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SOURCE MEASURE UNIT (X200)

USER MANUAL

Manual version: 2.1.2
Product code: P2005A
Product Version: 2.0
Firmware Version: 2.6
Software Version: 2.0

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Contents

1. EU Declaration of Conformity (DoC)

We

Company Name: Ossila BV

Postal Address: Biopartner 3 building, Galileiweg 8

Postcode: 2333 BD Leiden

Country: The Netherlands

Telephone number: +31 (0)718 081020

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

Product: Source Measure Unit – X200 (**P2005A2**)

Serial number: P2005A2- xxxx

Object of declaration:

Source Measure Unit – X200 (**P2005A2**)

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: Leiden
Date: 16/11/2021

Декларация за съответствие на ЕС
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2. Safety

2.1 Warning

- Do **NOT** connect external voltage sources to either SMU channel.
- The absolute maximum input voltage for the Vsense channels is ±12 V. Do **NOT** apply input while not powered.

2.2 Use of Equipment

The Ossila Source Measure Unit 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 a 24 VDC 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.

2.3 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 2.1. Hazard warning labels used in this manual.

Symbol	Associated Hazard
	Electrical shock

2.4 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.

2.5 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.

2.6 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.

3. Requirements

The Ossila SMU is compatible with our Front Panel software which is included with the system. It allows for simple operation of the SMU and precision voltmeter channels. **Table 3.1** details the minimum computer specifications for the Ossila SMU Front Panel software.

Table 3.1. Ossila SMU Front Panel requirements.

Operating Systems	Windows 10 or 11 (64-bit)
CPU	Dual Core 2 GHz
RAM	4 GB
Available Drive Space	200 MB
Connectivity	USB 2.0 Ethernet

4. Unpacking

4.1 Packing List

The standard items included with the Ossila Source Measure Unit are:

- The Ossila Source Measure Unit.
- 24 VDC power adapter.
- USB-B cable.
- USB memory stick pre-loaded with the user manual, software installer, QC data, and USB drivers.

4.2 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.

5. Specifications

The Ossila Source Measure Unit contains four channels: two source measure units (SMUs) and two precision voltmeters. There is also a general-purpose shutter/trigger to allow other instruments to be controlled or control the unit.

5.1 Specification Conditions

The specifications and information in this document are for the Ossila Source Measure Unit. All units meet these standard specifications when dispatched to the end-user.

The accuracy of both source and measurement of the unit are specified under the following conditions:

- Ambient temperature of 23°C ± 5°C, < 60% relative humidity.
- After a 30-minute warm-up period.
- Default measurement speed (OSR 5) unless specified.
- No filter.

5.2 Source Measure Units (SMU 1 and SMU 2)

The source measure units output a voltage and then measure both the voltage and current. The output voltage is always measured at the output of the BNC (rather than assuming it is at the set voltage) in case of any load effects (for example short circuiting the output or low impedances causing a small drop in voltage). Each source measure unit has manually selectable ranges so that both high and low currents can be measured accurately.

5.2.1 Power Specifications

The unit is specified for a maximum operation power as in **Table 5.1**. **Figure 5.1** shows the four-quadrant safe operation zone of the unit.

Table 5.1. DC power specification.

	Power per SMU channel (continuous)
Four-quadrant Operation Source / Sink	2 W (± 10 V at ±200 mA)

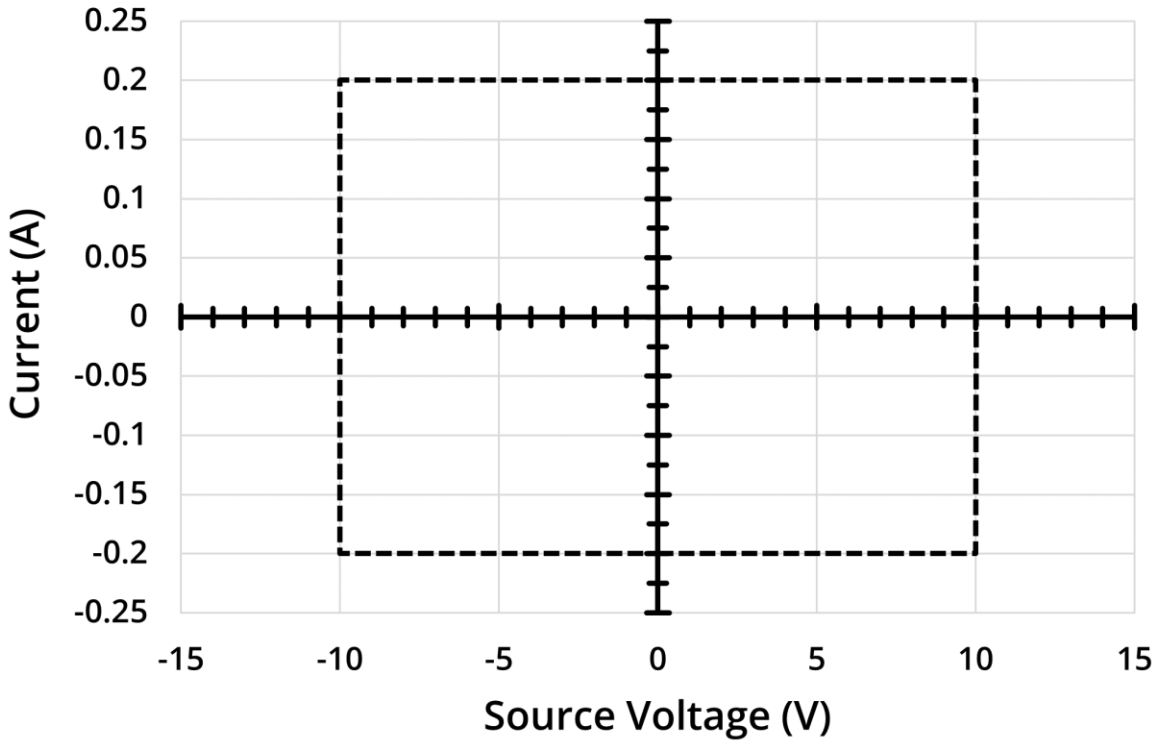

Figure 5.1. The four-quadrant safe operation zone.

There is some allowance for being beyond these limits (± 10 V and ±200 mA). The unit has internal voltage and current limits set at ±10.5 V and ±225 mA. If a voltage or current greater than these values is measured on either SMU, the red error LED next to the SMU will turn on and the output voltage of the SMU will be set to 0 V. This is a measure to reduce the possibility of damaging the unit due to excessive voltages or currents. The voltage and current limits can be changed programmatically, but they should not be increased past the default values as this will increase the possibility of damaging the unit.

5.2.2 Measurement Speed

The Ossila Source Measure Unit utilises a high-speed, 24-bit no Latency ΔΣ™ ADC. It provides ten speed/ resolution combinations (6.9 Hz/200 nV RMS noise to 3.5 kHz/25 µV RMS noise) which can be selected, with no latency between conversion results. Additionally, a double-speed mode can be selected, enabling output rates up to 7 kHz with one cycle latency. These modes are linked to a single variable called OSR (Oversampling Rate) which is used to program the unit and take the measurement. **Table 5.2** lists the various speed settings of the unit, with maximum measurement rates for both SMU and voltmeter channels.

Table 5.2. Measurement speed modes.

OSR [1] Index	ADC mode	ADC (samples/data point)	ADC [2] RMS Noise	SMU 1/2 [3] (data points/Sec)	Vsense 1/2 [3] (data points/Sec)
0	x 1	64	23 µV	N/A	N/A
1	x 1	128	3.5 µV	525	785
2	x 1	256	2 µV	276	414
3	x 1	512	1.4 µV	142	213
4	x 1	1024	1 µV	72	108
5	x 1	2048	750 nV	36	55
6	x 1	4096	510 nV	18	27
7	x 1	8192	375 nV	9	12
8	x 1	16384	250 nV	4.5	6
9	x 1	32768	200 nV	2.2	3

[1] OSR 10-19 will set the ADC in 2x mode with the same parameters of OSR 0-9, this will approximately double the unit's measurement rate.
[2] ADC noise increases by approximately √2 when OSR is decreased. Note that this is not the unit measurement noise levels.
[3] Values based on 1000 data points per measurement.

5.2.3 Voltage Source and Measurement Specifications

Table 5.3. Voltage source and measurement specifications.

Mode	OSR	Range	Accuracy	Precision	Resolution
Sourcing	N/A	± 10 V	± 10 mV	333 µV	1.7E-4
Measuring	1 to 4	± 10 V	± 10 mV	100 µV	1.0E-4
	5 to 9	± 10 V	± 10 mV	50 µV	1.0E-5

Warning: Do **Not** attach external voltage sources to either SMU channel as this may cause damage to the unit.

5.2.4 Current Measurement Specifications

The current measurement of the Ossila Source Measure Unit is spread over 5 ranges. Each range has a different maximum current, accuracy, and resolution. As the range number increases, the maximum measurable current decreases, but the accuracy and resolution increase.

Table 5.4. Current measurement specifications.

Range	Max Current	Accuracy [1]	Precision [2]	Resolution	Burden
1	±200 mA	±500 µA	10 µA	1 µA	< 10mV
2	±20 mA	±10 µA	1 µA	100 nA	< 10mV
3	±2 mA	±1 µA	100 nA	10 nA	< 10mV
4	±200 µA	±100 nA	10 nA	1 nA	< 10mV
5	±20 µA	±10 nA	1 nA	100 pA	< 10mV

[1] Accuracy has been measured at the maximum current of that range.
[2] Precision has been measured at the highest OSR (9).

Warning: Do **Not** apply currents to a SMU channel that are greater than the maximum current of the active range as this may cause damage to the unit.

5.3 Voltmeter (Vsense 1 and Vsense 2)

The Ossila Source Measure Unit has two additional voltage measurement channels marked as Vsense1 and Vsense2. They are designed to accurately detect small voltages while simultaneously having a wide dynamic range of ±10 V. **Table 5.5** lists the specifications of these additional channels.

Note: The Vsense modules share a ground plane with the SMU module of the same number (i.e., Vsense 1 shares a ground plane with SMU 1) and hence is not isolated.

Table 5.5. Voltmeter specifications.

OSR	Range	Accuracy	Precision	Resolution
1 to 4	1 to 5	±10 mV	100 µV	100 µV
5 to 9	1 to 5	±10 mV	50 µV	10 µV

5.4 Measurement Non-Linearity

The non-linearity in the measurement of the Ossila Source Measure Unit is kept well below the measurement accuracy of every range. Such non-linearity is common due to different amplification stages and analogue digital conversion processes.

5.5 Shutter/Trigger

The Shutter/Trigger can be used either as an input or an output. It can be used to send a trigger signal to other instruments or configured to wait for a trigger from other instruments. The voltage level of the Shutter/ Trigger is 5 volts and can source and sink up to 30 mA of current; higher currents may result in damage to the unit.

5.6 Physical Specifications

Table 5.6. Ossila Source Measure Unit physical specifications.

Channels	2 x source measure units (SMUs) 2 x voltmeters (Vsense) 1 x shutter/trigger
Channel Connectivity	BNC
PC Connectivity	USB Ethernet
Dimensions	Width: 125 mm Height: 55 mm Depth: 185 mm
Weight	0.55 kg
Power supply	24 VDC

6. System Components

The Ossila Source Measure Unit is comprised of the Ossila Source Measure Unit (**Figure 6.1**) and the Ossila SMU Front Panel Software (**Figure 6.2**).

Figure 6.1. The Ossila Source Measure Unit.

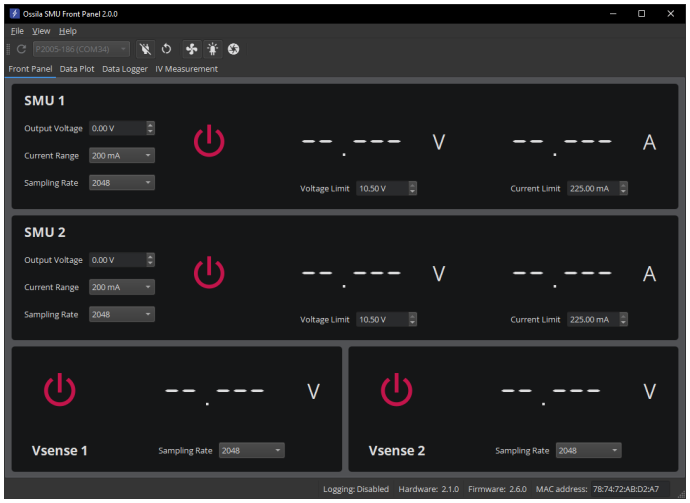

Figure 6.2. The Ossila SMU Front Panel software.

7. Installation

7.1 Power On

1. Connect the power supply first to the mains outlet, and secondly to the unit.
    I. The red and green power LED (at the back of the unit) and the fan will both switch on.
2. Leave for 30 minutes to warm up before performing any measurements.

7.2 USB Driver Installation

1. Connect the unit to the computer using a USB cable.
2. The USB drivers will be installed automatically.
    I. The unit will appear in the Device Manager under the Ports (COM & LPT) section as 'USB Serial Device (COMX)' as shown in **Figure 7.1**.
3. Alternatively, the USB drivers can be installed by running the 32-bit or 64-bit installation file located on the USB memory stick provided with the unit.

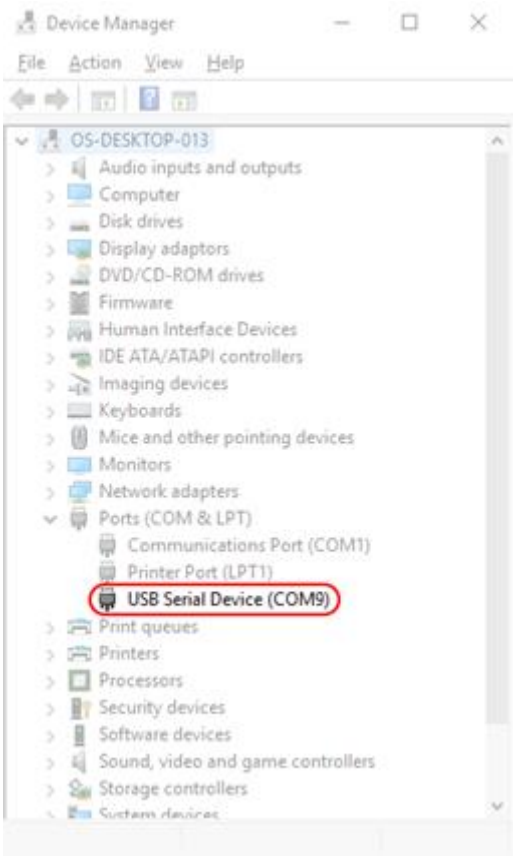

Figure 7.1. Ossila Source Measure unit in the Device Manager.

7.3 Connecting to a Network

The Ossila Source Measure Unit is designed to work with any network that supports DHCP. When the ethernet cable is plugged in, the unit will automatically detect and identify the network and register itself within a few seconds.

For most networks, the unit will need no further work – simply plug in and wait for the DHCP to work, and it is ready to go. However, there are two situations where more steps are required:

7.3.1 Networks Requiring Device Registration

Some large corporate networks (such as universities) have increased security levels and will only allow "known/registered" devices onto the network. If this is the case for your network, you will need to register the MAC address first. After this, the unit should be allowed on the network and will work as normal via DHCP (fully automatically from this point with no intervention). Many institutions have their own registration systems for computers and printers, and usually have online instructions on how to register a device. If needed, the MAC address of the unit can be obtained by connecting to it with the SMU Front Panel software over USB.

7.3.2 Static IP Networks

For a network without DHCP support, a static IP address must be set manually. This can be done by following these steps:

1. Connect the Source Measure Unit to a PC using a USB cable.
2. Disable the DHCP client of the device using the command "`eth0 set dhcp false`".
3. Set the IP address and other network parameters using the command "`eth0 set network ip-address subnet-mask gateway-ip dns-ip`".
4. Save the changes to the board so that they are loaded when the device powers on using the command "`eth0 save network`".
5. Disconnect the USB cable, then connect the Ethernet cable and the device should connect after a few seconds.

Alternatively, an external network router that supports DHCP can be used to connect to a static IP network.

7.4 SMU Front Panel Software Installation

1. Run the file 'Ossila-SMU-Front-Panel-Installer-vX-X-X-X.exe' on the USB memory stick provided.
2. Follow the on-screen instructions to install the software.

Note: The Ossila SMU Front Panel software and Source Measure Unit USB drivers can also be downloaded from **www.ossila.com/pages/software-drivers**

8. SMU Front Panel Software

1. Start the Ossila SMU Front Panel software and the window shown in **Figure 6.2** will open.
2. There are 6 main areas of the UI, which are detailed below:
    I. Tool Bar
    II. Front Panel
    III. Data Plot
    IV. Data Logger
    V. IV Measurement
    VI. Menu Bar

8.1 Tool Bar

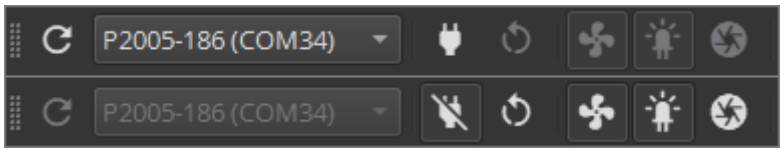

Figure 8.1. Tool bar before (top) and after (bottom) connecting to a Source Measure Unit.

	Search the USB ports and network for Source Measure Units. Discovered units will be displayed in the drop-down box.
	Connect to/disconnect from the selected Source Measure Unit.
	Restart the connected Source Measure Unit and reconnect to it.
	Toggles the colling fan of the connected Source Measure Unit on and off.
	Toggles whether the status LEDs of the SMU channels turn on when the channels are enabled.
	Toggles the shutter output on and off. When switched on the shutter outputs 5 VDC.

8.2 Front Panel

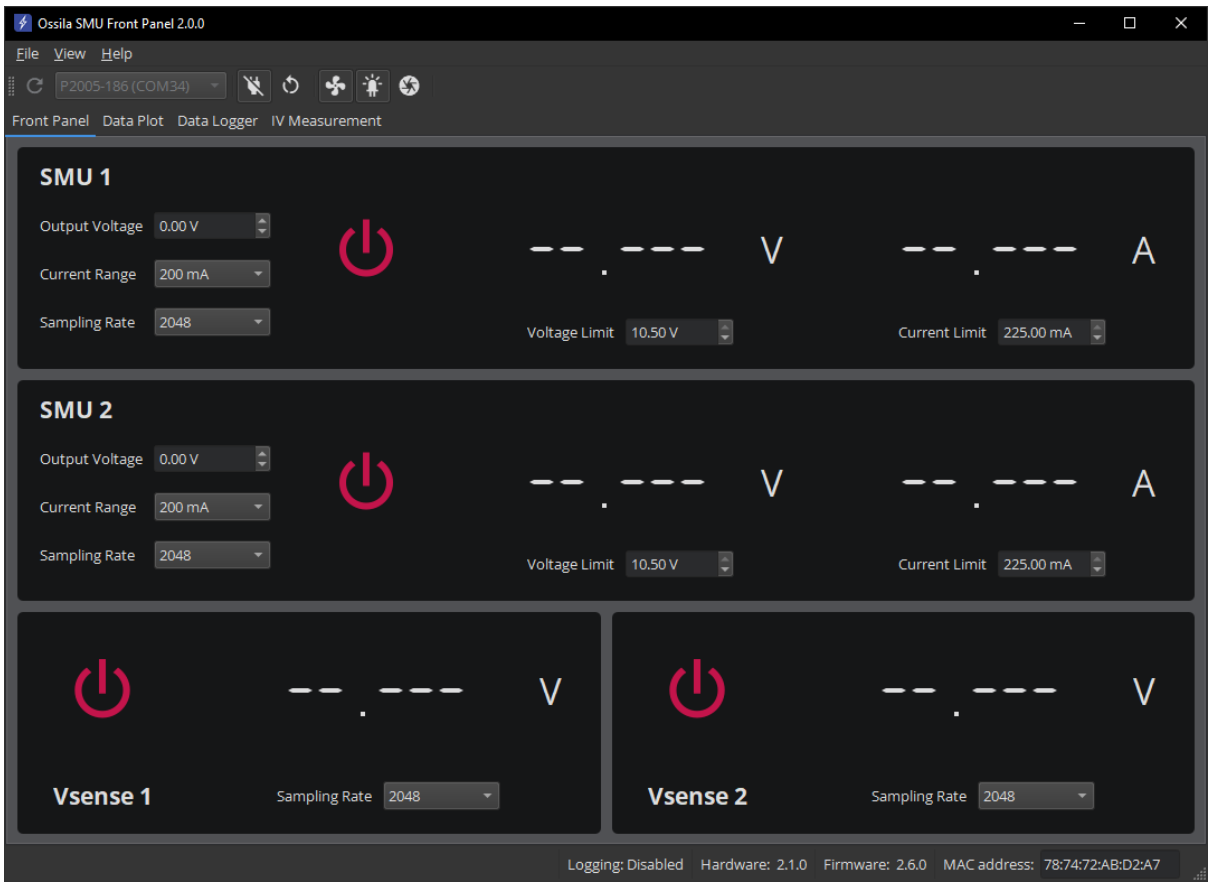

Figure 8.2. The Front Panel tab.

The Front Panel tab consists of a control panel for each of the channels on the Source Measure Unit: SMU 1, SMU 2, Vsense 1, and Vsense 2.

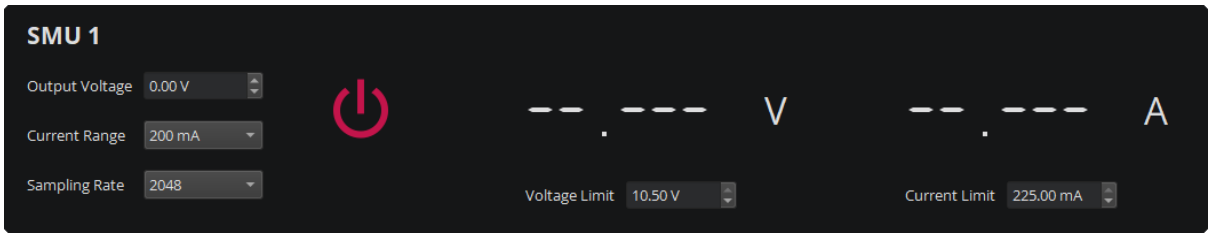

Figure 8.3. Control and output panel for the SMU channels.

Each SMU panel contains an on/off toggle button, voltage (left) and current (right) measurement displays, and the settings, which are detailed below.

Output Voltage	Sets the output voltage of the SMU channel in volts (maximum of ±10 V).
Current Range	The current range to use for the measurement. This defines the upper limit and sensitivity of current measurements as shown in **Table 5.4**.
Sampling Rate	The number of samples to take for each data point (the OSR, see **Section 5.2.2** for details). A higher sampling rate will increase the accuracy of a measurement but will increase the time taken for it to be performed.
Voltage Limit	The maximum voltage that the SMU channel can source. If output voltage is greater than this value, the SMU channel will automatically switch off and a warning will be displayed.
Current Limit	The maximum current that the SMU can measure. If measured current is greater than this value, the SMU channel will automatically switch off and a warning will be displayed.

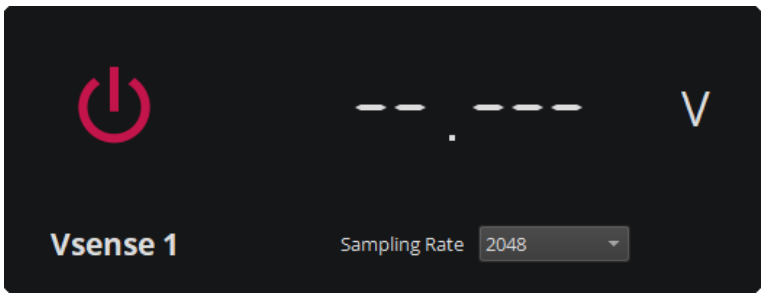

Figure 8.4. Control and output panel for the Vsense channels.

Each Vsense panel contains an on/off toggle button, the voltage measurement display, and the settings, which are detailed below.

Sampling Rate	The number of samples to take for each data point (the OSR, see **Section 5.2.2** for details). A higher sampling rate will increase the accuracy of a measurement but will increase the time taken for it to be performed.

8.3 Data Plots

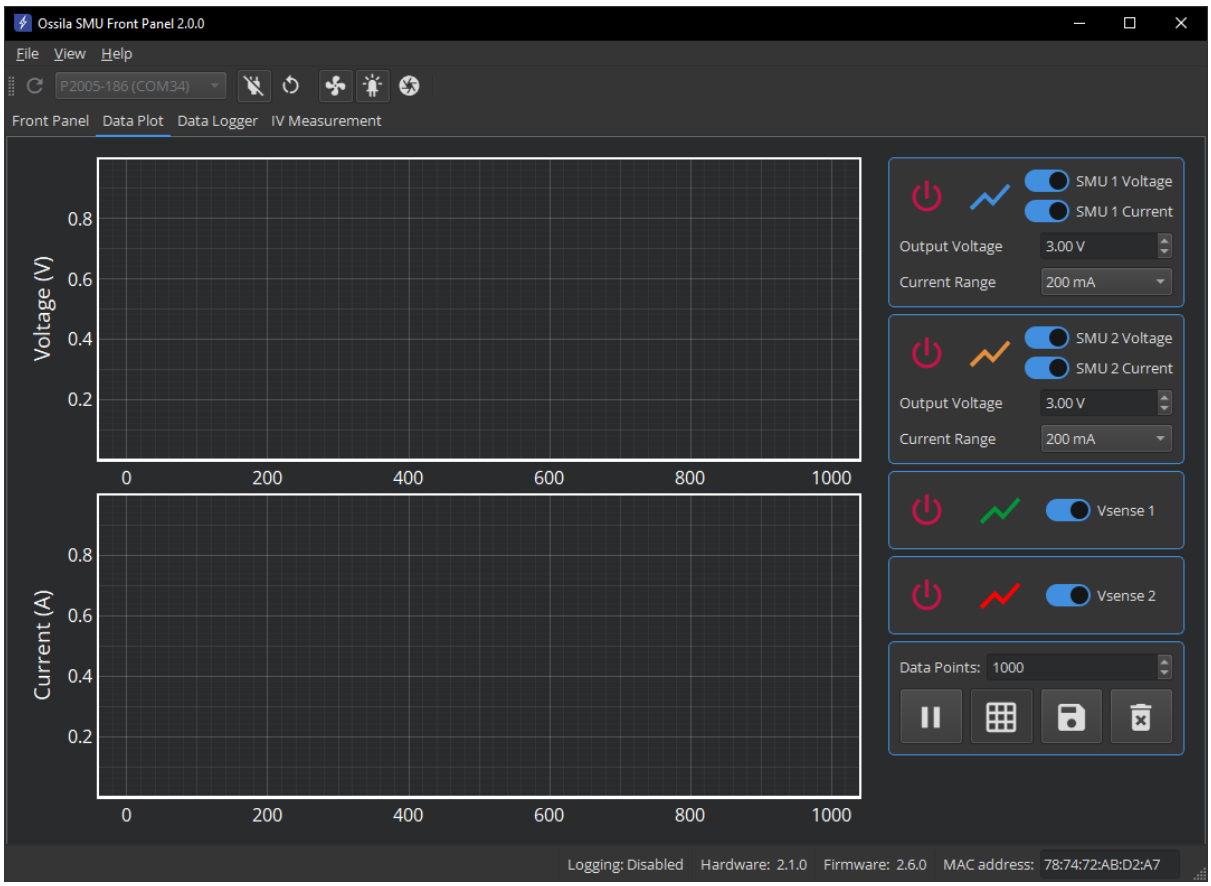

Figure 8.5. The Data Plots tab.

The Data Plots tab contains a pair of plots that display voltage and current readings from each of the channels on the Source Measure Unit. The upper plot displays voltage readings, and the lower plot displays current readings. Controls for channels and plotting can be found in the sidebar.

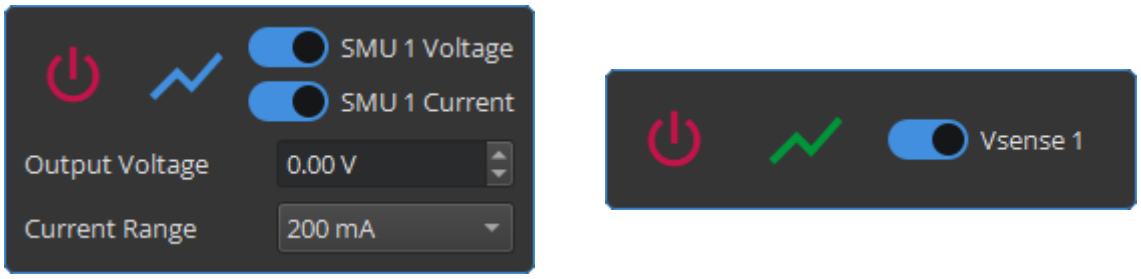

Figure 8.6. Control panels for the SMU and Vsense channels.

Each SMU panel contains an on/off toggle button, a legend line indicating the line colour for the device data, switches for toggling whether SMU data are displayed in the plots, and controls for Output Voltage and Current Range as described in **Section 8.2**. Vsense panels contain an on/off toggle, a legend line, and a switch for toggling Vsense data display.

Below the device control panels are the plot control buttons, detailed below.

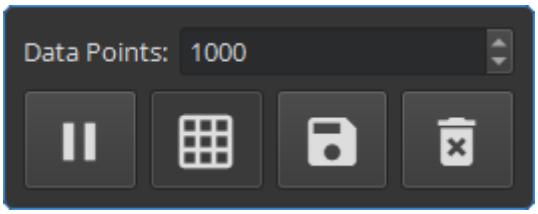

Figure 8.7. Data plot controls.

Data Points	The number of data points to plot for each channel.
⏸ ▶	Pause and resume plotting data.
▦	Toggle the gridlines on the plot on and off.
💾	Save the data in the plots to a comma separated value (.csv) or text (.txt) file. A file dialog will open to allow you to select a save file name and location.
🗑	Clear all data from the plots. A confirmation dialog box will be displayed.

8.3.1 Plot Display Controls

By default, the plots will automatically scale the axes of the plot to display all the data within it. The view can be controlled manually using the following mouse controls:

- Left or middle click and drag – pan the axes.
- Right click and drag – scale the axes.
- Scroll wheel – scale the axes.

A specific axis can be controlled by using these controls on the axis labels. The axes can be reset by clicking the 'A' button in the bottom-left of the plot, as shown in **Figure 8.8** (note, this button will only appear whilst the mouse cursor is over the plots).

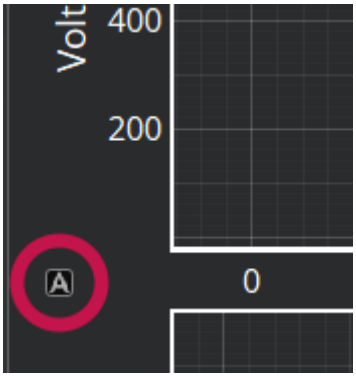

Figure 8.8. Button to reset the plot axes.

8.4 Data Logging

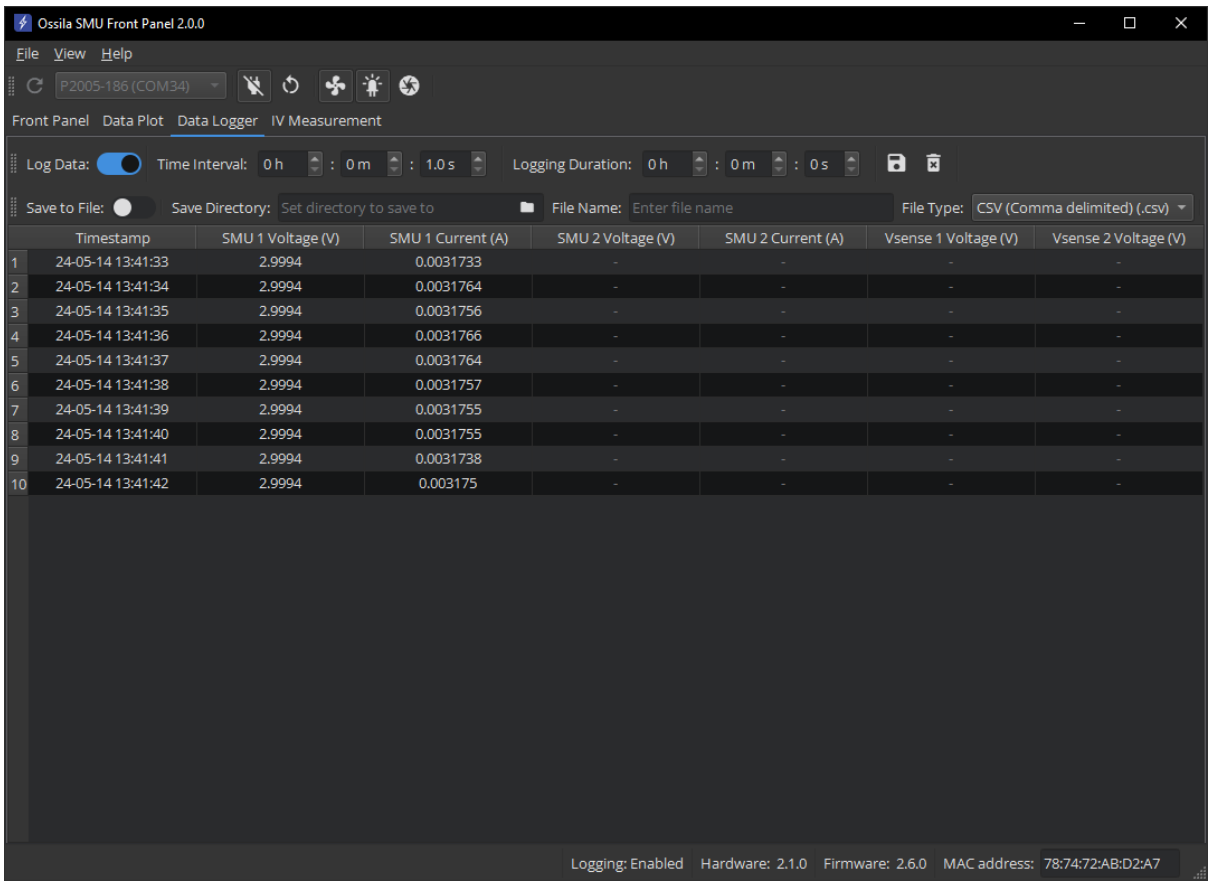

Figure 8.9. The Data Logger tab.

The Data Logger tab contains controls for periodically recording measurement data of the SMU and Vsense channels. While data logging is switched on, the measured values of both SMU and Vsense channels will be added to the table with a timestamp periodically. Logged data can optionally be saved to file as it is logged. There are several controls that can be used to customise data logging:

Log Data	Toggle logging data on and off.
Time Interval	The time to wait between logging measurements.
Logging Duration	The total duration to log data for. Logging will be automatically disabled when the duration has elapsed. The remaining duration is displayed on the right side of this tool bar.
	Save the data in the table to a CSV (comma delimited) (.csv) or text (tab delimited) (.txt) file. A file dialog will open to allow you to select a save file name and location.
	Clear all data from the table. A confirmation dialog box will be displayed.

Save to File	Toggle saving the data to file as it is logged in the table. The Save Directory, File Name, and File Type must be set to enable saving.
Save Directory	The file directory in which the saved data file is located or will be created. Clicking the file icon will open a dialog to browse to a directory.
File Name	The name of the file to save data to. If the file does not exist, it will be created before logging any data.
File Type	The type of file to save data to, CSV (comma delimited) (.csv) or text (tab delimited) (.txt).

8.4.1 Copying Data

Select the table cell or cells of the data to be copied, then either:

- Right-click on the highlighted cells and select 'Copy' from the menu.
- Press the copy keyboard shortcut (CTRL + C on Windows).

8.4.2 Deleting Table Rows

Select at least one row in each row to be deleted, then either:

- Right-click on the highlighted cells and select 'Delete' from the menu.
- Press the delete keyboard shortcut (Delete on Windows).

A confirmation dialog will appear before any data is deleted.

8.5 IV Measurement

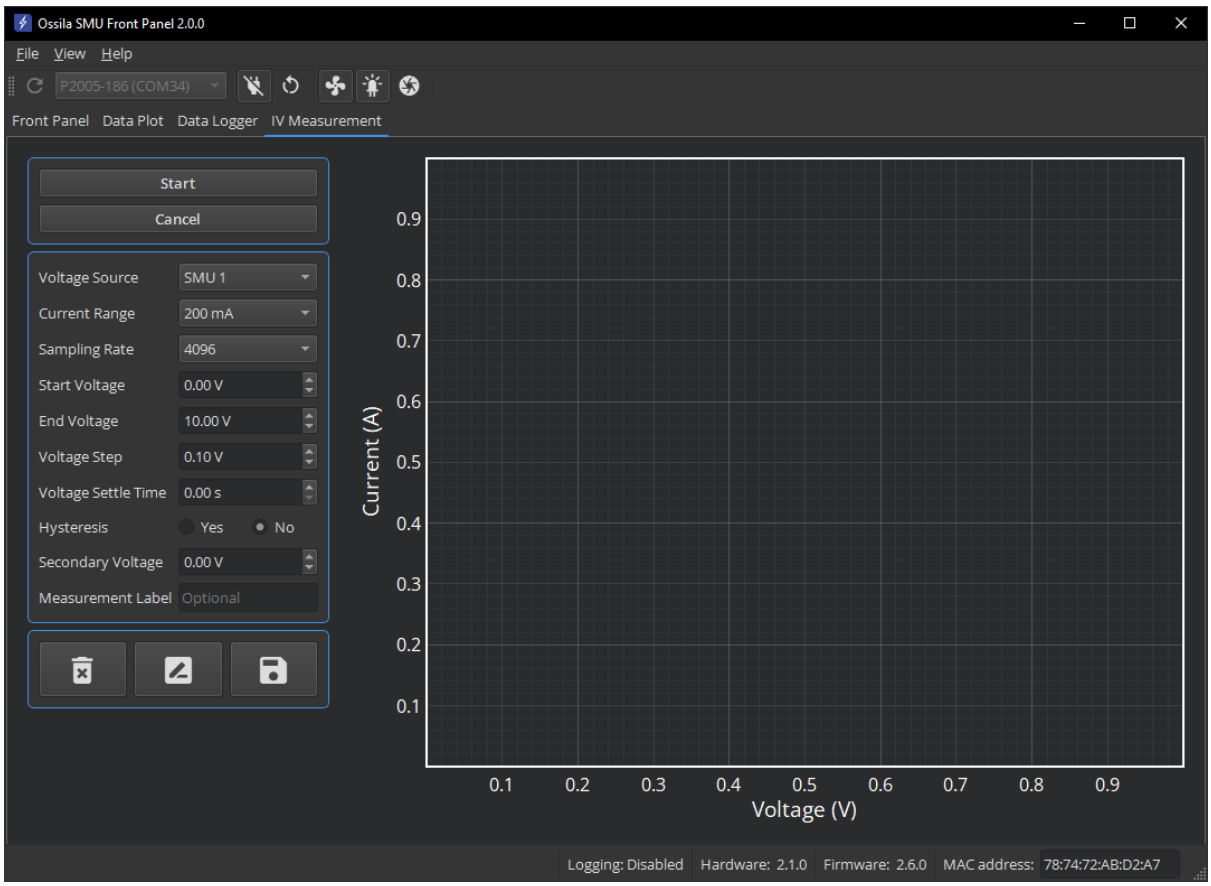

Figure 8.10. The IV Measurement tab.

The IV Measurement tab contains controls for perform current-voltage (IV) measurements. The measurement can be customised with the following settings:

Voltage Source	Which SMU channel to use for the IV measurement.
Current Range	The current range to use for the measurement. If autorange is selected, the software will automatically select the most appropriate range during the measurement.
Sampling Rate	The number of samples to take for each data point (the OSR, see **Section 5.2.2** for details).
Start Voltage	The voltage in volts at which to start the measurement.
End Voltage	The voltage in volts at which to end the measurement.
Voltage Step	The step size in volts for changing the voltage during the measurement.
Voltage Settle Time	The time in seconds between outputting a new voltage and measuring the current.

Hysteresis	Whether to perform a reverse IV measurement after the forwards measurement has completed. The reverse measurement uses the same settings as the forwards measurement, except with start and end voltages swapped.
Secondary Voltage	The voltage in volts to be output by the SMU channel not selected as the Voltage Source for the IV measurement. If set to 0 V, this will not be used.
Measurement Label	An optional label to give the IV measurement. Used to identify the measurement in the legend and selection windows.

When any of the below buttons are clicked, the window shown in **Figure 8.11** will open to allow selection of one or more IV measurements. Note, when relabelling, only a single measurement can be selected.

	Select IV measurements and save them to a CSV (comma delimited) (.csv) or text (tab delimited) (.txt) file. A file dialog will open to allow you to select a save file name and location.
	Select an IV measurement to change the label of.
	Select IV measurements to delete.

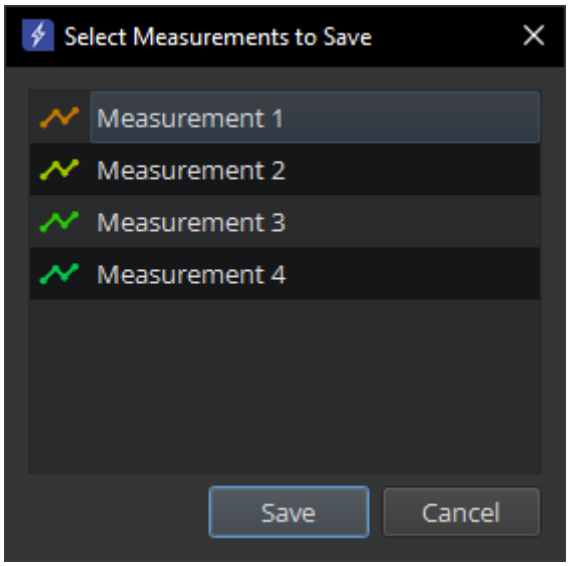

Figure 8.11. IV measurement selection window.

8.5.1 Plot Display Controls

The IV Measurement plot has the same controls as detailed in **Section 8.3**.

8.6 Menu Bar

8.6.1 File

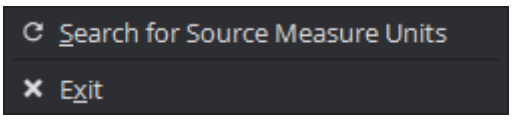

Figure 8.12. File menu options.

Search for Source Measure Units	Search the USB ports and network for Source Measure Units. Discovered units will be displayed in the drop-down box in tool bar.
Exit	Close the software.

8.6.2 View

Toggle Theme	Switch the software between light and dark themes.

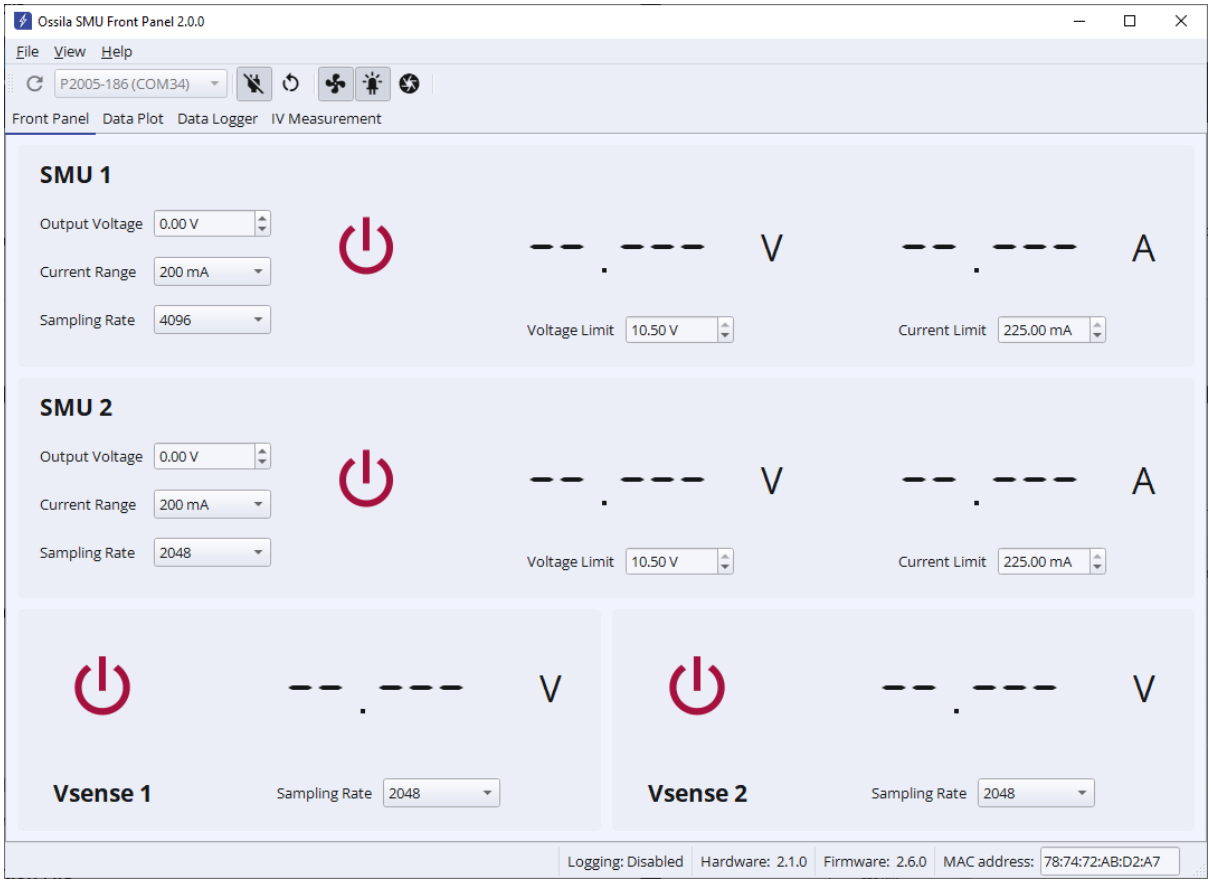

Figure 8.13. SMU Front Panel in light theme.

8.6.3 Help

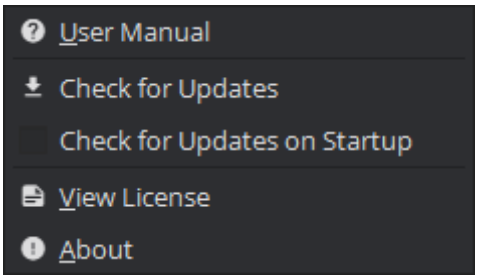

Figure 8.14. Help menu options.

User Manual	Open the user manual in your default web browser.
Check for updates	Check whether a newer version of the software is available to download and install. If an update is available a message will be displayed in the status bar with the latest version number. Clicking the message will take you to Ossila's website where you can download the new version.
Check for Software Updates on Startup	When checked the software will automatically check for software updates each time it starts.
License	Display software license information.
About	Display information about the software.

9. Advanced Measurements

If you want to perform a measurement that is not covered by the Front Panel software, you can control the Source Measure Unit directly using a variety of programming languages. More information and the available commands can be found in the Programming Documentation:

downloads.ossila.com/manuals/source-measure-unit-programming-documentation.pdf

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 10 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 cable is defective.	Try using a different USB-B cable, and contact Ossila if necessary.
	The USB drivers may not be installed or may not have installed properly.	Try installing or reinstalling the drivers, they can be downloaded from the address given in the Software Installation section.
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. Related Products

ITO Coated Substrates

Our range of ITO substrates for OPV, OLED, and sensing applications.

Product codes: S111 / S101 / S211 / S281 / S171

Flat Tip Tweezers

Provides a good substrate grip without scratching.

Product code: C121

FTO Coated Substrates

Designed to be used as transparent electrodes for thin-film photovoltaics.

Product codes: S301 / S302 / S303 / S304

Substrate Cleaning Rack

Holds 20 substrates for a variety of processing techniques.

Product codes: E101 / E102

Four-Point Probe

An easy-to-use tool for the rapid measurement of sheet resistance, resistivity, and conductivity of materials.

Product code: T2001A3

Solar Cell I-V Test System

Reliable and accurate characterisation of photovoltaic devices – no programming knowledge necessary!

Product codes: T2002 / T2003

LED Measurement System

Provides a low cost and complete solution for performing current-voltage-luminance characterisation of LEDs.

Product code: T2004 / T2005

Push-Fit Test Boards

For fast and secure electrical connections, this product makes PV and OLED device testing easy.

Product code: P2008A1 / P2011A1 / P2012A1