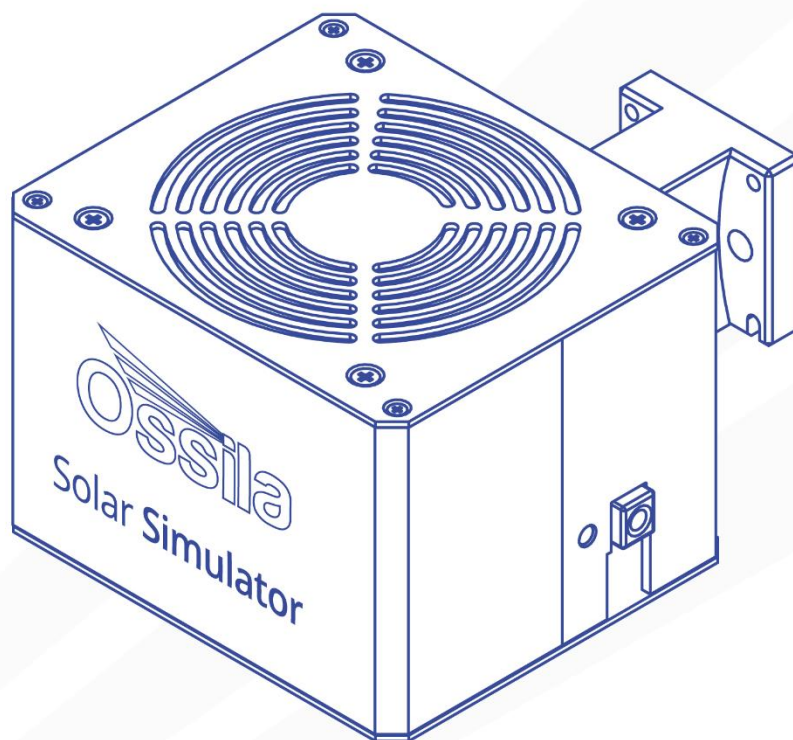


SOLAR SIMULATOR USER MANUAL

Manual version: 1.0.E

Product code: G2009

Product Version: 1.0



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1. Overview

The Ossila Solar Simulator is a small area, LED-based steady-state solar simulator. It can be used as a stand-alone unit or integrated into the Ossila Solar Cell I-V Test Systems for a complete characterisation system. Providing class AAA performance (IEC 60904-9:2020 Edition 3.0) over a 15 mm diameter area, it is an affordable solution for photovoltaic characterisation and any other analysis requiring an artificial solar spectrum.

The Ossila Solar Simulator is part of our Solar Cell Prototyping Platform, a complementary collection of substrates, materials, and equipment as part of a high-performance standard photovoltaic reference architecture. This platform enables researchers to produce high-quality, fully functional solar cells which can be used as a reliable baseline.

For more information: ossila.com/pages/solar-cell-prototyping-platform.



2. 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

Email Address: info@ossila.com

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

Product: Solar Simulator (G2009A1), Solar Simulator with Manual Stage (G2009B1)

Serial number: G2009A1-xxxx

Object of declaration:

Solar Simulator (G2009A1)

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

Photobiological safety of lamps and lamp systems IEC 62471:2006

Signed:



Name: Dr James Kingsley

Place: Leiden

Date: 16/11/2021

Декларация за съответствие на ЕС

Производител: Ossila BV, Biopartner 3 building, Galileiweg 8, 2333 BD Leiden, NL.

Декларира с цялата си отговорност, че посоченото оборудване съответства на приложимото законодателство на ЕС за хармонизиране, посочено на предходната(-ите) страница(-и) на настоящия документ.

[Čeština] Prohlášení o shodě EU

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Prohlašujeme na vlastní odpovědnost, že uvedené zařízení je v souladu s příslušnými harmonizačními předpisy EU uvedenými na předchozích stranách tohoto dokumentu.

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[Deutsch] EU-Konformitätserklärung

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[Eesti keel] ELi vastavusavaldus

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Kinnitame oma ainuvastutust, et loetletud seadmed on kooskõlas antud dokumendi eelmisel leheküljel / eelmistel lehekülgedel ära toodud asjaomaste ELi ühtlustamise õigusaktidega.

[Ελληνικά] Δήλωση πιστότητας ΕΕ

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Ar pilnu atbildību paziņojam, ka uzskaitītais aprīkojums atbilst attiecīgajiem ES saskaņošanas tiesību aktiem, kas minēti iepriekšējās šī dokumenta lapās.

[Lietuvių k.] ES atitikties deklaracija

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[Svenska] EU-försäkran om överensstämmelse

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Vi intygar härmed att den utrustning som förtecknas överensstämmer med relevanta förordningar gällande EU-harmonisering som finns på föregående sidor i detta dokument

3. Safety

3.1 Use of Equipment

The Ossila Solar Simulator 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, in accordance with European Commission regulations and British Standards. Use of any other electrical power cables, adaptors, or transformers is not recommended.

3.2 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
	Electrical shock
	Optical radiation
	Ultraviolet radiation

3.3 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.

3.4 Optical Hazards



The Ossila Solar simulator emits intense optical radiation in the ultraviolet, visible, and infrared regions of the electromagnetic spectrum. The device has been assessed according to IEC 62471:2006 (Photobiological safety of lamps and lamp systems) and assigned to Risk Group 3.

3.5 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.

4. Requirements

Table 4.1 details the power requirements and connectivity of the Ossila Solar Simulator.

Table 4.1. Ossila Solar Simulator requirements.

Power	24 VDC
Connectivity	USB-C

5. Unpacking

5.1 Packing List

The standard items included with the Ossila Solar Simulator (G2009A1) are:

- The Ossila Solar Simulator lamp.
- 24 VDC, 45 W power adaptor.
- USB memory stick loaded with data sheet, calibration data, and test data.

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 Ossila Solar Simulator specifications are shown in **Table 6.1**. See the data sheet included with the Solar Simulator for detailed specifications of the unit.

Table 6.1. Ossila Solar Simulator specifications.

Solar simulator type	Steady state
Illumination source	LED
Spectral match classification	A
Spatial non-uniformity classification (minimum diameters)	15 mm – A 25 mm – B 32 mm – C
Temporal instability classification	A
Spectral deviation	<70%
Spectral coverage	>80%
Working distance	85 mm
Warm up time	5 minutes
Dimensions	Length: 105 mm; Width: 90 mm; Height: 80 mm
Weight	600 g

7. System Components

The Ossila Solar Simulator Lamp is supplied with a 24 VCD, 45 W power adapter.



Figure 7.1. The Ossila Solar Simulator lamp front (left) and back (right).

8. Installation

The Solar Simulator lamp should be mounted appropriately such that air is free to circulate above and below the unit. There are 3 available mounting options:

1. **Height adjustable stage (sold separately).** The Solar Simulator lamp bracket is directly attached to the Z-stage platform, allowing manual adjustment of the lamp height. The lamp is attached to the stage using four M3 bolts as shown in **Figure 8.1**.

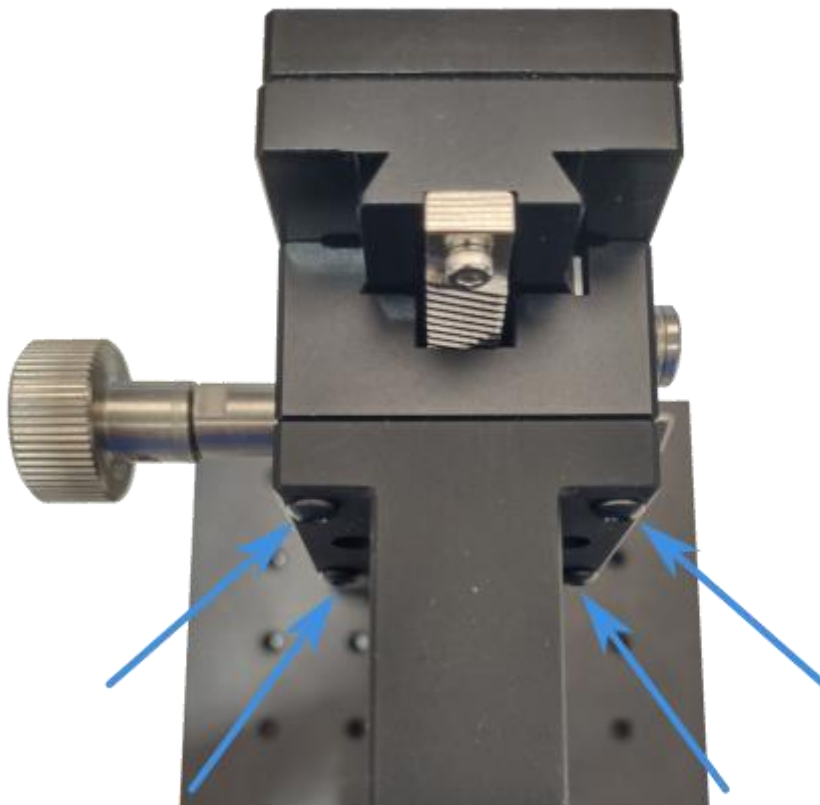


Figure 8.1. Mounting positions for attaching the Solar Simulator to the vertical stage platform.

2. **Fixed bracket integrated with the Ossila Solar Cell I-V Test System – Automated (sold separately).** The Solar Simulator lamp is affixed to a bracket mounted onto the automated version of the Ossila Solar Cell I-V Test System with four M3 bolts. There are two possible mounting positions available. The lower position is used when a 20 x 15 mm substrate measurement bracket is attached to the IV system, while the higher position is used when a 25 x 25 mm substrate measurement bracket is attached to the I-V system. The two possible positions are shown in **Figure 8.2**.



Figure 8.2. Bracket for mounting Solar Simulator on an Ossila Solar Cell I-V Test System - Automated. Left mounting is for 20 x 15 mm substrates, right for 25 x 25 mm substrates.

3. **Custom mounting.** The Solar Simulator lamp can be mounted to any user-supplied mounting platform using four M3 bolts and/or two M6 bolts, so long as there is unrestricted airflow 5 cm above and below the lamp unit. The mounting bracket dimensions are shown in **Figure 8.3**

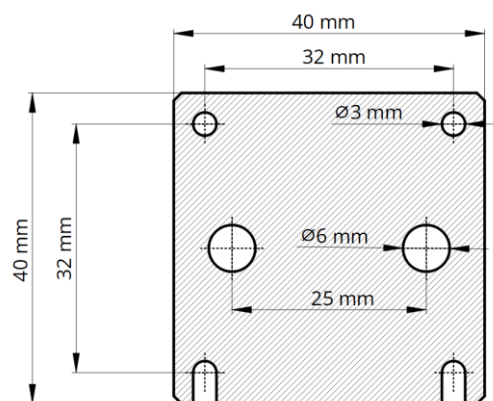


Figure 8.3. Mounting bracket dimensions.

Mount the Solar Simulator lamp according to one of options above. Connect the 24 VDC power adaptor to the power socket on the side of the unit.

9. Operation

When the system is first powered on, the light output will be 1 Sun (1000 W/m^2) at 85 mm below the bottom faceplate of the system. While the LEDs are turning on, the indicator light (next to the power button) will illuminate white. When the system reaches one sun after approximately 2 seconds, the indicator light will turn green. We suggest leaving the system to run for 5 minutes before starting measurements to allow the system temperature and LED output to stabilise.

The colour of the indicator light specifies the system operating conditions as listed in **Table 9.1**.

Table 9.1. Indicator light meanings.

Indicator Light Colour	Meaning
White	System is changing LED power
Green	Output is 1 sun (100 mW/cm^2)
Blue	Output is a calibrated power value other than 1 sun
Yellow	Output is uncalibrated (user has specified individual LED channel powers)
Intermittent flashing red	High temperature warning
Continuous flashing red	System error (see section 13).

The Ossila Solar Simulator connects to a computer through a USB connection. The device has a USB-C port located on the underside of the lamp, as shown in **Figure 9.1**. A USB cable should be used to connect the Solar Simulator to the computer. Communication is only possible when the system is turned on.

Warning: Ensure that the system is powered off when plugging and unplugging a USB cable.



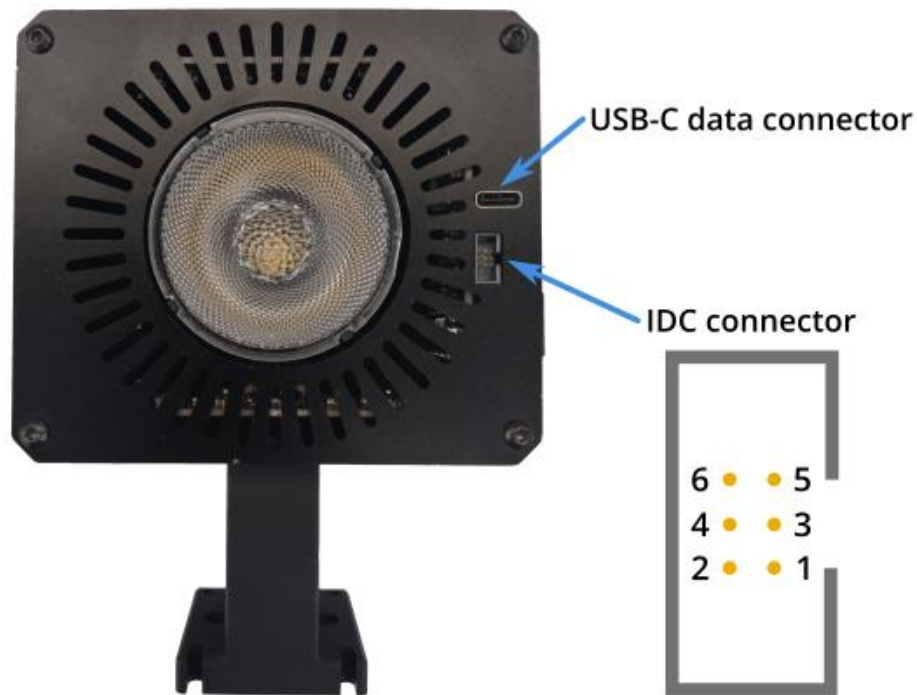


Figure 9.1. Connectivity ports of the Solar Simulator.

An external shutter control pin is provided through the IDC connector interface. The shutter pin is controlled through a serial command (see [Section 12.2](#)).

Table 9.2. ICD connector pin layout.

Pin	Function
1	Shutter
2	GND
3	NC
4	NC
5	NC
6	GND

10. Maintenance

The Ossila Solar Simulator is a sealed unit and requires no maintenance if used under the recommended conditions.

11. Solar Simulator Console

The Ossila Solar Simulator Console enables you to control the output of the Ossila Solar Simulator without having to use serial commands. You can choose the overall power level or control each LED in the Solar Simulator individually to tailor the output to your specific requirements.



Figure 11.1. Solar Simulator Console software.

11.1 Requirements

Table 11.1 details the power requirements and connectivity of the Ossila Solar Simulator.

Table 11.1. Ossila Solar Simulator Console requirements.

Operating System	Windows 10 or newer (64-bit)
CPU	Dual Core 2 GHz
RAM	4 GB
Available Disk Space	142 MB
Monitor Resolution	1440 x 960
Connectivity	USB

11.2 Installation

1. Install the Ossila Solar Simulator Console software on your PC.
 - I. Run the file 'Ossila-Solar-Simulator-Console-Installer-vX-X-X-X.exe'.
 - II. Follow the on-screen instructions to install the software.
2. Connect an Ossila Solar Simulator to your PC using a USB-C cable.

Note: The Ossila Solar Simulator Console software can also be downloaded from ossila.com/pages/software-drivers

11.3 Operation

11.3.1 Connecting to a Solar Simulator

When the software is started it will automatically search for any connected Ossila Solar Simulators and populate the connection box with their serial numbers.

The Solar Simulator serial number shown in the connection box is automatically connected to, and its current power settings are read to initialise the console.

11.3.2 Solar Simulator Controls

General controls for the Solar Simulator are located in the control bar at the top of the window.

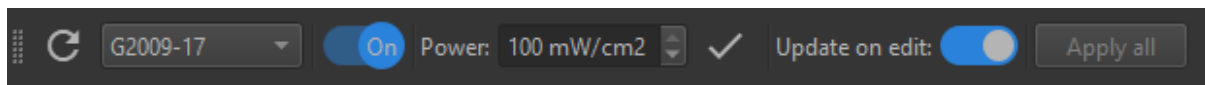
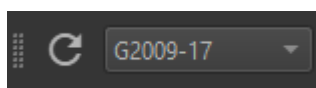


Figure 11.2. Solar Simulator Console general controls.

The control bar has the following sections:

(I) Connection



The dropdown box lists the serial numbers of any connected Solar Simulators. Selecting one will read its current power settings and update the console correspondingly.

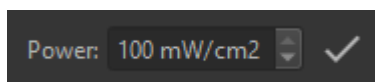
To search for connected Solar Simulators, click the button.

(II) Power Switch



Toggles the lamp output on and off. When switching on, the lamp will return to the power settings it had when it was switched off.

(III) Lamp Output Power

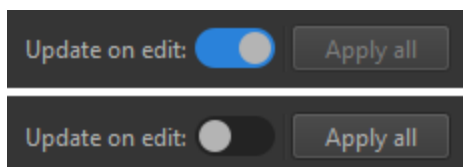


Sets the overall output power of the Solar Simulator in mW/cm².

When **Update on Edit** is checked the output will be changed when the **Enter** key is pressed or you click outside the power box.

Clicking the button will change the output power to the value in the box.

(IV) Update on Edit



While **Update on Edit** is checked any changes made to the overall power or to individual LED power in the software the output of the connected Solar Simulator will be immediately updated.

When unchecked, the **apply** () buttons must be clicked to change the output of the connected Solar Simulator.

The **Apply all** button will update all LEDs using the individual power settings. This button is disabled whilst **Update on Edit** is checked.

11.3.3 Individual LED Controls

The rest of the software contains controls for each individual LED in the Solar Simulator.



Figure 11.3. Example individual LED controls.

An individual LED's controls consist of 3 parts:

(I) LED Wavelength

The central wavelength of the LED. Cool white and warm white are broad band LEDs with ranges of 400 – 750 nm and 400 – 800 nm respectively.

(II) Power Controls

The output power of an LED can be changed by either moving the position of the slider or entering the desired power percentage directly. If **Update on Edit** is checked the LED's output power will be changed to the new value.

(III) Apply Button

The **apply** (✓) button will set the LEDs output to the current value of the power controls when **Update on Edit** is unchecked.

11.3.4 Updates

The software will check whether any updates are available when it starts up. If an update is available a message will be displayed in the lower right of the window with the latest version number. Clicking the message will take you to [Ossila's website](#) where you can download the new version.

12. Command Library

The Solar Simulator communicates with a host computer through a serial command library. When connected to a PC, the system will appear as a COM port, to which the serial commands could be sent. This section describes the command protocol and lists the available commands.

12.1 Command Format

Commands should be sent to the Solar Simulator in ASCII format, and responses from the Solar Simulator will also be in ASCII format.

All commands sent to the Solar Simulator have a start and end delimiter, < and > respectively. Only commands enclosed by these delimiters will be acknowledged by the device. If any invalid commands are sent between delimiters, the system will return <Invalid Command>. Commands can be setting commands or query commands.

Setting commands have the format <*parameter:value*>, where *parameter* is the setting to be changed, and *value* is the new value. The new value will be either a floating-point number, integer, or Boolean (0 or 1). Floating point numbers can be sent in scientific notation (e.g., 123e4 or 123E4). If a command requires an integer and a floating-point value is sent, the system will round the number down to an integer. If a Boolean is required and a non-zero floating-point number (or integer other than 0 or 1) is sent, the system will interpret it as a 1. If a setting command is successfully implemented, the system will echo back the command.

Query commands have the format <*parameter?*>. These commands allow the user to find current system settings without modifying them. If a query command is successfully interpreted, the system will return <*parameter:value*>.

12.2 Setting Command List

Command	Function	Expected Value
<power:value>	Sets the calibrated irradiance at the working distance.	0 or integer between 10 and 100. This is the irradiance (in mW/cm ²). Irradiances calibrated at every 10 mW/cm ² are stored in the system memory (i.e., 10 mW/cm ² , 20 mW/cm ² , 30 mW/cm ² etc.). Power can be set at an intermediate value, but the LED powers will be based on an interpolation between the calibrated values.
<chX:value>	Sets the power of LED channel X (see Table 12.1).	Integer between 0 and 100. This is the power in % of the maximum LED power. Setting an LED power in this way will put the system in to custom power mode.
<save:1>	Save the current setting to memory so that it is recalled when the system is powered on.	
<shutter:value>	Activates or deactivates shutter pin.	0 (output is 0V) or 1 (output is 3.3V).

12.3 Query Command List

Command	Function	Return
<power?>	Returns the current calibrated power.	<power: <i>value</i> > where <i>value</i> is an integer between 0 and 100, representing the irradiance (in mW/cm ²). If the system is in custom power mode, the device will return <power: <i>undef</i> >.
<chX?>	Returns the % power of LED channel <i>X</i> (see Table 12.1).	<chX: <i>value</i> > where <i>value</i> is an integer.
<device?>	Returns the device name.	<device: G2009>
<firmware?>	Returns the firmware number.	<firmware: <i>value</i> > where <i>value</i> is the firmware version (returned as a float).
<serial?>	Returns the serial number.	<serial: <i>value</i> > where <i>value</i> is the serial number (returned as an integer).
<temp?>	Returns the system temperature.	<temp: <i>value</i> > where <i>value</i> is the temperature in degrees Celsius.
<shutter?>	Returns the state of the shutter pin.	<shutter: <i>value</i> > where <i>value</i> is either 0 (shutter pin at 0V) or 1 (shutter pin at 3.3V).
<ledtime?>	Returns the total time the LED has been active.	<ledtime: <i>value</i> > where <i>value</i> is the number of minutes at least one LED channel has been turned on.
<error?>	Returns the current error state.	<error: <i>value</i> > where <i>value</i> is either: 0 – no error 1 – low voltage detected 2 – high temperature 3 – LED fault If an error other than 0 is returned, please see Section 14 .

12.4 LED Channels

Table 12.1 lists the channel numbers and corresponding wavelengths for each LED in the Solar Simulator.

Table 12.1. LED channels and their central wavelengths.

Channel	Central Wavelength
1	390 nm
2	450 nm
3	515 nm
4	Cool white (400 – 750 nm)
5	Warm white (400 – 800 nm)
6	600 nm
7	630 nm
8	660 nm
9	730 nm
10	850 nm
11	950 nm

13. Example Code

The following code is written in the Python programming language and shows how to set up the device, read, and plot a spectrum.

```
# The PySerial library is required to communicate with the Solar Simulator
# Ensure that it is installed on your system before running this script
import serial

# Open a serial connection to the Solar Simulator
# Here we use the 'with' statement to connect to the Solar Simulator, as this will automatically
# handle closing the connection when the with-block is exited, even if an error occurs
# In this example, the Solar Simulator is attached to COM port 18
# It is likely to be a different port on your computer
# In windows, you can see which port has been assigned in the Device Manager
with serial.Serial('COM18') as simulator:

    # We can read the current irradiance from the device using the <power?> command
    # The command needs to be converted into a byte array before being sent to the spectrometer
    # This is done using the encode() method
    simulator.write('<power?>'.encode())

    # The Solar Simulator will return the current irradiance
    # We can read its response with the readline() method
    # The decode() function is used to convert the response to a string
    response = simulator.readline().decode()

    # If we print the response, we will see <power:xxx> where xxx is the irradiance at the working
    # distance in in mW/cm^2
    print(response)

    # The irradiance can be changed using the <power:xxx> command
    # Here we set it to 50 mW/cm^2
    simulator.write('<power:50>'.encode())

    # The spectrometer will echo back the command if successful
    response = simulator.readline().decode()

    # The response will be <power:50>
    print(response)

    # Once the script is complete, close the interface to the Solar Simulator
    simulator.close()
```

14. 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.	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.
The system loses power.	Incorrect power adapter.	Ensure that the power adapter is 24V and can supply a minimum of 1.87A
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.
Intermittent red flashing indicator light. Solar simulator output is on.	High temperature.	Reduce ambient temperature if possible. Ensure vents at the top and bottom of the system are not blocked.
Continuous red flashing indicator light. Solar simulator output is off.	Low input voltage. System will return error code 1.	Ensure the correct power adapter (24V) is used.
	Temperature limit exceeded. System will return error code 2.	Turn off the system and allow to cool.
	LED failure. System will return error code 3.	Contact Ossila for repair.
The indicator LED does not turn green.	The start-up power has been modified.	Use the USB connection to send the command <code><power:100></code> followed by <code><save:1></code> to reset it to 1 sun.

15. Related Products

15.1 Related Consumables



ITO Coated Substrates

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

Product codes: S111 / S211 / S2006



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

15.2 Related Equipment



Solar Cell I-V Test System

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

Product codes: T2002 / T2003



Source Measure Unit

Source voltage, measure current, get data. Simplify and accelerate your data collection!

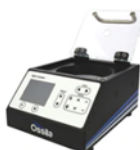
Product code: P2005A2



Push-Fit Test Boards

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

Product code: P2008A1 / P2011A1 / P2012A1



Spin Coater

Product high-quality coatings without any substrate warping. Perfect for busy labs with limited space.

Product code: L2001A3