PV Master 10

USER MANUAL

V1.2

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Thank you!

Thank you very much for your investment in our unique instrument. These are top-quality instruments which are designed to provide you years of reliable service. This guide has been prepared to help you get the most from your investment, starting from the day you take it out of the box, and extending for years into the future.

Support

When you are working with our products we want to provide you with the greatest possible benefits. If you need any support, we are her to assist you.

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1 Introduction

This manual contains important information and tips on how to use the NEO Messtechnik instruments safely, properly and efficiently. Its purpose to help you to avoid danger, repair costs, and down time as well as to help maintain reliability and life of the instruments.

The PV Master 10 is an All-in-one measurement instrument for photovoltaic plants combining with the latest technology. It can be used for leakage checks, performance tests and current measurement with high accuracy. The conformity of the device according to international standards enables the user to generate reliable and accurate reports for various applications.

The LCD touch screen, that is also readable under sunlight, proves to be very comfortable for mobile measurement tasks. In combination with the internal battery pack the PV Master 10 operates up to 4,5 hours without any external power source.

Equipped with USB 3.0, Ethernet (GBit), telecommunication modem, Wi-Fi and Bluetooth, the PV Master enables remote configuration and multi-device monitoring.

Main Features

- IV-curve tracing for up to 20 strings (with the extension box)
  Measurement time <200ms
- For voltages up to 1500V per string
- Currents up to 30A per string
- Leakage measurement and Distance to fault for user safety
- Current measurement
- Remote and mobile functions (LAN, WLAN, UMTS)
- Powerful x64-Intel-CPU, up to 8GB Memory
- High speed, high-capacity SSD (2 x 256GB max.)
- Direct analyzing on the sunlight readable multi-touch screen LCD and HDMI port for external monitor
- Versatile PV Performance software including analyzer, data storing, reporting

2 Safety Information

In order to ensure safe operations of this instrument, all notes and warnings in these instructions must be observed at all times.

All test leads must be securely attached to the PV system while testing. Always use the PV Master connectors supplied or alligator clips to connect the test leads to the PV system for testing. Test probes must not be used without alligator clips.

Never disconnect the test leads during an active measurement. This may result in electrical arcing and may damage the PV Master.

Do not attempt to turn off the PV Master during an active measurement.

The PV Master is intended for use in a dry environment only.

The PV test terminals maximum rating: 1500V DC open circuit voltage and 30A short circuit current. Do not exceed this rating. The DC supply must be isolated from earth/ground during testing.

2.1 General Safety

- Carefully read this manual before using the instrument.
- Use the instrument according to these instructions only.
- Use the instruments only under environmental conditions described in the technical data.
- Personnel assigned to use the instrument must have read this reference manual and fully understood the instructions herein.
- The instruments may only be operated by trained personnel. Any maloperation can result in damage to property or persons.
- The input voltage shall not exceed the values rated in the technical data. With this product, only use the power cable delivered or defined for the host country.
- There is no guarantee if you exceed the values for your safety.
- The power supply must be within the limits given in the technical data.
- Always make a visual inspection of used equipment such as leads and clamps before use.
- Use fuses (500mA) if you connect the instrument directly to voltage where no fuse is available or high short circuit power is given.
- The product heats during operation. Make sure there is adequate ventilation. Ventilation slots must not be covered!
- When connecting to the banana plug sockets, only use cables with 4mm/0.16” safety banana connectors and plastic housing. Always insert plugs completely.
- DO NOT insert objects into sockets or ventilation slots.
- DO NOT open the instrument or remove any of its housing components. Don’t carry out any modifications, extensions or adaptions at the instrument. If instrument is opened by the customer, all guarantees are invalidated.
- DO NOT use the system if equipment covers or shields are removed.
- DO NOT use the system in rooms with flammable gases, fumes or dust or in adverse environmental conditions.

- The use of the measuring system in schools and other training facilities must be observed by skilled personnel.
- Please contact a professional if you have doubts about the method of operation, safety or the connection of the system.
- Please be careful with the product. Shocks, hits and dropping it from already lower level may damage your system.
- Do not switch on the system after transporting it from a cold into a warm room and vice versa. The thereby created condensation may damage your system. Acclimatize the system unpowered to room temperature.
- Maintenance must be executed by qualified staff only.
- DO NOT operate damaged equipment: Whenever it is possible that the safety protection features built into this product have been impaired, either through physical damage, excessive moisture, or any other reason, REMOVE POWER and do not use the product until safe operation can be verified by service-trained personnel. If necessary, return the product to NEO Messtechnik sales and service office for service and repair to ensure that safety features are maintained.
- This manual is to be supplemented by existing national safety standards for accident prevention and environmental protection.
- The instructions provided in this manual and the associated software and hardware manuals are considered part of the rules governing proper usage.
- Observe local laws when using the instrument.
- The use of measuring devices under CAT II, III or IV conditions can be dangerous! Under these conditions, only appropriately trained / tested / informed about safety precautions may take measurements (for safety categories see also technical reference manual). If a measuring device, a cable or an accessory of a lower category or voltage is used, this lower category / voltage applies to the entire group (device + cable + accessories)
- DO NOT disconnect under load!
- DO NOT short circuit two wires to be measured by bringing the test leads into contact with them.
- DO NOT use our equipment with Magnet Adapters if you are a person wearing electronic medical devices such as peacemaker.
- The protection rating of the PV Master 10 and the extension box is IP2X.
- The protection rating of the Sensor box light is IP42.

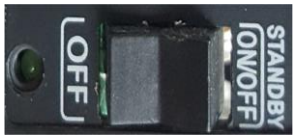
2.2 Battery Handling

Lithium-Ion rechargeable batteries require routine maintenance and care in their use and handling. Do not leave batteries unused for extended periods of time, either in the product or in storage. When a battery has been unused for 3 months, check the charge status and charge or dispose of the battery as appropriate.

Please especially consider the following points for storing the device:

- Charge the battery more than 50% of capacity before storage.
- Charge the battery more than 50% of capacity at least once every three months.
- Store the battery at temperatures between 5 °C and 20 °C (41 °F and 68 °F).
- The battery self-discharges during storage. Higher temperatures (above 20 °C or 68 °F) reduce the battery storage life.

If you will not use the instrument for longer time, always switch the Power button to OFF (bottom position). This enables the maximal power saving mode and will protect your battery of being over-discharged. Over-discharge of Li-Ion batteries has huge influence on their lifetime.



Position	Function
Right	Start (push switch)
Middle	ON after start or standby (returns to this position after push)
Left	OFF (MAX. power saving mode, useful for long term device storage)

If you start instrument after over-discharge or you didn't use it for a long time, the instrument may take several minutes to start up (even if fans are active). The integrated PC will start operation not before battery charge level will reach nominal operating conditions.

2.3 Warranty

The warranty for the instrument is 2 years – usual operating conditions preconditioned.

2.4 Recycling

- This is an electronic instrument and must be recycled according to the WEEE – directive. Do not throw away.
- More information see: http://ec.europa.eu/environment/waste/weee/index_en.htm
- Dispose of the test set in accordance with the legal environmental regulations in the country.

2.5 CE Conformity

- This instrument is compliant with the CE - requirements.
- **EMC Directive 2014/30/EU**
- **Test Procedure:**
  - EN 55011: 2009 + A1:2010(Group 1), Class A
  - EN 61326-1: 2013
  - EN 61000-3-2: 2014
  - EN 61000-3-3: 2013
- **EMI (EN55011):**
  - Conducted Emission (CE)
  - Radiated Emission (RE)
- **EMS (EN61000-4-2 ~ 11):**
  - Electrostatic discharge (ESD: EN61000-4-2)
  - Radiated RF immunity (RS: EN61000-4-3)
  - Electrical Fast Transient/BURST (EFT: EN61000-4-4)
  - Surge (Surge: EN61000-4-5)
  - Conducted RF immunity (CS: EN61000-4-6)
  - Voltage dip/interruption (DIP: EN61000-4-8/11)
- **Safety: EN 61010-1: 2010**

2.6 RoHS

- This product is compliant with the RoHS - Directive.
- For further information see: http://ec.europa.eu/environment /waste/rohs_eee/index_en.htm

3 Hardware

This chapter describes all the hardware features, like connector, ports and support stand.

3.1 Instrument

There are 2 banana connectors for IV curve and voltage measurement, one banana connector for ground connection and one ODU connector for Current Inputs on the top plate. Furthermore, there is one ODU connector for the sensor box, providing the PV Master with the temperature and solar irradiation data.

On the right side of the case are three fans for internal heat controlling.

Sunlight readable multi-touch LCD on the front side.

Device support and handle are on the rear side mounted. In addition, you can operate the touch screen with a touch pen located on the top of the back.

On the left side of the case are the computer interface, GPS antenna connector, battery indicator LED, power on/off switch and AC power inlet.

3.2 Power ON/OFF Switch

The Power ON/OFF switch is located on the left side on the bottom and has the following three functions, depending on its position.

Position	Function
Top	Start (push switch)
Middle	ON after start or standby (returns to this position after push)
Bottom	OFF (MAX. power saving mode, useful for long term device storage)

3.3 Connector Pins

All the connector pins for measurements are located on the top side.
2 banana connectors for IV-curve and voltage measurement are on the very left (red and black PV). The ODU connector on the left (SENSOR) is for the external sensor box. The banana connector for the ground (FGND) on the left side is used for the leakage measurement of the plant. The last ODU Sensor on the right side is for connecting a current clamp. The status LED on the upper right side shows the measurement status, it's blinking while measuring. Next to the status LED there is the GPS antenna for location tracking.

3.3.1 Voltage and IV-curve measurement inputs

The device has banana connectors on its top side for measuring a Voltage input signal or the IV-curve for one string (extendable with the extension box) up to 1500V. Combined with the extension box it is possible to connect 20 strings at the same time, each of those strings can have the maximum of 1500V.

Pin	Signal
Red	String V+
Black	String V-

3.3.2 Sensorbox Input

The sensor box is connected to the SENSOR connector.
This allows the PV Master to get temperature and solar irradiance data to create the correct IV-curve comparison.

3.3.3 Ground connector

The green-yellow connector FGND is used for the leakage measurement to connect to the ground of the PV plant. It is important to connect the clamp to a blank spot without varnish insulation.

Example 1 - Ground-mounted PV system

In this example the ground is connected to the equipotential bonding of the plant via alligator clip.

Example 2 – Rooftop- mounted PV system

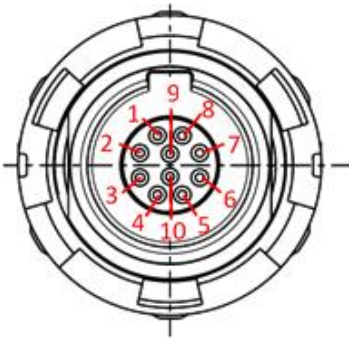
For rooftop mounted systems it is often best to connect the ground to the mounting of the plant like in the picture on the right.

3.3.4 Current Input

For current measurement it is possible to either connect a Rogowski ($2V_p$ max.) coil or a current clamp ($10V_p$ max.) to the clamp connector.

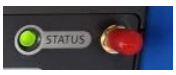
10pin ODU connector

Current sensors like Clamps, Rogowski-coils and other current sensors can be connected using the following pin assignment.



Pin	PV Master
1	Signal +
2	Signal- / GND
3	FGND
4	Rogowski +
5	TEDS
6	GND
7	Isolation GND
8	Isolation +9V
9	+15V
10	-15V

3.3.5 WIFI Antenna



The SMA jack connector is prepared for external WIFI antennas having a SMA plug type connector.

3.4 Sensor box

The PV Master sensor box is required for measuring the weather conditions (temperatures and solar irradiation). This box contains the pyranometer, the ambient temperature sensor and the connector for the module temperature sensor. The sensor box is available in 2 versions, namely light and expert, whereby the expert version can be customized.

3.4.1 Sensorbox light

The Sensorbox light has a class C pyranometer for measuring the solar irradiation and two PT100 sensors (one external, one internal) for measuring the ambient and module temperature. The cable leading to the PV master (sensor box input) is connected to the blue connector on the right-hand image. The red connector is used to connect the PT100 sensor which is attached to the module. There is a black protective cap on the pyranometer which must be removed during the measurement. It is recommended that this protective cap is always left on for transport.

The sensor box can be attached to the module frame or the PV mounting using the holder as shown in the following illustration. The ball joint allows the box to be aligned at the same angle to the sun as the modules.

3.4.2 Sensorbox expert

NEO Messtechnik has three different types of Sensorboxes to offer. There is the Sensorbox expert 2, Sensorbox expert 5 and Sensorbox expert Wireless. All expert sensorboxes have a touchscreen display, WLAN, two pyranometer inputs and temperature inputs. Each of these

boxes offers its own advantages. The different sensor boxes can be recognized by the article number:

Sensorbox expert 2

PY2TCK2 (2x pyranometer, 2x thermocouple type K)

PY2PTH2 (2x pyranometer, 2x PT100)

PY2PTT2 (2x pyranometer, 2x PT1000)

Sensorbox expert 5

PY2TCK5 (2x pyranometer, 5x thermocouple type K)

PY2PTH5 (2x pyranometer, 5x PT100)

PY2PTT5 (2x pyranometer, 5x PT1000)

Sensorbox wireless

The temperature measurement is done by a wirless temperature sensor.

Solar radiation measurement

The solar radiation measurement can be done by any type of pyranometer or reference cell. The sensor box expert offers 2x inputs for Solar radiation measurement and supports measurements at bifacial PV panels.

3.5 Extension box

With the extension box, the measuring time can be shortened considerably, as up to 20 strings can be connected simultaneously, with each individual string having a maximum current of 30A and a maximum voltage of 1500V. To do this, the extension box must be connected to the PV master at the bottom right ports. The sensor box is connected to the

bottom left of the box. A more detailed connection diagram is provided in chapter 4 Connection instructions. The connector "- COM" is the common negative pole which connects all negative poles of the individual channels within the box.

IMPORTANT!

For the leakage measurement the common ground cannot be used.

3.5.1 Computer Interface

The computer interfaces are located on the left top side

One 1GBit Ethernet interface, two USB3.0, one USB2.0 interfaces and one HDMI port for an external monitor.

HDMI Port	
Pin	Signal
1	TMDS data2+
2	TMDS data2 shield
3	TMDS data 2-
4	TMDS data 1+
5	TMDS data1 shield
6	TMDS data 1-
7	TMDS data 0+
8	TMDS data0 shield
9	TMDS data 0-
10	TMDS clock +
11	TMDS clock shield
12	TMDS clock -
13	CEC
14	NC
15	DDC clock
16	DDC data
17	GND
18	+ 5V
19	Plug detected

2 x USB 3.0	
Pin	Signal
1	VCC
2	Data-
3	Data+
4	GND
5	SSRX-
6	SSRX+
7	GND Drain
8	SSTX-
9	SSTX+

1 GB LAN	
Pin	**Signal**
1	BI_DA+
2	BI_DA-
3	BI_DB+
4	BI_DC+
5	BI_DC-
6	BI_DB-
7	BI_DD+
8	BI_DD-

USB 2.0	
Pin	Signal
1	VCC
2	Data-
3	Data+
4	GND

3.5.2 Battery indicator LED

NO. of ON LED	Remaining battery
5	80~100%
4	60~80%
3	40~60%
2	20~40%
1	0~20%

3.5.3 Fan

Three Fans for internal heat control are located on the right side. Two fans input the cold air, while the third outputs the internal warm air. The speed of the fans is controlled depending on the internal temperature. Additionally, metal mesh filters out the external dust particles.

3.5.4 Terms and definitions

PV

The abbreviation PV stands for Photovoltaic

STC conditions

For photovoltaic systems, STC conditions typically refer to Standard Test Conditions. These conditions are used to specify the testing environment for assessing the performance of solar panels or photovoltaic modules. STC conditions include:

Irradiance: Standard Test Conditions specify a solar irradiance level of 1000 watts per square meter (W/m^2) to simulate sunlight intensity.

Temperature: The cell temperature during testing is set at 25 degrees Celsius (77 degrees Fahrenheit) to standardize the performance evaluation.
Air Mass: STC assumes an air mass of 1.5, which represents the path length of sunlight through the Earth's atmosphere.

V_{OC} – Open circuit voltage

The open-circuit voltage (Voc) in a photovoltaic system refers to the maximum voltage a solar panel/string can produce when there's no load attached to it (i.e., no current is flowing). It represents the potential difference across the terminals of the solar panel/string when there's no external circuit connected, allowing electrons to move freely within the cell.

I_{SC} – Short circuit current

The short-circuit current (I_{sc}) in a photovoltaic system represents the maximum current that flows through a solar panel/string when the circuit is shorted, creating a zero-resistance path across its terminals. This condition occurs when the positive and negative terminals of the solar panel/string are directly connected without any load in the circuit.

V_{MPP} – Maximum power point voltage

VMPP (Maximum Power Point Voltage) in photovoltaics refers to the voltage at which a solar panel/string generates its maximum power output. It represents the specific voltage level at which the solar module/string operates most efficiently to produce the highest amount of electrical power while considering varying sunlight conditions and temperature.

IMPP – Maximum power point current

IMPP (Maximum Power Point Current) in photovoltaics refers to the highest current a solar panel/string can produce at its maximum power output. It represents the optimal current level that the solar module/string generates when operating at the Maximum Power Point (MPP), where the panel generates the most electricity under specific conditions of sunlight intensity and temperature.

IV-curve

The IV (current-voltage) curve in photovoltaics illustrates the relationship between the current (I) and voltage (V) output of a solar panel/string under varying conditions of sunlight intensity and temperature. It represents the electrical characteristics of the solar device.

4 Connection instructions

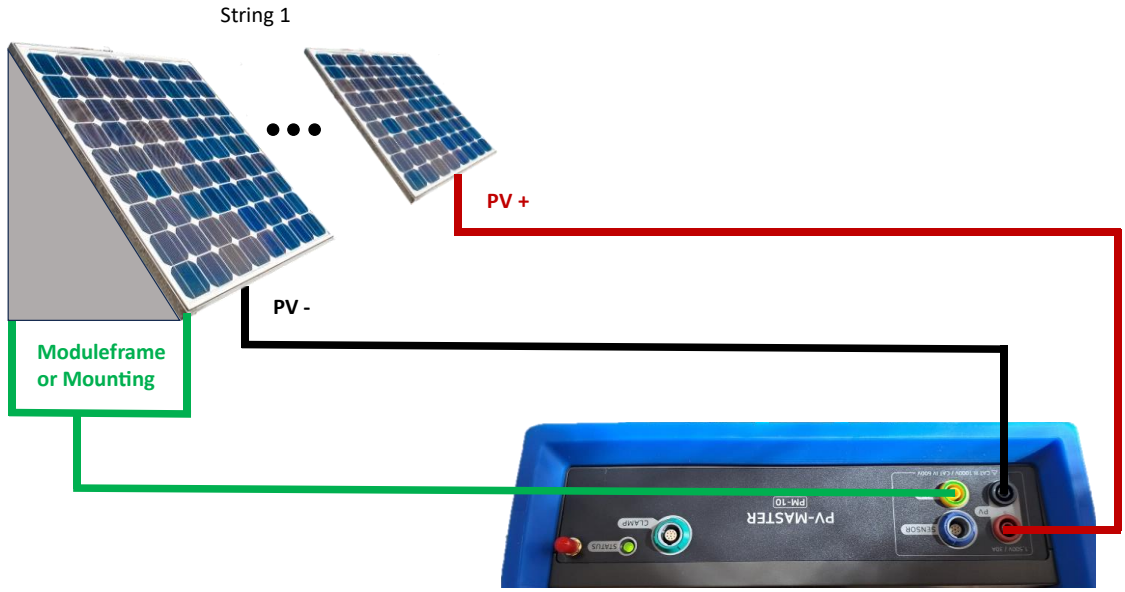
This section describes how the PV Master is connected to the components of the PV system and linked to the sensors and accessories of the PV Master. Please follow these instructions exactly to avoid damage to the appliance or personal injury. If you have any further questions or uncertainties, please contact the NEO Messtechnik information hotline.

4.1 Single channel leakage measurement

The following figure shows the measurement setup for leakage measurement of a single channel (string) using the PV Master. No accessories (sensor box, extension box) are required for leakage measurement apart from the measuring cables and the pick-up tips/clamps. As described in chapter 3.3.3, the earth connection can be established either via the mounting of the system or the module frame. Then the positive and negative cables of the PV string need to be connected to the PV master.

IMPORTANT!

Before this connection can be made, however, the load must be disconnected from the system (switch off the DC switch). It must be ensured that no power is generated by the photovoltaic system anymore and that the DC current is zero. Otherwise, danger to human beings or the measurement instrument is caused.

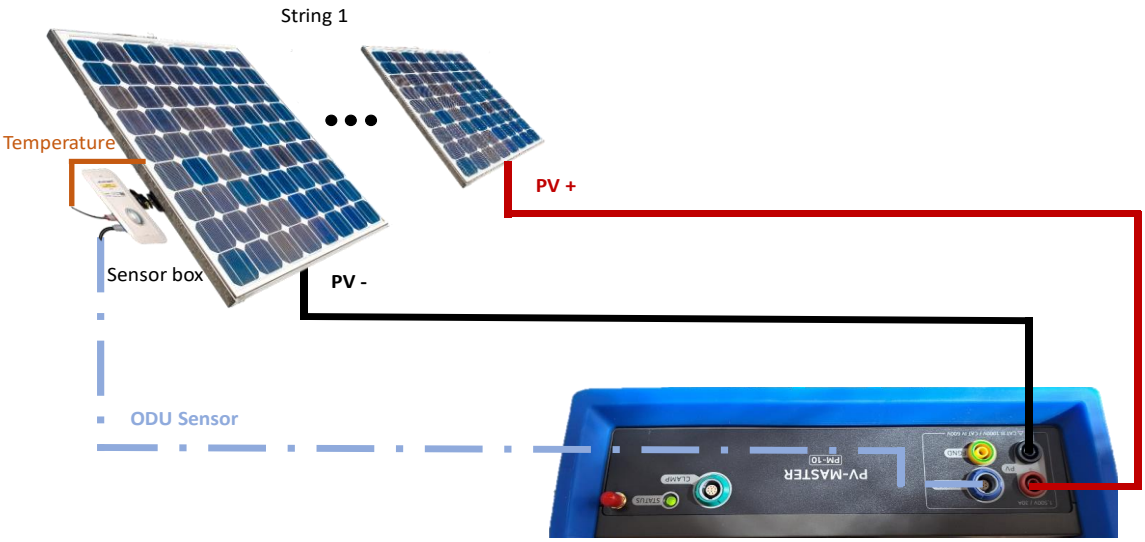


4.2 Single channel IV-curve measurement

For single-channel IV curve measurement, only the sensor box needs to be connected to the module frame or the rails of the system. The plus and minus cables can be taken directly from the leakage measurement. The temperature sensor must be positioned on the module in such a way that none of the cells are shaded by the sensor.

IMPORTANT!

The sensor box must be aligned in the same orientation to the sun as the photovoltaic modules are positioned.



The following minimal conditions have to be met to be able to measure an IV-curve

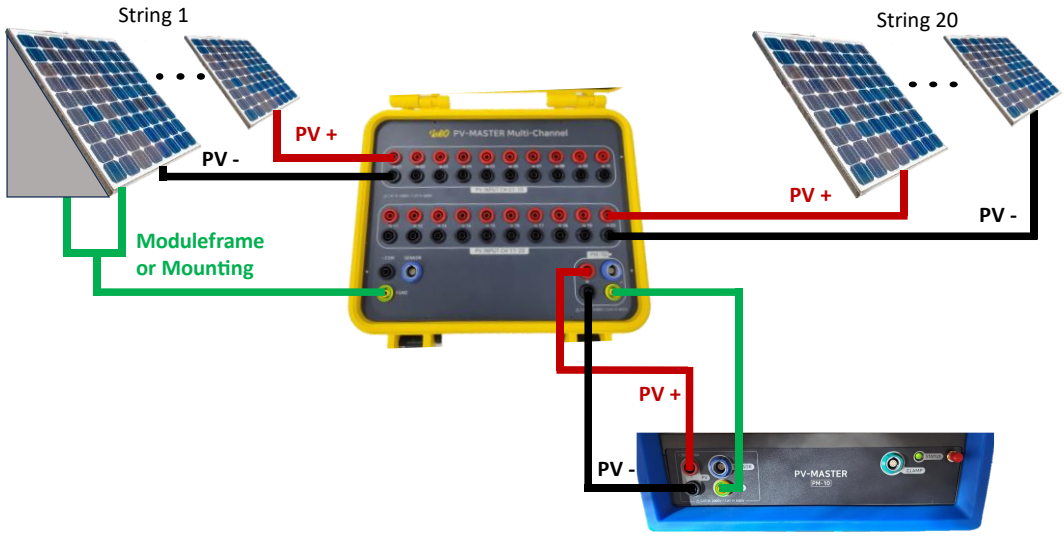
PM-10: IV-Curve min. U_{oc}=10V

PV-MULTI20 Version 1 (2023): IV-Curve min. U_{oc}>200 V

PV-MULTI20 Version 2 (2024): IV-Curve min. U_{oc}>50 V

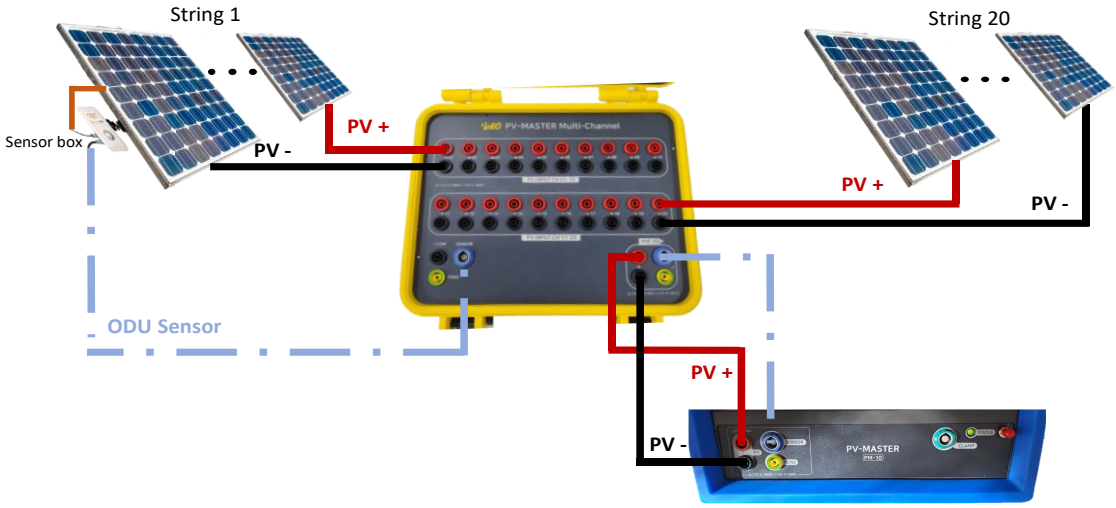
4.3 Multichannel leakage measurement

To measure several strings simultaneously, the extension box is connected to the PV master. To do this, the Ground, PV+ and PV- connectors are connected to the respective connector. The strings can then be connected to the inputs of the extension box. Up to 20 strings can be connected for one measurement. The inputs to be used can be selected in the software.



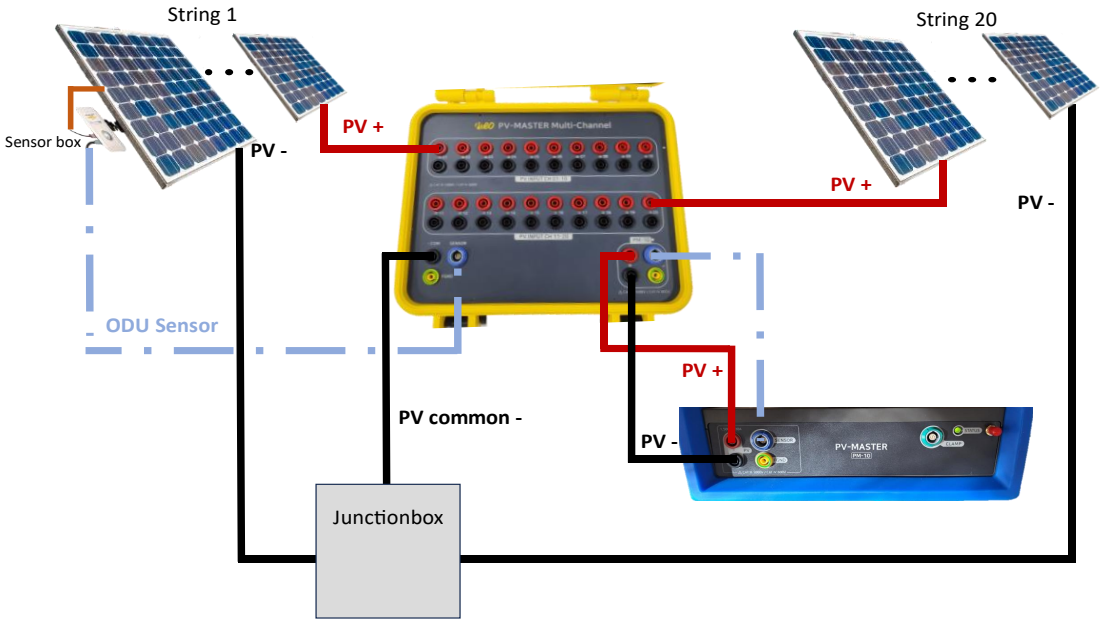
4.4 Multichannel IV-curve measurement

For the subsequent IV-curve measurement, only the sensor box needs to be installed on the module frames or rails. Otherwise, the procedure is the same as for the leakage measurement (except that the ground connection is not required).



4.5 Multichannel IV-curve measurement using common minus

If there is a common negative pole in the generator connection box, this can also be connected directly to the common negative of the extension box. This saves having to connect each negative pole of the individual strings.



5 Software

The measurement software is included with the device, while additional report and management software can be installed as it may be necessary. For further information, we would like to refer to the software manual.

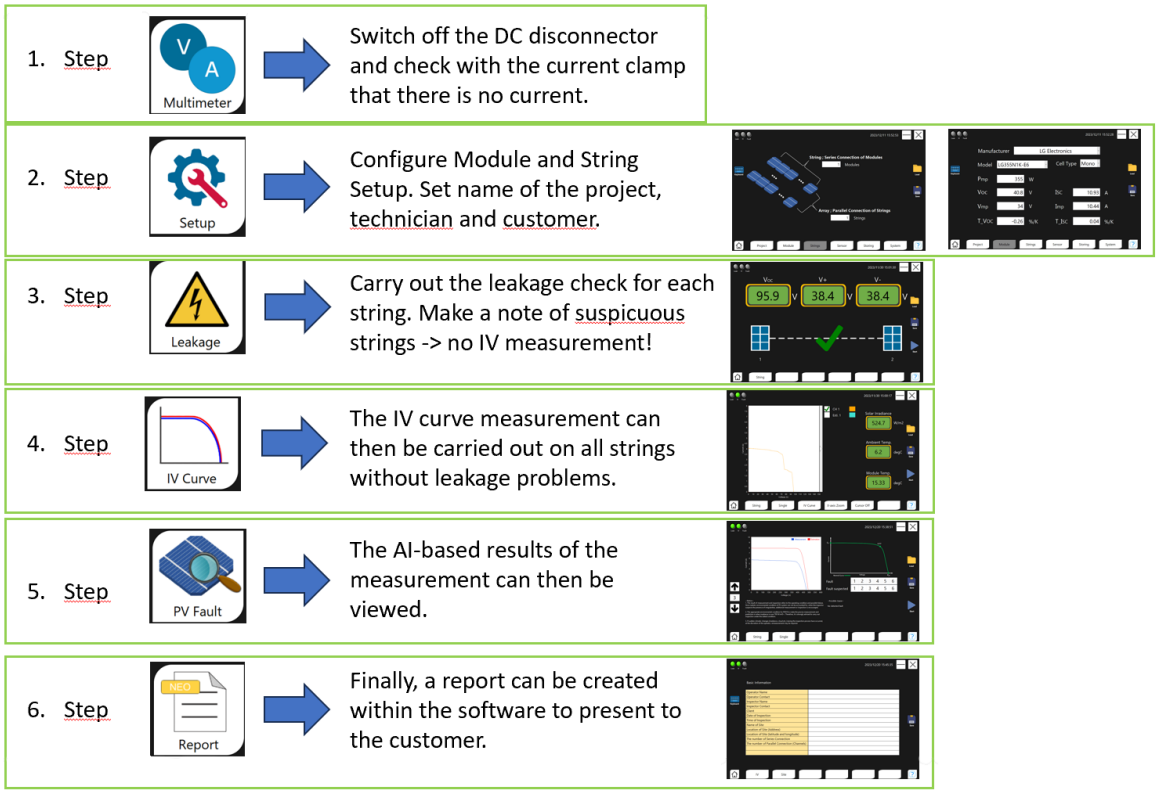
5.1 Start Measurement Software

After turning on the instrument, the NEO Software will automatically be started. If not, the software can be started by the shortcut on the desktop.

Note: The instrument always starts-up in the last used configuration (Sampling Rate, connection, range, language etc.)

5.2 Sequencing diagram

The following diagram describes the rough sequence of a measurement with the PV Master 10. You will find the more detailed procedure below.



5.3 Main

When the software is started, the main screen is displayed. It consists of an Auto Mode, the Leakage Measurement, the IV Curve Trace function, the Multimeter, the PV Fault Function, the Reporting Tool and the Setup Mode. The 

button can be used to view the saved data of measurements that have already been carried out. This applies to the leakage check, the IV curve measurement and the automatic fault diagnosis. To do this, simply click on load, select the saved file and load it. Depending on which results you want to see, click on Leakage, IV curve or PV fault after loading the file.

Continuous automatic measurements can be carried out using the **auto mode**. If the device has been properly installed with all the required sensors, monitoring can be carried out in this manner.

The **leakage check** must be carried out at the start of the measurement to rule out any risks. This indicates whether leakage currents occur in the system.

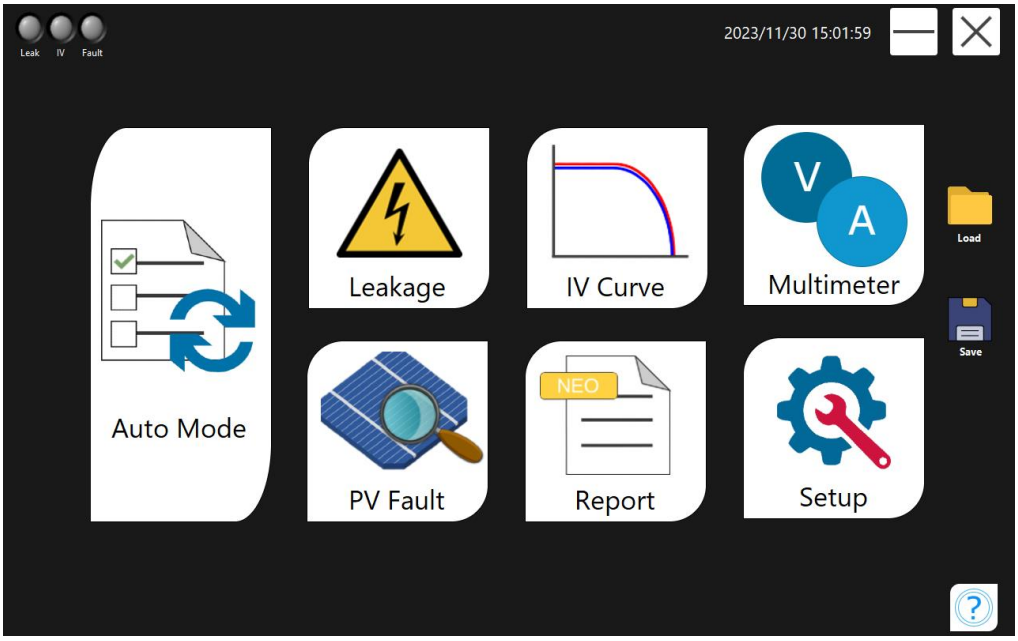
The **IV curve** measurement is the actual performance measurement of the system; the measured curve can be used to determine how much power loss occurs and why.

In **multimeter** mode, the PV Master acts like a multimeter. Irradiation, temperatures, DC currents and DC voltages can be measured.

PV Fault is the AI-based diagnostic function. The artificial intelligence compares the measured curves with a database of faulty curves. This allows the PV Master to determine the causes of faults independently.

Simple measurement reports can be created directly on the PV Master using the **report** function.

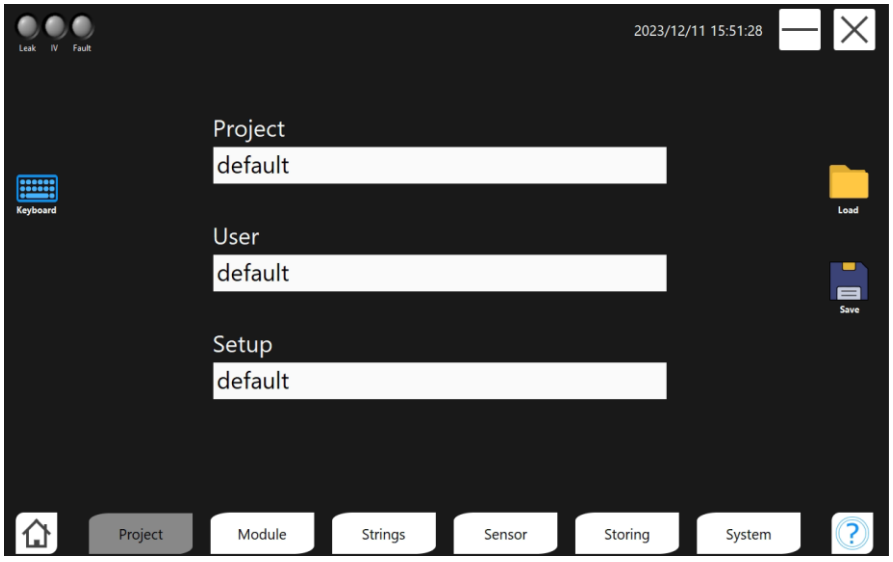
All settings can be adjusted under **Setup**.



5.4 Setup

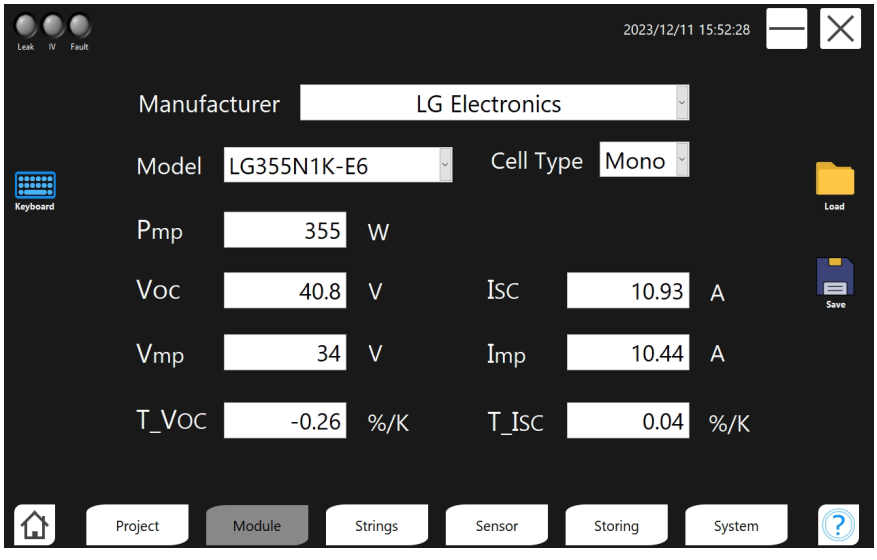
5.4.1 Project

When the Setup button is pressed, the Setup Mode is initiated, starting with the Project section. Here, projects, users and setup files can be created, and they can be loaded and saved using the Load and Save options. The filename is automatically generated from the Setup entry. On the left, there is an option to open a screen keyboard. The house symbol on the bottom takes you back to the Main Screen.



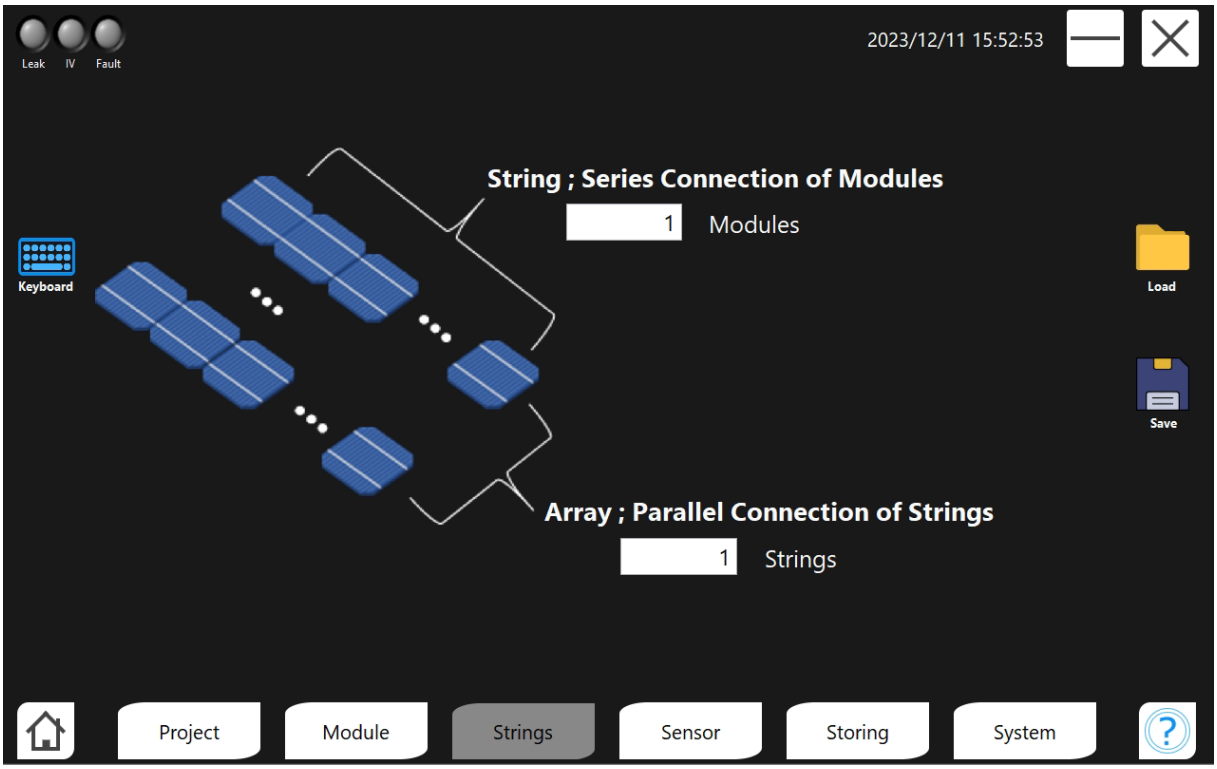
5.4.2 Module

In the Modules tab, the module can be configured. You can either load one directly from the database or manually enter data. Retrieve the information from the manufacturer's datasheet.

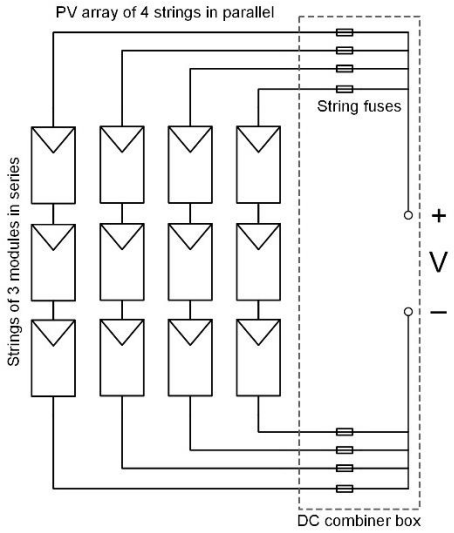


5.4.3 Strings

In the Strings tab, you can define how many modules are connected in series and how many in parallel. If you only want to measure a single module, select 1 Module Serial and 1 Module Parallel, as shown in the image below. If the strings have different numbers of modules, these would have to be measured separately (with their own setup).



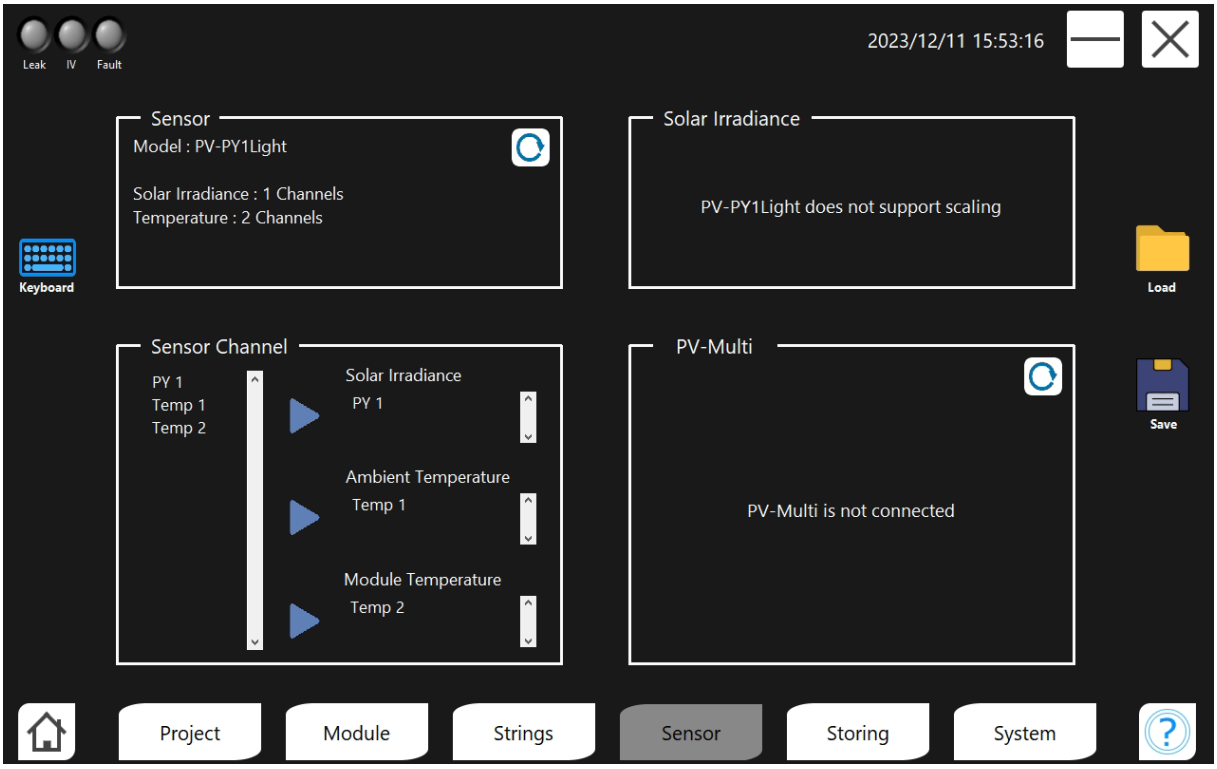
Example:



In this example there are 4 strings connected in parallel which all meet in the DC combiner box. Each string has 3 modules connected in series. For this example, the number 3 would have to be entered in the software under Modules and the number 4 under Strings.

5.4.4 Sensor

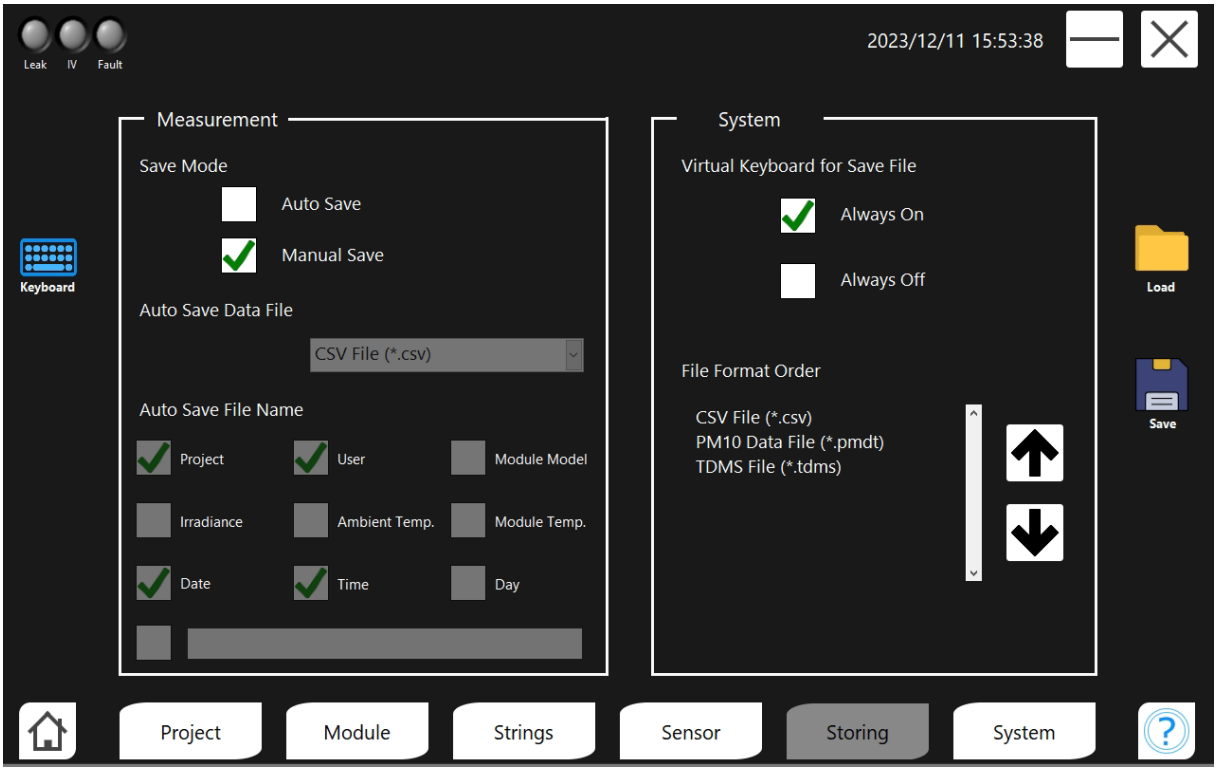
Here you can see an overview of the external sensors that have been connected. You can check whether the connected sensors have been initialized correctly. The PV-Multi window shows the connection status of the extension box. If the extension box is not used, the window can be ignored. In the Solar Irradiance window the scaling of the Pyranometer can be changed. This is not needed if the Sensor box light is used, as the scaling factor is already integrated.



5.4.5 Storing

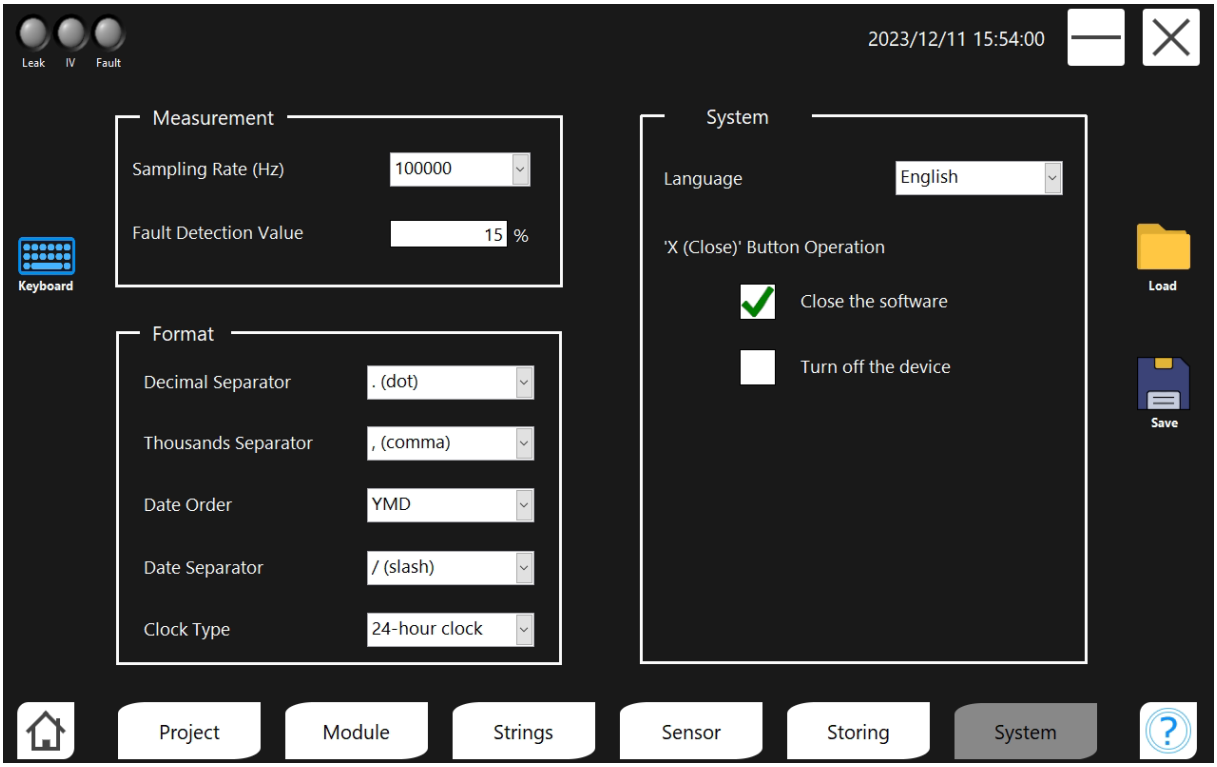
Here, you can make various settings for both the measurement and the system. You can activate the Automatic Save Mode or you can choose the Manual Mode:
Auto-Save: All executed measurements automatically will be saved
Manual – Save: After measurement the data needs to be saved manually by pressing the following button 

In the System section, you can show or hide the virtual keyboard. You can also change the order in which files are stored under File Format Order.



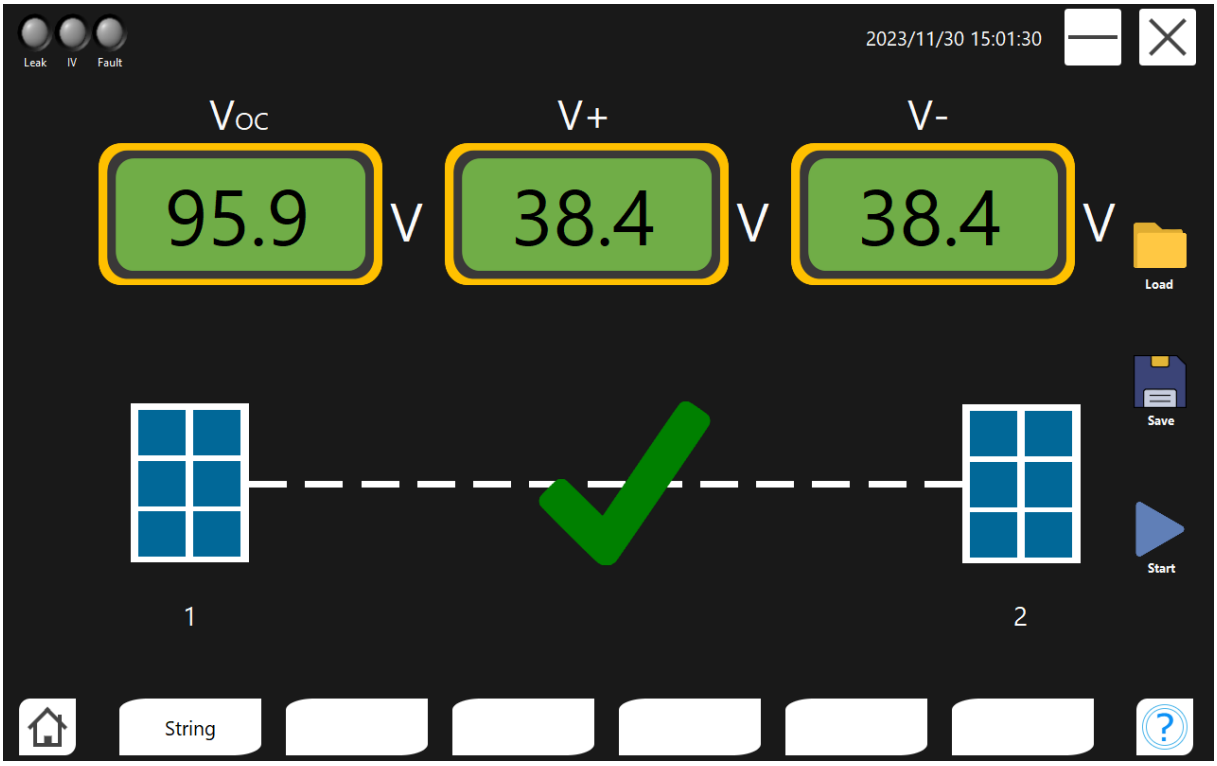
5.4.6 System

In the System section, you can make settings regarding the measurement, data format, and system. You can choose the sampling rate and define or adjust the Fault Detection Value, with default values being 100000 S/s and 15%. Format settings, such as Decimal Separator, Thousands Separator, Date Order, Date Separator, or Clock Type, can be configured under Format. In the System category, you can customize the language and specify the action when clicking on the X in the software.



5.5 Leakage measurement

When all settings have been configured, the Leakage Measurement can be performed. This can be done optionally for the string or array. To initiate, click on the blue 'Start' button.



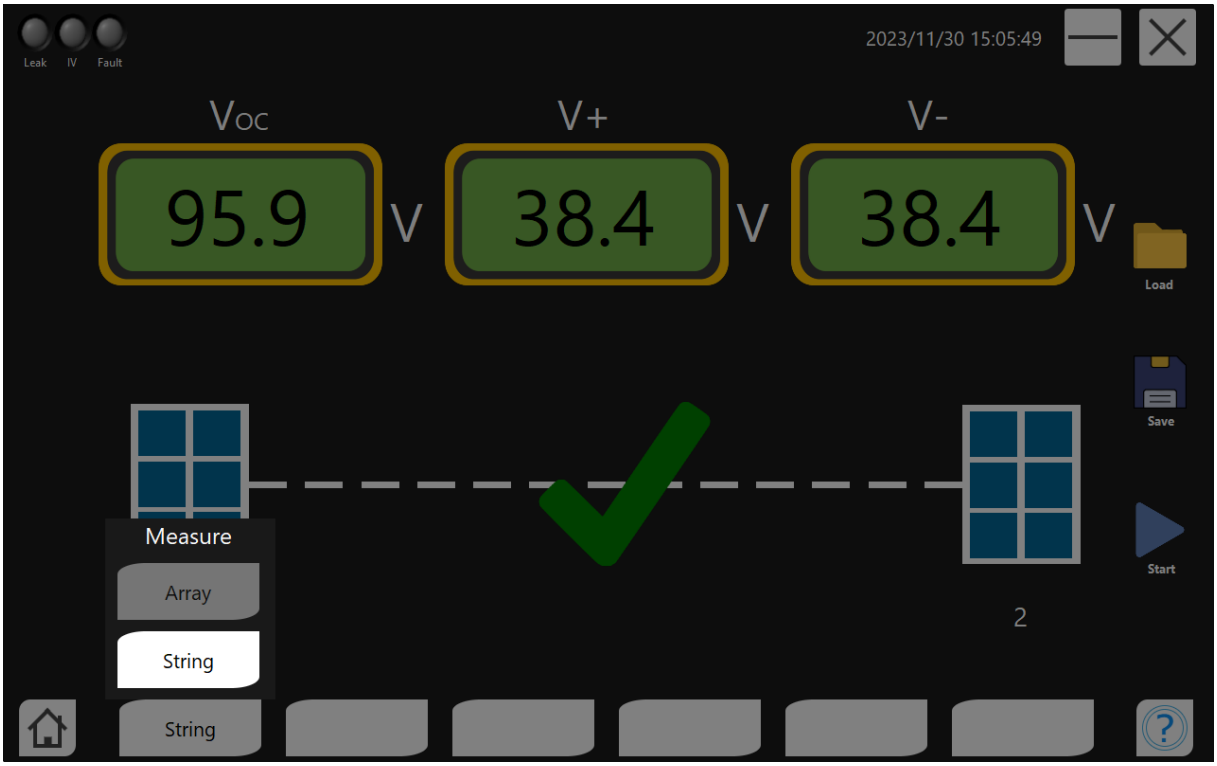
IMPORTANT!

Do not perform an IV curve measurement on strings with leakage errors! There is a danger to life!

IMPORTANT!

Leakage measurement must not be carried out for PV systems where one pole is at earth potential (e.g. - to GND).

5.5.1 String/Array



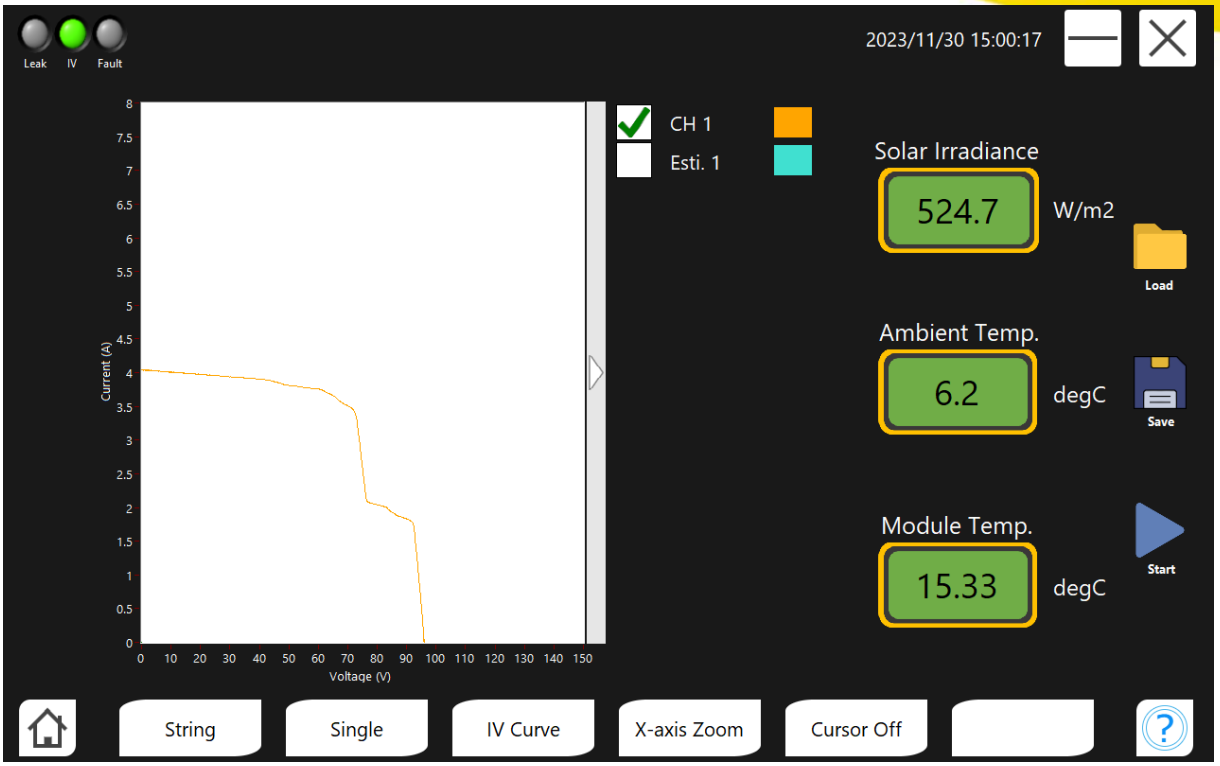
5.6 IV Curve

The IV Curve function offers various features and display options, which will be explained in the following points. To start the measurement, click on 'Start'. You will then see the IV Curve and the ability to toggle STC (Esti. 1) on and off. On the right, you can view the Solar Irradiance, Ambient Temperature, and Module Temperature (in degrees Celsius).

IMPORTANT!

Do not perform an IV curve measurement on strings with leakage errors! There is a danger to life!

Note: For PV systems where one pole is at earth potential (e.g. - to GND), the IV curve may only be carried out if proper operation of the PV system has been ensured beforehand. Otherwise, the measurement is carried out at your own risk.


Leak
IV
Fault
2023/11/30 15:00:17
CH 1
Esti. 1
Solar Irradiance
524.7
W/m2
Load
Ambient Temp.
6.2
degC
Save
Module Temp.
15.33
degC
Start
Current (A)
Voltage (V)
String
Single
IV Curve
X-axis Zoom
Cursor Off

5.6.1 String/Array

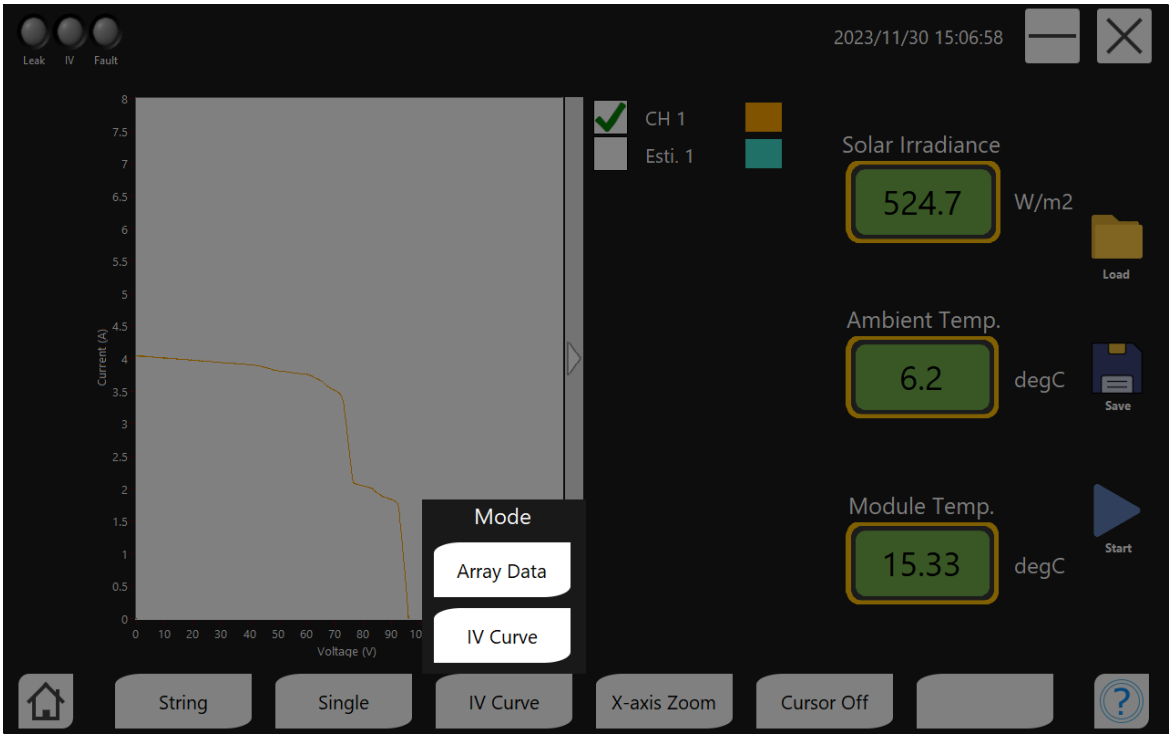
You can switch between String and Arrays easily.

5.6.2 Data display

You can switch between different display options, including Single, All, and User-defined. This allows a combined or a clear analysis of the data.

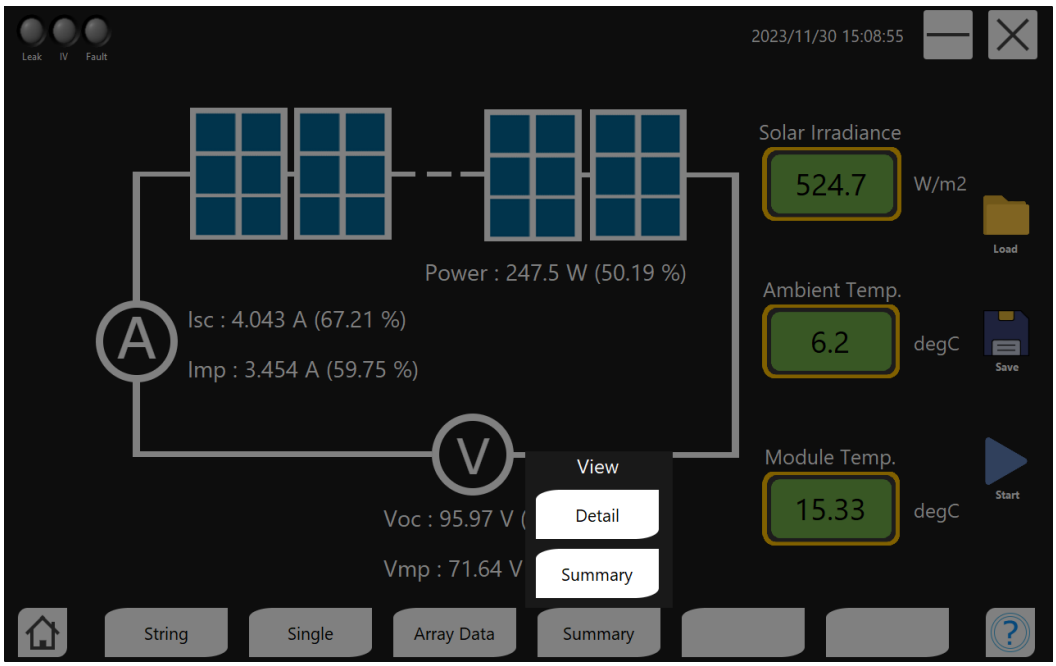
5.6.3 IV Curve/Array Data

You can toggle between two modes by clicking on 'IV Curve'. You can choose either the IV Curve view or access the Array Data view. If you select the Array Data view, as shown in the next point, you can choose between 'Summary' and 'Detail'.



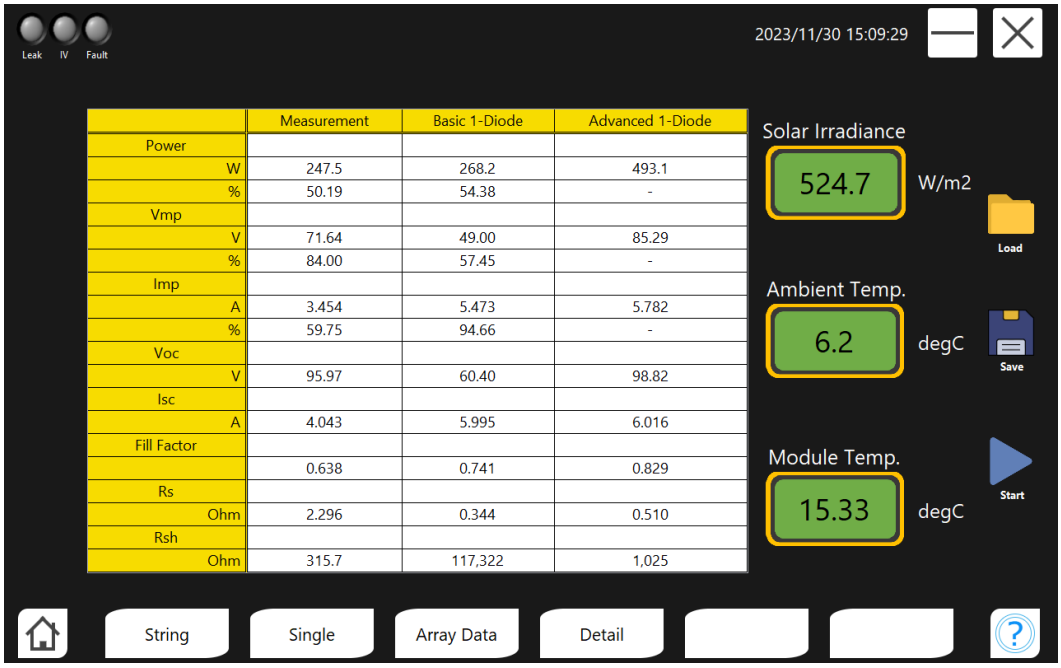
5.6.4 Array data – Detail/Summary

The most important characteristics (see chapter 3.5.4) of an IV curve measurement are displayed in the Array Data tab.



5.6.5 Array Data – Detail

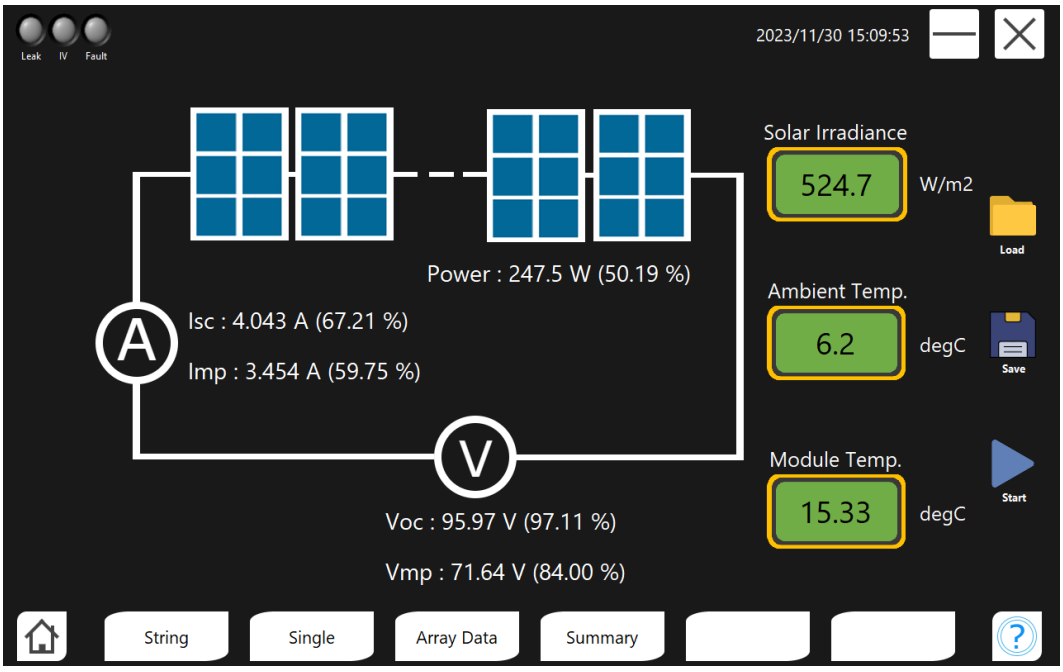
When you activate 'Detail', you will get a tabular overview of the measurement values. Two different calculation models are used in the PV Master. The basic 1 diode model and the advanced 1 diode model. These can be compared and represent the expected curve.



	Measurement	Basic 1-Diode	Advanced 1-Diode
Power			
W	247.5	268.2	493.1
%	50.19	54.38	-
Vmp			
V	71.64	49.00	85.29
%	84.00	57.45	-
Imp			
A	3.454	5.473	5.782
%	59.75	94.66	-
Voc			
V	95.97	60.40	98.82
Isc			
A	4.043	5.995	6.016
Fill Factor			
	0.638	0.741	0.829
Rs			
Ohm	2.296	0.344	0.510
Rsh			
Ohm	315.7	117,322	1,025

5.6.6 Array Data – Summary

When you activate 'Summary', you will get a graphical overview of the measurement data.



5.6.7 Graphic Tools

For data analysis, various tools are available to you.

Click Unzoom: Zooms out one step on click on diagram.

Click Zoom: Zooms in one step on click on diagram.

Free Zoom: Create a square by clicking, holding and dragging the mouse to zoom in.

Y-axis Zoom: Enlarge the Y-axis by clicking and dragging the mouse.

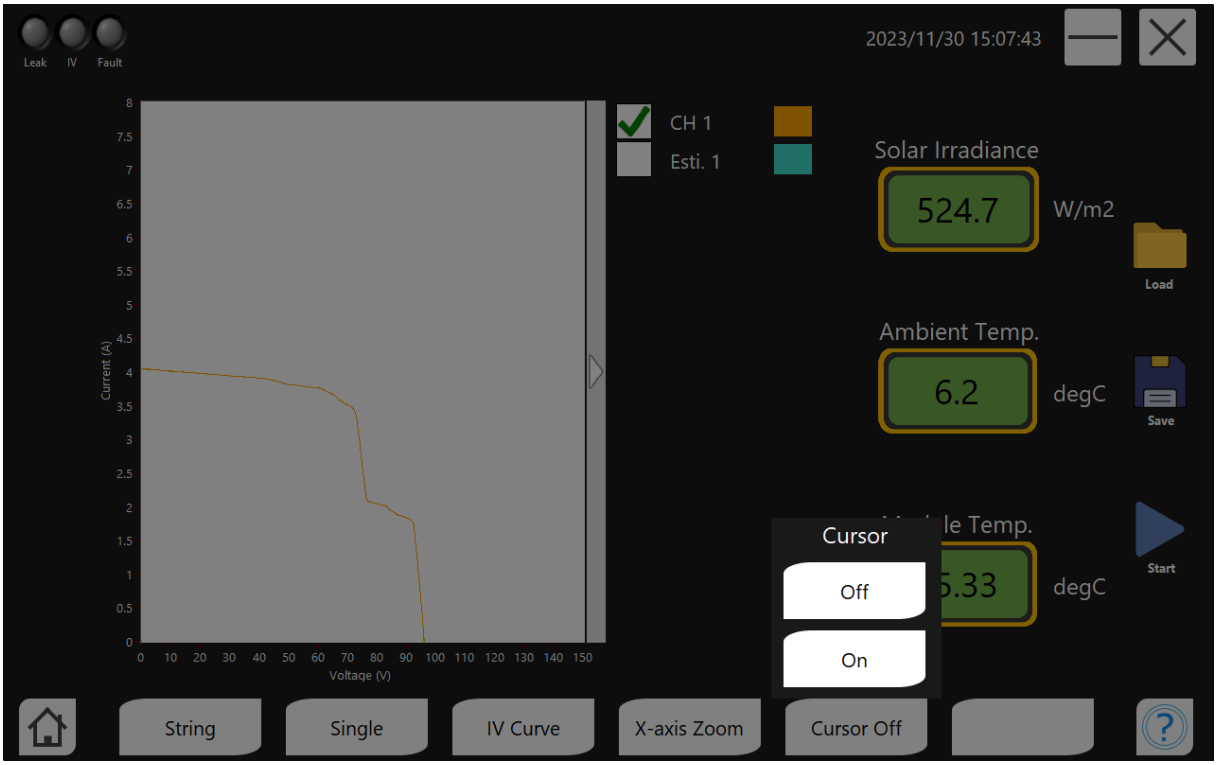
X-axis Zoom: Enlarge the X-axis by clicking and dragging the mouse.

Move: Lets you move the IV curve within the diagram by clicking and dragging the mouse.

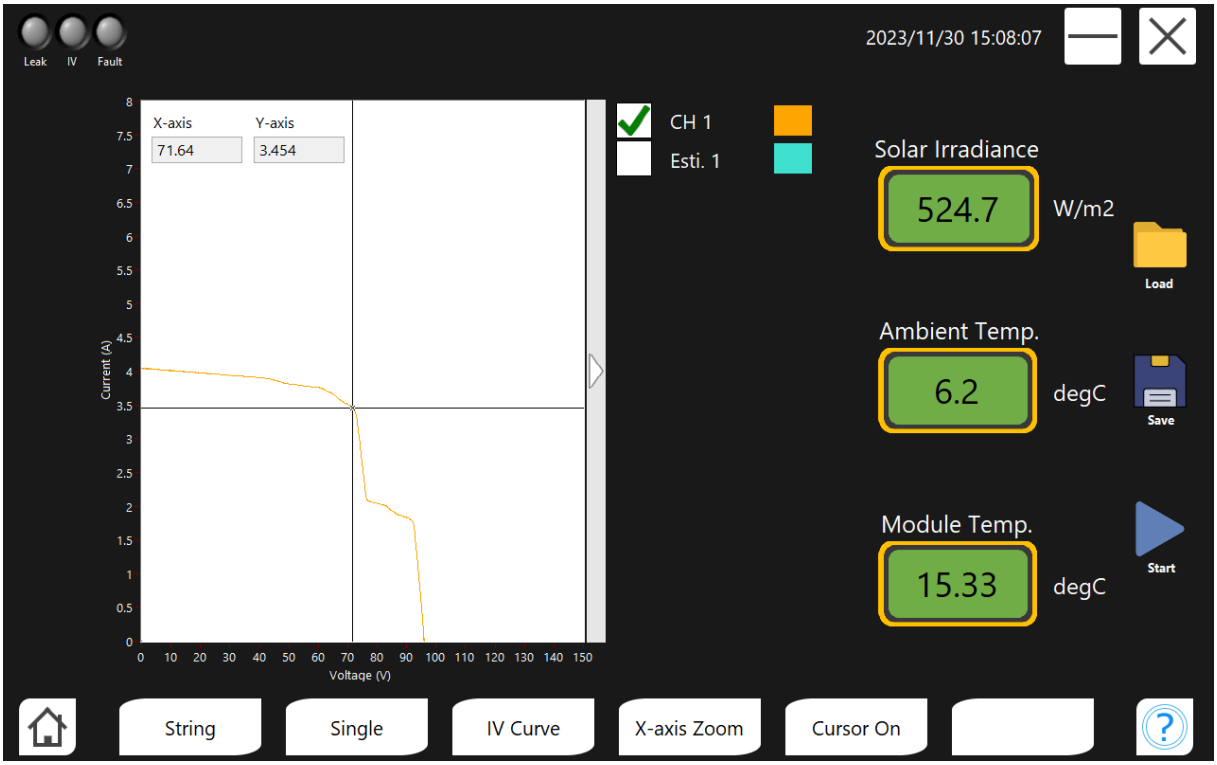
Reset: Resets everything to the initial view.

5.6.8 Cursor Toggle

You can activate the cursor, giving you the ability to traverse each point of the IV Curve with the cursor. In a pop-up table, you can view the cursor data (see the following point).

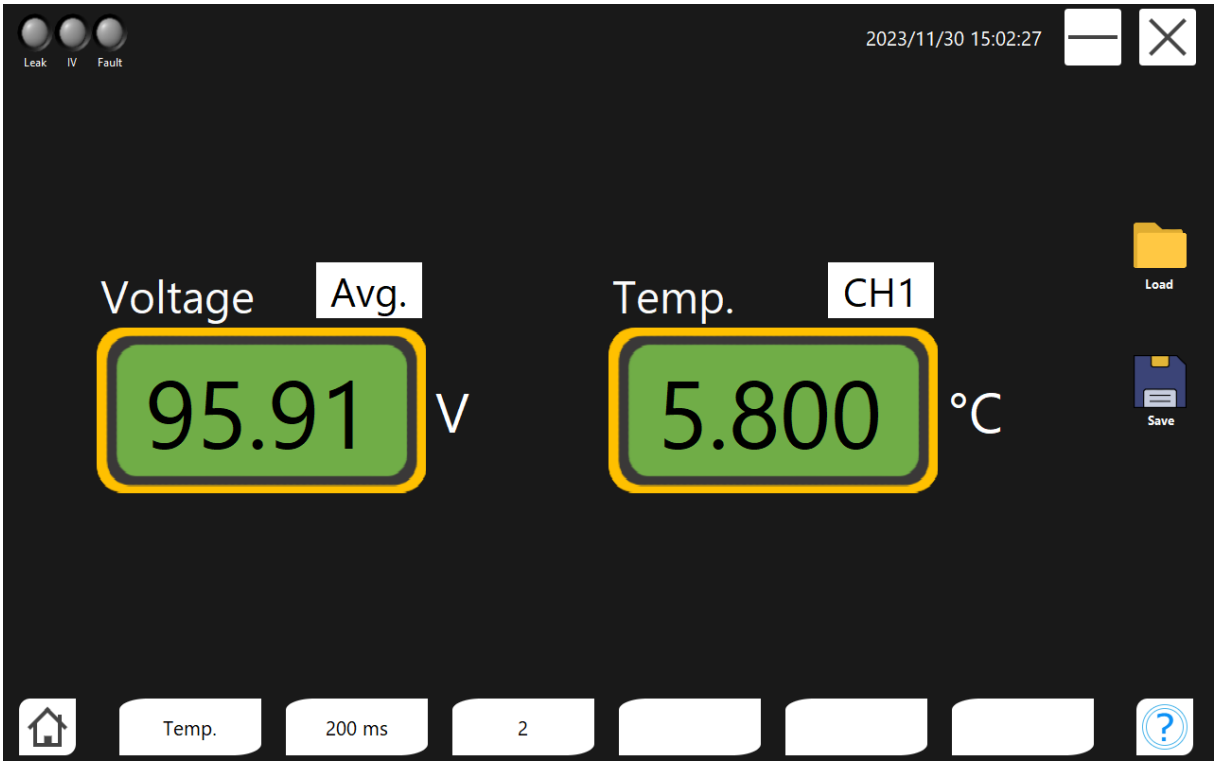


5.6.9 Cursor On



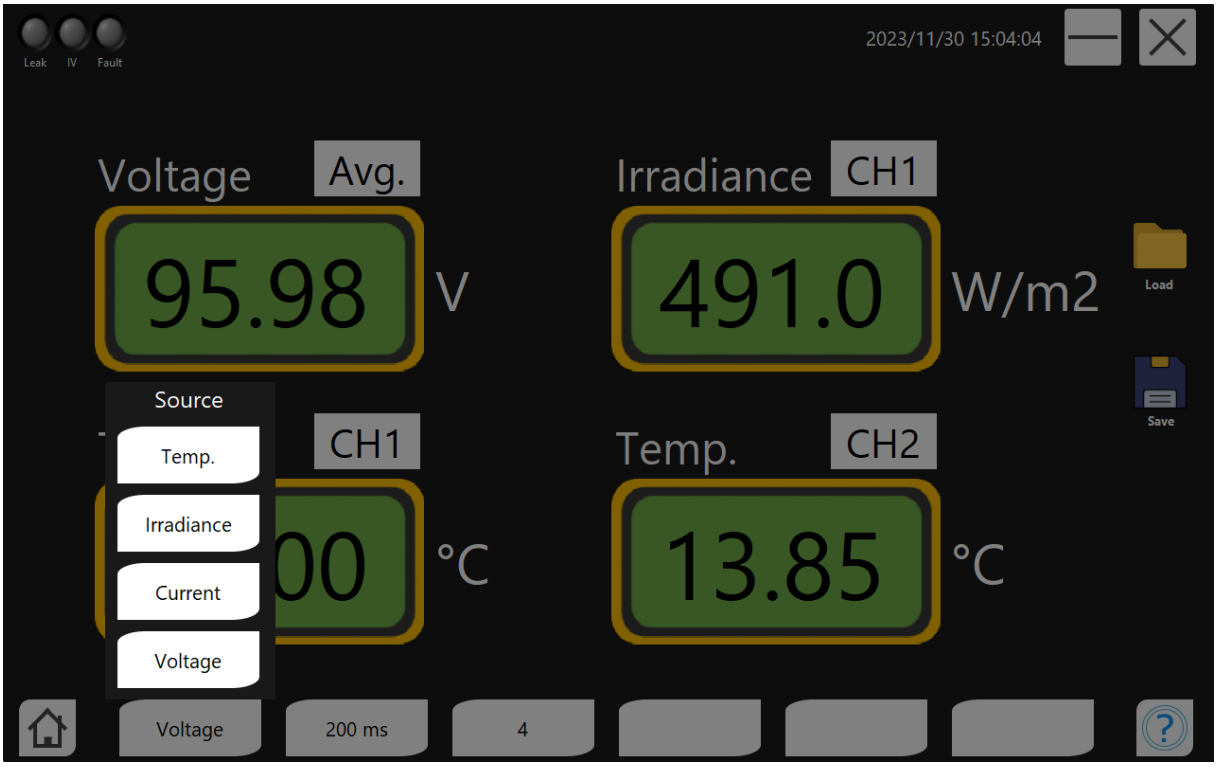
5.7 Multimeter functions

In the multimeter, you can display various digital displays, including voltage, current, temperature, and solar irradiance. You can also customize the time and quantity of displays. To change a display parameter, click on a variable (e.g., voltage) and then select the desired display; it will be reassigned accordingly. By clicking on the grey area above the display (CH1), you can change either the input channel (if more available, like for Temperature) or change between Average (Avg.) or RMS value.



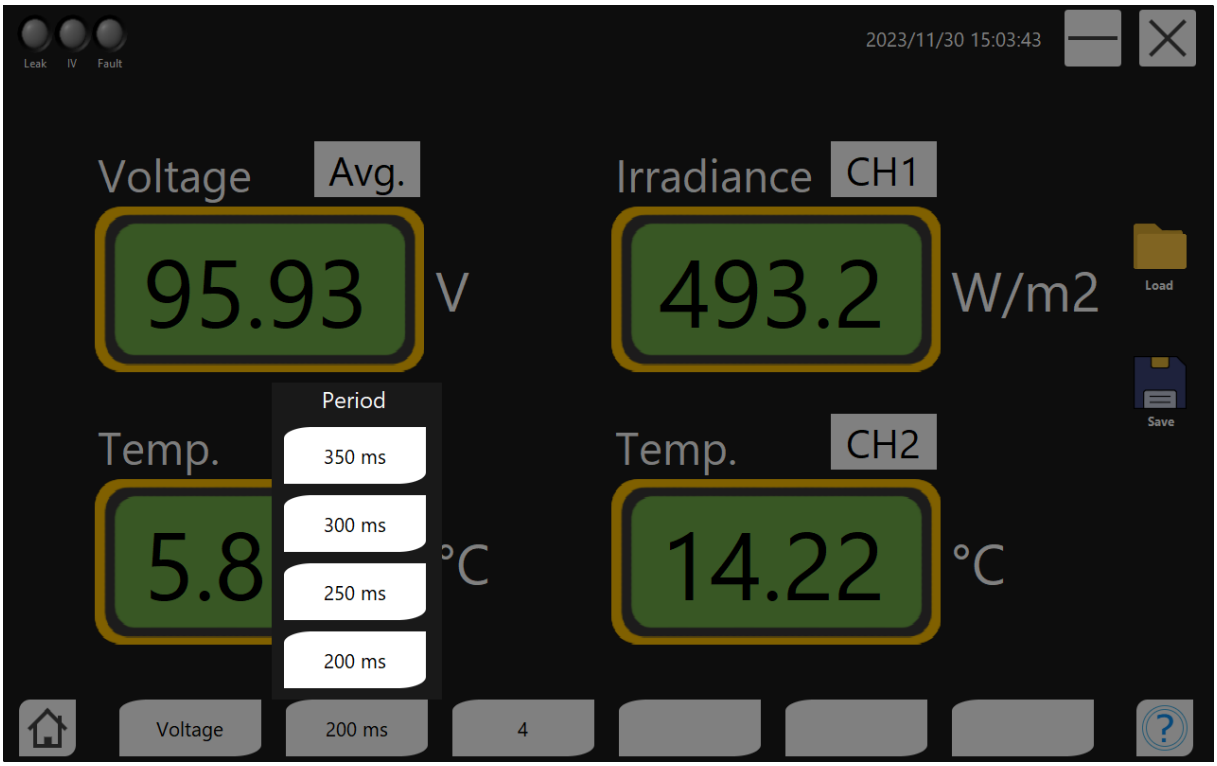
5.7.1 Input source

You can switch between temperature, irradiance, current, and voltage. To assign to a display, first click on the variable (e.g., current), and then click on the display. This will assign the clicked display to the new variable.



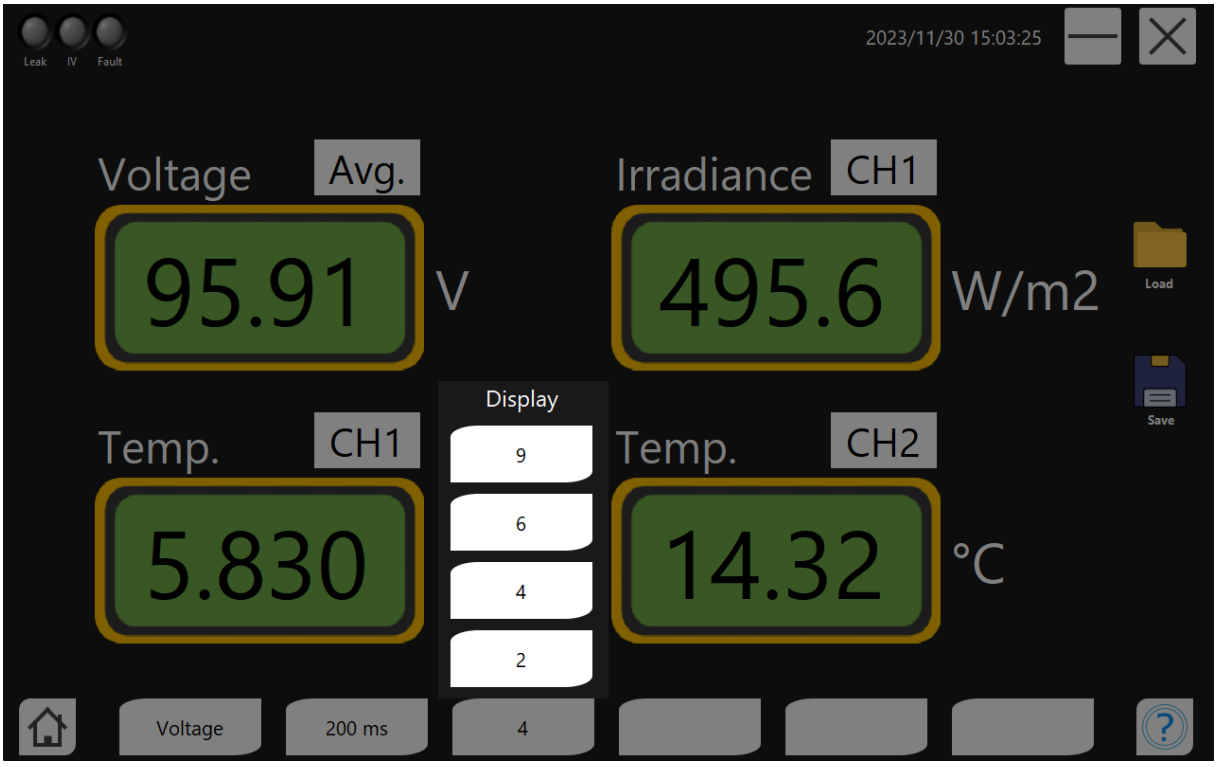
5.7.2 Period

You can adjust the update rate of the displays as shown in the image below.



5.7.3 Display (number of measurement points)

You can display a varying number of screens by selecting according to the list.



5.8 PV Fault (Automatic fault diagnosis)

In development, coming soon…

5.9 Report

In development, coming soon…

5.10 Auto Mode

In development, coming soon…

6 Quickstart Guide

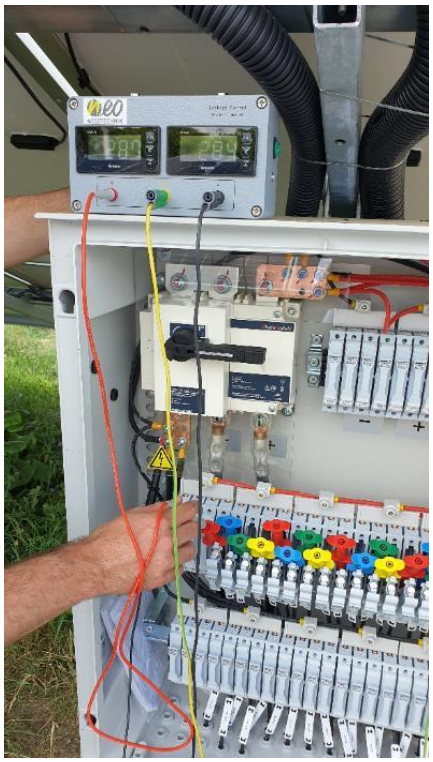
This Quickstart guide is intended as a quick measuring guide so that you can use your device as quickly as possible. However, the entire manual should be read and understood before carrying out the measurement in order to avoid personal injury and damage to property.

6.1 Disconnect Inverter and Remove Fuses

System must be completely unpowered. Disconnection of Inverter and then removal of the Fuses.

6.2 Safety Check via PV Potentiometer

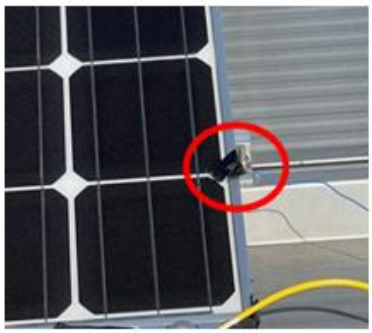
To perform the Safety Check you can use the PV Master or any other PV Potentiometer. In this image a PV Potentiometer was used. Measure DC+ and DC- to GND simultaneous. If there is a difference between the two measured voltages, the measurement must not be continued on the affected strings, as there is a risk to the device and the measurement technician. This means that current is flowing at some point in the string. The affected module is displayed with the Distance to Fault function of the PV Master. If the difference is less than 10%, the measurement can be continued.



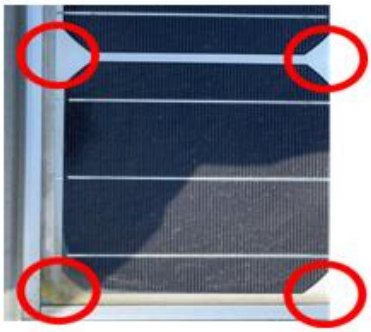
No.	+ to F.G (V_1)	F.G to - (V_2)	Measurement Photo
CH 1	305 V	305 V	
CH 2	432 V	178 V	
CH 3	350 V	258 V	
CH 4	311 V	312 V	

6.3 Install Environmental sensors

Connect Pyranometer, Ambient Temperature and Modul Temperature sensors and fix it for example according to the pictures shown below.



Thermal couple attached on photovoltaic module

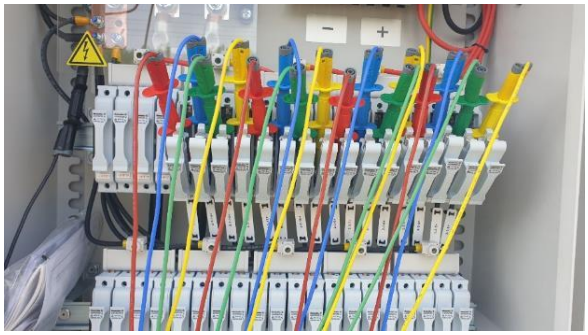


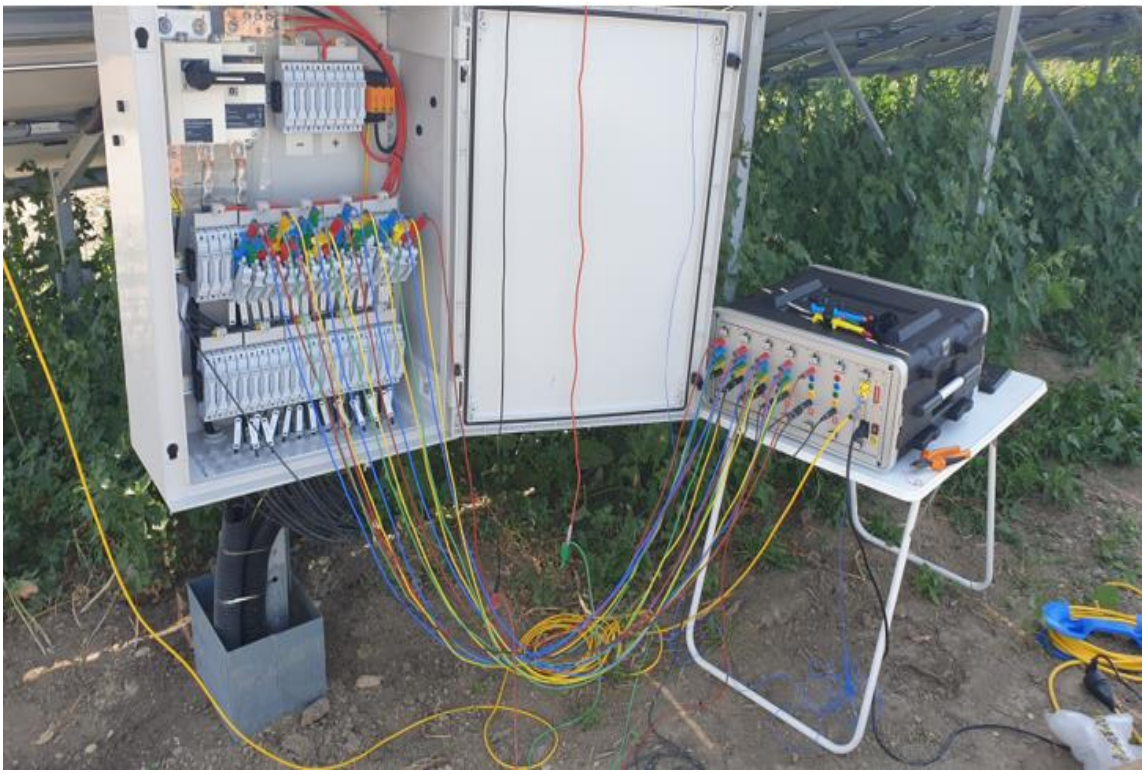
Thermal couple attachable position

Thermal couple on the back of photovoltaic module

6.4 Connect Strings

Connect the Strings to the device. In the picture the PV Master 80 was used.

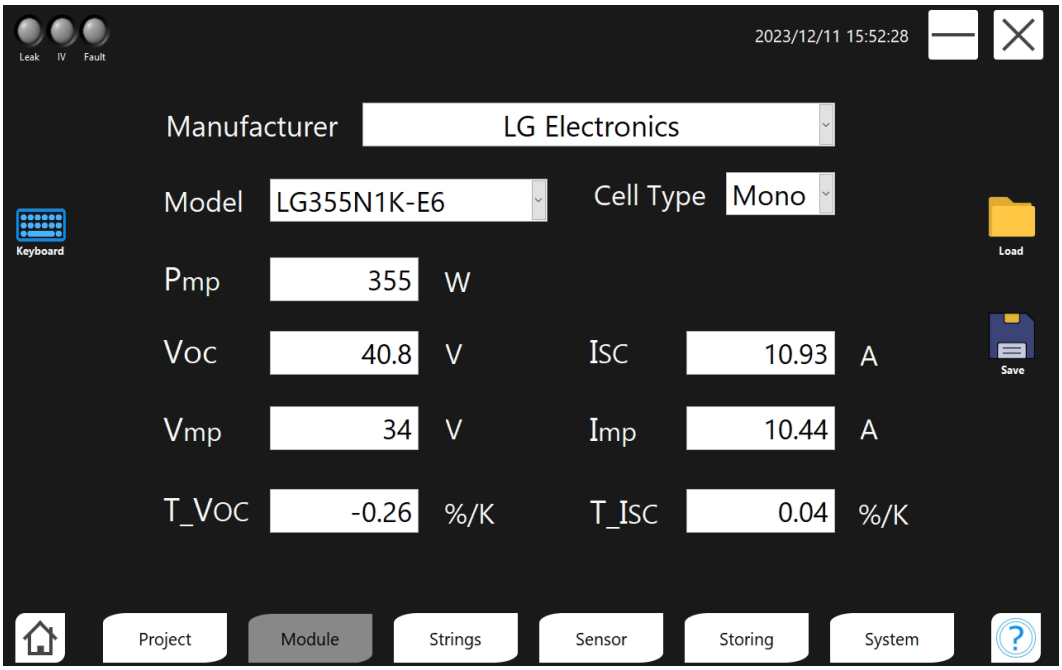




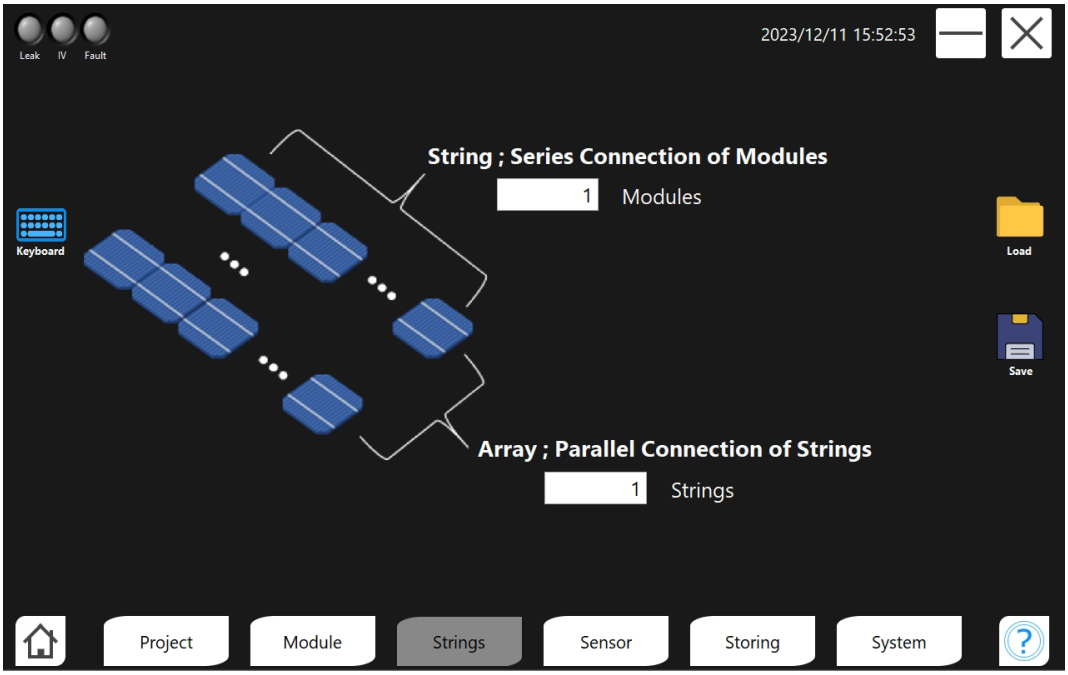
6.5 Software Setup

Perform the String setup and the Module setup. The Module information you can get via the Datasheet and the String configuration from the documentation of the PV Installation.

Module Setup

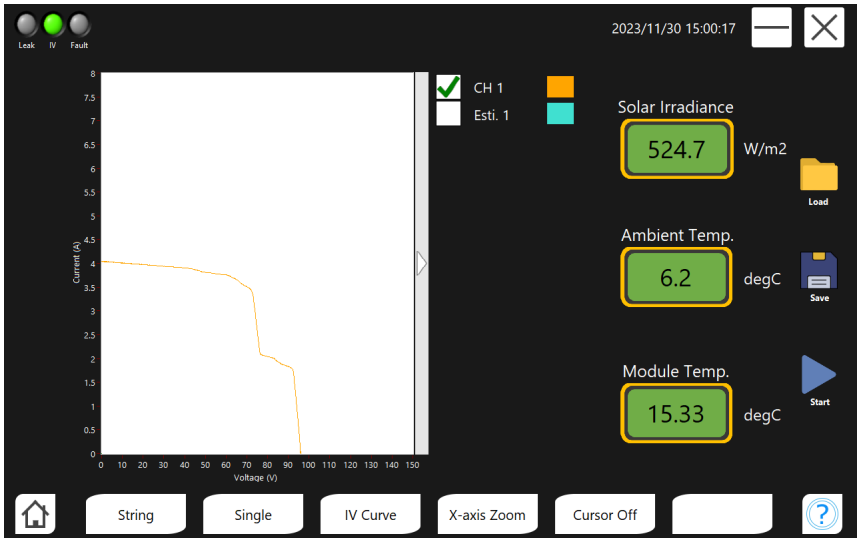


String Setup



6.6 Execute Measurement

When all settings and safety measurements are done, you can start the IV Curve Measurement. **It is forbidden to perform IV Curve tracing at strings where safety check failed.** In the picture below PV Master 70 was used.



7 Further Manuals and Links

There are a couple of additional manuals and information available for our products.

All information can be found on our webpage in the download section.

www.neo-messtechnik.com

- **Example PV Inspection Report**

  An exemplary IV measurement report.
- **Examples of faulty IV curve**

  Gives examples of which types of faults affect the IV curve of PV systems and how.
- **NEO Messtechnik Brochure**

  Showing all products and accessories available.
- **Quick Start Manual**

  This quick start manual is available online and as PDF.

8 Technical Data and Specifications

Analogue				
Channel	I-V Curve		1 (Optional; max 20)	
	Multimeter		Voltage 1 CH, Current 1 CH	
	Environmental Sensor		Solar Irradiance	Max. 2 CH
			Temperature	Max. 5 CH
Input Range	I-V Curve	Voltage	± 1500 Vp MAX	
		Current	± 30 Ap MAX	
	Current	Clamp	± 10 Vp MAX	
		Rogowski	± 2 Vp MAX	
ADC	Type		SAR	
	Data Rate		1 Msps Max	
Current Sensor Power supply			Bipolar ± 15 V (1.3 A) or Isolated 9 V	
Sensor TEDS	Current		1 TEDS / CH	
	Analogue Input		1 TEDS for All CH	
Isolation Type			Sensor Isolation	
Isolation Voltage				
Communication for Environmental Sensor			RS485 / Wifi 802.11 b	

8.1 Environment and Mechanical

Processor		Intel® Processor E3940 @ 1.6GHz
Storage		2x 256 GB Samsung SSD
Display		10.1” TFT LCD (Touch Screen), 1280x800
PC interface		2xUSB 3.0, 1xUSB 2.0, 1x HDMI
Battery (Li-ion)	Capacity	90 Wh
	Charging Time	About 4 hours 10 min.
	Operating Time	About 4hours 40 min. (Maximum)
Power supply		DC 12 VDC
Size (width x length x height)		298 x 225 x 95 mm
Temperature range	Operating	0°C ~ +60°C
	Storing	-20°C ~ +80°C

8.2 DC Clamp 2000DC

	CLAMP-2000DC
Type	**Hall Effect**
Range	20 A AC rms
Bandwidth	40 Hz to 20 kHz[1] [-3dB]
Accuracy [+25° C]	**DC (0 - 1000A)** ± 0,8 % of reading ± 0,5 A **DC (1000 - 1500A)** ± 1,8 % of reading ± 0,5 A **Overall Acc. (0 - 1000 A)** ± 2,5 % of reading ± 0,5 A[3] **Overall Acc. (1000 - 1500 A)** ± 3,5 % of reading **Overall Acc. (1500 - 1800 A)** ± 5 % of reading
Phase Error [50Hz]	**100 mA - 0,5 A** not specified **0,5 A - 1 A** ± 2 ° **1 A - 20 A** ± 2 °
Sensitivity [mV/A]	10
Temperature Coefficient	± 0,15 % of reading per °C
GENERAL	
Dimension [mm]	205 x 60 x 15
Conductor Diameter [mm]	32
Cable length [m]	3
Operating Temperature	0 °C to +50 °C
Operating Humidity	
Supply voltage	+ 9V
Plug and measure (TEDS)	
STANDARDS / SAFETY	
Safety Standards	EN61010-1:2010 EN61010-2-031:2002 EN61010-2-032:2012
Safety category	CAT I 300V
EMC Standards	EN61326-2-2:2013

[1]) Additional error of 1% at 20kHz

[2]) with NEO calibration typ. ≤ 0,3 % of reading

[3]) with NEO calibration typ. ≤ 1,5 % of reading

8.3 Ambient Temperature PT100/PT1000 Sensor

YAGEO NEXENSOS

W-EYK, Einsteck-Pt-Temperatursensor mit Edelstahlgehäuse nach DIN EN 60751

Temperatureinsatzbereich -40 °C bis +500 °C

- Pt-Sensor gekapselt in einem Edelstahlgehäuse
- Glasfaserisolierte Anschlussdrähte für Hochtemperatur-anwendungen
- Hohe maximale Betriebstemperatur +500 °C
- Weitgehend beständig gegen Fette, organische und anorganische Basen und Laugen (mittlere Konzentration)

Das formstabile Schutzrohr aus Edelstahl ermöglicht eine einfache Montage in entsprechenden Bohrungen. Einsatzgebiete sind z.B. Temperaturmessungen in Gasen oder HVAC-Anlagen mit erhöhten Temperaturen. Die Messgenauigkeit ist für Temperaturen zwischen 0 °C und 100 °C optimiert.

Nennwiderstand (Element) R_0 [Ω]	Toleranzklasse (Element)	Bestellnummer	Verpackung
Pt 100	F 0,10 (1/3 B)	30500109	Plastikbeutel
Pt 1000	F 0,10 (1/3 B)	31500989	Plastikbeutel

Temperaturbereich der Toleranzklasse
Gültigkeit der Klasse F 0,10 (1/3 B) 0 °C bis +100 °C

Temperaturkoeffizient
TK = 3850 ppm/K

Ansprechzeit
Wasser (v = 0,4 m/s) $t_{0,5}$ = 3,2 s
$t_{0,9}$ = 9,6 s

Messstrom
Pt100 Ω: 0,3 bis 1 mA
Pt1000 Ω: 0,1 bis 0,3 mA
(Selbsterwärmung berücksichtigen)

Langzeitstabilität (Sensorelement)
Der Drift des Widerstandswertes bei 0 °C nach einer Lagerung von 1000 Stunden in Luft an der definierten oberen Temperaturgrenze ist nicht höher als der Wert der Grenzabweichung der angegebenen Genauigkeitsklasse nach DIN EN 60751.
Ein typischer Drift von R(0 °C) beträgt 0,04 % nach 1000 Stunden bei +500 °C.

Selbsterwärmung (Sensorelement)
0,4 K/mW bei 0 °C

Aufbau- und Verbindungstechnologie
Schweißen, Crimpen, Hartlöten, Weichlöten, Anklemmen

Das Bild dient nur zu Illustrationszwecken

YAGEO Nexensos GmbH, Deutschland
Web: www.yageo-nexensos.de
Kontakt: nexensos.germany@yageo.com

Dokument: 20003959423 Part 000 Version 02 I Status: 03/2023

YAGEO
NEXENSOS

W-EYK, Einsteck-Pt-Temperatursensor mit Edelstahlgehäuse nach DIN EN 60751

Temperatureinsatzbereich -40 °C bis +500 °C

Gehäuse
Rohr mit geschlossenem Ende
Edelstahl 1.4571 (316 Ti)

Anschlussleitung
Glasseide isoliertes, verdrilltes Drahtpaar aus Nickel
2 x 0,5 mm (AWG24), gesamt 2 x 320 mm lang

Leiterwiderstand
0,269 Ω (0,42 Ω/m)

Anwendungsbereiche

- HVAC
- Datenaufzeichnung
- Laborinstrumente
- Ofentemperatur
- Hochtemperaturerfassung

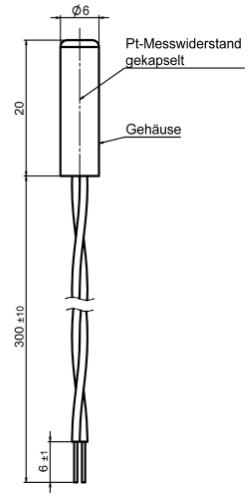
Eigenschaften

- Korrosionsbeständiges Schutzgehäuse aus Edelstahl
- Hochtemperatur Anschlussdrähte mit Glasseidenisolierung
- Für eine Vielzahl von Temperaturerfassungsanwendungen
- Erhältlich in den Widerstandswerten Pt100 oder Pt1000
- Maximale Betriebstemperatur: +500 °C

Kundenspezifische Anpassungen sind für folgende Eigenschaften in hohen Volumen umsetzbar:

- Länge der Kabelverlängerung
- Sensorelement: Typ und Widerstand
- Stecker

Dimensionen und Toleranzen in mm



Das Bild dient nur zu Illustrationszwecken

Widerstand vs. Temperaturtabelle

RoHS konform

YAGEO Nexensos GmbH, Reinhard-Heraeus-Ring 23, 63801 Kleinostheim, Deutschland

8.4 Module Temperature PT100 Sensor

Member of GHM GROUP

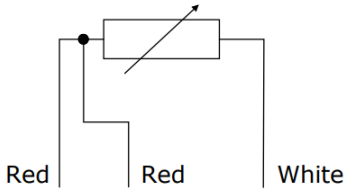
TP878.3

Contact temperature probe for solar panels

TECHNICAL CHARACTERISTICS

Sensor	3-wire Pt100
Measuring range	-40…+150 °C
Accuracy	Class B
Use	Contact measurements
Dimensions	10 x 30 x 5 mm
Probe head material	Aluminum
Fixing	Equipped with double sided acrylic tape
Cable	3 x AWG24 TPE isolated Length 3 m Ending with free wires

CONNECTIONS



8.5 PYRANOMETER – Sensor box light

Member of GHM GROUP

LPSILICON-PYRA04

LPSILICON-PYRA04
PYRANOMETER

The LPSILICON-PYRA04 pyranometer measures the global solar irradiance (W/m²) by using a Class C ISO 9060:2018 silicon photodiode.

The special geometry and the diffuser allow to have a pyranometer field of view of 180 degrees according to cosine law.

The pyranometer is suitable for the measurement of natural sunlight. Under conditions of overcast sky or measures of reflected light is recommended to use a thermopile pyranometer (model LPPYRA03 or LPPYRA02).

The LPSILICON-PYRA04 pyranometer can be used in measurements of GLOBAL SOLAR IRRADIANCE in the field of renewable energies such as solar thermal and solar photovoltaic.

The base with level LPBL (provided as an accessory) can be used to facilitate the assembly and placement in plan level.

The photocurrent generated by photodiode is converted into a voltage by the shunt resistance. The wiring diagram is reported in Fig. 2 and Fig. 5.

Features

LPSILICON-PYRA04 with 5 m fixed cable and open wires on the cable end, typical output 20 µV/(W/m²). Different cable lengths available upon request.

Electrical properties

The photodiode current signal is converted into voltage through the shunt resistance, according to the Fig. 2.

Directional sensor properties

The measurement of radiation across a surface is possible if the probe surface is a Lambert receiver.
The difference between theoretical and measured response is shown in Fig. 3.

The excellent concordance between the measured response and cosine law allows to use the equipment even when the sun has a very low elevation and then perform corrective actions throughout the year.

Spectral properties

The 97% of solar energy that reaches above the atmosphere (WMO) is confined to 290 nm to 3000 nm spectral range. The ideal tool for measuring this radiation should have a flat response at least in this spectral range. The spectral characteristics of LPSILICON-PYRA04 pyranometer are determined primarily by the photodiode and marginally by the diffuser. The spectral response curve is shown in Fig. 4, together with a typical solar spectrum.

The spectral response of LPSILICON-PYRA04 does not cover all the solar spectrum and is not constant. Reliable measurements can be obtained only if the LPSILICON-PYRA04 pyranometer is calibrated with light whose spectrum is equal to the light to be measured. Under clear sky the value of radiation measured by pyranometer has uncertainty less than 3%. In overcast conditions, at sunrise or sunset, the solar spectrum is quite different from that used to calibrate the instrument and therefore the measurement error increases.

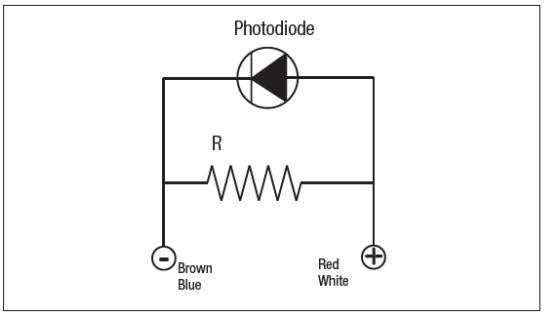


Fig. 2

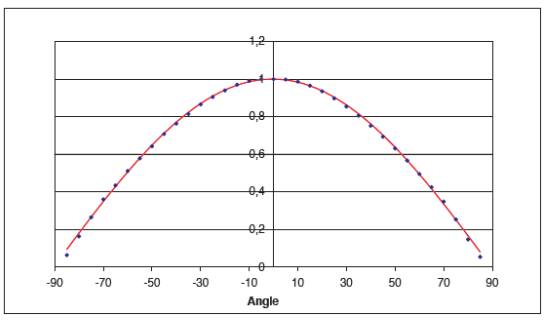


Fig. 3

Positioning

LPSILICON-PYRA04 can be used outdoor for long periods. The probe can be fixed by two M4 threaded holes that are located on the base (Fig. 5) or through the levels based LPBL.
To protect the probe from electrostatic discharges, ground the metallic housing of the pyranometer locally (**note:** the cable shield is not connected to the housing).

You should take care that the diffuser surface is clean and free of deposits. If necessary, the diffuser can be washed with water and a towel for cleaning optical. The probe can be mounted on the support LPBL (accessory) fitted with level for proper placement on work surface.
N.B.: The probe is not designed to be submerged in water.

Calibration

The probe calibration is performed by comparison with a second class pyranometer by using a solar simulator with appropriate filters that reproduce the solar spectrum at AM 1.5 (air mass index 1.5).

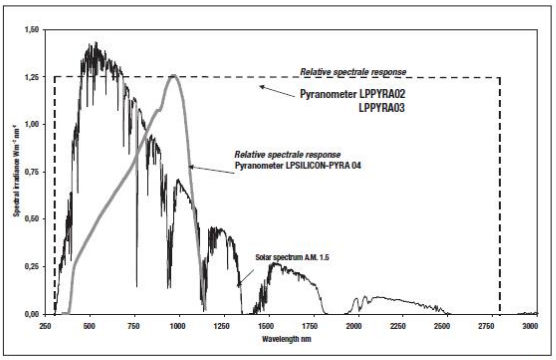


Fig. 4

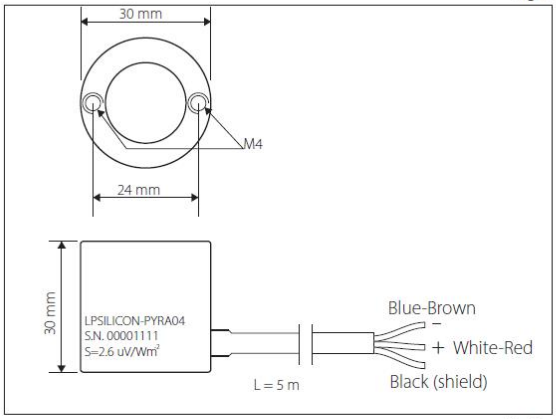


Fig. 5

Connect black (shield) and blue/brown (-) wires together to reduce signal noise.

Technical specifications	
Typical sensitivity	20 µV/W/m²
Measuring field	0…2000 W/m²
Spectral range	400…1100 nm
Response time	<0.5 s
Non-linearity	<1%
Non-stability	< |±2| % per year
Temperature drift	< |±0.15| %/°C
Calibration uncertainty	<3%
Directional response @ 1000 W/m² according to the cosine low	< |±30| W/m²
Output	analogue voltage
Working temperature	-40 °C....+70 °C
Impedance output	25 Ω
Body material	anodized aluminium
Protection Degree	IP67

ORDERING CODES:

LPSILICON-PYRA04: Pyranometer with silicon photodiode with 5 m fixed cable and open wires on the cable end.
Spectral range: 400…1100 nm.

The probe can be connected to the series of converters/amplifiers:
- HD978TR3 and 978TR5 for the 4-20 mA output.
- HD978TR4 and HD978T6 for the 0-10 Vdc output.

LPBL: Base with levelling device for LPSILICON-PYRA04

LPSILICON-PYRA04BL: Pyranometer with silicon photodiode with 5 m fixed cable and open wires on the cable end.
Spectral range: 400…1100 nm. Supplied with base with levelling device.

8.6 Scope of Delivery

With the instrument, the following additional components are provided as seen below.

(Touch pencil) 

PV Master 10

Power supply and cable

Bag

Sensorbox (optional)

Contact Probes

Alligator clamps 20

Test lead adapters (MC4)
red 1x and blue 1x

Test leads 2m CATIII 1500V
CATIV 1000V 1x red, 1x black

Temperatur Sensor
(PT100/PT1000/TCK)

ODU cable

Sensorbox Mounting bracket

Test lead GND

8.7 Accessories

Please check the NEO Messtechnik brochure or webpage (www.neo-messtechnik.com) to see all available accessories for the instrument.

9 Maintenance and Care

Regular calibration

The Instrument must be calibrated at regular intervals as determined by the accuracy requirements of the application. For most applications a one-year cycle is appropriate. Accuracy specifications are only guaranteed if adjustments are made at regular calibration intervals. Accuracy specifications are not guaranteed unless a one-year calibration cycle is followed. Calibration cycles beyond 2 years are not recommended for any application.
Regardless of which calibration cycle you choose; it is always a good to perform a complete readjustment at each calibration cycle. This keeps the instrument within specification for the next calibration cycle and provides the best stability in the long run. Before your instrument is delivered, it is calibrated. Detailed calibration reports can be requested.

Service & Repair

The team of NEO Messtechnik performs any kinds of service and repairs to your system to assure a safe and proper operation in the future. Contact us for more information. Maintenance work should be done by NEO Messtechnik only.

Training

We offer various training options (In-House, On-Site, Remote). Contact your local distributor or NEO Messtechnik directly.

Measurement Service

We are happy to execute measurement services for our clients. From supporting measurement setups, data analysis to complete measurements with measurement reports we offer the full scope of services.

Revision History

12.12.2023	Version 1	Initial Version of Manual
18.12.2023	Version 2	1. Revision of Manual

Contact

When you are working with our products we want to provide you with the greatest possible benefits. If you need any support, we are her to assist you.

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