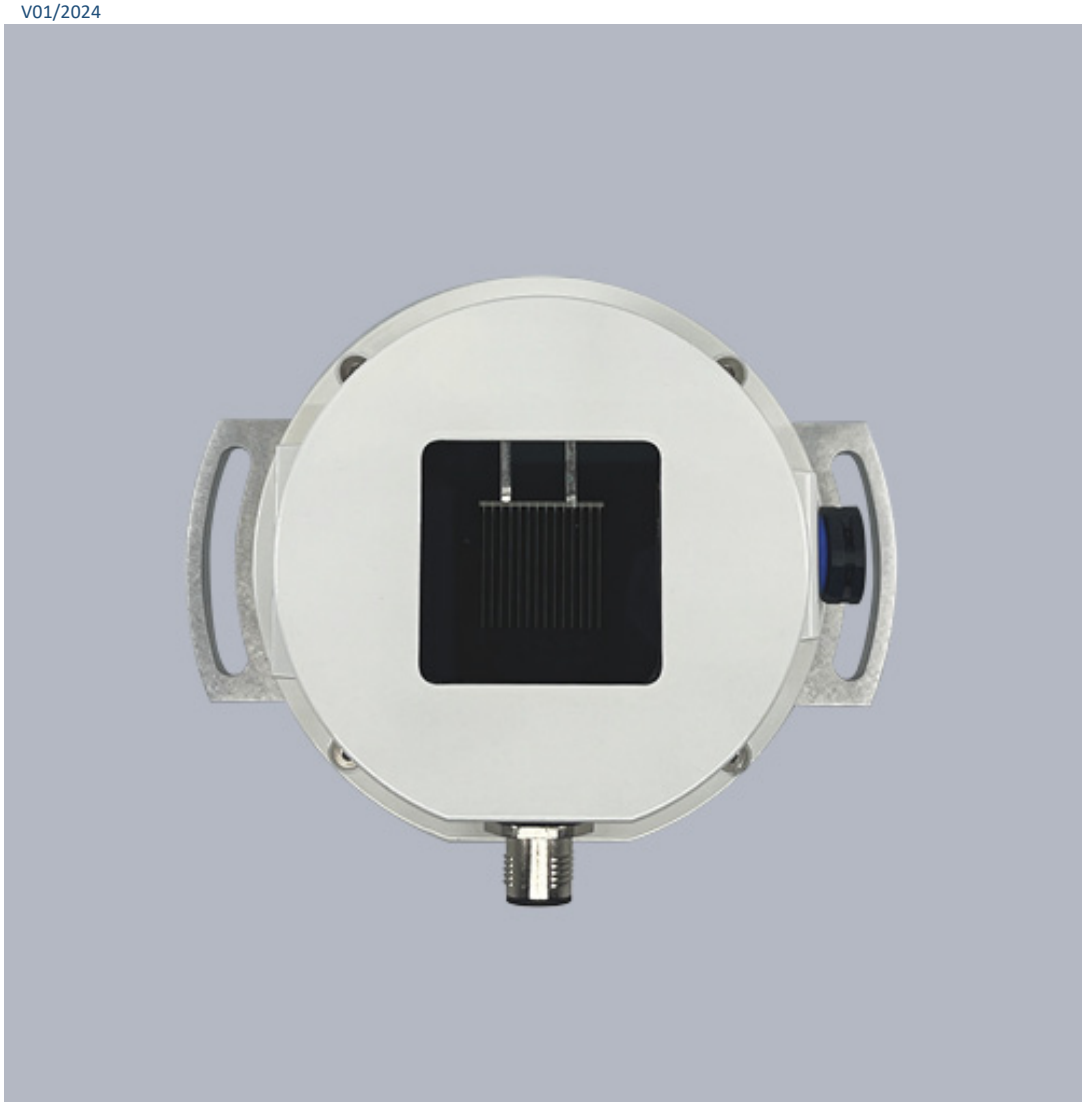
Quick Start Guide

Outdoor Reference cell

RR-1070-A / RR-1070-M / RR-1070-MT

V01/2024



Outdoor PV reference cell (RR-1070)

Introduction

RR-1070 is a sophisticated Mono-Crystalline reference cell used in photovoltaic (PV) plants for monitoring performance ratios. Models with Analog (RR-1070) and Digital Output (RR-1070-M/MT (MODBUS 485) providing unique features.

Analog Output: This refers to the reference cell having the capability to produce an output signal that varies continuously as the light intensity changes. Analog outputs are typically used in simpler monitoring systems where the data is directly read by analog input devices.

Digital Output (MODBUS 485): MODBUS 485 is a type of digital communication protocol used in industrial environments. In the context of your reference cell, this implies it can send data digitally over a network, which is essential for integration with modern PV plant monitoring systems. Digital outputs are more immune to noise and allow for longer transmission distances compared to analog outputs.

Tilt Sensor (M / MT versions):

This sensor detects the inclination angle of the reference cell. The tilt angle can significantly impact the amount of solar radiation a cell receives. By monitoring this, the system can better understand the performance characteristics of the PV modules under different conditions.

Internal Temperature Measurement (A / M/ MT versions):

The reference cell has the capability to measure its own temperature. Temperature is a crucial factor affecting PV cell efficiency. Higher temperatures typically decrease the efficiency of solar cells. By measuring its temperature, the reference cell can provide data to correlate the temperature effects on cell performance.

Back Module Temperature Sensor (MT version):

This sensor measures the temperature at the back of the solar panel. The back module temperature is a more accurate representation of the operating temperature of the solar panel than ambient temperature measurements. This data is vital for assessing the performance of the solar panels under real operating conditions.

Suitability for Performance Ratio Monitoring at PV Plants:

The performance ratio (PR) is a key metric in assessing the efficiency and health of a PV plant. It's the ratio of the actual energy output of the PV plant to the theoretical energy output if the plant operated at its nominal efficiency under the same irradiance conditions.

By providing detailed and accurate data on irradiance (through the analog or digital outputs), panel inclination (tilt sensor), and temperature (internal and back module temperature sensors), this reference cell allows for precise monitoring and calculation of the PR.

The combination of these features enables a comprehensive analysis of the plant’s performance, taking into account environmental and operational variables.

Overview

Figure 1: The RR-1070

The RR-1070 is a stable encapsulated Mono-Crystalline silicon solar cell having an area of 20x20mm. The solar cell is calibrated for the AM1.5G spectrum and should be used to monitor the irradiance for PV-applications. The External Quantum Efficiency (EQE) of each device is measured and delivered with the instrument. This allows for the determination of the Performance Ratio (PR) of PV-Devices of any type (not limited to silicon). This allows for precise spectral mismatch corrections when measuring PV-Modules.

Unpacking

Inspect the Item:

- Once everything is unpacked, inspect the item for any damage or defects.
- If everything looks good, you can proceed to set it up or use it as intended.

Dispose of or Recycle Packaging:

- Break down the box for recycling if possible.
- Dispose of any non-recyclable packing materials responsibly.

Keep Important Documents:

- Set aside the calibration certificate that came with the item.

Table 1. Box content

Item	**Comment**
Reference cell	RR-1070-A / M / MT
Calibration certificate	
External Quantum Efficiency (EQE)	Download file
PVConfig Software	Document that describes download instruction for PVConfig software, manual and External Quantum Efficiency curve.
Cable	Optional

Installation

Setting up a reference cell in a photovoltaic (PV) plant is a crucial step for accurate performance monitoring. The process involves selecting the right location, installing the cell correctly, and integrating it with the monitoring system. Here's a general guide on how to do this:

1. Select the Right Location:
    - Choose a location that represents the general irradiance conditions of the entire PV plant.
    - Ensure the reference cell is exposed to the same environmental conditions as the PV modules.
    - Avoid shaded areas and consider factors like angle and orientation to match that of the PV modules.
2. Mount the Reference Cell:
    - Mount the reference cell securely, ensuring its orientation (tilt and azimuth) matches that of the PV panels it's monitoring. This is crucial for accurate comparison.
    - The height of the installation should minimize shading from the ground or nearby objects while still being easily accessible for maintenance.
    - Keep access to the cell for regular maintenance.
3. Connect to Monitoring System:
    - If the reference cell has analog output, connect it to the data logger's analog input channels.
    - For digital outputs like MODBUS 485, ensure compatibility with your monitoring system and connect it accordingly. This might involve configuring network settings or address parameters on both the reference cell and the monitoring system.

4. Integrate with the PV Monitoring System:
    - Ensure the data from the reference cell is correctly integrated into the PV monitoring system.
    - This might involve configuring software settings, setting up data logging intervals, and ensuring correct data transmission.
5. Configure and Test the System:
    - Once everything is connected, configure the system according to your monitoring requirements. This includes setting up thresholds, alerts, and data recording intervals.
    - Test the system to ensure that the reference cell is functioning correctly and the data is accurately recorded and reported.
6. Regular Maintenance and Calibration:
    - Regularly check the reference cell for dirt, damage, or shading issues, and clean it as necessary.
    - Recalibrate the cell at intervals recommended by the manufacturer to ensure ongoing accuracy.
7. Data Analysis and Adjustment:
    - Regularly analyze the data collected to monitor the performance of the PV plant.
    - Use the insights gained from the reference cell data to make adjustments for optimizing the performance of the PV plant.

Connections

The RR-1070 has an M12 connector with 5 contacts and is shielded to be used with 5 wire shielded cables.

Sensor output wiring for analog model A:

Code	Brown	White	Blue	Black	Gray
RR-1070-A	Signal +	Signal -	NTC	NTC	GND

Digital wiring for MODBUS RTU model M/MT:

Code	Brown	White	Blue	Black	Gray
RR-1070-M/MT	Voltage+	Voltage-	Modbus A	Modbus B	GND

M12 Connector

The M12 male connector is a standard sensor/actuator connector using an A-polarized insert.

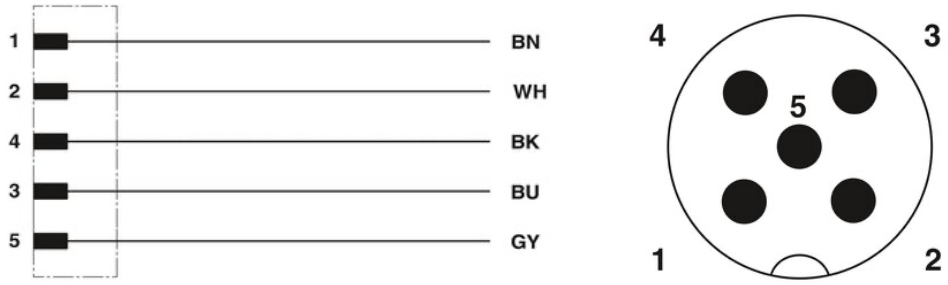


Figure 2: Color coding and pin numbering

Specifications

Table 2. RR-1070 series general specifications

Measurement Range	0 to 2000W/m2
Cell material	Mono crystalline Silicon
Cell dimensions	20x20mm
Window	EVA and PV glass
Operating temperature	-40 to 80°C
Temperature sensor	NTC (NTCLE350E4103FHB0) -55°C to 85°C
Shunt	500mΩ, 0.2ppm/K
Short circuit current (I_{sc})	Approx. 130mA (65mV over shunt)
Measurement uncertainty sensitivity	±1.8% in I_{sc} @1000W/m^2, 25°C, Airmass1.5G
Operating temperature range	-40ºC to 80ºC / 100%

Table 3. RR-1070-M specifications

Output	Modbus RS-485 RTU
Cell Temperature	+/- 0.3º

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Table 3. RR-1070-MT specifications

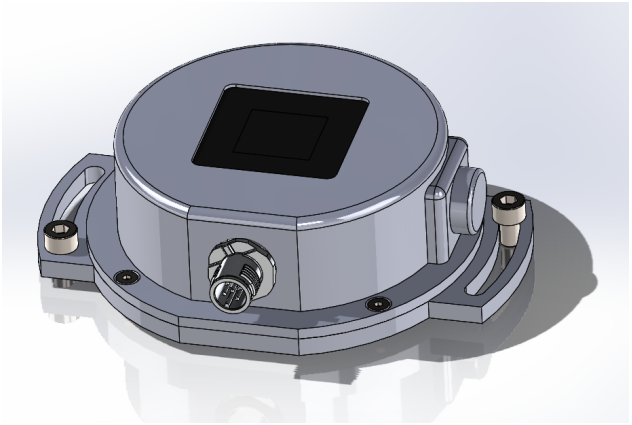
Output	Modbus RS-485 RTU
Cell Temperature	+/- 0.3º
Tilt	+/ 1ºC
Back Module Temperature	+/- 0.5º

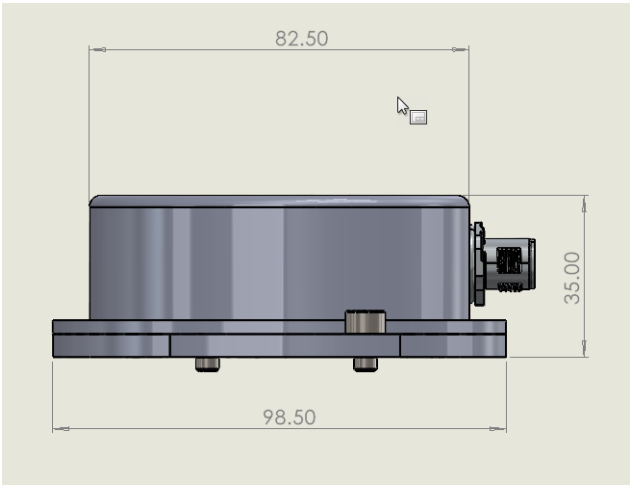
Version 01/24

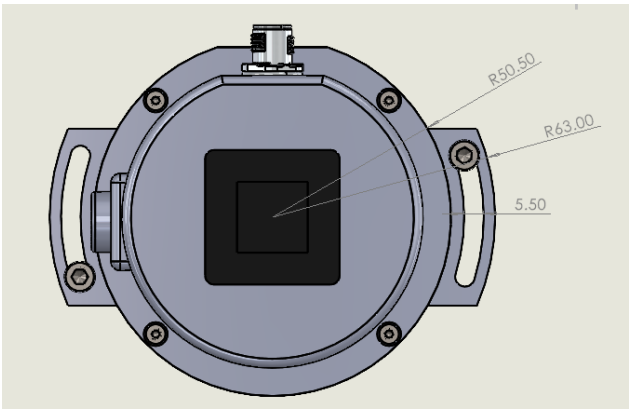
Digital models:

Input voltage	5 to 28VDC
Power	< 100mW
Isolation power supply	2 kV
Isolation RS485	5 kVrms
Modbus RTU RS485 Baudrate	9600, 19200, 38400, 57600, 115200
Tilt/roll sensor	±0.2°
External temperature sensor (model RR1070-MT)	Length: 2m Accuracy: ±0.5°C

Drawings







Installation

1. Setup

- The installation base or mast should have enough load capacity for the instrument to be mounted. Fix the reference cell securely to the base or mast with bolts and nuts; otherwise, the instrument may drop due to gale or earthquake, which may lead to unexpected accidents.
- Make sure the instrument and the cables are installed in a location where they will not get soaked.
- When using this instrument by connecting to a measuring instrument, make sure to connect the shield cable to either the signal ground terminal on the measuring instrument side or GND (the reference potential on the single end input side). Noise may be included in the measurement data.
- Although this product is tested to meet EMC Directive compliance requirements, it may not fully satisfy its primary specification/performance when using this product near following locations where strong electromagnetic wave is generated. Please pay attention to the installation environment.
    - Outdoor : High voltage power line, power distribution facility, etc.
    - Indoor : Large-size chiller, large rotation device, microwave, etc.
- Do not install in area that cause salt damages. It may cause malfunction by paint peeling off or corrosion. When installing in area with risk of salt damages, make sure to take following measures: 1. Wrap the connector with self-fusing tape, 2. Change the fixing screw to bolt screw made of aluminum, 3. Run the cables in resin pipe or metal pipe treated with salt-resistant paint such as molten zinc plating, 4. Periodically clean.
- Do not use this instrument in vacuum environment.
- If the cable and main unit are in risk for getting damaged by birds and small animals, protect the cable and the main unit by using: 1. Reflective tape, 2. Repellent, 3. Cable duct, 4. Installing bird-spike.

2. Handling

- Be careful with glass window when handling instruments. Strong impact to this part may damage the glass and may cause injuries by broken glass parts.

3. Power Supply

- Make sure to ground the grounding cable on the power supply cable. When grounding is insufficient, it may cause not only measurement error due to noise and electric surge, but also cause electric shock and leakage accidents.
- Check the voltage and types (AC or DC) of specified power supply before connecting this instrument. When improper power supply is connected, it may cause malfunction and/or accident.
- Use this instrument with 0.5A fuse connected to the power supply line in series. Without connecting the fuse, it has risks of generating heat and fire due to large-current flowing by the power supply when internal damage on the electronics will occurs.

Modbus RTU

Table A1. Modbus RTU communication protocol (Version from 01/24)

Optional item	Remarks
Electrical specifications	EIA-485
Connection form	Multi-drop method (1 for Master, 31 for Slave, 32 for total)
Communications protocols	Modbus RTU *1 (Slave)
Communication speed baud rate	2400, 4800, 9600, **19200**, 38400, 115200 bps
Data length	8 Bit
Stop bit	1 bit/2 bit *2
Parity bit	None/Odd/**Even**
Communication distance	Max.1000m (ideal value)
Error detecting system	CRC-16

Table A2. Modbus RTU data format

Format	Abstract
U16	Unsigned 16bit Integer
S16	Signed 16bit Integer
U32	Unsigned 32bit Integer
S32	Signed 32bit Integer
F32	IEEE754 32bit floating point format
Str	ASCII characters string

Table A3. Modbus RTU Default settings

Modbus ID (address)	Last 2 digits of serial number
Baudrate	19200
Parity	Even
Stopbits	One

Table A4. Modbus Registers

Address	Function	Format	Description
0	Model	U16	Model number of the transmitter. (RR1070:0x042E)
1	0	U16	Fixed value 0
2	Comp. Irr.	F32	Adjusted solar radiation intensity. Unit: Wm^{-2}
3			
4 to 7	RESERVED		
8	Internal temperature	F32	Temperature measured by the internal temperature sensor
9			
10 to 13	RESERVED		
14	X-axis tilt angle	F32	X-axis component of the tilt angle (degree)
15			
16	Y-axis tilt angle	F32	Y-axis component of the tilt angle (degree)
17			
18	Raw.Irr	F32	Intensity of solar radiation before correction Unit: Wm^{-2}
19			
20	ADmV	F32	Sensor output voltage Unit: mV
21			
22	External temperature	F32	Temperature measured by the external temperature sensor (RR1070-MT only).
23			

Note: All other registers can be viewed and adjusted using the pvconfig software.

Download from eko-instruments.com product page

Analog model

The analog model (RR1070-A) outputs the irradiance as a voltage reading over the internal shunt. At 1000Wm-2 this reading is about 65mV, the exact value is given on the calibration sheet and can be found on the instrument label.

The sensor temperature can be calculated from the NTC resistor value that is mounted on the internal solar cell. This is an NTC with the following MPN: NTCLE350E4103FHB0

The conversion method can be found in the table A5.

Table A5. Modbus Registers

T [°C]	R [Ω]	T [°C]	R [Ω]	T [°C]	R [Ω]	T [°C]	R [Ω]	T [°C]	R [Ω]	T [°C]	R [Ω]
-30	176133	**-6**	44559	**18**	13681	**42**	4914	**66**	2007	**90**	912
-29	165591	**-5**	42268	**19**	13072	**43**	4723	**67**	1938	**91**	884
-28	155746	**-4**	40108	**20**	12493	**44**	4540	**68**	1872	**92**	857
-27	146545	**-3**	38071	**21**	11943	**45**	4365	**69**	1809	**93**	831
-26	137944	**-2**	36150	**22**	11420	**46**	4198	**70**	1748	**94**	806
-25	129900	**-1**	34336	**23**	10923	**47**	4038	**71**	1689	**95**	782
-24	122374	**0**	32624	**24**	10450	**48**	3885	**72**	1633	**96**	759
-23	115329	**1**	31007	**25**	10000	**49**	3739	**73**	1578	**97**	737
-22	108732	**2**	29480	**26**	9572	**50**	3599	**74**	1526	**98**	715
-21	102553	**3**	28036	**27**	9165	**51**	3465	**75**	1476	**99**	694
-20	96761	**4**	26672	**28**	8777	**52**	3336	**76**	1428	**100**	674
-19	91332	**5**	25381	**29**	8408	**53**	3213	**77**	1381		
-18	86239	**6**	24161	**30**	8056	**54**	3095	**78**	1336		
-17	81461	**7**	23006	**31**	7721	**55**	2982	**79**	1293		
-16	76976	**8**	21912	**32**	7401	**56**	2874	**80**	1252		
-15	72765	**9**	20877	**33**	7097	**57**	2770	**81**	1212		
-14	68809	**10**	19897	**34**	6807	**58**	2671	**82**	1173		
-13	65091	**11**	18968	**35**	6530	**59**	2575	**83**	1136		
-12	61596	**12**	18088	**36**	6266	**60**	2484	**84**	1101		
-11	58310	**13**	17253	**37**	6014	**61**	2396	**85**	1066		
-10	55218	**14**	16462	**38**	5773	**62**	2312	**86**	1033		
-9	52308	**15**	15711	**39**	5543	**63**	2231	**87**	1001		
-8	49569	**16**	14999	**40**	5324	**64**	2153	**88**	970		
-7	46989	**17**	14323	**41**	5114	**65**	2079	**89**	940		

PVConfig

The RR1070-M and RR1070-MT can be configured using the pvconfig tool. This software can be downloaded for free from the pvblocks.com website. Go to the download section to find pvconfig and use the appropriate installer. It will run on Windows, MacOS and Linux and provides basic support for setting up the device.

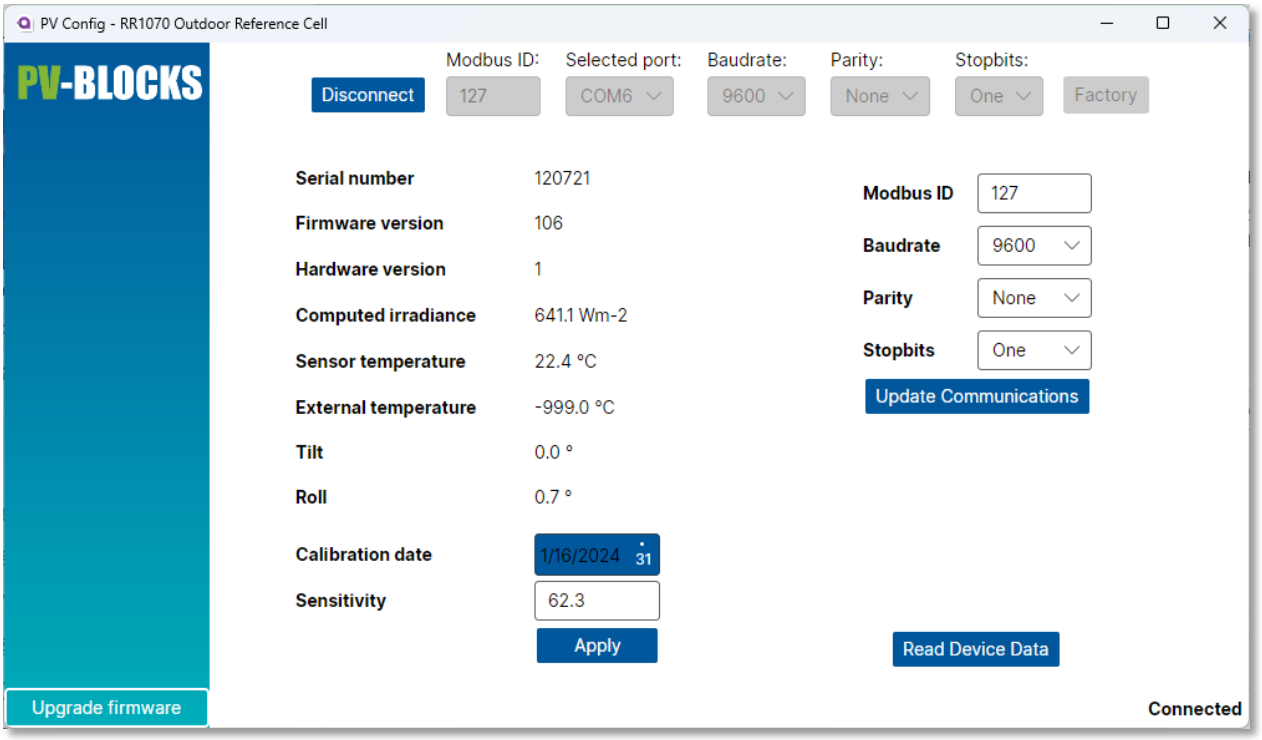


Figure A1: pvconfig configuration software

To configure an RR1070-M(T) device, you will need to use a USB/RS485 converter. For example, the USB-S-kit. This interface can be used to provide power (5V) and RS485 communications directly.

When the device is taken from the package the default communications settings are: 19200, Even, One. The RS485 Modbus address is the same as the last two digits of the serial number.

Example:

Select the COM port assigned to the USB/RS485 adapter and fill in the settings:

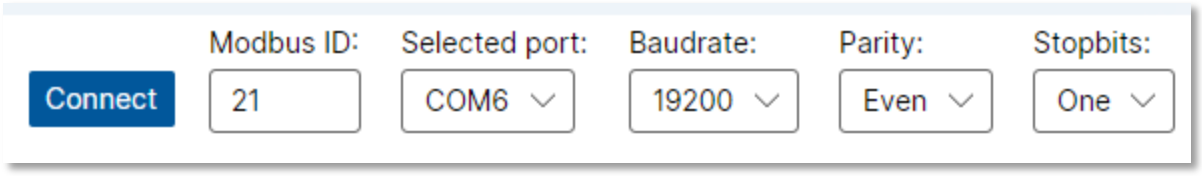
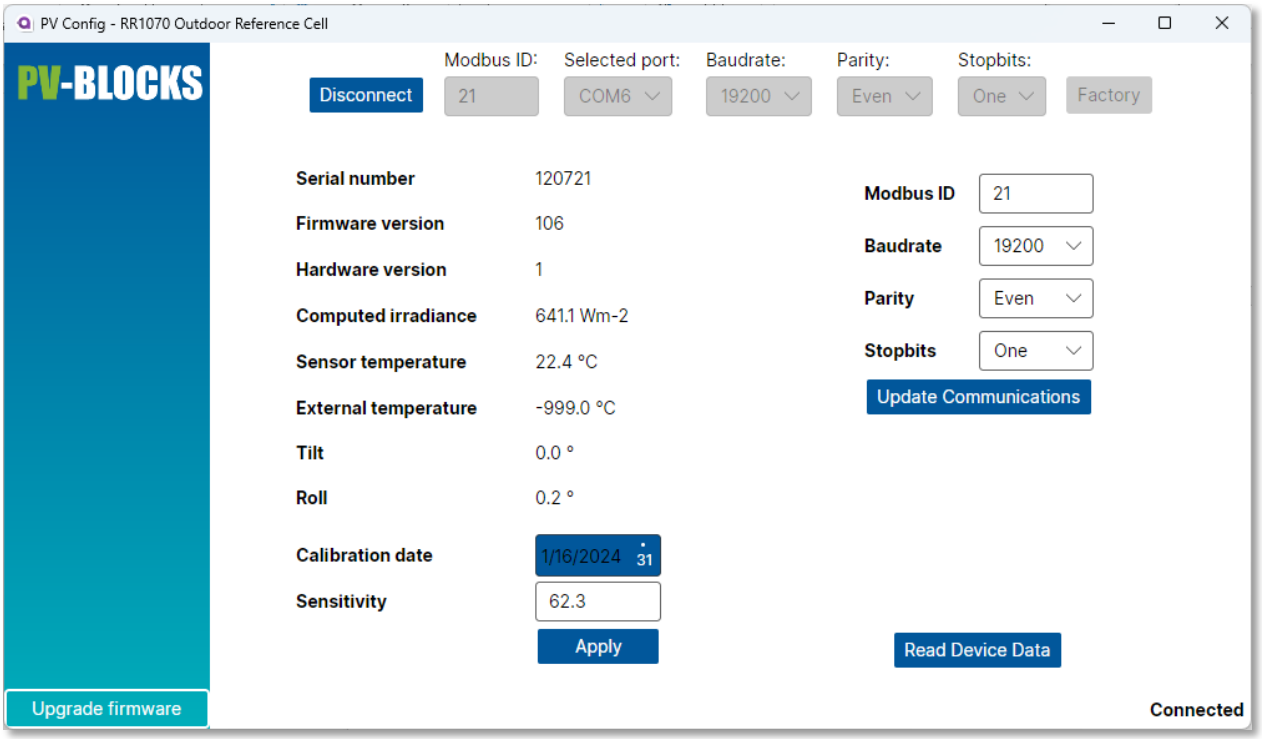


Figure A2: Communication setting

In this case the serial number of the device is 1207**21**, which results in the Modbus address (ID) of 21.

Press ‘Connect’ to retrieve all data of the device.



If the connection is successful, all data is shown as can be seen above. By pressing the 'Read Device Button' button, the information is updated. You can change the calibration value and date. This will be saved into the instrument after pressing the 'Apply' button.

The Modbus ID and communication parameters can be changed. After pressing 'Update Communications' this will be stored in the instrument. The connection will be closed, and the new communication settings/Modbus Id are automatically selected in the connect settings.

Recovery

In the case of loss of Modbus ID and/or communication parameters use the following steps to recover.

- Remove the power from the RR1070-M(T)
- The first 5 seconds after powerup the instrument is listening to Modbus ID 127 and uses communication parameters: 9600, None, 1
- Press the 'Factory' button in the software. This will set the above factory communication settings to the controls.

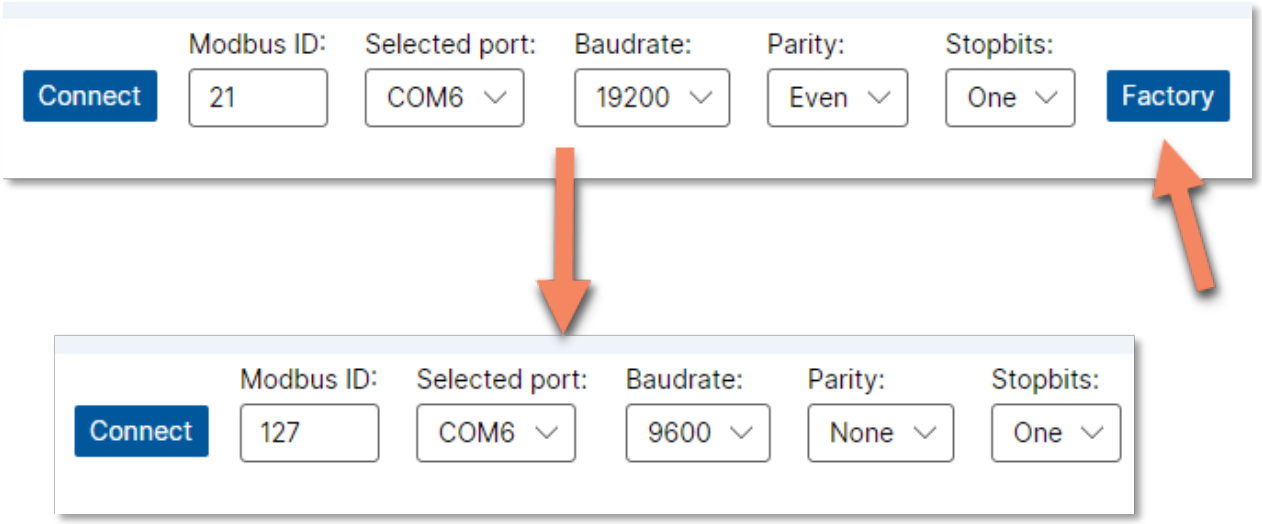


Figure 3: Press the factory button to select startup communication parameters

- Apply power to the RR1070-M(T) and within 5 seconds press the 'Connect' button.
- The data will now be read from the device and the stored Modbus ID and communication parameters are shown.
- You can now Disconnect the sensor, use the correct communication values, and connect again.

Warranty

For warranty terms and conditions, contact EKO or your distributor for further details.

EKO guarantees that the product delivered to customer has been verified, checked and tested to ensure that the product meets the appropriate specifications. The product warranty is valid only if the product has been installed and used according to the directives provided in this instruction manual.

In case of any manufacturing defect, the product will be repaired or replaced under warranty. However, the warranty does not apply if:

Any modification or repair was done by any person or organization other than EKO service personnel.

The damage or defect is caused by not respecting the instructions of use as given on the product brochure or the instruction manual.

Environment

WEEE Directive 2002/96/EC

(Waste Electrical and Electronic Equipment)

- This product is not subjected to WEEE Directive 2002/96/EC however it should not be mixed with general household waste. For proper treatment, recovery and recycling, please take this product(s) to designated collection points.
- Disposing of this product correctly will help save valuable resources and prevent any potential negative effects on human health and the environment, which could otherwise arise from inappropriate waste handling.

RoHS Directive 2002/95/EC

- EKO Instruments has completed a comprehensive evaluation of its product range to ensure compliance with RoHS Directive 2002/95/EC regarding maximum concentration values for substances. As a result all products are manufactured using raw materials that do not contain any of the restricted substances referred to in the RoHS Directive 2002/95/EC at concentration levels in excess of those permitted under the RoHS Directive 2002/95/EC, or up to levels allowed in excess of these concentrations by the Annex to the RoHS Directive 2002/95/EC.

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