Solar Plant Supervisory System
User Manual

rev. 1.22

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Table of contents

Change History

legend:
+ new feature
x change/update
- deleted feature

v1.22, 2014-05-02
  x SMB specifications updated.
  x Bus length specifications extended to 1000m.
  + Instructions how to set CAN baudrate added.

v1.21, 2013-02-12
  + SMB derating curve added.
  x Device weights updated.

v1.20, 2012-09-09
  x SMB accuracy increased from 1.5% to 0.5%.
  x SCU-20 replaced with SCU-P20 (power supply added inside).
  - PSU unit removed.
  + MGU-P20 (Modbus Gateway) device added.
  x COM-PCS replaced with COM-SAN (Sanrex inverter adapter).
  + COM-SAT (Satcon inverter adapter) module added.
  + COM-KAC (Kaco inverter adapter) module added.
  - RADIO-MODEM option removed.

v1.19b, 2012-08-04
  + Photo of CAN ground rail connection and terminals.
  x Distance between signal and power lines must be at least 50cm.

v1.19a, 2012-04-01
  x Explanation added, both 24V and signal lines must be shielded.

v1.19, 2011-09-20
  - Optional connection mode with no external power supply abandoned.

v1.18, 2011-06-15
  + COM-XXX universal communication controller introduced.
  + Weather station added to connection diagram.
  - DC Combiner Box monitoring contact is now optional feature.

v1.17, 2011-06-02
  + SCU Modbus option (-MB) added.
  + Reference cells 1000W/m2 and 1400W/m2 are now available.

v1.16, 2010-11-24
  + Solar Web features explained.
  + Commissioning and Troubleshooting sections added.
  - SMB is now supplied with no predefined position number.

v1.15, 2010-10-03
  + Warnings section added.
  + String Diode Box device added.
  + NAD Manager device added.
  x Disconnector switch ABB-S804-PV replaced with SACE-TMAX-PV.

v1.10, 2010-03-25
  + DC Combiner Box added.
  + Tools section added.
  + Web setup section added.
  x 24Vdc wire gauge changed recommendation.
  x List of published technical data expanded.

v1.00, 2009-11-5
  + Operation and Maintenance sections added.

v0.80, 2009-06-15
  + First public release.

Warnings

This manual contains important instructions for the Solar Plant Supervisory System that must be followed during installation and maintenance procedures. Read carefully and keep for future reference.

Warning: Hazardous voltage is present on the product when the system is operating.

Warning: Contains components that may become hot during normal operation.

Warning: Only trained and qualified personnel should be allowed to install, replace, or service this equipment.

Warning: No connections or disconnections are to be made during operation. Turn disconnector switch off before any installation and maintenance procedures.

Warning: This product can only function correctly if it is transported, stored, set up and installed correctly, and operated and maintained as recommended. Failure to comply with applicable codes and standards can result in damage to equipment or serious injury to personnel.

Warning: To minimize the risk of safety problems, follow all applicable local and national codes that regulate installation and operation of your equipment. These codes vary geographically and may change with time, it is your responsibility to determine which codes should be followed, and to verify that the equipment, installation, and operation comply with the latest revision of codes.

Caution: We do not guarantee the product described in this manual is suitable for your application, nor do we assume any responsibility for your product design, installation or operation.

Caution: Take care not to damage the terminals by using inappropriate tools or wires.

Caution: Sensitive electronics inside can be destroyed when touched electrostatically charged. Discharge via earth potential before touching and wear appropriate protective gear.

Warning: Disposal of this product should be handled according to national laws and regulations.

1. Overview

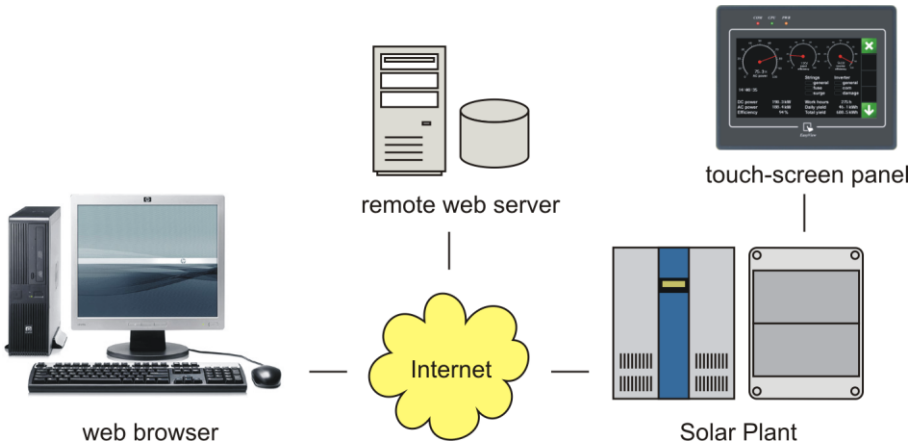
SPSS is a complete solution for monitoring solar power plants. It offers measurement, status and summary data, locally or remotely.

Comparing to a non-monitored system, SPSS provides faster error detection and better troubleshooting, resulting in bigger and more predictable yield. Early warning sub-system may show error before damage is made, ensuring energy production approach the theoretical maximum. Anti-theft protection is included in the basic system.

SPSS consists of:

- String Monitor Box..... SMB
- String Diode Box ..... SDB
- DC Combiner Box ..... DCB
- Solar Controller Unit ..... SCU
- Modbus Gateway Unit ..... MGU

String Monitor measures currents, monitor fuses, surge protectors, voltage and temperature, and sends all data to solar controller. Update rate is cca. 2 seconds. Positive and negative currents are measured separately and compared, to detect a possible leakage.



System is accessible locally (touch panel and Solar Mini software), and remotely (Solar Web software installed on a PC server). Both recent measurements and stored dbase data are available. If Internet connection is not available, options are GPRS or radio modem.

A variety of optional equipment exist, like weather station or camera. Standard industrial i/o modules (0..10V, 4..20mA) are also available. SPSS is fully open and programmable, giving system integrators possibility to incorporate their own solutions.

Inverter is integrated in the system, so all measurements and statuses, as well as history data, are available through touch panel and Internet. For inverter installation and maintenance, check documentation supplied by manufacturer.

2. Order Code

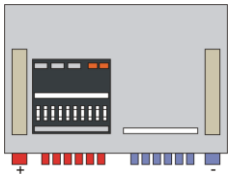
2.1. Standard equipment

SMB-10-x-x-x-x-x-x (String Monitor Box), where x may be empty (default) or one of the following options:

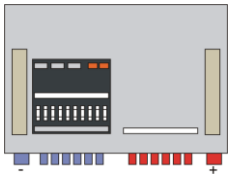
- plastic housing with transparent lid (default)
- stainless steel housing (option S)

- 10 strings, 10 fuses (positive only, common minus), 10 measurements, earthed or galvanically isolated (default)
- 10 strings, 10 fuses (negative only, common plus), 10 measurements, earthed or galvanically isolated (option N)
- 10 strings, 10+10 fuses (plus and minus), 10+10 measurements, earthed or galvanically isolated (option PN)

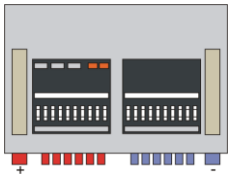
default



N



PN



- cage-clamp wire terminals and cable glands (10 strings, default)
- faston terminals and cable glands (10 strings, option F)
- faston terminals and cable glands, two strings in parallel (20 strings, option Fx2)
- Multi-Contact Solarline MC3 (PV-ADSP3/BP3) connectors (10 strings, option MC3)
- Multi-Contact Solarline MC3 (PV-ADSP3/BP3) connectors, two strings in parallel (20 strings, option MC3x2)
- Multi-Contact Solarline MC4 (PV-ADSP4/BP4) connectors (10 strings, option MC4)
- Multi-Contact Solarline MC4 (PV-ADSP4/BP4) connectors, two strings in parallel (20 strings, option MC4x2)
- custom connector options available

- fuse 6-16A, 1.5*Isc (as specified by panel maker, option F6, F8, F10, F12 or F16, required, no default value)

- no disconnector (default)
- with disconnector switch (option D)
- with disconnector switch and auxiliary contact (option DA)

- side mounting ears, 4x10mm screws (default)
- pole mounting bracket (option POLE)
- custom mounting options available

Example: SMB-10-MC4-F16-D (monitor box in plastic housing with transparent lid, MC4 connectors for 10 strings, 16A fuses and disconnector switch).

SDB-10-x (String Diode Box), where x may be one of the following options:

- faston terminals and cable glands (10 strings, option F)
- Multi-Contact Solarline MC3 (PV-ADSP3/BP3) connectors (10 strings, option MC3)
- Multi-Contact Solarline MC4 (PV-ADSP4/BP4) connectors (10 strings, option MC4)
- custom connector options available

DCB-x-x (DC Combiner Box), where x may be one of the following options:

- number of inputs (2-20, required, no default value)
- fuse (option F32, F40, F63, F80, F100, F125 or F160, required, no default value)

Example: DCB-12-F100 (DC combiner box with 12 inputs (for 12 SMBs), and 24 fuses (plus and minus), 100A each).

SCU-P20-x (Solar Controller Unit + 24V power supply), where x may be empty (default) or the following option:

- GSM/GPRS modem, Internet connection and SMS access (option GSM1)

MGU-P20 (Modbus Gateway Unit + 24V power supply)

No options, only one version is available.

2.2. Optional equipment

COM-SAN
Communication controller for Sanrex inverters. Compatible with 100/250/500kW central inverters. It should be mounted inside inverter, instead of RS/232/485 converter.

COM-SAT
Communication controller for Satcon inverters. Compatible with all Satcon central inverters. Mounted inside inverter.

COM-KAC
Communication controller for Kaco inverters. Compatible with all Kaco Powador XP inverters. Mounted inside inverter.

REF-CELL
Standard insolation reference measurement cell, 0..1000 (REF-CELL-1000) or 0..1400 (REF-CELL-1400) W/m^2, used to calculate PV efficiency. Extended range is suitable for tropic locations.

ES-A
External temperature sensor, measuring outdoor or panel temperature. 5m cable, connects to string monitor.

TS-H
Ambient temperature and humidity sensor for indoor use (inverter house), connects to CAN bus.

WEATHER-STATION
Module to gather meteorological data: wind, temperature, humidity, rain. Includes central unit (Vaisala WXT-520) and communication adapter (COM-WXT).

IP-CAMERA
Visual plant overview, displaying live video. Camera is selected according to application.

GSM-ROUTER
GSM/3G router, internet connection for multiple solar controllers and optional devices, e.g. IP camera.

INFO-DISPLAY
Large (100x60cm) LED display, showing production, power and other data. Various sizes available on request.

2.3. Software

SOLAR-WEB-x (full-featured monitoring/control system), where x may be one of the following options:

- PC Linux server, preinstalled and ready to use (hardware+software) (option HW)
- software ready to be installed by user (software only) (option SW)
- account on www.solar-cybro.com server (username/password only) (option AC)

Features:

- on-line monitoring measurements and status signals
- remote access and control using standard web browser
- hosted locally or remotely on commercial hosting service
- data-base storage for long-term access and analysis
- simple one-click data export to spreadsheet program
- immediate email notification in case of failure
- anti-theft alarm, access control and video surveillance

SOLAR-MINI
Quick plant overview, displaying live data. Provides a simple interface, preconfigured for the actual plant. Running on a Windows-based PC, in a local network. Small footprint allows running on lightweight touch panels.

SOLAR-SCOPE
Set of software tools for plant commissioning and maintenance.

OPC-SERVER
Communication driver which provides SCADA connection for other manufacturers.

CUSTOM-SCADA
Monitoring system made upon user requirements, based on Solar-Web, Iconics Genesis32 or other SCADA system.

2.4. Tools

Screwdriver WAGO type 3
- used to connect/disconnect SMB input terminals
- item no. 210-621 (5.5x0.8mm flat, partially isolated shaft)

Screwdriver WAGO type 2
- used to disconnect SMB communication and I/O terminals
- item no. 210-620 (3.5x0.5mm flat, partially isolated shaft)

Torque wrench M10
- torque 10..20Nm
- used to connect/disconnect SMB output terminals

Fuse puller, Cooper Bussman type FP-2
- isolated pliers for safe exchange of PV fuses

Service toolbox kit
- contains screwdrivers, torque wrench and fuse puller

NAD Manager
- electronic device for setting communication addresses
- may be used for commissioning and replacing faulty device
- 2m cable (RJ9/RJ9) included

2.5. Spare parts

String monitor box

- fuse 6, 8, 10, 12 or 16A
- surge protection plug-in replacement module
- pressure equalizing element (Goretex)
- transparent cover with seal

Power supply unit

- overvoltage protection

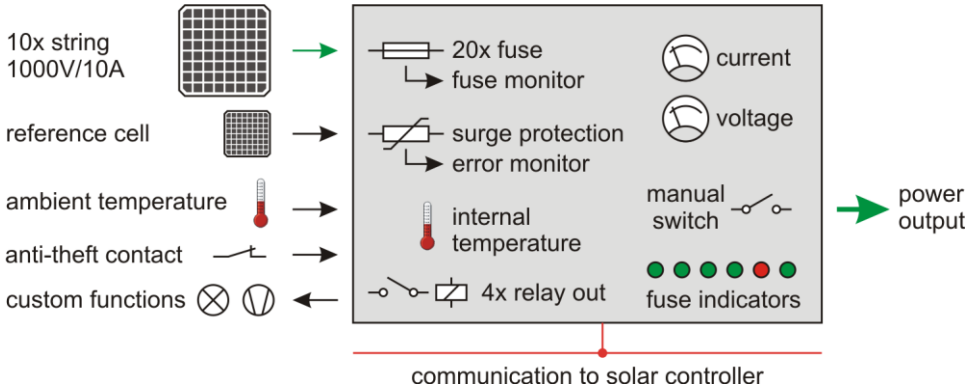
DC combiner box

- fuse 32, 40, 63, 80, 100, 125 or 160A

3. Devices

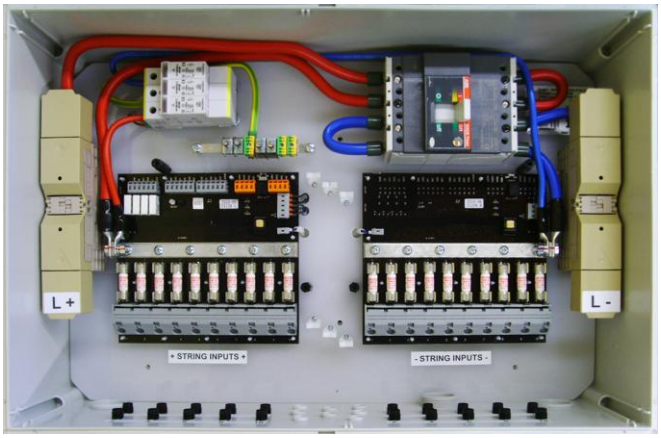
3.1. String Monitor Box

String monitor measures currents, monitor fuses, surge protectors, voltage and temperature, and sends measurements to solar controller.

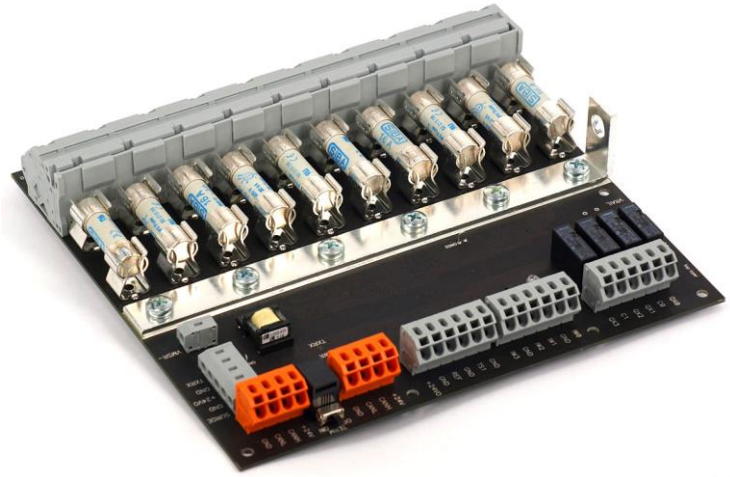


Both positive and negative legs are measured (option PN). If currents are not same, a current leak is reported. Update rate is cca. 2 seconds.

Picture shows insides of monitor box, plastic box version with disconnector switch.



Communication connectors (orange) are located on the back side. Custom input and output connectors are gray.



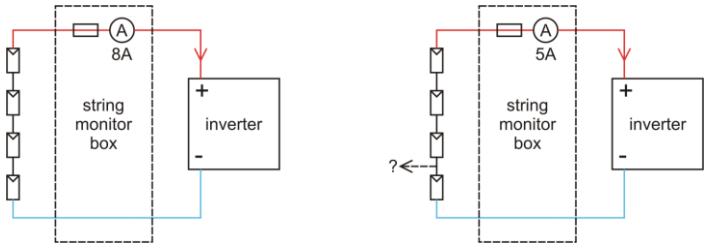
Termination should be on for last device in chain (position number 100). Other devices should have termination switch in off position.

Positive/negative current

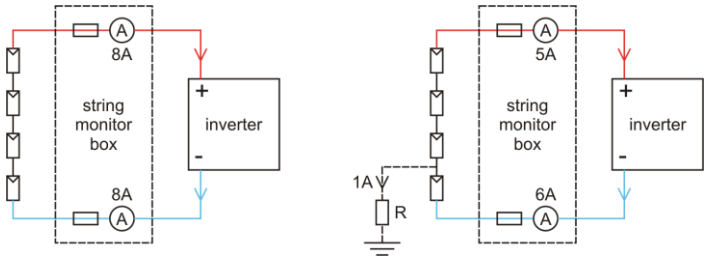
Measuring both positive and negative currents ensures better failure detection.

Example:

Assume grounded system with 8A nominal string current. Over time, string output decreases to 5A.



Measuring only positive side, it is not possible to determine the failure. It may be caused by different reasons: faulty panel, dirty panel, lousy connection, shortcut, corroded connector, bad measurement or other. In such case, failure detection relies on experienced and well-equipped technician, operating on-site.

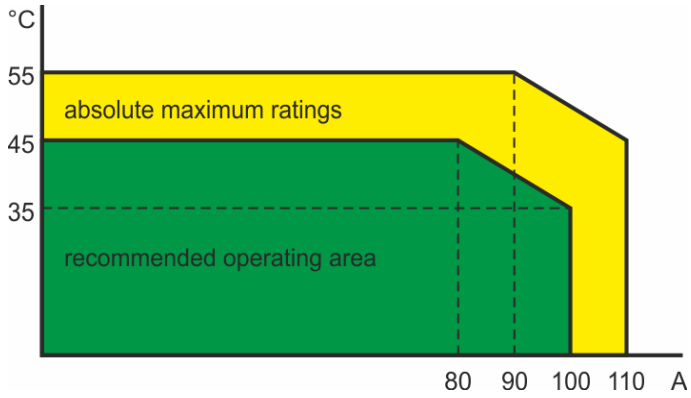


Measuring both sides, the failure become obvious - there should be a partial shortcut, leaking 1A to ground. String power is cut in half. Investigation is made remotely, and technician is asked to perform a very specific task ("shortcut to ground somewhere between 1st and 2rd panel").

Derating curve

Stresses at or above those listed under the absolute maximum ratings may cause permanent damage to the device. Prolonged exposure to conditions near maximum ratings may cause accelerated aging and deterioration.

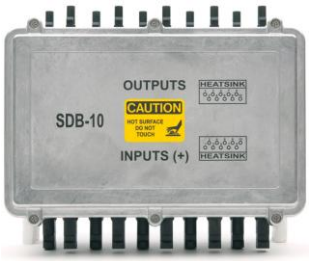
Derating curve specifies the recommended operating conditions. Y axis is ambient temperature, X axis is output current. For a reliable long-term operation, it is adviced to keep operating conditions inside the green area. Longer exposure to conditions in yellow area may not cause instant malfunction, but will certanly affect reliability and limit the life span.



For example, if ambient temperature is expected to reach 40°C, output current should not exceed 90A.

3.2. String Diode Box

String diode box provides a serial diode for each string. Diodes protect strings against reverse current, which may occur when panels are shaded.



3.3. DC Combiner Box

DC combiner box is a passive combiner for power lines coming from string monitors, and going to inverter.

Each input has both positive and negative fuse, and disconnector switch.

3.4. Solar Controller Unit

Solar controller provides power supply for string monitors, opto-isolation, and surge protection. It combines measurements from string monitors, inverter and other devices; to calculate power, energy and averages.

Features:

- connection for up to 20 string monitors
- read data from various inverter manufacturers and models
- 4.3" full-color touch-screen
- 100-240Vac input, 24Vdc power supply output for string monitors
- overvoltage protection + CAN/CAN opto-isolation
- Ethernet TCP/IP, DHCP client or static IP
- MODBUS TCP/RTU gateway
- operating hours, reset monitor, bus quality monitor
- configurable alarms and warnings
- automatic calculation of section and plant summaries
- automatic connection to remote scada (push connection)
- simulation mode

3.5. Modbus Gateway Unit

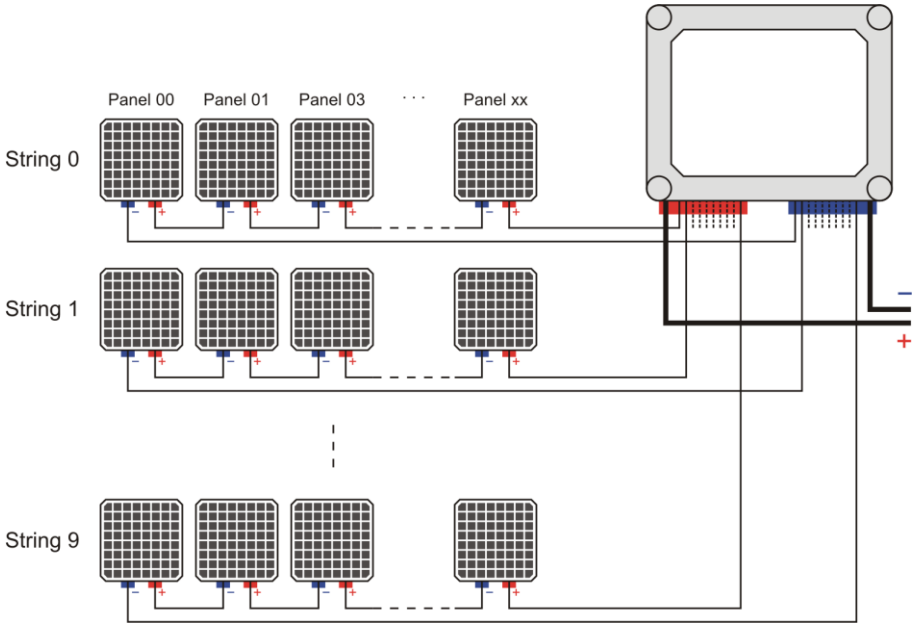
Gateway from string monitors to Modbus controller. It provides power supply for string monitors, opto-isolation, and surge protection. Hardware is similar to solar controller, without touch screen.

Features:

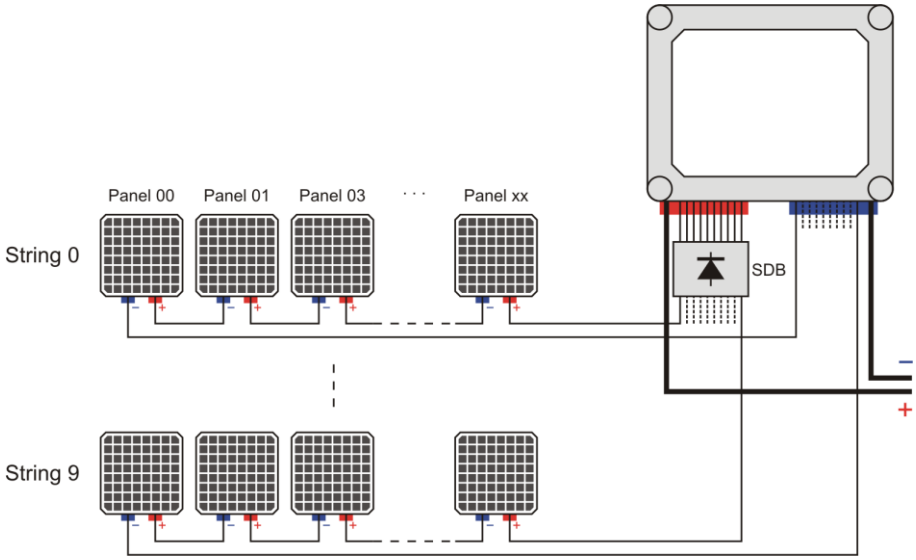
- connection for up to 20 string monitors
- red/green status indicator
- 100-240Vac input, 24Vdc power supply output for string monitors
- overvoltage protection + CAN/CAN opto-isolation
- Ethernet TCP/IP, DHCP client or static IP
- MODBUS TCP/RTU gateway

4. Connecting

Connecting PV modules into strings, and connecting strings to string monitor:



Connecting PV modules into strings, and connecting strings to string monitor, with string diode box:



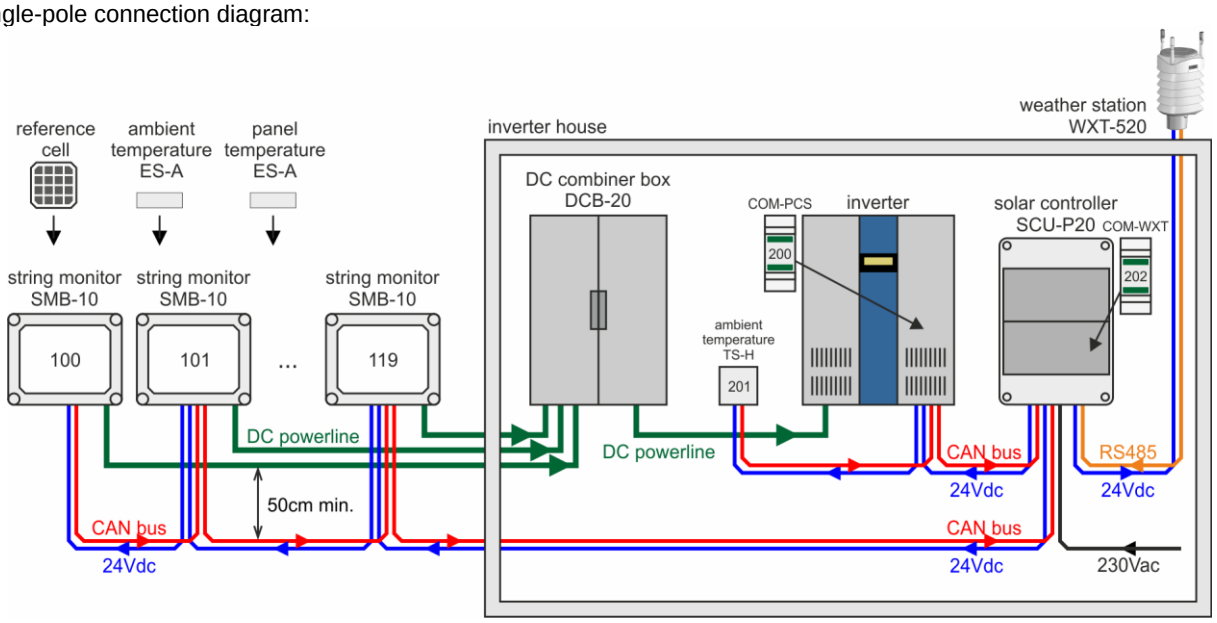
Each string monitor may have up to 10 strings connected. Actual number of strings may be less, or even different among string monitors. However, strings must be connected in order, first on input 1, second on input 2, third to input 3, etc.

The following example shows a possible way to connect 54 strings:

device	SMB	SMB	SMB	SMB	SMB	SMB
position number	100	101	102	103	104	105
connected strings	10	10	10	8	8	8

Solar controller automatically determines number of connected strings, there are no configuration parameters related.

Single-pole connection diagram:



Reference cell, ambient temperature and panel temperature position is configurable, sensors may be connected to a nearest string monitor. Maximum cable length (from sensor to SMB) is 5 meters.

Communication cable must be connected in line (not star) configuration, from PSU to last string monitor. Branching is not allowed. 24Vdc cable should follow the same path. Minimum distance between CAN/24Vdc and power cables is 50cm.

Termination switch should be set to "on" position for last device in chain (position number 100). Other devices should have termination switch set to "off" position.

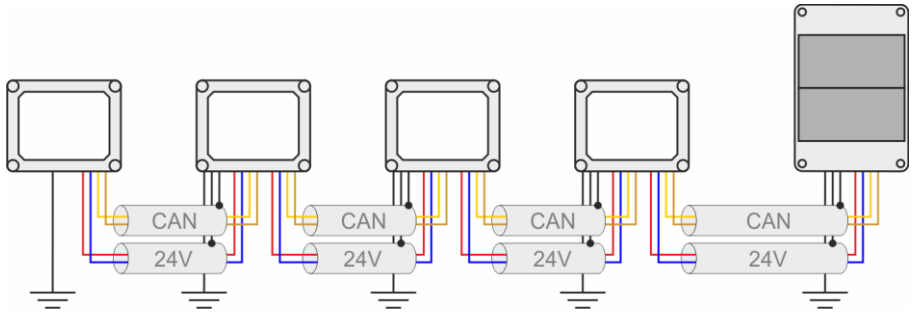
Wire gauge for 24Vdc supply:

	total bus length						
string monitors	100m	200m	300m	400m	500m	750m	1000m
1 to 5	0.5mm^2	0.5mm^2	0.5mm^2	0.75mm^2	0.75mm^2	1.5mm^2	2.5mm^2
6 to 10	0.5mm^2	0.5mm^2	0.75mm^2	1.5mm^2	1.5mm^2	2.5mm^2	2.5mm^2
11 to 15	0.5mm^2	0.75mm^2	1.5mm^2	1.5mm^2	2.5mm^2	2.5mm^2	2.5mm^2
16 to 20	0.75mm^2	1.5mm^2	1.5mm^2	2.5mm^2	2.5mm^2	2.5mm^2	-

Wire gauge for CAN bus:

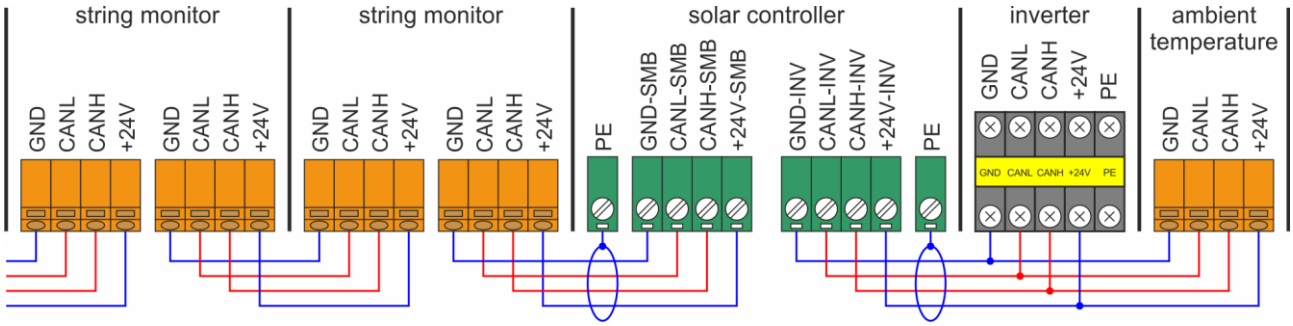
	total bus length						
	100m	200m	300m	400m	500m	750m	1000m
baudrate	100kbps	100kbps	100kbps	50kbps	50kbps	20kbps	20kbps
wire gauge	0.25mm^2	0.25mm^2	0.5mm^2	0.5mm^2	0.5mm^2	0.75mm^2	0.75mm^2

Both CAN and 24Vdc cables must be shielded, e.g. RE-Y(ST)Y 2x1.5mm^2 + 2x0.5mm^2. Shield is connected to ground for outgoing cable, and isolated for ingoing - each cable is grounded once, closer to solar controller.

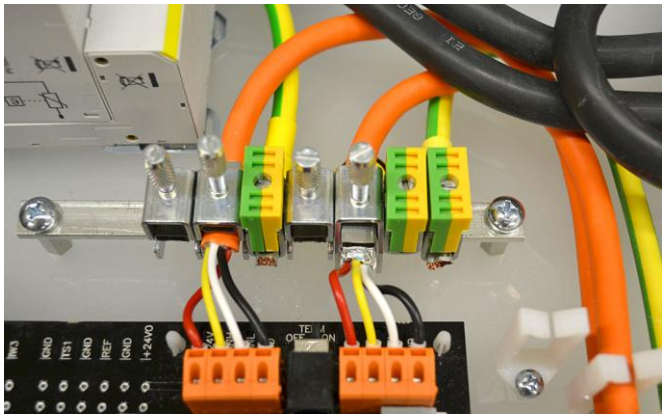


Grounding should be made according to local regulations. Ground wire must be at least 2.5mm^2.

Wiring diagram:

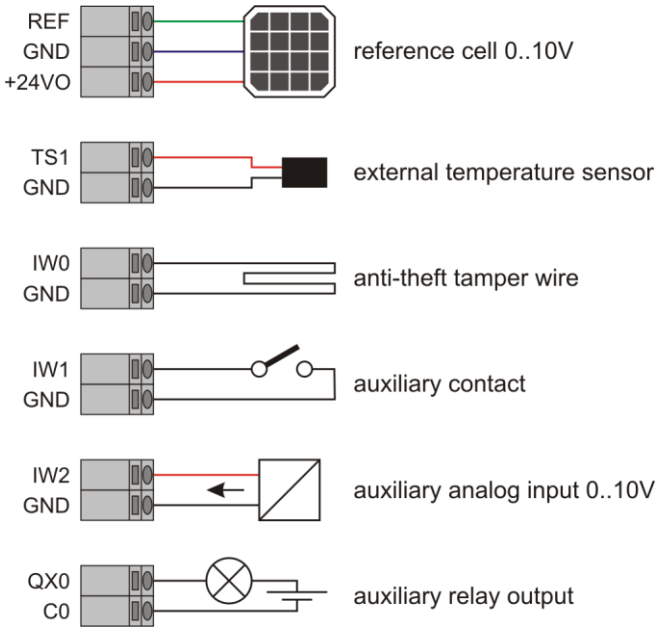


Wiring detail:



Optional equipment

According to user requests, various optional equipment may be connected:



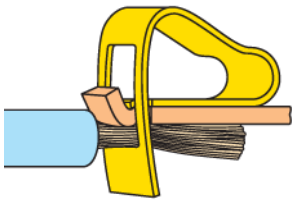
Reference cell cable shield should be tied to ground rail.

If external temperature sensor (ES-A) comes with shielded cable, it should not be connected.

Sensor TS-H must be properly oriented. Label "THIS SIDE UP" is visible when housing is open. If sensor is oriented in a wrong direction, temperature readout will be inaccurate.

Wiring operation

PV input terminals (20mm pitch)

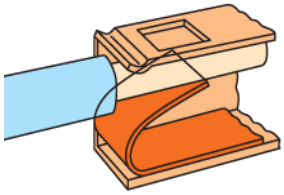


Strip off
Remove insulation 12-13mm.

Connect
Open clamp using screwdriver (WAGO type 3), and insert wire with no force.

Disconnect
Open clamp using screwdriver (WAGO type 3), and remove wire with no force.

Communication and I/O (5mm pitch)



Strip-off
Remove isulation 10-12mm.

Connect
Insert wire into cage clamp with moderate force. No tools needed.

Disconnect
Open clamp using screwdriver (WAGO type 2), and remove wire with no force.

We recommend stranded wire and ferrules.

5. Commissioning

Commissioning is a process of setting plant into operation. This chapter describes actions and measures needed to ensure flawless operation. Commissioning should be performed by a certified professional. Damage which may happen because of improper handling is not covered by warranty.

5.1. Prerequisites

1. Mounting

Check whether devices are installed according to specifications. Devices should be attached firmly, wobbling is not acceptable. Front covers should be closed and properly sealed.

2. Wiring

Obtain report from wiring company. Check wiring against the specifications. Pay special attention to shielding, grounding and communication lines.

5.2. Regular operation

1. Serial numbers

Use a sheet of paper to write down serial numbers of connected devices. Serial number is printed on a label, attached to device. Pay a special attention to correct order. By a convention, first string monitor is one the on the far end of the line, opposite of solar controller. Do not start counting other way around.

device	SMB 1	SMB 2	...	SMB 20	COM-PCS	TS-H	COM-WXT
serial number	9817	9973	...	9912	9517	9914	9288

2. Termination switch

Open box cover (transparent lid) of the first device (far end of the cable), and set termination switch to "on". Close and secure cover. Check that all other termination switches are set to "off".

device	SMB 1	SMB 2	...	SMB 20	COM-PCS	TS-H	COM-WXT
termination switch	on	off	off	off	-	-	-

Termination resistor on the another side is set permanently (inside power supply or solar controller).

If in doubt that switches are set correctly, use a multimeter to check resistance between CANL and CANH. Resistance should be about 60 ohms, or a little more when cables are very long or thin. If resistance is below 60 ohms, two or more termination switches are set to "on" position. If resistance is 120 ohms or more, no termination switch is "on". During the measurement, power supply must be off.

3. Power supply

Turn-on solar controller, check that PWR LED (green) and RUN LED (red) are on.

Turn-on power supply for string monitors. Go through string monitors, one by one, and check that power LED (green) is steady "on", no blinking or flickering. If not, skip to troubleshooting section.

4. Check communication

Connect NAD manager (or CyBroIexManager) and check that all devices are listed. If not, skip to troubleshooting section.

5. Set communication address

Default address, given by factory, is equal to serial number. Each device should be given a new address, the one which reflect it's position.

By convention, position numbers for string monitors are going from 100 to 119 (or less, if fewer then 20 monitors are used). Position 100 is farthest and 119 is closest to the inverter. Position number 200 is used for inverter (COM-PCS), 201 for indoor temperature sensor (TS-H) and 202 for weather station (COM-WXT). For other (optional) devices, consult tech support.

Use NAD manager to change address from serial number to position number, according to the following table. Repeat procedure for each device, until all addresses are changed.

device	SMB 1	SMB 2	...	SMB 20	COM-PCS	TS-H	COM-WXT
position number	100	101	...	119	200	201	202
old address	9817	9973	...	9912	9517	9914	9288
new address	100	101	...	119	200	201	202

To make the identification easier, when a string monitor is selected, ALERT LED (red color, high-brightness) is flashing.

When finished, check that each address is set properly.

6. Setting parameters

Use SCU touch panel to set working parameters (Settings menu).

section_number	Section in which solar controller belongs (0-no sections, 1-section A, 2-section B, 3-section C...). Used to calculate section totals.
smb_count	Number of string monitors connected to solar controller. Allowed range is 1 to 20. Used to calculate summary data.
inverter_nominal_power	Nominal power of connected inverter in kW. Leave zero if no inverter is connected. Used to calculate percentage of maximum power.
pv_reference_range	Nominal range of photovoltaic reference cell [W/m^2]. When insolation is equal to given value, cell output should be 10.000V. Typical values are 1000 and 1400 W/m^2. Used to calculate insolation.
panel_surface	Total surface of all PV panels connected to solar controller [m^2]. Has to be calculated as number of panels multiplied by total active surface, given by manufacturer. Used to calculate panel efficiency.
energy_price	Buy-out price for one MWh of output energy [euro]. Used to calculate income.
pv_reference_position	Position where PV reference cell is actually connected. Position is given as 0 to 19, corresponding to string monitor position numbers 100 to 119.
ambient_temperature_position	Position where ambient temperature sensor is actually connected. Position is given as 0 to 19, corresponding to string monitor position numbers 100 to 119.
panel_temperature_position	Position where panel temperature sensor is actually connected. Position is given as 0 to 19, corresponding to string monitor position numbers 100 to 119.
temperature_limit	Acceptable string monitor internal temperature [°C]. Used as a limit for over-heating alarm.
difference_enable	Enable difference detection alarm (0-disable, 1-enable). Alarm is reported when corresponding positive and negative currents differ more than specified. Alarm is not active if current output power is lower than 20% of maximum power.
difference_limit	Acceptable difference between positive and negative leg [A].
power_loss_enable	Enable power loss detection alarm (0-disable, 1-enable). Alarm is reported when one string has significantly lower output then others. Alarm is not active if current output power is lower than 20% of maximum power.

power_loss_percent	Percent of average power to detect power loss error [%]. Average power is defined as total power divided by number of strings.
theft_enable	Enable theft detection alarm (0-disable, 1-enable). Alarm is reported if tamper wire is broken. Leave disabled if tamper wire is not connected.
logo_selection	Select which logo to display on solar controller panel (0-Robotina, 1-SanRex).
date/time	Current date and time, displayed in international notation (ISO 8601, yyyy-mm-dd, hh:mm:ss). Time is given in 24-hour format. Local time is used, no daylight saving.

Example:

section number	1	(section A)
number of string monitors	12	(actual number of connected string monitors)
inverter nominal power	250kW	(100, 250 or 500kW)
pv reference range	1000W/m^2	(standard reference for moderate climate zones)
panel surface	2556m^2	(15 x 10 x 12 = 1800 panels, 1800 x 1.42m^2 = 2556m^2)
energy buy-out price	380.02€	(0.38 EUR/kWh)
pv reference position	0	(reference is connected to first string monitor)
ambient temperature position	0	(ambient temperature sensor is connected to first string monitor)
panel temperature position	1	(panel temperature sensor is connected to second string monitor)
temperature limit	60°C	(maximum expected temperature)
difference enable	1	(on)
difference limit	0.5A	(maximum expected imbalance)
power loss enable	1	(on)
power loss percent	75%	(maximum expected difference)
theft enable	0	(off)
logo selection	0	(Robotina logo)

7. Write parameters to EEPROM

To make them permanent, parameters should be written to EEPROM.

To do this, enter write magic as 31415, then set write request. When parameters are written, both write magic and write request will reset to zero.

To check if parameters are written correctly, change one parameter (e.g. select another logo), then set read request. When reading is finished, parameter will return to correct value. Check also that all other parameters are set correctly.

8. System errors

Use SCU panel to check for errors: open Controller and go one page down. In case of an error, go back to step 4.

9. Internet connection

To check Internet connection, open Info page and press Send push button.

If connection is established, display will show round-trip time in milliseconds.

If connection is not established, round-trip time will keep running 10 seconds, then reset to -1.

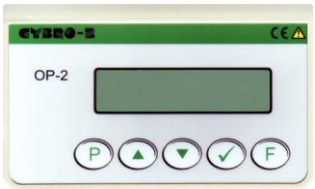
5.3. Operating procedures

Replace broken string monitor

1. Replace broken string monitor with a new one.
2. Connect strings, power and communication lines.
3. Power-on and set communication address to match the replaced unit.

Set string monitor address (using NAD Manager)

NAD manager is handheld device used to set IEX-2/CAN communication addresses. It can be connected anywhere on the bus. Four wires are used, two for 24V power supply, and two for communication. The best way to connect is directly to SMB board, using enclosed RJ9/RJ9 cable.



1. Connect NAD Manager.

2. Wait until software initialization is done (approximately 30 seconds).

3. Use ▲ and ▼ buttons to select device, then press ✓ button.

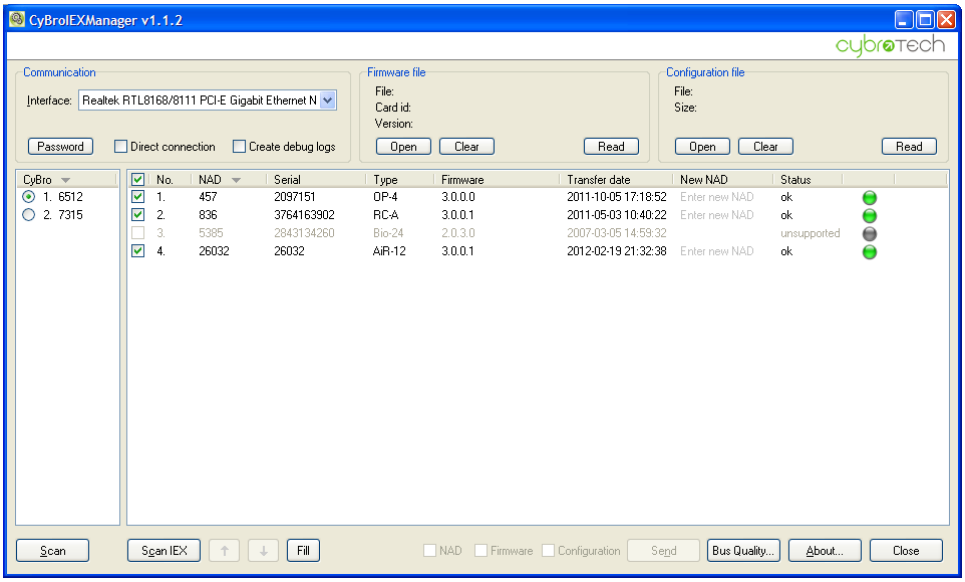
4. Use ▲ and ▼ buttons to set new communication address, then press ✓ button.

When string monitor is selected, internal "Alert" LED is blinking red, to identify selected device.

Back side has RJ-9 (4P4C) female connector, used for 24V power supply and communication. Use the enclosed adapter to connect NAD manager directly to solar controller, string monitor, or to the nearest bus connection.

Set string monitor address (using IEX Manager)

CyBroIexManager is software used to set communication addresses. It is connected to solar controller using Ethernet.



Basic functions are the same as NAD Manager. It is a recommended method for a large power plant.

Set string monitor address (using IEX Loader)

IEX loader is tool for firmware update, but it can also be used for communication address. It connects directly to bus using USB-to-CAN adapter. IEX loader is backup solution, used when Ethernet is not available.

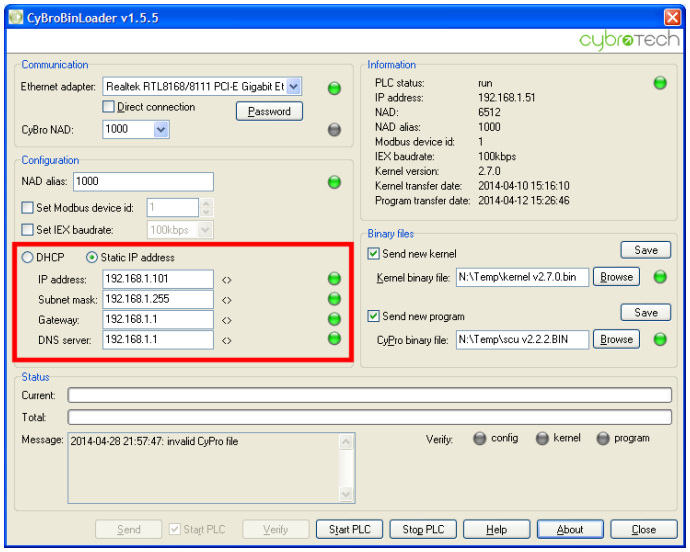
Configure solar controller IP address

Solar controller by default use DHCP server to obtain IP address. This is a preferable method.

When static IP address is needed, the prefered way is to use DHCP server with static allocation (also known as "IP reservation" or "Static DHCP"). This option is provided by most quality routers.

When Static DHCP is not available, use CyBroBinLoader to assign static IP address:

1. Select Ethernet adapter
2. Use CyBro NAD drop-down list to select controller
3. Select Static IP address, enter IP address, subnet mask, gateway and DNS server
4. Press Send button



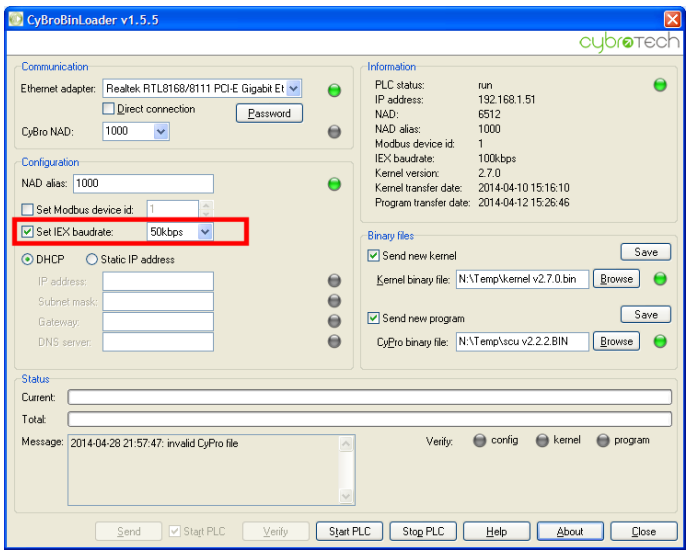
Note that static address may be assigned without kernal or plc program. If binary files are not selected, program will read kernel, make modifications and write it back to plc. Retentive variables are preserved, non-retentives will be initialized.

If controller is not automatically recognized, use direct connection. Connect PC directly to solar controller, one-to-one, no switches or routers in between. After connecting, PC may need a few minutes to set auto-configured IP address, check system tray. When address is assigned, start CyBroBinLoader, check Direct connection, and continue same as before.

Set IEX-2/CAN bus baudrate

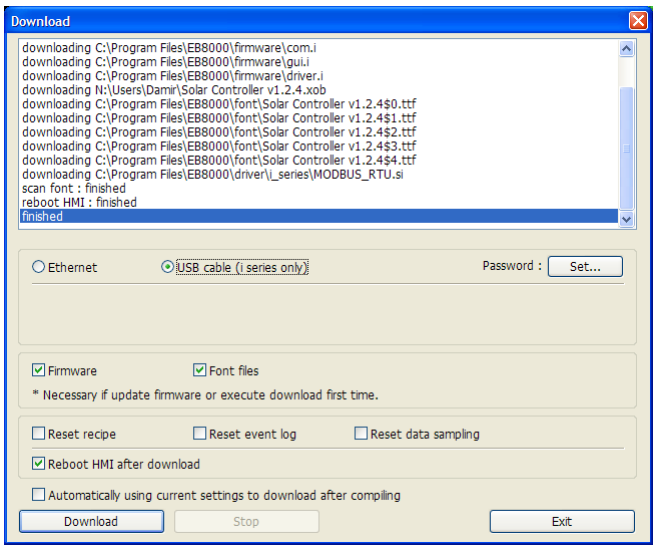
Default IEX-2/CAN baudrate is 100kbps. For a bus longer then 300m, baudrate must be adjusted (check "Connections" section):

1. Select Ethernet adapter
2. Use CyBro NAD drop-down list to select controller
3. Select new baudrate
4. Press Send button



Update solar controller firmware

1. Use CyBroBinLoader to send kernel and plc program to device.
2. Use EasyBuilder8000 and USB cable to send touch panel software.



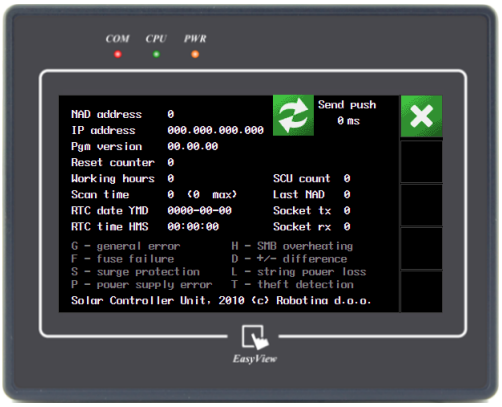
3. Set configuration parameters.

Replace broken solar controller

1. Replace solar controller (alternatively, replace only broken component: CyBro, power supply or touch panel).
2. Set configuration parameters.
3. Solar Mini, edit configuration file, replace old NAD with a new one.
4. Solar Web, page and data logger configuration, replace old NAD with a new one.

Configure Internet connection

To check Internet connection, press "Send push" button.



When connection is established, round-trip time from controller to server is displayed. Typical values are 50-200ms for wired connection, 200-400ms for 3G connection, and 500-1000ms for GPRS/EDGE.

If connection is not established, after a few seconds -1 will appear.

Note: UDP port 8442 on router/firewall should be open for both sending and receiving.

Set configuration parameters (using touch panel)

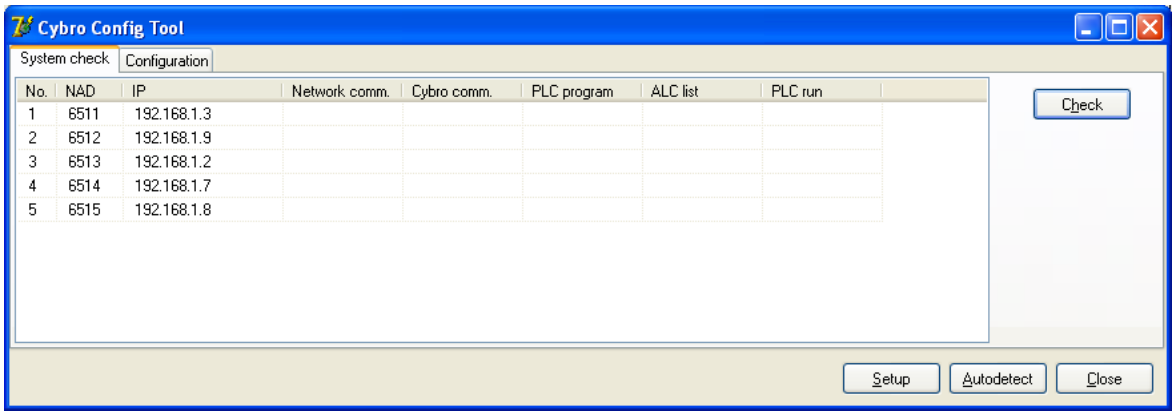
- open settings screen
- press parameter button
- enter new value and press ENT

If wrong digit is entered, press BS (backspace) to clear last digit, or ES (escape) to ignore whole input.

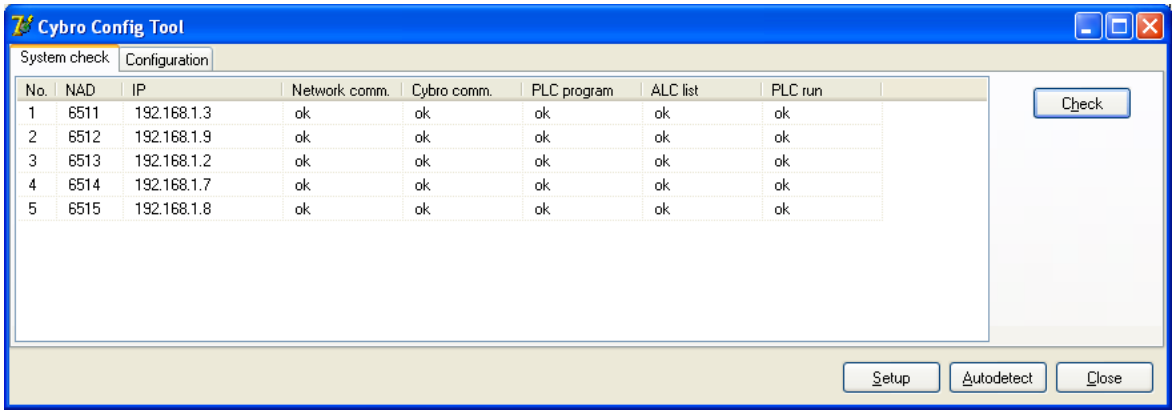
Set configuration parameters (using CyBroDataTool)

This method may be used when solar controllers are connected in local network. All controllers are set at once.

- start CyBroDataTool
- open Setup, select network adapter and connection type
- press Autodetect button - list of solar controllers will appear

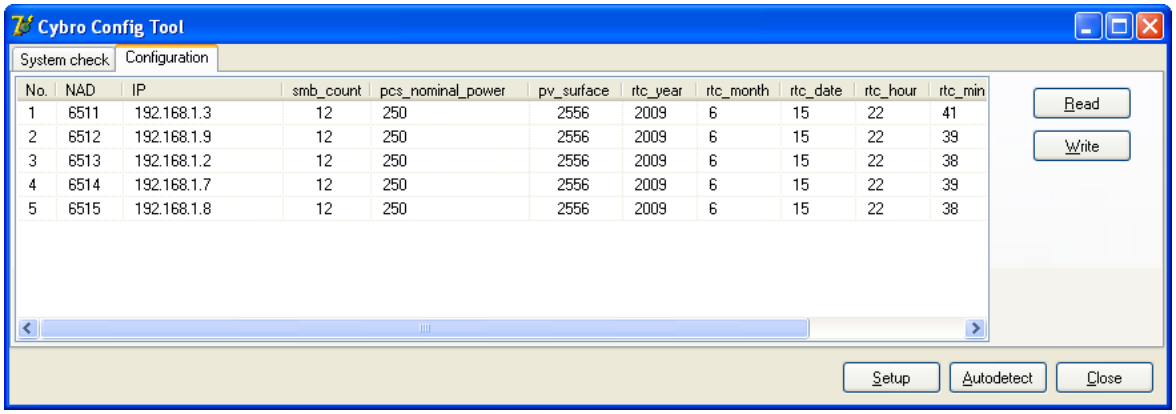


- press Check button - all fields should be "ok"



- switch to Configuration tab
- enter parameters

- press Write button

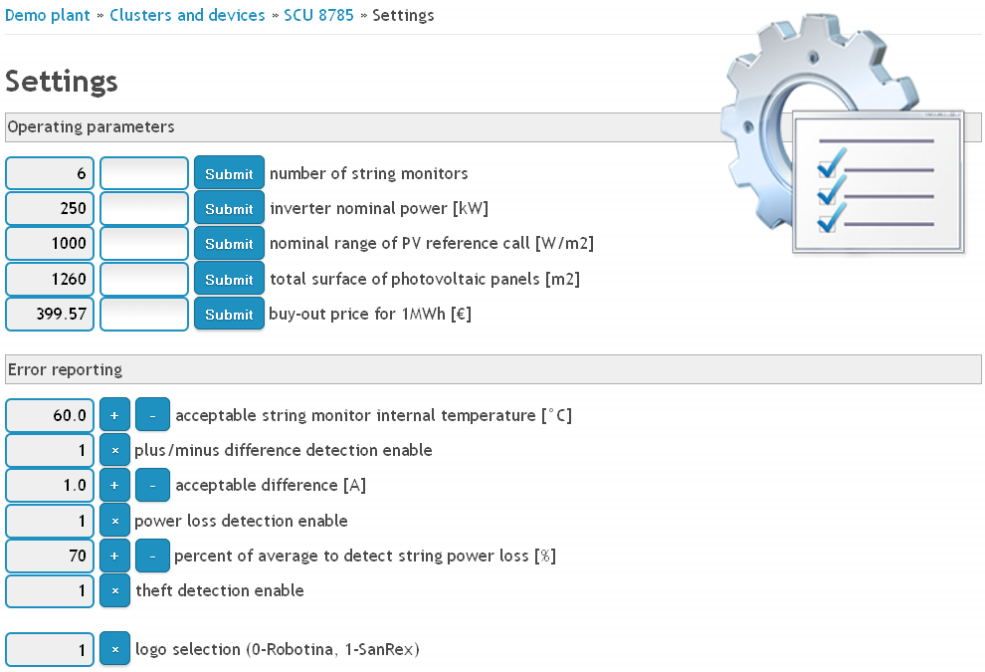


After writing, program automatically read values back, to verify that data is written correctly. If value entered is out of range, it will be limited automatically.

Set configuration parameters (using Solar Web)

This method may be used if plant is already connected to Internet, or local Solar Web server is installed. Access credentials (username and password) with write permission are needed.

- open www.solar-cybro.com
- log on using your username and password
- open plant settings page
- set parameters



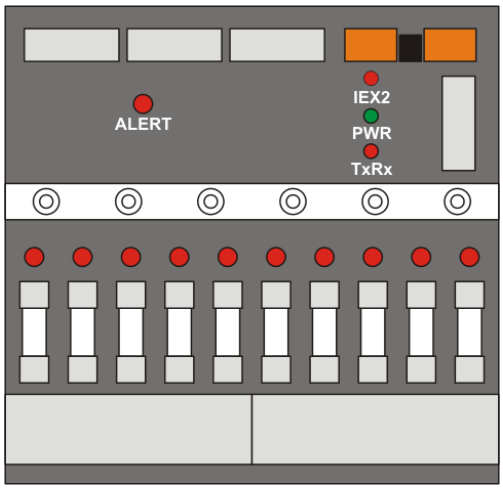
Parameters must be written to EE memory.

5.4. Troubleshooting

String monitor not communicating

1. Use digital multimeter to check power supply. PWR LED should be on.
2. Check communication wiring. When properly connected, IEX2 LED should be blinking.
3. Use CyBroIexManager to check (and resolve) duplicate communication address.
4. Replace string monitor.

String monitor indicators



PWR on - power supply ok
off - no power supply
blinking - internal error or faulty power supply

IEX2 blinking - communication ok
on - no communication, faulty wiring
off - no communication

TxRx blinking - slave board ok
on/off - slave board error

FUSE off - fuse ok
blinking - fuse blown (only when string voltage is present)

ALERT blinking - device selected by NAD manager

COM-PCS indicators

PWR on - power supply ok (CAN bus side)
off - no power supply (CAN bus side)
blinking - internal error or faulty power supply

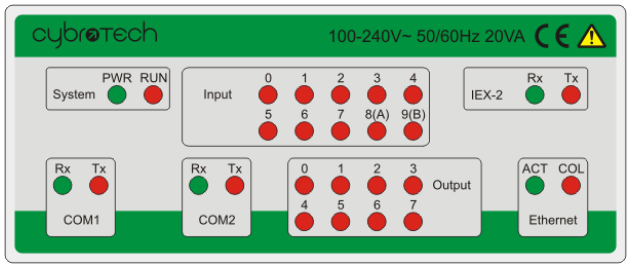
IEX2 blinking - communication ok
on - no communication, faulty wiring
off - no communication

+5V on - power supply ok (inverter side)
off - no power supply (inverter side)

Tx blinking - transmitting to inverter ok
off - no communication to inverter

Rx blinking - receiving from inverter ok
off - no communication from inverter

Solar controller indicators



PWR on - power supply ok
off - no power supply
blinking - internal error or faulty power supply

RUN on - program ok
off - program stopped, check run/stop switch
blinking - program error

COM2 Tx/Rx blinking - touch panel ok
Tx blinking, Rx off - touch panel not connected
Tx/Rx off - internal or configuration error

IEX-2 Tx/Rx blinking - communication to string monitors ok
Tx/Rx on - communication error, one or more wires not connected
Tx blinking, Rx off - error, shortcut between communication lines
Tx/Rx off - internal or configuration error

ETH ACT blinking - Ethernet ok
COL blinking - collisions detected
ACT off - not connected or no traffic

6. Maintenance

There is very little to replace during a product lifetime, components are selected to provide lifetime of 25 years or more. However, local regulations, and manufacturer recommendations for electrical installations ought to be respected.

On regular basis we suggest the following:

Daily maintenance

SPSS continuously monitors relevant working parameters. Measurements are summarized in main status signal:

 no errors, system is working fine
 error encountered

Maintenance employee is expected to check status daily. In case of an error, he finds the cause and immediately take measures to correct the problem. Prolonged response may result with damage of equipment and decreased yield.

If system is connected to Internet, daily maintenance may be performed remotely.

If system is equipped with SMS alarm system (option GSM1), daily maintenance is not required, therefore status checking may be performed weekly. If system is set to automatically send reports, status checking may be performed monthly.

Yearly maintenance

Detailed visual inspection is expected each year, starting from the third year after installation. Plastic cover shall be removed and visual inspection carried out. Based on result, the following actions should be taken:

- in presence of dust or stains (liquid), transparent cover with seal should be replaced
- if traces of condensed water are detected, pressure equalizer element should be replaced
- all screws in power circuit should be checked and, if needed, tightened to the specified torque

We suggest IR camera inspection to detect possible hot spots. If hot spot is detected, screw should be tightened, and inspected again.

In a specially tough conditions (high average temperature, presence of sea water, salt or thin dust), more often inspection or even systematic replacement may be indicated.

Spare parts

Spare parts are available from Robotina and distributors, while consumables are available from Robotina, distributors and specialized resellers.

Fuses	There is no need to systematically replace fuses as a part of maintenance procedure. However, plant designer may decide preventive replacement to increase better availability of the plant. Preventive replacement may reduce heat loss and increase product lifetime.
Surge protection	Surge protection devices (SPD) are monitored through auxiliary contacts by SMB. They need no special maintenance, only replacement if SPD is broken.
Disconnector switch	In normal operating conditions, disconnector switch requires no special maintenance. However, humidity or air pollution may oxidize contacts and increase pole resistance, resulting in excess heat dissipation.

Maintenance cost

Although only a few parts are systematically replaced, there is a chance that some elements fail in period of 25 years.

Estimated cost of replacement parts (without consumables like fuses, SPD replacement modules) is 5% of SPSS price. Since no actual data is available yet, estimate is based on artificial aging and statistics.

7. Technical Data

7.1. String Monitor Box

Input

DC voltage	1000V max.
Measurement	0..1100V range, ±0.5% accuracy
DC current for each string	10A nominal, 12A max.
Current measurement	0..12A range, ±0.5% accuracy
Measurement period	2s (100kbps), 4s (50kbps) or 10s (20kbps)
Power loss for each string	1.2W typ. (1mΩ clamp + 7mΩ fuse + 2mΩ shunt + 2mΩ track = 12mΩ)
Connection	cage clamps + cable glands (default) faston/MC3/MC4/custom connectors (option)
Cable cross section	1.5..16mm^2 (16..6 AWG)
Overvoltage protection	SPD 1kV (4kV max.), protection level type 2
Fuse	yes, each input

Output

DC voltage	1000V max.
DC current	100A @ 55°C, 110A @ 45°C max. (plastic) 90A @ 55°C, 110A @ 45°C max. (stainless steel)
Connection	cable glands + 120mm^2 stud terminals, M10 nuts, 10..20Nm torque
Cable cross section	120mm^2 max.
Disconnector switch	ABB SACE, TMAX PV T1D-160

Communication Cable

Type	2 x 0.5..2.5mm^2 shielded twisted pair (24V power supply) 2 x 0.25..0.75mm^2 shielded twisted pair (CAN/IEX-2 communication)
Length	1000m max. (check "Connecting" section for limitations and details)
Connection	cable glands + 2x4 pole cage clamps, orange, PCB mounted, 2.5mm^2 connectors (one for incoming and one for outgoing cable), shield grounded
Termination	internal, 120ohm on last device (manually activated by mini-switch)

Control Circuit

Power supply	24V (18..26V)
Power consumption	50mA typ. (24V, P+N version, relay 4x off, LED off) 120mA max. (24V, P+N version, relay 4x on, LED on)
Withstanding voltage	5kV AC RMS 50Hz 3 seconds 8kV 1.2us/50us pulse
Lacquer finish	15kV/mm
Creepage distance	10mm
Clearance	9.6mm
PCB flammability rating	UL94-V0
Communication	IEX-2/CAN, 100/50/20kbps, autoselect
Fuse control status	yes, 25V typ. failure detection level
Overvoltage protection status	yes
Internal temp. measurement	yes, -50..+100°C, ±0.5°C accuracy
External temp. measurement	yes, -50..+100°C, ±0.5°C accuracy, digital sensor, cable length up to 20m
Photovoltaic reference cell	yes, 0..10V, 1000..1400W/m^2, ±0.5% accuracy, 24V power supply
Anti-theft protection	yes, close-circuit tamper wire
General-purpose inputs	4 analog/digital inputs, 0..10V or contact (internal pull-up 12V/2mA)
General-purpose outputs	4 relay outputs 3A/250V

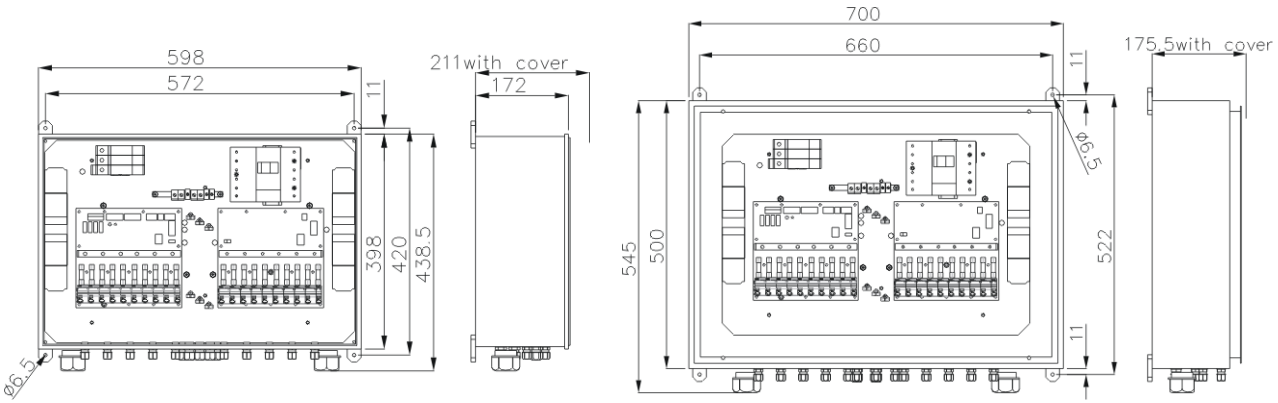
Mechanical & Environmental

Installation	outdoors, shaded area
Material, base & clear lid	polycarbonate
Electrical insulation	totally insulated
Flammability rating	UL94-5V
Glow wire test	960°C, halogen free
UV resistance	UL 508
Vibration test	10..57Hz/0.075mm, 57..150Hz/1G, XYZ, 10 sweeps per axis
Impact resistance	IK 08
Ingress protection	IP 65
Grey parts color	RAL 7035
Transparent clear cover	smoked grey
Ambient temperature	-25..+55°C (-13..130°F)
Thermal resistance	0.35K/W
Relative humidity	0..95% non-condensing
Dimensions	598 x 398 x 211mm (23.5" x 15.7" x 8.3") (plastic) 700 x 500 x 170mm (27.5" x 19.6" x 6.7") (stainless steel)
Weight	12kg (plastic) 21kg (stainless steel)
Package	725 x 570 x 245mm (plastic)

Standards

LVD	EN 50178
EMC	EN 61000-6-2, EN 61000-6-4
CE	yes

Dimensions



plastic

stainless steel

7.2. String Diode Box

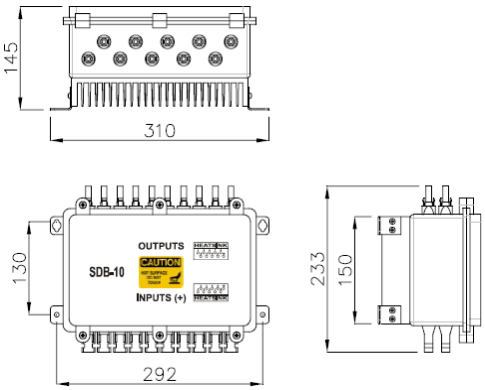
Input & output

Number of inputs	10
Input connection	faston/MC3/MC4/custom connectors (option)
Number of outputs	10
Output connection	faston/MC3/MC4/custom connectors (option)
Number of diodes	10
Forward current for each string	20A max.
Voltage drop	1.2V @ 10A
Reverse voltage	1600V max.

Mechanical & Environmental

Dimensions	310 x 233 x 145mm (WxHxD)
Weight	3.7kg

Dimensions



7.3. DC Combiner Box

Input

Number of inputs	2..20
Number of fuses	2 x number of inputs
Voltage	1000V max. (fuse to 125A), 900V max. (fuse 160A)
Current (each input)	100A max. (fuse rating: 1,5 x Isc)
Connection	ring-lug, hole 8mm
Cable cross section	120mm^2 max.

Output

Number of output cables	2..10 (5 positive, 5 negative)
Connection	ring-lug, hole 12mm
Cable cross section	120mm^2 max.

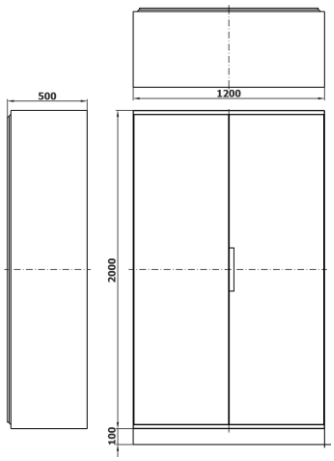
Control Circuit

Supply	24V (18..26V)
Power consumption	120mA typ.
Monitoring	overvoltage protection and switch disconnector (option)

Mechanical & Environmental

Dimensions	1200 x 2000 x 500mm (WxHxD) (DCB-20, for other types consult factory)
Weight	cca. 300kg (DCB-20)

Dimensions



7.4. Solar Controller / Modbus Gateway Unit

Power supply

Nominal input voltage	230Vac or 115Vac, manually selectable
Allowed voltage range	176..264V or 85..132V
Frequency	47..63Hz
Input current	0.7A max. or 1.3A max.

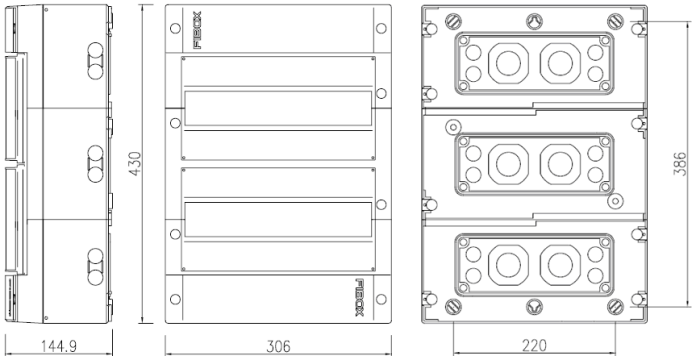
Control Circuit

Monitor boxes per controller	20 max.
Communication	IEX-2/CAN
Baudrate	100/50/20kbps, software selectable
Ethernet connection	10/100BASE-T, cable autodetect
Cable length	100m max. (SCU to switch)
Category	CAT5 or better
IP address	DHCP (default) or static (option)

Mechanical

Installation	indoor
Material, base & clear lid	polycarbonate
Electrical insulation	totally insulated
Flammability rating	UL94-5V
UV resistance	UL 508
Impact resistance	IK 08
Transparent clear cover	smoked grey
Ingress protection	IP 20
Ambient temperature	0..+45°C
Relative humidity	0..95% non-condensing
Dimensions	430 x 306 x 145mm
Weight	5.0kg

Dimensions



8. Appendix

8.1. Available signals

String monitor

smb00_current_p0..9 ..... Positive side measured current in 0.1A units (e.g. 82 means 8.2A).
smb00_current_n0..9 ..... Negative side measured current in 0.1A units (e.g. -82 means -8.2A).
smb00_voltage ..... Measured output voltage (V).
smb00_pv_reference ..... Photovoltaic reference cell measurement (W/m2).

smb00_fuse_error_p0..9 ..... Positive side fuse error.
smb00_fuse_error_n0..9 ..... Negative side fuse error.
smb00_fuse_error ..... Common fuse error, logical OR of all positive and negative fuses.
smb00_surge_error ..... Surge protection error.

smb00_general_error ..... One or more system errors occurred (timeout, program or hardware error).
smb00_timeout_error ..... Communication failed, no messages are coming from the module.
smb00_program_error ..... Internal or configuration error detected, module is not functional.
smb00_hardware_error ..... Module detected hardware (measurement_status) or communication error.

smb00_iex_power_supply ..... Measured power supply voltage in 0.1V units (e.g. 242 means 24.2V).
smb00_measurement_status ..... Measurement status: 0-measurement ok, 1-master board error, 2-slave board error. If slave board is not present, no error is indicated.
smb00_slave_board_status ..... Status of slave pcb board (0-present, 1-missing).

smb00_temperature_0 ..... Measured internal temperature, multiplied by 10 (e.g. 247 means 24.7°C).
smb00_temperature_1 ..... Measured external temperature, multiplied by 10 (e.g. 247 means 24.7°C).

smb00_sensor_error_0 ..... Temperature sensor 0 (internal) is not working properly.
smb00_sensor_error_1 ..... Temperature sensor 1 (external) is not working properly.

smb00_ix00..03 ..... Binary input (0-open, 1-closed).
smb00_iw00..03 ..... Analog input 0, potentiometer or voltage 0..10V (0..1023).
smb00_qx00..03 ..... Relay output (0-open, 1-closed).

smb00_alert_led ..... LED for visual module identification (0-off, 1-on).

Inverter

inv00_ac_voltage ..... Measured output AC voltage, in 0.1V units, range 0..420V.
inv00_ac_current ..... Measured output AC current, in 0.1A units, range 0..137.4A (100kW), 0..343.6A (250kW) or 0..687.3A (500kW).
inv00_ac_power ..... Current output AC power, in 0.1kW units, range -10..100kW (100kW), -25..250kW (250kW) or -50..500kW (500kW).
inv00_ac_frequency ..... Measured output frequency, in 0.1Hz units, range 0..100Hz.

inv00_dc_voltage ..... Measured input DC voltage, in 0.1V units, range 0..500V.
inv00_dc_current ..... Measured input DC current, in 0.1A units, range 0..200A (100kW), 0..500A (250kW) or 0..1000A (500kW).
inv00_ac_energy ..... Total integral power in 0.1kWh units.
inv00_ac_energy_today ..... Total integral power today, in 0.1kWh units.

inv00_ac_current_total ..... Measured total output AC current, in 0.1A units.
inv00_ac_power_total ..... Calculated total output AC power, in 0.1kW units.
inv00_dc_current_total ..... Measured total input DC current, in 0.1A units.

inv00_temperature_0 ..... Temperature inside inverter, measured by inverter, in 0.1°C units.
inv00_temperature_1 ..... Temperature inside inverter, measured by com module, in 0.1°C units.

inv00_status ..... Inverter status (0-offline, 1-error, 2-stop, 3-run).
inv00_status_code ..... Inverter-specific status code (see inverter manual).
inv00_error_code_0-3 ..... Inverter-specific error code (see inverter manual).

inv00_general_error ..... One or more system errors occured (timeout or program error).
inv00_timeout_error ..... Communication failed, no messages are coming from the module.
inv00_program_error ..... Internal or configuration error detected, module is not functional.

inv00_bus_error..... Module detected a number of communication errors, but it is still working.

inv00_com_error..... Communication with inverter is broken.

inv00_iex_power_supply ..... Measured power supply voltage, in 0.1V units, range is 0..30V.

inv00_dc_power ..... Inverter input power [0.1kW].
inv00_ac_power ..... Inverter output power [0.1kW].
inv00_ac_power_ratio ..... Inverter output power in percents [0.1%].
inv00_efficiency..... Inverter efficiency, ac_power/dc_power [%].
inv00_ac_energy ..... Total output energy measured and integrated by inverter [0.1kWh].
inv00_ac_energy_today ..... Total output energy for present day [0.1kWh].

Solar controller

version_major..... Version of plc program, 1st byte.
version_minor..... Version of plc program, 2nd byte.
version_release ..... Version of plc program, 3rd byte.

reset_counter..... Counts number of resets.
operating_hours..... Total operating hours from first start [h].

push_req ..... Set to send push message and start timer.
push_roundtrip..... Time from sending push message to receiving acknowledge [ms].

smb_count..... Number of string monitor boxes in system (0..20).
inverter_nominal_power ..... Nominal power of inverter [kW].
panel_surface..... Total surface of all photovoltaic panels [m2].
energy_price..... Buy-out price for 1MWh of output energy [eurocent].
temperature_limit..... Acceptable smb internal temperature [0.1°C].
difference_enable ..... Enable difference detection alarm (0-disable, 1-enable).
difference_limit ..... Acceptable positive/negative current difference [0.1A].
power_loss_enable..... Enable power loss detection alarm (0-disable, 1-enable).
power_loss_percent ..... Percent of string average power to detect power loss error [%].
theft_enable..... Enable theft detection alarm (0-disable, 1-enable).

simulation_enable..... Enable simulation of smb and inverter measurements.
accelerated_time ..... Speed-up rtc time, to see accelerated simulation.
simulate_fuse_error..... Simulate fuse failure (0-disable, 1-enable).
simulate_surge_error..... Simulate surge protection failure (0-disable, 1-enable).
simulate_power_supply_error..... Simulate low power supply voltage (0-disable, 1-enable).
simulate_overheating_error..... Simulate string monitor internal overheating (0-disable, 1-enable).
simulate_difference_error..... Simulate positive/negative current imbalance (0-disable, 1-enable).
simulate_power_loss_error..... Simulate string power loss (0-disable, 1-enable).
simulate_theft_detection..... Simulate theft detection (0-disable, 1-enable).
simulate_inverter_trip ..... Simulate inverter failure (0-disable, 1-enable).

smb_voltage ..... Common DC voltage of string array, derived from smb measurements [V].
smb_current[0..19]..... Sum of positive string currents for each smb [0.1A].
smb_current_total..... Total sum of all string currents [0.1A].
smb_power[0..19] ..... Power per string monitor, voltage*current [0.1kW].
smb_power_total ..... Total string power, measured by string monitors [0.1kW].
smb_string_count[0..19] ..... Number of active strings detected on a given string monitor (0..10).
smb_string_count_total ..... Total number of detected active strings.

smb_general_error_total ..... Combined general error of all configured strings.
smb_fuse_error_total..... Combined fuse error of all configured strings.
smb_surge_error_total ..... Combined surge protection error of all configured strings.
smb_power_supply_error[0..19] ..... String monitor 24V power supply is out of limits.
smb_power_supply_error_total ..... Combined power supply errors.
smb_overheating_error[0..19]..... Internal string monitor temperature is too high.
smb_overheating_error_total..... Combined overheating errors.
smb_difference_error[0..19]..... At least one string has positive/negative current imbalance.
smb_difference_error_total..... Combined current difference errors.
smb_power_loss_error[0..19] ..... String monitor power output is too low, a string is possibly broken.
smb_power_loss_error_total ..... Combined power loss signal.
smb_theft_detection_total ..... Combined theft detection signal.
smb_combined_error..... Combined error status for all string monitors (0-ok, 1-error).

insolation ..... Current sun power measured by reference cell [W/m2].
panel_efficiency..... Efficiency of photovoltaic panels [%].

plant_combined_error..... Combined error status for whole plant (0-ok, 1-error).

The list is for informative purposes only. For scada reference, ask for latest csv file. This file is automatically generated for each software revision.

8.2. Status tree

Supervisory system provides status signals related to string monitors, inverter, and the plant as a whole. Signals are combined tree-like, ending with combined_error signal. If combined_error is off, the whole plant is working properly.

combined_error

- smb_combined_error
  - smb_general_error_total
    - smb00_general_error
      - smb00_timeout_error
      - smb00_program_error
    - smb01_general_error
    - ...
    - smb19_general_error
  - smb_fuse_error_total
    - smb00_fuse_error
      - smb00_fuse_error_p0
      - smb00_fuse_error_n0
      - ...
      - smb00_fuse_error_p9
      - smb00_fuse_error_n9
    - smb01_fuse_error
    - ...
    - smb19_fuse_error
  - smb_surge_error_total
    - smb00_surge_error
    - smb01_surge_error
    - ...
    - smb19_surge_error
  - smb_power_supply_error_total
    - smb_power_supply_error[0]
    - ...
    - smb_power_supply_error[19]
  - smb_overheating_error_total & temperature_limit
    - smb_overheating_error[0]
    - ...
    - smb_overheating_error[19]
  - smb_difference_error_total & difference_limit & difference_enable
    - smb_difference_error[0]
    - smb_difference_error[1]
    - ...
    - smb_difference_error[19]
  - smb_power_loss_error_total & power_loss_percent & power_loss_enable
    - smb_power_loss_error[0]
    - ...
    - smb_power_loss_error[19]
  - smb_theft_detection_total & theft_enable
    - smb_theft_detection[0]
    - ...
    - smb_theft_detection[19]
- inv_combined_error
  - inv00_general_error
    - inv00_general_error
      - inv00_timeout_error
      - inv00_program_error
  - inv00_com_error
  - inv00_operation_error

8.3. Touch panel screens