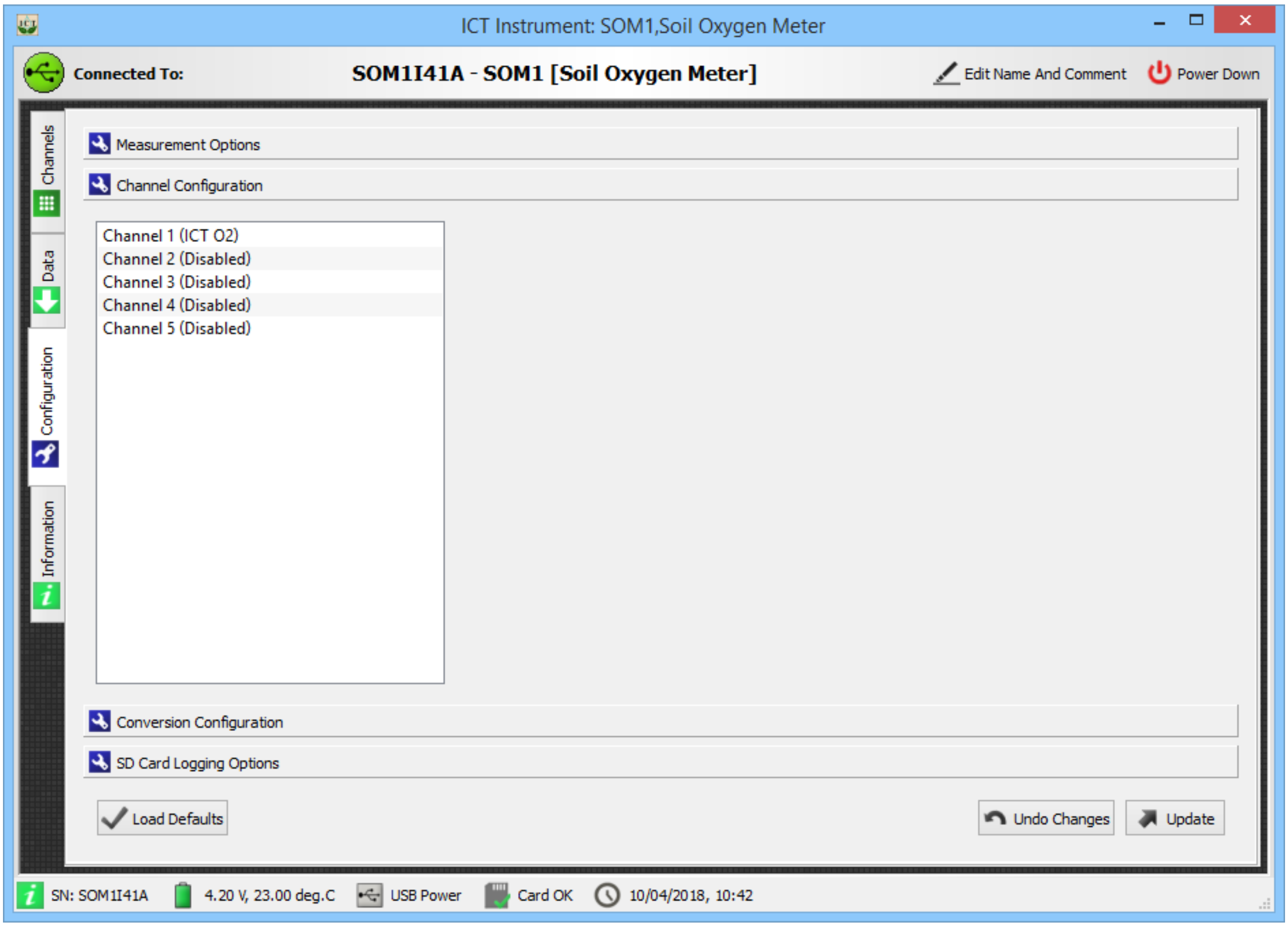
8.1.3 Measurement Suspend and Time Delay

This option allows you to set a time for the instrument to begin logging. This can be handy for completely setting up an instrument prior to 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.

8.2 Sensor Configuration

8.2.1 Channel Configuration

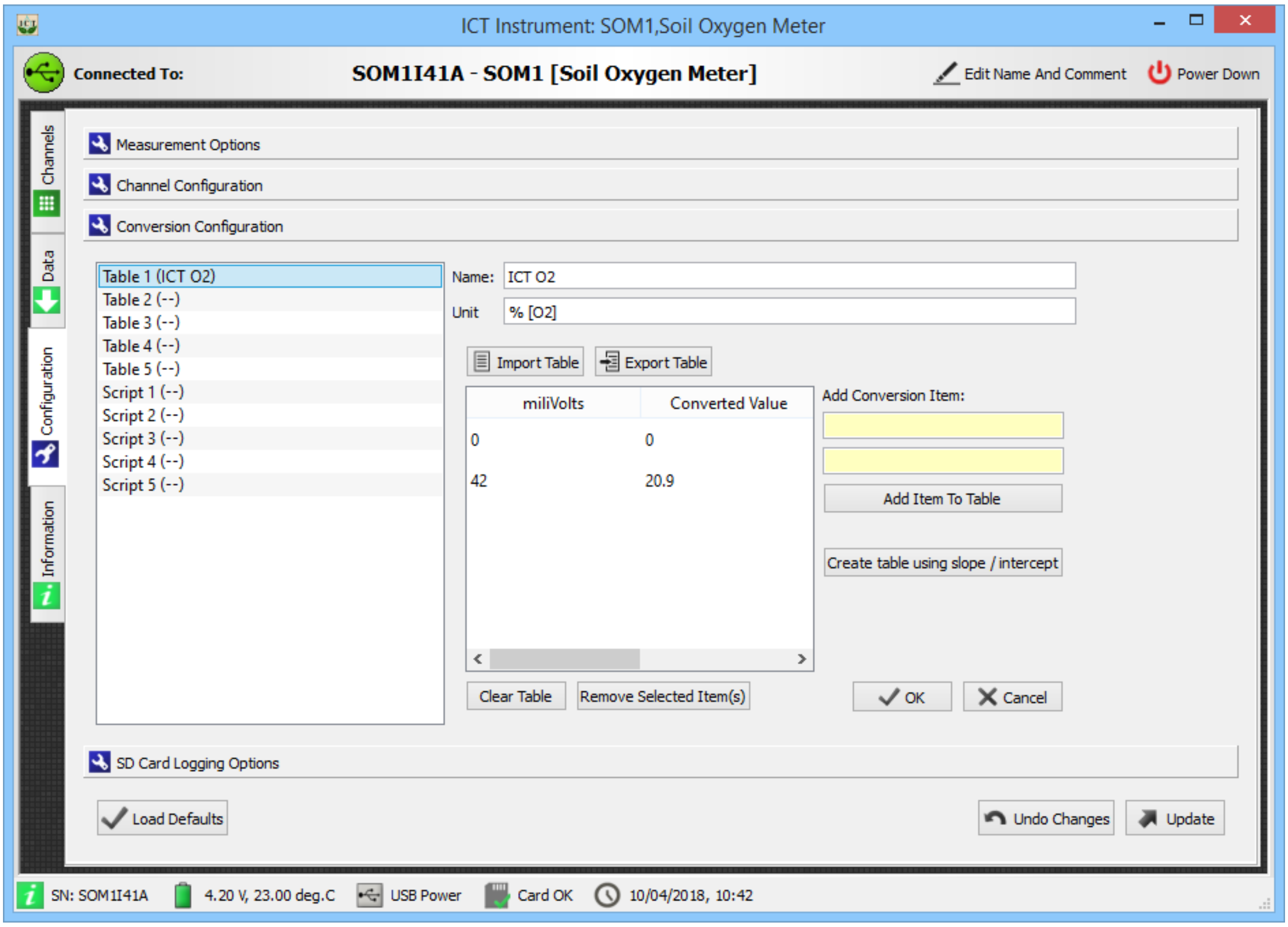
Channel configuration allows you to select a conversion table or script to apply to an input channel. Typically, the appropriate scripts for the sensors will be pre-loaded and configured.



8.2.2 Conversion Configuration

Conversion Configuration allows conversion scripts and tables to be added. These can be assigned to a channel in Channel Configuration.

When your instrument arrives from ICT International it will be preloaded with all necessary tables and/or scripts.



8.2.3 Advanced Configuration

The Advanced Configuration section is used to combine 2 single-ended inputs into a single differential input. This should not be altered unless instructed to do so by ICT International technical support.

8.2.4 SD Card Logging Options

Options for additional parameters to be logged to the data file. By default, all these options are enabled. ICT International recommend logging these options.

Raw millivolt data: Raw mV outputs from the sensors. Useful for post processing or changing conversion options.

Internal battery information: Internal battery voltage and temperature. Used for troubleshooting and diagnostics.

External supply information: External power supply voltage and current. Used for troubleshooting and diagnostics.

9. Download Data

The Data tab can be used for basic data visualisation, SD card management, and to download data files from the instrument.

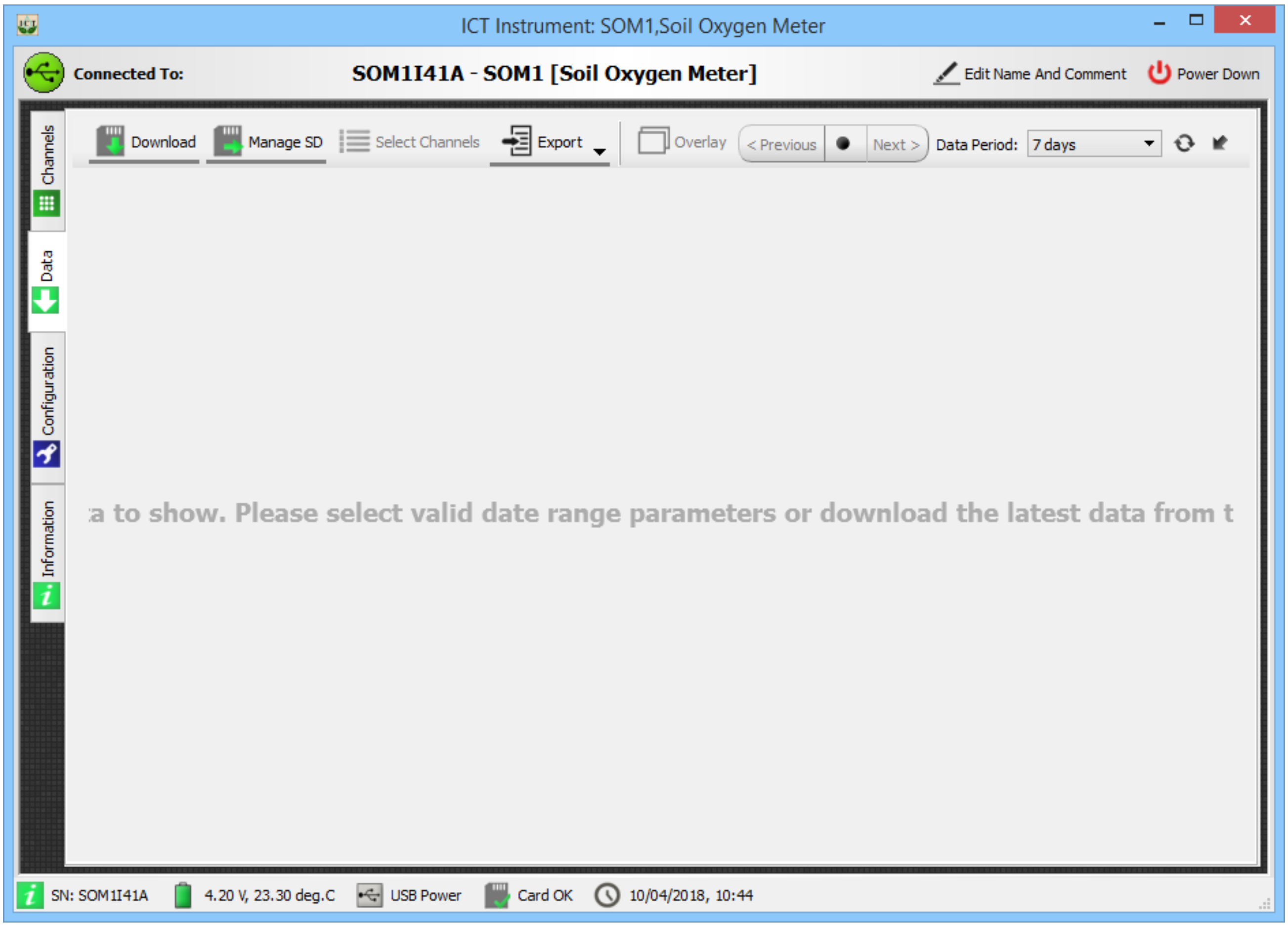
Data is stored on the MicroSD card in csv format. The MicroSD card can also be removed from the logger and read by a computer.

Download saves the instrument data to the Dataview repository and allows for basic graphing from the data tab. On Windows, the repository is located at: %localappdata%\ICT\Data Files

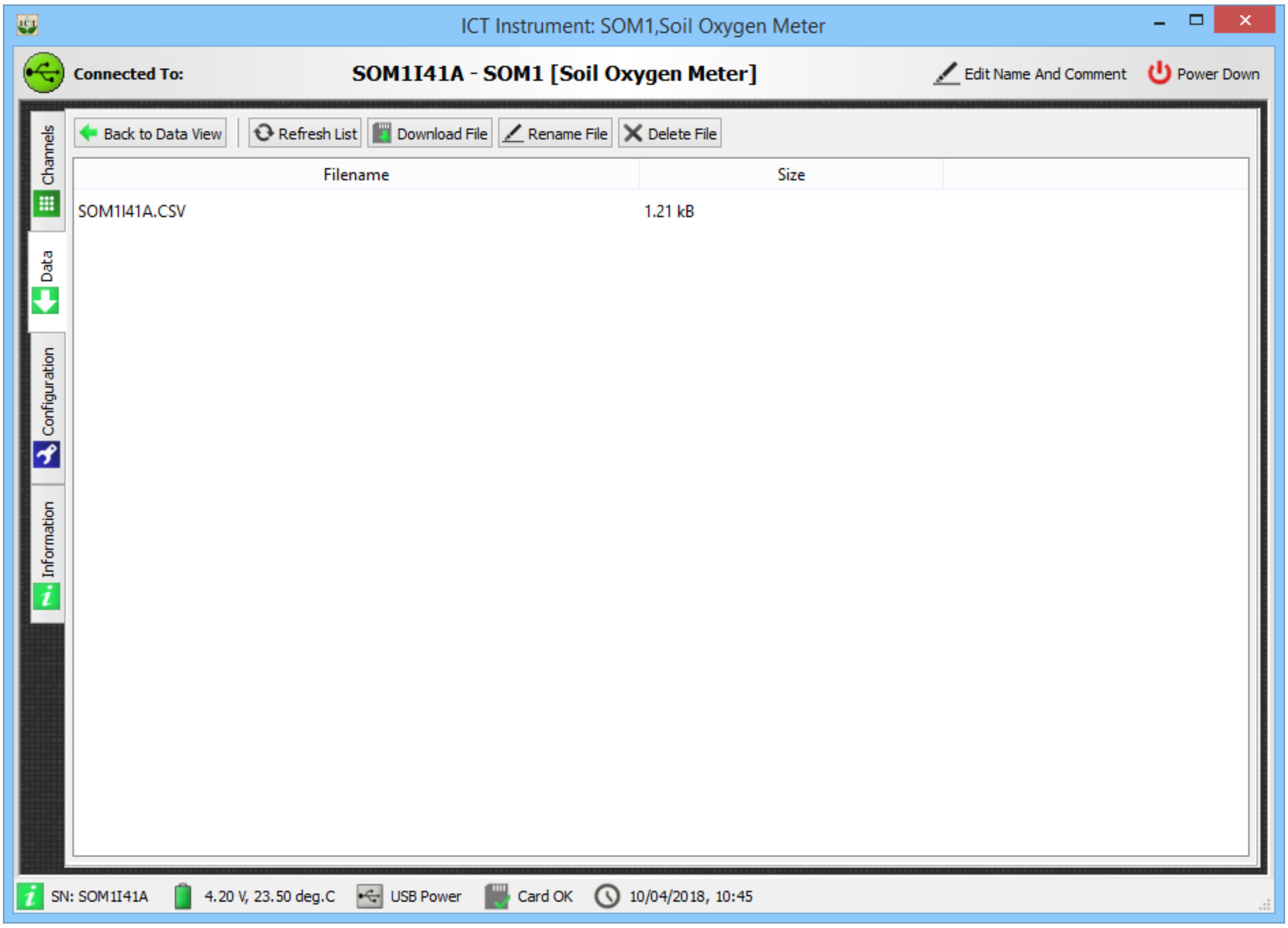
Select Channels is used to select which logger outputs (channels) are displayed on the plot.

Export provides some options for exporting a CSV file of the data:

> **Export Clean** includes measurement data and column headings.
> **Export with Headers** includes measurement data, column headings and the instrument Serial, name and comment.
> **Export a Copy** includes all diagnostic data, in addition to the data and headers. This is what is recorded by the instrument.



Manage SD displays the content of the instrument SD card.



Refresh List loads the list of files currently present on the SD card.

Download File downloads the selected file to the location of your choice.

Rename File allows you to change the name of the selected file. Note that if the instrument data file is renamed a new file will be created for measurements from that point onward. This is typically useful when re-installing an instrument at a new site, the old datafile can be renamed and kept as a backup.

Delete File deletes the selected file.

Appendices

ICTO2 Manual and Calibration

Introduction

The ICTO2 Soil Oxygen Sensor performs measurements based on a galvanic cell principle. It is a passive sensor and does not require voltage input. The sensor has automatic temperature compensation from an inbuilt thermocouple compensation circuit.

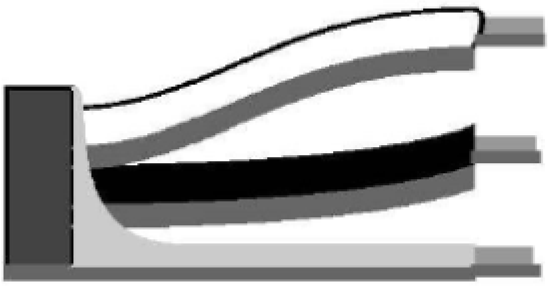
The sensors are Teflon coated and made from long-lasting plastics. Operational life expectancy in the field is five years.

Specifications

Operating Theory	Galvanic battery + porous membrane sheet
Shape	Diameter: 35mm. Length: 65mm. (Cable connector length: 50mm)
Output	45-65 mV at 20.9% O_2
Accuracy	±0.5%
Weight	220 grams, including 5m cable
Cable Length	5m
Temperature Effect	At 100% RH and 20.9% O_2 sensor output is 20.8% at 5°C, 19.4% at 40°C. At 0% RH and 20.9% O_2 sensor output is not influenced by temperature.
Operating Temperature	0-40°C

Wiring Diagram

Connect the sensor to a measurement device capable of measuring a millivolt signal with a range of approximately 0-60mV to cover a range from 0-20.95%.



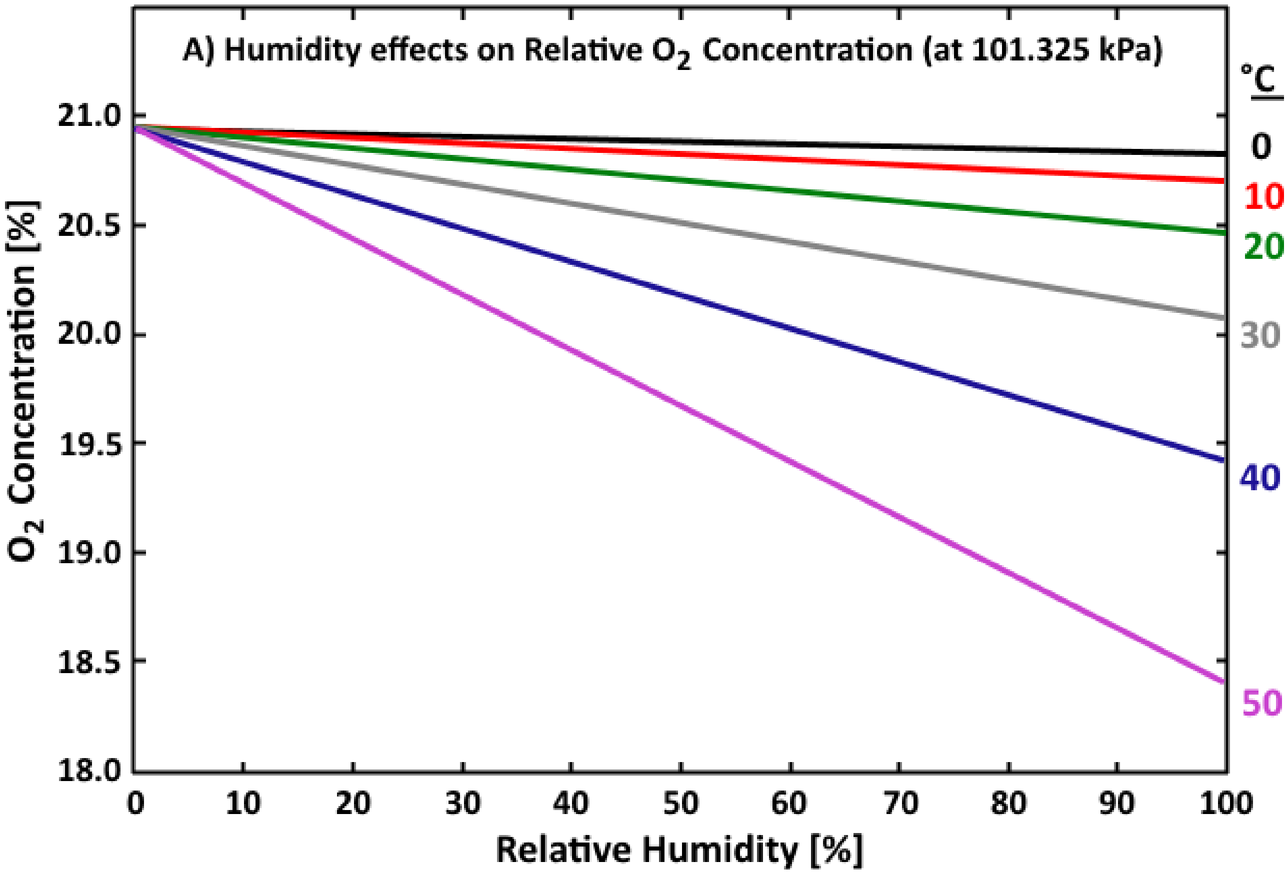
Theory

Absolute and Relative Gas Concentration:

Gas phase oxygen concentration can be described as both absolute and relative. Assuming dry air (0% RH), relative oxygen concentration is 20.95% and is the same at any elevation and temperature around the world. Absolute gas concentration in air changes with temperature and pressure as described by the ideal gas law. The ICTO2 responds to absolute oxygen concentration but is internally compensated for temperature to give relative oxygen uncompensated for pressure. The ICTO2 is typically used to measure relative oxygen. The mV measurements from ICTO2 sensors are converted to % O_2 using a linear conversion table. If pressure is logged at the experiment site, corrections for pressure can be applied to the measured oxygen concentration. The variation of pressure over altitude will have a significant effect on the ICTO2 relative oxygen concentration measurements. The ICTO2 must be calibrated by the user in a controlled environment at the same altitude as the final installation site.

Effect of Humidity on Oxygen Concentration

When the absolute humidity of the environment increases, the percentage concentration of the gas, including oxygen, decreases. That is, water molecules displace the oxygen and thus cause an actual decrease in relative oxygen concentration. The effect of water vapour on relative oxygen concentration, shown as a function of relative humidity and temperature is shown in the figure below.



The air in soil is typically saturated with water vapour.

Sensor Calibration

The ICTO2 outputs a voltage that can be converted to relative oxygen concentration. The measured relative oxygen concentration is internally compensated for temperature. The output of the ICTO2 is a linear relationship to relative oxygen concentration assuming no change in barometric pressure.

To convert the sensor output voltage to relative oxygen (in % O_2), the measured voltage output of the sensor in millivolts (mV_m) is multiplied by a calibration factor (CF).

1. $$O_2 = CF \times mV_m$$

The calibration factor is derived by dividing the ambient relative oxygen concentration of air (20.95% O_2) by the measured voltage output from the sensor millivolts under calibration conditions.

2. $$CF = \frac{20.95}{mV_c}$$

Where mV_c is the sensor output in mV. See the ICTO2 Calibration Procedure for the method to determine mV_c. The calibration factor varies from sensor to sensor and a sensor specific calibration must be derived for individual sensors.

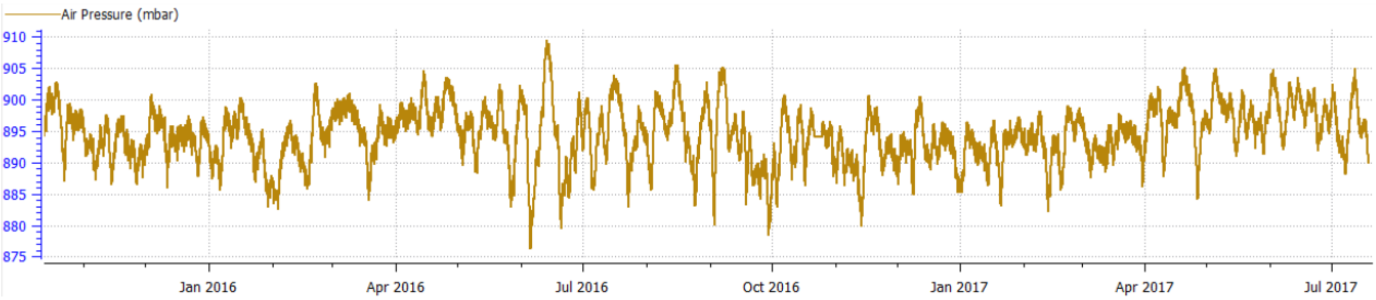
Effect of Barometric Pressure on Oxygen Concentration

A barometric pressure correction can be applied to the relative oxygen measurement from equation 1. The equation to correct relative oxygen measurements for barometric pressure is:

3. $$\mathbf{O_2\% = measured\ O_2\%(\frac{P_c}{P_m})}$$

Where P_c is the barometric pressure at the time of calibration, and P_m is barometric pressure at the time of the measurement.

The plot below shows 1.5 years of pressure data in Armidale (NSW, Australia), where a deviation in pressure of 34 mbar is measured.



The maximum error in O_2% measurement that would result if barometric pressure corrections were not applied to relative O_2 measurements in this example, assuming a 20.9% relative oxygen concentration and assuming the sensor was calibrated when barometric pressure was 893 mbar for the above example would be ±0.4% O_2.

Unless pressure corrections are applied, the user must calibrate at an altitude that is close to that where it is installed.

ICTO2 Calibration Procedure

1) The ICTO2 sensor has a four-digit serial number engraved on the top of the sensor body. The sensor wire should also be labelled with this serial number or other identification. Individual ICTO2 sensor calibrations should be recorded with the sensor serial number.
2) Place the ICTO2 sensor/s in air and out of direct sunlight in a room with some airflow. Orient the sensors with the opening pointed downward, but not blocked. The sensor output can be effected by dropping or shaking the sensor, this should be avoided.
3) Verify the sensor output is between 35 - 60mV using a multimeter or the SOM1. A new sensor should be between 35 and 60mV. Verify that the sensor is not oversensitive by measuring the sensor output while

lightly tapping it (you should not see changes greater than 3mV). If the voltage is not between 35 - 60mV and/or is over sensitive, the sensor may be defective.

4) Connect the ICTO2 sensor/s to the SOM1.
5) Setup the logger so that it records the mV output of the sensors connected, logging at 5-minute intervals for a minimum of 48 hours (3 nights is recommended). Do not move the sensors for the duration.
6) If barometric pressure correction is being applied to the relative oxygen measurements, you will need to measure barometric pressure over the calibration period.
7) Download the data after the test period.
8) Plot the mV values for the sensor/s being calibrated and check that the difference between the maximum and minimum recorded mV values is no more than 2mV per sensor. If the data shows a large variation or spikes in the data set, the sensor may be defective.
9) Determine the maximum mV value. The maximum value is the mV_c value needed in equation 2 used to derive the calibration factor (for example, mV_c = 48.5 mV). Find the corresponding barometric pressure at this time (this is the value of P_c in equation 3).
10) Create a conversion script or lookup table for the sensor.

Recalibration

The life expectancy of the ICTO2 sensor is approximately five years when place in standard atmospheric pressure exposed to 20.95% relative oxygen concentration at a temperature of 25°C. Higher temperatures will result in a shorter life expectancy and lower temperature a longer life expectancy.

Recalibration of the sensor can be done periodically. The sensor signal decreases by approximately 1 mV per year (or approximately 2% of signal output) at 25% oxygen. This signal decrease yields an increase in calibration factor of approximately 2% per year.

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