Four-Point Probe System

User Manual

Manual version 3.0.A

Product code: T2001A3

Product Version 3.0

Software version: 2.0

Contents

1. Overview

The Ossila Four-Point Probe System is a low-cost solution for rapid and reliable characterisation of conducting thin-films. The compact design offers the ideal solution for a busy lab where space is at a premium.

Operation of the system is controlled by specifically-designed PC software which automatically calculates appropriate geometrical correction factors for the sample to give accurate values for the sheet resistance. If the sample thickness is provided, the software will further calculate resistivity and conductivity.

2. EC Declaration of Conformity

We

Company Name: Ossila Limited

Postal Address: Solpro Business Park, Windsor street.

Postcode: S4 7WB

City: Sheffield

Telephone number: +44 (0)114 2999 180

Email Address: info@ossila.com

declare that the DoC is issued under our sole responsibility and belongs to the following product:

Product: Four-Point Probe (**T2001A3**)

Serial number: T2001A-3000-2000-2000- xxxx

Object of declaration:

Four-Point Probe (**T2001A3**)

The object of declaration described above is in conformity with the relevant Union harmonisation legislation:

EMC Directive 2014/30/EU

RoHS Directive 2011/65/EU

Signed:

Name: Dr James Kingsley
Place: Sheffield
Date: **01/10/2018**

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3. Safety

3.1 Warning

Warning

Absolute maximum input voltage is ±12 volt. DO NOT apply input while not powered.

3.2 Use of Equipment

The Ossila Four-Point Probe System is designed to be used as instructed. It is intended for use under the following conditions:

- Indoors in a laboratory environment (Pollution Degree 2)
- Altitudes up to 2000m
- Temperatures of 5°C to 40°C; maximum relative humidity of 80% up to 31°C.

The unit is supplied with an 18 V/1.67 A power adapter with a power cord for the country of purchase, in accordance with European Commission regulations and British Standards. Use of any other electrical power cables, adaptors, or transformers is not recommended.

3.3 Hazard Icons

The following symbols can be found at points throughout the rest of the manual. Note and read each warning before attempting any associated operations associated with it:

Table 3.1. Hazard warning labels used in this manual.

Symbol	Associated Hazard
	General warning or caution, which accompanying text will explain
	Electrical shock

3.4 General Hazards

Before installing or operating the Ossila Four-Point Probe System, there are several health and safety precautions which must be followed and executed to ensure safe installation and operation.

3.5 Power Cord Safety

Emergency power disconnect options: use the power cord as a disconnecting method and remove from wall. To facilitate disconnect, make sure the power outlet for this cord is readily accessible to the operator.

3.6 Servicing

If servicing is required, please return the unit to Ossila Ltd. The warranty will be invalidated if:

- Modification or service has been carried out by anyone other than an Ossila engineer.
- The Unit has been subjected to chemical damage through improper use.
- The Unit has been operated outside the usage parameters stated in the user documentation associated with the Unit.
- The Unit has been rendered inoperable through accident, misuse, contamination, improper maintenance, modification, or other external causes.

3.7 Health and Safety – Servicing

Servicing should only be performed by an Ossila engineer. Any modification or alteration may damage the equipment, cause injury, or death. It will also void your equipment's warranty.

4. Requirements

The system requires a computer running Windows (Vista or newer) with an available USB (recommended) or network port. Further details are given in **Table 4.1**.

Table 4.1. Four-Point Probe requirements.

Monitor Resolution	• The software requires a monitor resolution of at least 1440 x 900. *I.* The optimum resolution is 1920 x 1080.
Power	• The system requires an 18 V DC power supply. • A power supply fitting this description is provided along with the system.
USB	• To use the USB, your controlling device should support USB communication. A USB-B cable is supplied with system. *NOTE: The USB connection does not supply power to the system.*
Network	• The system should be connected to a network supporting 10/100Mbps transmission. • DHCP must also be running on the network, and available to the system for the device to operate properly. I. To check if DHCP is running on your network you should attempt to connect another device to the network as you would the system. • If the device automatically obtains an IP address, then DHCP is working correctly.

5. Unpacking

5.1 Packing List

The standard items included with the Ossila Four-Point Probe System are:

- The Ossila Four-Point Probe.
- 18 V / 1.67 A power adapter with a cord set specifically for country of operation (UK, USA, EU, or AU).
- USB-B cable.
- USB memory stick pre-loaded with the user manual, USB drivers, QC data, and software installer.
- 100 nm ITO coated glass substrate (20 x 15 mm).

5.2 Damage Inspection

Examine the components for evidence of shipping damage. If damage has occurred, please contact Ossila directly for further action. The shipping packaging will come with a shock indicator to show if there has been any mishandling of the package during transportation.

6. Specifications

The Four-Point Probe System measurement specifications are shown in **Table 6.1**, and the physical specifications are shown in **Table 6.2**.

Table 6.1. Four-Point Probe System measurement specifications.

Voltage range	±100 µV to ±10 V
Current range	±10 nA to ±150 mA
Sheet resistance range	3 mΩ/□ to 10 MΩ/□
Measurement accuracy	< ±4%
Measurement precision	±0.5%

Table 6.2. Four-Point Probe System physical specifications.

Probe Spacing	1.27 mm
Rectangular Sample Size Range	Long Edge Minimum: 4 mm Short Edge Maximum: 60 mm
Circular Sample Size Range (Diameter)	4 mm to 76.2 mm
Maximum Sample Thickness	10 mm
Overall Dimensions	Width: 145 mm Height: 150 mm Depth: 240 mm

7. System Components

The Four-Point Probe System is comprised of three items: the Ossila Four-Point Probe System (**Figure 7.1**), power adaptor (**Figure 7.2**), and the Ossila Sheet Resistance Software (**Figure 7.3**).

Figure 7.1. The Ossila Four-Point Probe.

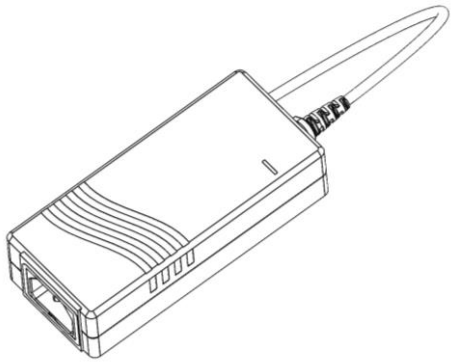

Figure 7.2. The 18 VDC power adaptor.

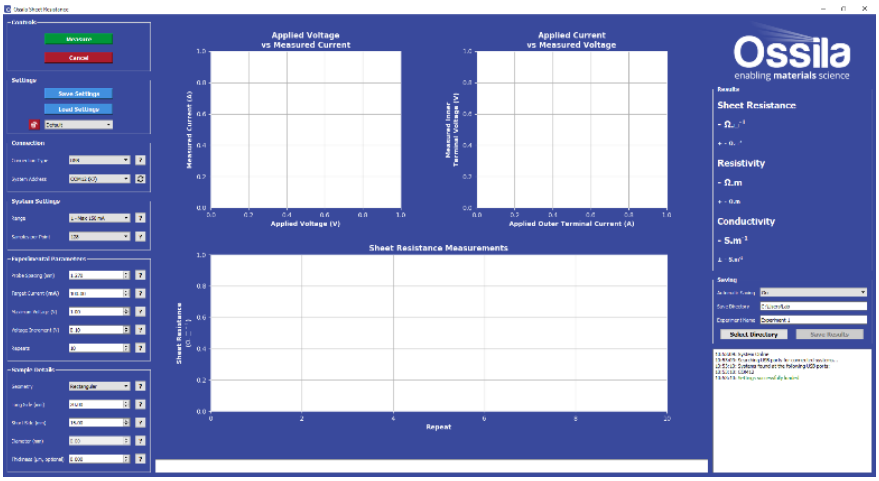

Figure 7.3. The Ossila Sheet Resistance software.

8. Installation

1. Install the Ossila Sheet Resistance software on your PC.
    I. Run the file 'Ossila-Sheet-Resistance-Installer-vX-X-X-X.exe' on the USB memory stick provided.
    II. Follow the on-screen instructions to install the software.
2. Install the Source Measure Unit USB drivers on your PC.
    I. On the USB memory stick provided, open the 'SMU-Driver' folder and run either 'Windows 32-bit SMU Driver' for 32-bit operating systems or 'Windows 64-bit SMU Driver' for 64-bit operating systems.
    II. Note that, on Windows 10, the drivers will install automatically when the unit is connected.
    III. If the drivers fail to install, please refer to the SMU USB Driver Installation Guide found on the USB memory stick.
3. Connect the 18 V DC power adaptor to the power jack on the rear of the unit.
4. Connect the unit to your PC using the provided USB-B cable, or an Ethernet cable if preferred.
    I. If you are using a USB connection and the unit is not detected, please refer to the SMU USB Driver Installation Guide found on the USB memory stick.

Note: *The Ossila Sheet Resistance software and Source Measure Unit USB drivers can also be downloaded from https://www.ossila.com/pages/downloads.*

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9. Operation

9.1 Taking a Measurement

1. Place your sample in the centre of the vertical stage.
2. Raise the platform until the probes have retracted approximately half-way into their housing.
    I. One full turn of the micrometer (after initial contact is made) is a good way to ensure that there is good electrical contact between the probes and your sample.
    II. Ensure that the probes make contact with the centre of the sample.
    III. For rectangular samples the longest edge should be aligned parallel to the probes.
3. Start the Ossila Sheet Resistance software. The window shown in **Figure 9.1** will open.
4. Set the appropriate settings in the software (explained in more detail in **Section 0**).
5. Click the 'Measure' button.
    I. The unit will apply a voltage and measure the current across the sample.

II. The voltage will be increased until either the target current is achieved, or the maximum voltage is reached.
    - If the maximum voltage is reached before the target current is achieved the measurement will cancel.

III. If the target current is achieved, the **sheet resistance** will then be measured.

IV. The measurement will be repeated for the number of times set in the 'Repeats' field, and the average will be displayed on the right.
    - These measurements will use the applied voltage found in the initial sweep to supply the current.

V. If a thickness has been provided, the average **resistivity** and **conductivity** will also be displayed.

6. If automatic saving is turned on, the measurement data and settings will then be saved.

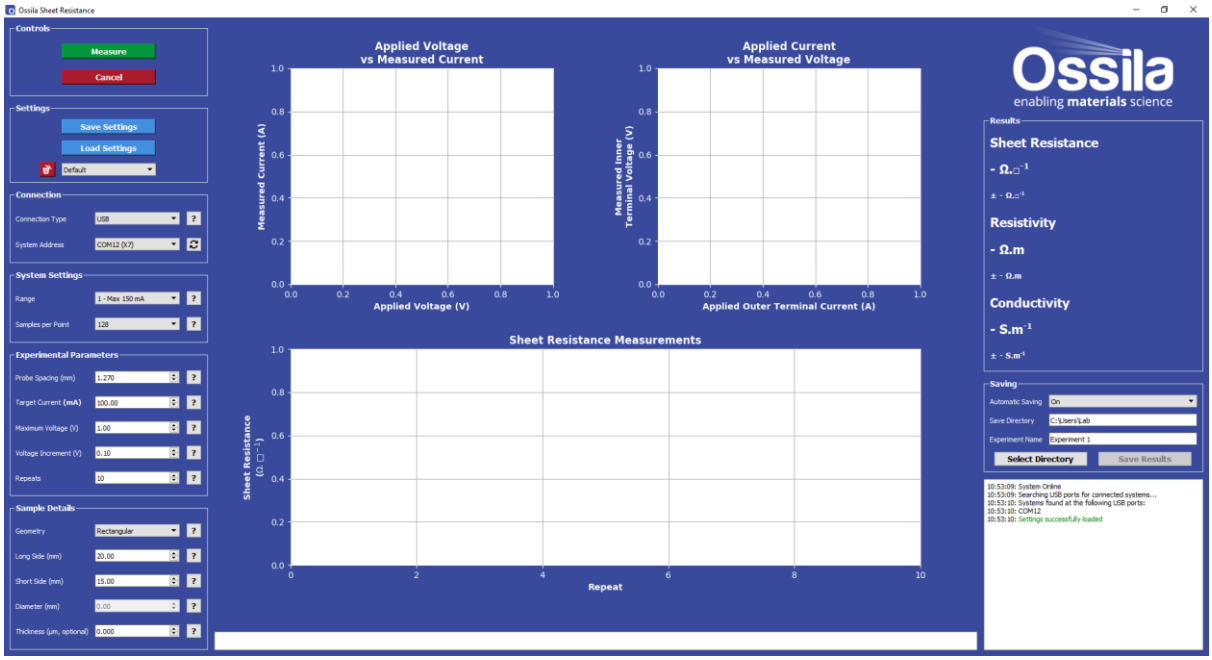


Figure 9.1. Ossila Sheet Reisistance software.

9.2 Software Settings

There are several settings in the program which must be filled in before taking a measurement. These are found in the column on the left of the window, as shown in **Figure 9.2**. Additionally, information about each setting can be found by clicking the '?' buttons next to each field.

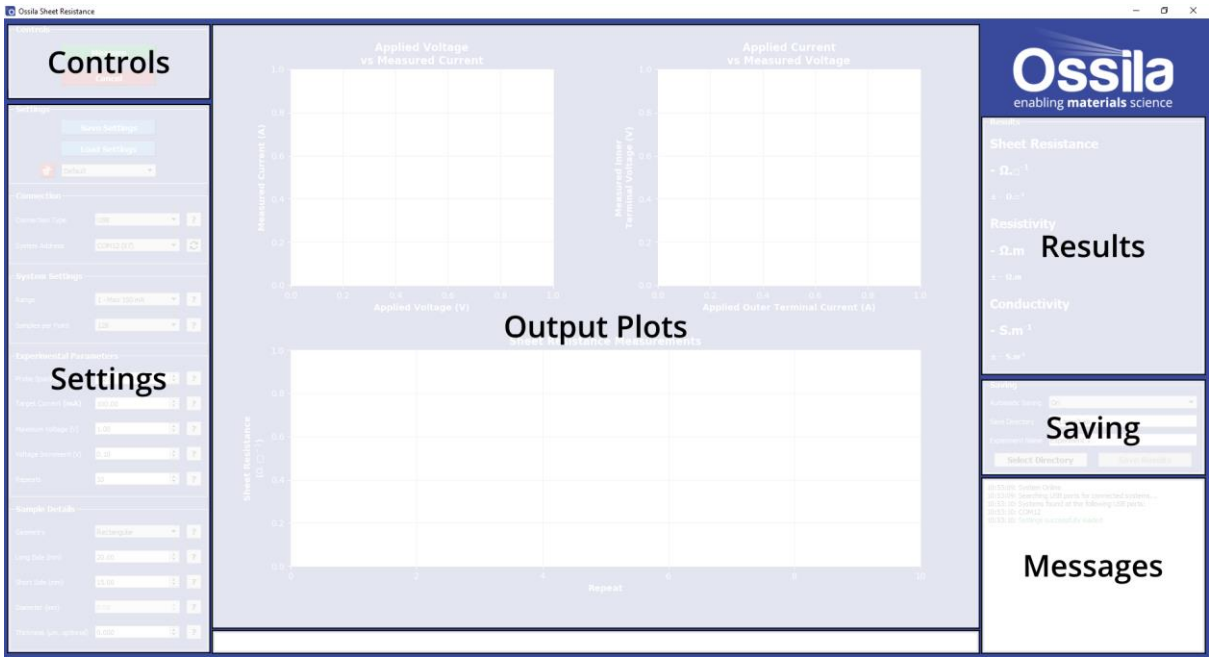


Figure 9.2. Layout of the Ossila Sheet Resistance software window.

9.2.1 Connection

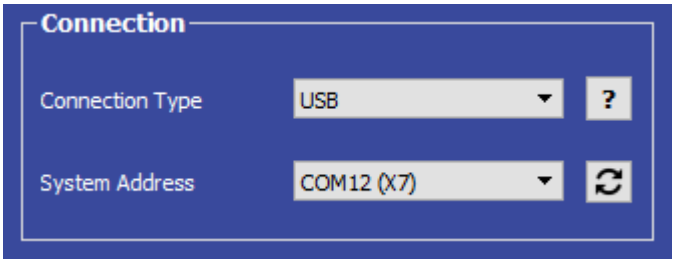


Figure 9.3. Connection settings.

(I) Connection Type

- Select the type of connection you are using, either USB or Ethernet.
    I. Any connected units will be automatically detected when a selection is made and the 'System Address' box will be populated.
        - The software will search for units connected via USB on start-up.
    II. To rescan for connected units (in case the connection is changed) click the refresh icon next to the 'System Address' box.

(II) System Address

- Select the COM port or IP address of the connected unit you intend to use (USB and Ethernet connection respectively).
    I. This box will be populated automatically with the addresses of any units connected to the computer via the method selected in the 'Connection Type' box.

9.2.2 System Settings

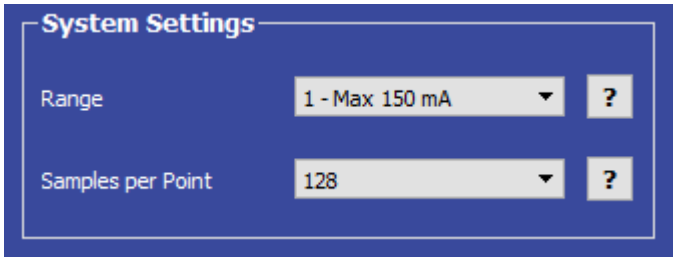


Figure 9.4. System settings.

(I) Range

- Select the range of currents to be used for the measurement.
    I. This defines the upper limit and accuracy of current measurements that can be performed by the unit. The values for each range are given in **Table 9.1**.
    II. The maximum current values for each range are also shown in the range selection box.

Table 9.1. Maximum current and accuracy for the different range settings for the Four-Point Probe System.

Range	Maximum Current	Accuracy
1	150 mA	±200 µA
2	20 mA	±10 µA
3	2000 µA	±1 µA
4	200 µA	±100 nA
5	20 µA	±10 nA

(II) Samples per Point

- Select the number of samples to be taken for each measurement.
    I. A higher number of samples per point will improve the accuracy and precision of the measurement. However, this will increase the time taken for it to be performed.

9.2.3 Experimental Parameters

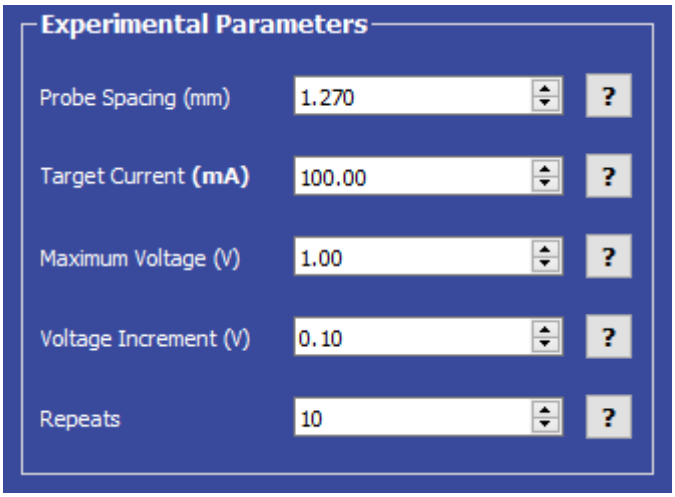


Figure 9.5. Experimental parameters settings.

(I) Probe Spacing

- Sets the spacing between each of the probes in mm.
    I. This is required to determine the appropriate geometric correction factor for the sample being measured.

(II) Target Current

- Sets the current to apply to the sample for the measurement.
- The units and maximum values of this field will be dependent upon the selected Range.
- This value can be positive or negative.
- The value that should be used for this field is dependent upon the resistance of the sample being tested (see **Section 9.3**):
    I. Higher values for less resistive samples.
    II. Lower values for more resistive samples.

(III) Maximum Voltage

- Sets the maximum voltage in volts that can be applied to the sample to achieve the target current.
    I. 10 V is the maximum that can be set.
    II. The polarity of the voltage will be set automatically, based upon the target current.

(IV) Voltage Increment

- Sets the step size for increasing/decreasing the voltage when trying to achieve the target current.

(V) Repeats

- Sets the number of measurements that will be taken to generate an average for the results.

9.2.4 Sample Details

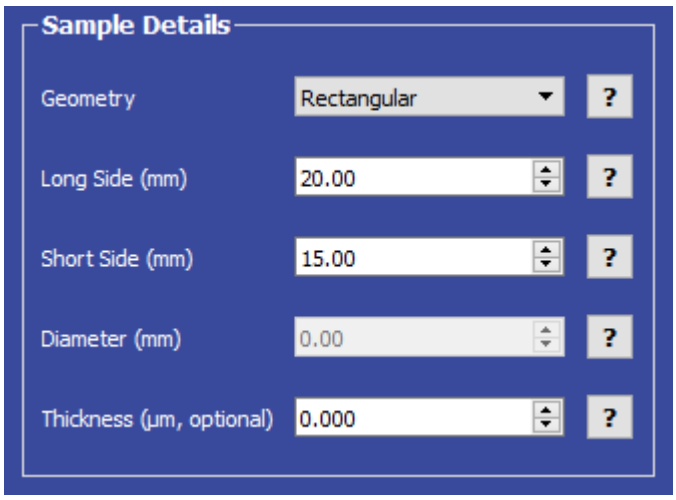


Figure 9.6. Sample details settings.

(I) Geometry

- Select the geometry of the sample being measured.
    I. This is required to calculate the geometrical correction factor for the current sample.
    II. If the shape of the sample is irregular, consider whether it is closer to rectangular or circular and then estimate what size of that shape could fit within the sample.

(II) Long Side (Rectangular Sample)

- Sets the length of the long side of the sample in mm (if the sample is rectangular).
    I. This is required for calculating the appropriate geometrical correction factor.

(III) Short Side (Rectangular Sample)

- Sets the length of the short side of the sample in mm (if the sample is rectangular).
    I. This is required for calculating the appropriate geometrical correction factor.

(IV) Diameter (Circular Sample)

- Sets the diameter of the sample in mm (if the sample is circular).
    I. This is required for calculating the appropriate geometrical correction factor.

(V) Thickness (Optional)

- Sets the thickness of the sample in µm.
    I. This enables the calculation of the resistivity and conductivity of the sample.
    II. It is not needed for sheet resistance measurements, thus can be set to 0 if not known.

9.2.5 Saving and Loading Settings

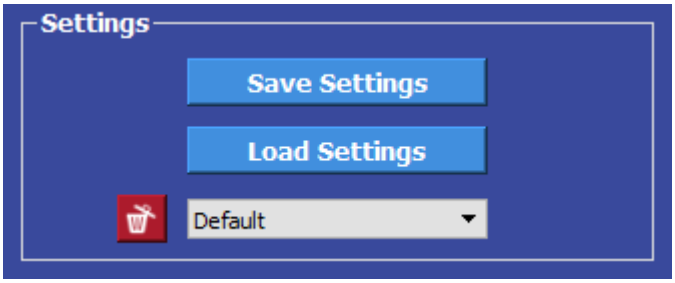


Figure 9.7. Controls for saving and loading settings profiles.

(I) Save Settings

- Saves the current settings as a profile that can be loaded quickly for use at another time.
- When clicked, you will be prompted to name the settings profile.
    I. If the name is already in use, you will be asked if you wish to overwrite the previous profile.
    II. The name cannot contain the characters: \ / : * ? " < > |
    III. You can change the default settings by choosing the name 'Default'.
- The settings profile will be added to the drop-down box using the given name.

(II) Load Settings

- Opens a dialog box to navigate to a settings file that has been created as part of a previous measurement.
    I. The settings fields will be populated with the values in the settings file.

(III) Settings Profiles

- Select a saved settings profile from the drop-down box.
    I. The settings fields will be populated with the saved values.
- Settings profiles can be deleted by selecting the profile' and then clicking the red 'delete' icon next to the drop-down box.

9.2.6 Saving Results

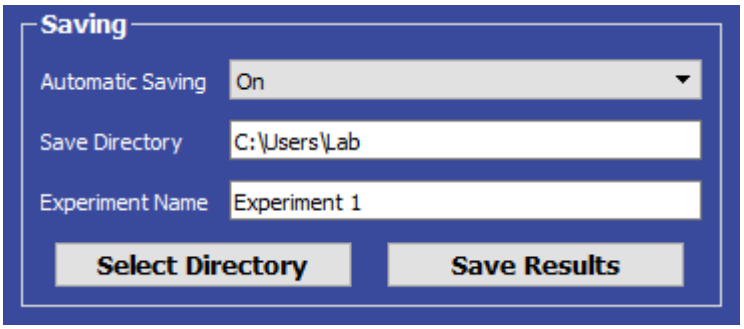


Figure 9.8. Save settings pane.

(I) Automatic Saving

- The program allows for data to be saved automatically, as well as manually once the measurement is complete.
    I. To enable or disable automatic saving, choose the appropriate option from the drop-down box.
    II. For automatic saving, the 'Save Directory' and 'Experiment Name' fields must be filled in before the measurement can start, these are detailed below.

(II) Save Directory

- Sets the location in which to save the results.
- This can be set either by:
    I. Manually typing the directory into the field.
    II. Copying and pasting it from your file explorer.
    III. Clicking the 'Select Directory' button, which will open a dialog box to allow the selection of a folder to save to.

(III) Experiment Name

- Sets the name of the folder in which the files will be saved.
    I. The name cannot contain the characters: \ / : * ? " < > |

(IV) Save Results

- Clicking this button will manually save the measurement results.

(V) Saved Data Format

- When saving, a folder with the chosen experiment name will be created in the specified directory and populated with 3 .csv (comma separated value) files:
    I. The data for the initial current-voltage sweep.
    II. The sheet resistance measurements.

III. The settings of the experiment (this file can be loaded by the program if you wish to use the same settings again).

Note: *If you forget to change the experiment name, your previous files will not be overwritten as the filenames include the date and time the file was saved.*

9.2.7 Controls

Figure 9.9. Controls of the Ossila Sheet Resistance software.

(I) Measure

- Clicking this button will start the measurement using the chosen settings.
- This button cannot be clicked if the software has not detected a unit.

(II) Cancel

- Stops a measurement that is currently in progress.
    I. Note that if the measurement is stopped before it completes, the user will be unable to save the experimental data.

9.3 Choosing a Target Current

The choice of target current will depend upon how resistive the sample is. Lower target currents should be set for samples with higher resistivity and vice versa.

Examples

1. For the 100 nm indium tin oxide (ITO) sample provided:
    I. A target current between **1 and 10 mA (Range 2)** should be used because the sample is fairly conductive.
    II. The sample should have a sheet resistance between **14 and 16 Ω/□** (see **Figure 9.10**).
2. A less resistive material, such as a 100 nm aluminium film (sheet resistance of **~265 mΩ/□**):
    I. A target current of **greater than 10 mA (Range 1)** is required to be able to measure a decrease in voltage between the inner probes.
3. More resistive materials (sheet resistance **≈kΩ/□**):

I. A target current of **100 – 1000 µA (Range 3)** is needed as the resistance of the material prevents higher currents from being reached.

4. If the resistances are higher than that, even lower target currents **(Range 4 or 5)** will be required.

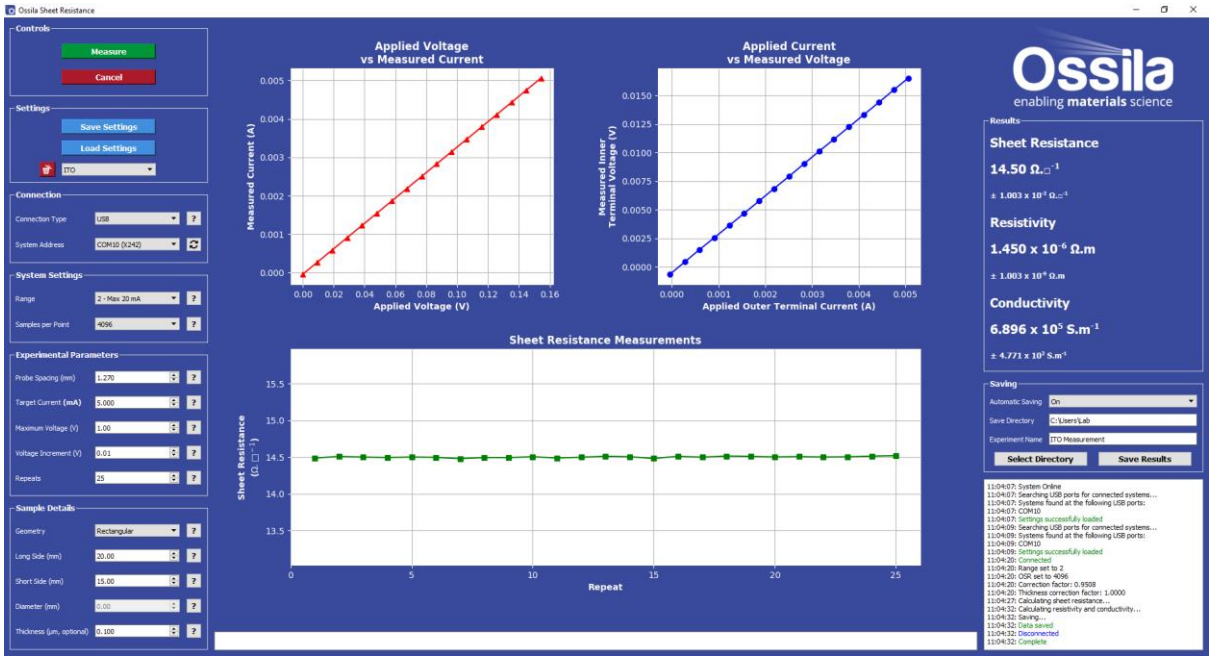


Figure 9.10. Typical output plots and measurement results for a 100 nm layer of ITO on a 20 x 15 mm glass substrate.

Best Practice

If you are unsure how resistive your sample is, the best technique for measuring sheet resistance is as follows:

1. Start with **Range 1** currents (10 – 150 mA).
2. If these currents cannot be reached, attempt to use **Range 2** currents (1 – 20 mA).
3. Keep decreasing the target current and switching to lower current ranges until the target current can be achieved.

10. Troubleshooting

Most of the issues that may arise will be detailed here. However, if you encounter any issues that are not detailed here, then contact us by email at info@ossila.com. We will respond as soon as possible.

Problem	Possible Cause	Action
No power/display	The power supply may not be connected properly.	Ensure the system is firmly plugged into the power supply, and that the plug is connected to both the adaptor and a working power socket.
	The power supply adaptor has a fault.	Contact Ossila for a replacement power supply adaptor.
Software does not start	The wrong version of Windows is installed on the computer.	Install the software on a computer with Windows Vista or newer.
	The software has not installed properly.	Try reinstalling the software.
Cannot connect to the system via USB	The USB cable may not be connected properly.	Ensure the USB cable is firmly plugged in at both ends.
	The USB cable may not be connected to a working USB port.	Try connecting the unit to a different USB port on the computer.
	The USB drivers may not be installed, or may not have installed properly.	Try installing or reinstalling the USB drivers. If the drivers on the USB provided are not working, try following the Windows 7 installation instructions found in the Installation Guide.
	The USB cable is defective.	Try using a different USB-B cable, and contact Ossila if necessary.
Cannot connect to the system via network	The MAC address of the unit is not registered with the internal network.	Register the system on the network using the MAC address obtained via a USB connection (see Source Measure Unit manual).
	The Ethernet cable may not be connected properly.	Ensure the Ethernet cable is firmly plugged in at both ends.
	The Ethernet cable is defective.	Try using a different Ethernet cable.

11. List of Associated Products

Compatible substrates

ITO Glass Substrates – Unpatterned (S111)

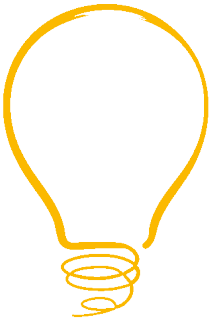
FTO Coated Glass – Unpatterned (S301/S302/S303/S304)

Full ITO Scale-Up Substrates (S281)

UV Ozone Cleaner (L2002A1)

12. Revision History

Rev	Date	Description
A	Nov 2018	Initial version



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