● 15P00EPB410 ●

SMART STRING BOX LT

STRING BOXES FOR PV SYSTEMS

USER MANUAL

- INSTALLATION GUIDE -

Issued on 06/10/2016
Rev. 01

English

- This manual is integrant and essential to the product. Carefully read the instructions contained herein as they provide important hints for use and maintenance safety.
- This product is to be used only for the purposes it has been designed to. Other uses should be considered improper and dangerous. The manufacturer is not responsible for possible damages caused by improper, erroneous and irrational uses.
- Elettronica Santerno is responsible for the product in its original setting.
- Any changes to the structure or operating cycle of the product must be performed or authorized by Elettronica Santerno.
- Elettronica Santerno assumes no responsibility for the consequences resulting by the use of non-original spare-parts.
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SMART STRING BOX LT

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1. GENERAL INFORMATION ON THE PRODUCT

1.1. Scope of this Manual and for Whom this Manual is Intended

This manual covers the following Smart string box LT Class II models:

- SSB 16 LT03 1000V II

This manual must be read by:

- Installers
- Operators
- Plant manager

Please refer to section 1.3.

1.2. Symbols Used

KEY:

DANGER

Indicates an operating procedure which, if not carried out correctly, may lead to injuries or even death caused by electric shock.

WARNING

Indicates an operating procedure which, if not carried out correctly, may cause serious damage to equipment.

NOTE

Indicates important information concerning use of the equipment.

PROHIBITION

Strictly forbids the execution of operating procedures.

1.3. Definitions

Installer

Technician responsible for setting up, positioning and installing the equipment in compliance with the system diagram and in accordance with first-class, professional criteria.

Operator

Worker who has been suitably trained and informed on the risks and relative safety procedures to be adopted. The operator can carry out routine maintenance on the equipment.

Plant manager

Person who co-ordinates or manages system management activities and is responsible for ensuring health and safety standards are adhered to.

Technical room

Place used for housing the technological systems such as the wiring, plumbing, heating, air-conditioning, lifting and telecommunications systems.

It is equipped with suitable forced-air ventilation and/or air conditioning and is also fitted with appropriate safety devices governing access, maintenance and fire-prevention.

Person in charge of running the electrical system (System Manager)

Person with the highest level of responsibility concerning operation of the electrical system. If required some of his/her tasks may be delegated to others.

Person in charge of working activities (Works Supervisor)

Person with the highest level of responsibility concerning the execution of work. If required some of his/her tasks may be delegated to others.

The Works Supervisor must give all persons involved in the execution of work activities the relative instructions concerning reasonably foreseeable dangers which may not be immediately apparent.

Skilled electrician

Someone who has been trained and has enough technical knowledge or experience to enable him/her to avoid the dangers which may be generated by electricity.

Instructed person

Someone who has been adequately advised or supervised by a skilled person to enable him/her to avoid the dangers which may be generated by electricity.

1.4. Smart String Box LT

The SMART STRING BOX LT products have been designed for maximum reliability and life expectancy, based on numerous years of experience working with large ground and rooftop installations, complies with the most stringent national and European safety directives.

Careful and precise design down to the very last detail and strict quality control guaranteed by standard ISO 9001 are the strong points of a reliable product which is able to maintain its features unaltered over time.

Designed to last in even the most arduous environmental conditions, Elettronica Santerno string boxes guarantee wide safety margins during daily use.

These and other design features are what position SMART STRING BOX LT at the highest level of reliability and performance for photovoltaic field energy production.

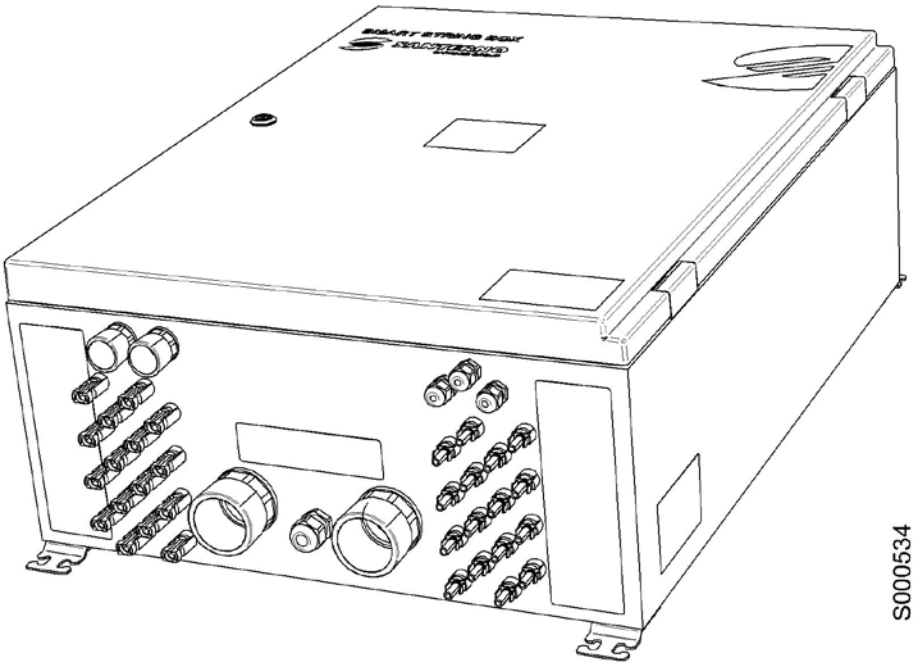


Figure 1: SMART STRING BOX LT

1.5. Operating Principle

Medium- and large-power PV generator systems are made up of a high number of strings. To optimize the connection topology and enhance the protection and monitoring systems, the parallel connection of the strings is usually carried out on more than one level, usually a first parallel level and a second parallel level.

Elettronica Santerno offers a complete range of products for string parallel connections, STRING BOX LS, SMART STRING BOX LS and SMART STRING BOX LT for creating the first parallel level and the Sunway DC-Parallel for creating the second parallel level.

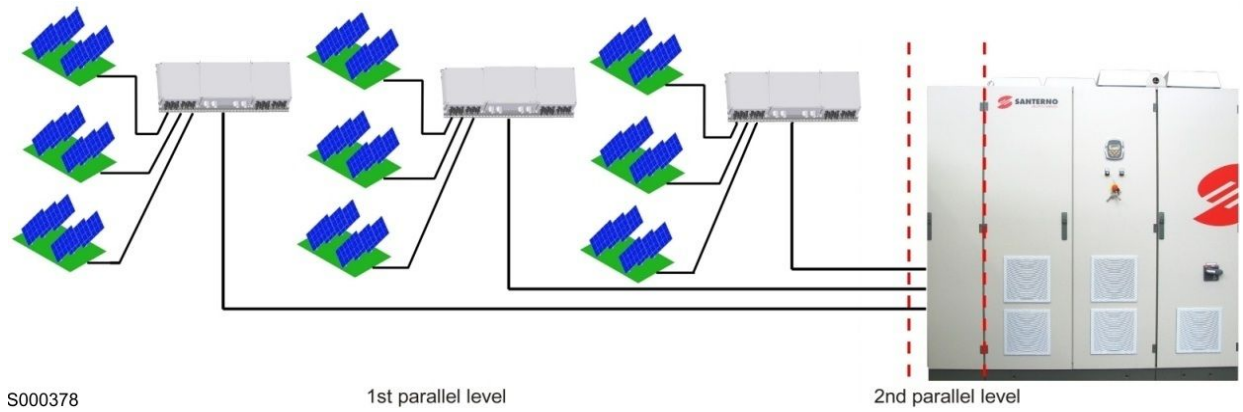


Figure 2: Block diagram of the first and second parallel levels

The SMART STRING BOX LT is made up of the following function blocks:

- String connection section, including:
  - Safety fuses,
  - Parallel connection of the PV generator strings,
  - Surge protection device (SPD),
  - Current sensors,
  - Control board capable of detecting connection failures and malfunctions;
- Output section, including:
  - On-load circuit breaker;
- Interface section, including:
  - RS485 serial link isolation board
  - Environmental inputs

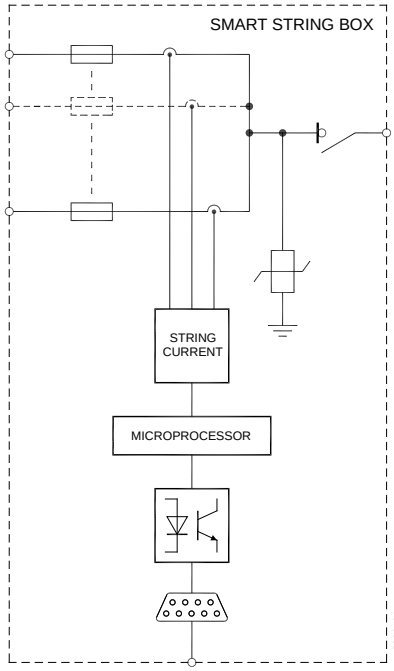


Figure 3: Single-line diagram of a Smart String Box LT

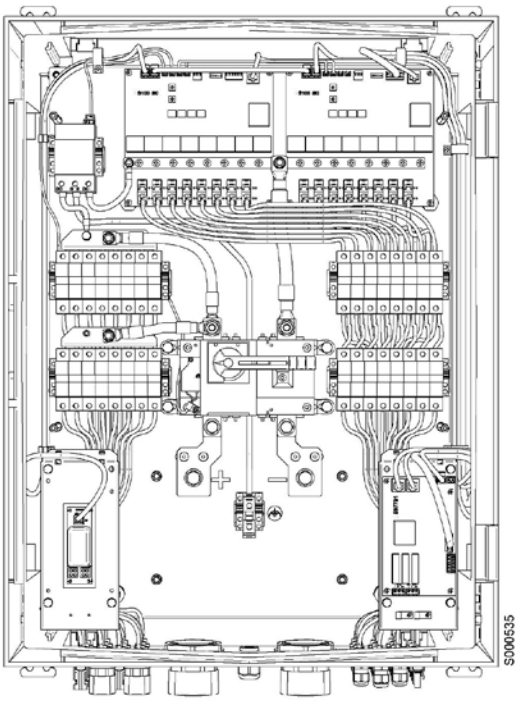


Figure 4: Inside of a Smart String Box LT

1.5.1. Main Integrated Standard Functions

The main integrated standard functions of SMART STRING BOX LT are listed below:

- Possibility to connect up to 16 strings.
- Measurement of each individual string current.
- Mismatch detection.
- String opening alarm and detection of poor performance.
- Two environmental measurements (solar radiation and temperature).
- Fuses on both poles (fuses are not supplied).
- DC on-load disconnect switch.
- Surge Protection Devices (SPDs).
- Detection of the status of the DC disconnect switch.
- Detection of the status of the SPD.
- Quick-fit PV connectors.
- Box made of self-extinguishing glass fibre reinforced polyester, UV resistant.
- IP65 degree of protection.
- Serial communications system completely integrated with the Elettronica Santerno remote control system, featuring alarm indication in the event of communications loss.
- Advanced self-diagnostics.
- Complete integration with the Sunway Station.

1.5.2. Optionals

The main optional functions of the SMART STRING BOX LT are listed below:

- Fuse kit, on demand.
- Version with cable-glands on output cables.

NOTE

The fuse kit is supplied separately.

1.5.3. Attached Documentation

Each SMART STRING BOX LT is supplied with a leaflet including the basic safety instructions.

The following documents are available for download from santerno.com:

Name of the document	Scope
Installation Guide	Contains all the information necessary for the assembly, installation and maintenance of the product
Programming Guide	Contains the product operating measurements and programming parameters

Table 1: Documentation available for download from santerno.com

1.5.4. Preservation of the Documentation

All documents must be kept for the entire life span of the equipment together with the system documentation. They must be kept in a place where they are readily available.

1.5.5. References for the Electronic Board ID Codes

The table below indicates the electronic board ID codes used in the electrical and mechanical schematic.

ID code	Description
ES977	Communications and environmental inputs board
ES1004	String control board
ES1005	230 V~ /12 V supply unit board

Table 2: Electronic board references

2. CAUTION STATEMENTS

This section covers safety statements. The non-observance of the safety instructions below may cause serious injury or death and equipment failure. Carefully read the instructions below before installing, starting and operating the equipment.

Only competent personnel must carry out the equipment installation.

SAFETY RECOMMENDATIONS TO FOLLOW DURING USE AND INSTALLATION OF THE EQUIPMENT:

NOTE

Always read this instruction manual thoroughly before starting the equipment.

DANGER

ALWAYS PROVIDE FUNCTIONAL EARTH BONDING.

OBSERVE THE PRESCRIPTIONS CONCERNING CONDUCTOR SECTION INDICATED IN SECTION 12.6.3.

WARNING

Do not connect supply voltages which exceed the rated voltage. If voltage exceeding the rated value is applied, the internal circuits may be damaged.

In the event of an alarm, please consult section 11 TROUBLESHOOTING. Only restart the equipment once the problem has been rectified.

Do not carry out isolation tests between the power terminals or between the control terminals.

Make sure that the screws on the connection terminal board have been tightened correctly.

Observe the ambient conditions for installation.

The electronic boards contain components which are sensitive to electrostatic charges. Do not touch the boards unless absolutely necessary. Should this be the case, take all the necessary precautions to prevent damages caused by electrostatic charges.

2.1. Precautions for Use and Prohibitions

DANGER

RISK OF ELECTRIC SHOCK

NEVER carry out operations on the equipment when it is powered.

EXPLOSION AND FIRE RISKS

The risk of explosion or fire may exist if the equipment is installed in a room containing flammable vapours. Do not install the equipment where there is a risk of explosion or fire.

PROHIBITION

The product described in this manual has not been designed to operate in potentially explosive atmospheres. Consequently, installation in such an environment is strictly prohibited.

PROHIBITION

It is forbidden to make any technical or mechanical modifications to the product even when out of warranty.

Elettronica Santerno is not responsible for any risks that may arise due to unauthorised alterations, modifications or tampering.

PROHIBITION

It is strictly prohibited to operate inside the SMART STRING BOX LT to carry out short circuit tests concerning the strings.

Any system testing must be carried out on the individual strings only once that have been disconnected from the product.

2.2. Intended Use

The SMART STRING BOX LT products constitute a modular system for creating parallel strings for PV modules.

The product envisages an output on-load disconnector which is capable of cutting off the connection of the PV field subsection.

Observe the maximum operating voltage indicated in the product technical characteristics found in section 11 TROUBLESHOOTING.

The product must only be used as prescribed in this manual. The DC power supply must come from the PV field only.

Any use other than that described in this manual is to be considered inappropriate and therefore improper.

2.3. Qualified Technical Personnel

All work on SMART STRING BOX LT products must be carried out by skilled technical personnel only. By skilled personnel it is intended persons who have been suitably trained to carry out the work in question.

To commission and use the SMART STRING BOX LT, personnel must know and understand the instructions for installation and use. In particular, all safety warnings must be strictly observed.

2.4. Specific Dangers Linked to Photovoltaic (PV) Systems

PV systems have certain characteristics which are the source of additional hazards and are described below:

- A live current source is connected. Depending on the operating conditions, there may be live voltage from the PV generator or from the electrical grid. This must be taken into consideration, particularly when disconnecting parts from the system.
- Very high DC voltages are involved (with no periodic zero crossings) hence failure or the incorrect use of fuses or plugs may cause electric arcs.
- The short-circuit current of the PV generator is only slightly higher than the maximum operating current and furthermore is linked to radiation. This means that fuses may not always blow in the event of a short-circuit.
- The PV generator grid is usually an IT type, i.e. it is only earthed in the event of a fault or energy leakage. For connection to PV fields with earthing pole, connection is of the TN type, but the earth connection is protected by a fuse which may trip in the event of a single fault.
- In the event of a fault (for example a short-circuit), cutting off a generator with a high number of branches may prove to be somewhat difficult. Take great care to ensure each sub-field disconnect switch has been opened before going near the devices installed in the technical room.

2.5. Personal Protective Equipment

Maintenance technicians must be provided with the following personal protective equipment as envisaged by European Directives and relative implementation of the same on national territory.

SYMBOL		DESCRIPTION
	Safety glasses/face shield	Throughout operations
	1000 V high-voltage insulated gloves	Throughout operations
	Dielectric helmet	Throughout operations
	Safety footwear/dielectric boots	Throughout operations
	Insulated tools	Throughout operations
	Operators must also be provided with a suitable means of communication for contacting the emergency services if necessary.	

NOTE

It is always advisable to work on the electrical cabinets with THE POWER SUPPLY SWITCHED OFF and the equipment in safety conditions (please refer to section 2.7).

2.6. Execution of Work

Maintenance, configuration modifications and management operations require the involvement of all production and maintenance personnel. These activities **must be carried out in observance of health and safety regulations.**

The Standards and Laws governing this aspect vary depending on the personnel involved, methods of access and/or the tasks which may be carried out on the product and envisage constructive measures aimed at guaranteeing adequate levels of safety.

Standard EN 50110-1, second edition, identifies the people who are granted access to the product:

- Person in charge of running the electrical system (System Manager).
- Person in charge of work activities (Works Supervisor).
- Skilled electrician.
- Instructed person.

Please refer to section 1.3.

Standard EN 50110-1 governs the way work in a plant is carried out and the relationship between the aforementioned persons who may work on the plant to maintain the electrical safety conditions stipulated by European Directives.

This standard and its national equivalents must therefore be adhered to whenever it is necessary to access a PV system.

2.7. Safety Procedure

Always place the equipment in safety conditions before carrying out any kind of operation inside the box involving removing the polycarbonate protective panels providing IP20 degree of protection in respect to live parts, even when the box front cover is open. To do this, follow the instructions provided below:

- Make sure that the inverter connected to the SMART STRING BOX LT is not running, i.e. that it is STOPPED.
- Open the inverter DC side switch.
- Open the disconnector of all the string boxes connected to the same inverter.
- Open the cover of the SMART STRING BOX and open the disconnect switch (there is NO need to remove the polycarbonate safety panel).
- Disconnect all the strings.
- Cut off 230 V~ auxiliary power supply by opening the relative switches and check that the terminals in question are in fact disconnected.
- Remove the polycarbonate protective cover and use a multimeter to check that voltage is not present between the input copper bars, the output copper bars polarities, among the poles and the earth.
- Proceed with the operation in question.

The RS485 serial circuit and the environmental sensors input circuit are SELV (Safety Extra-Low Voltage) circuits which are galvanically isolated from the PV field circuits.

DANGER

ELECTRIC SHOCK HAZARD

The area not protected from the polycarbonate panel has a rated voltage of 230Vac in the auxiliary power supply terminals.

2.7.1. Polycarbonate Protective Panels

The SMART STRING BOX LT is fitted with internal polycarbonate protective panels. Live parts which are most exposed to possible inadvertent contact are protected by these panels made of polycarbonate, a transparent, break-proof material which is resistant to high temperatures. The panels make it possible to visually inspect the box inside in relative safety once the cover has been removed.

There are two polycarbonate panels that may be separately removed:

- Panel to access the terminals for the connection of the output cables that can be removed by loosening screws A and by slightly folding the polycarbonate sheet,

- Panel protecting the contacts with the live parts, removable by loosening nuts B.

PROHIBITION

It is not necessary to remove the panel fastened by nuts B when installing, commissioning and maintaining the product. Only Elettronica Santerno's after-sales technicians are authorised to remove this panel.

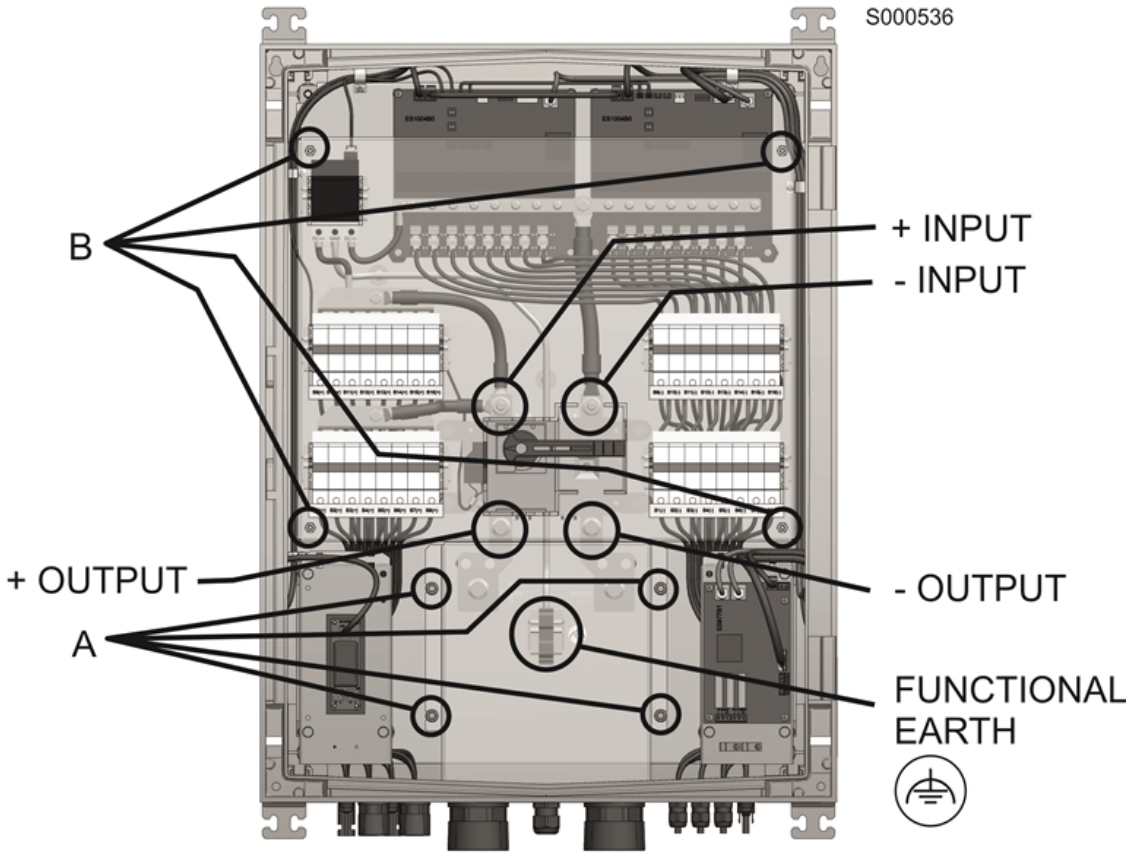


Figure 5: Position of the screws (A and B) to remove the polycarbonate panel and measurement points

3. DESCRIPTION OF THE PRODUCT

3.1. Composition of the SMART STRING BOX LT

Figure 6 shows the block diagram of the SMART STRING BOX LT, including:

- Set of 16 fuses on the string inputs of the positive pole
- Set of 16 fuses on the string inputs of the negative pole
- Surge Protection Device (SPD)
- On-load disconnector
- String control board, ES1004 (x 2)
- 230 V~/12 V Supply unit board, ES1005
- Serial interface and environmental measurement input board, ES977

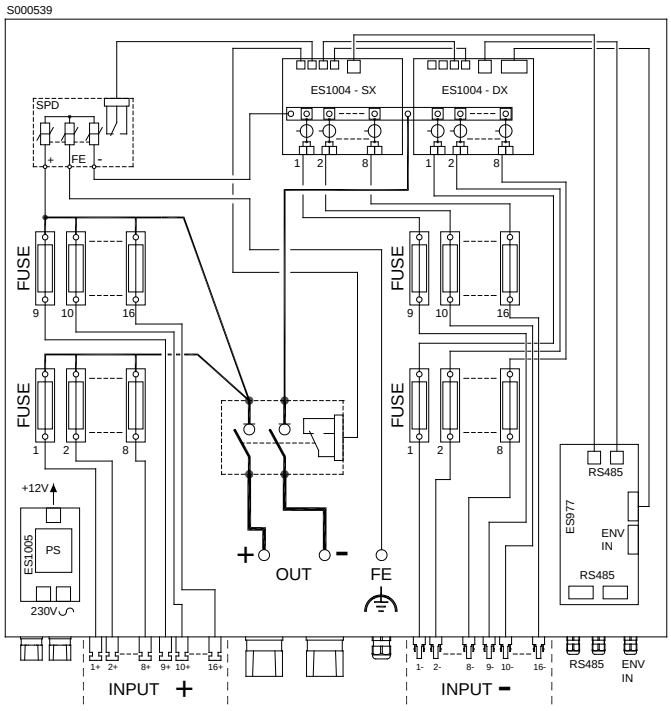


Figure 6: Internal wiring diagram of a SMART STRING BOX LT

Figure 7 shows the internal view of a SMART STRING BOX LT.

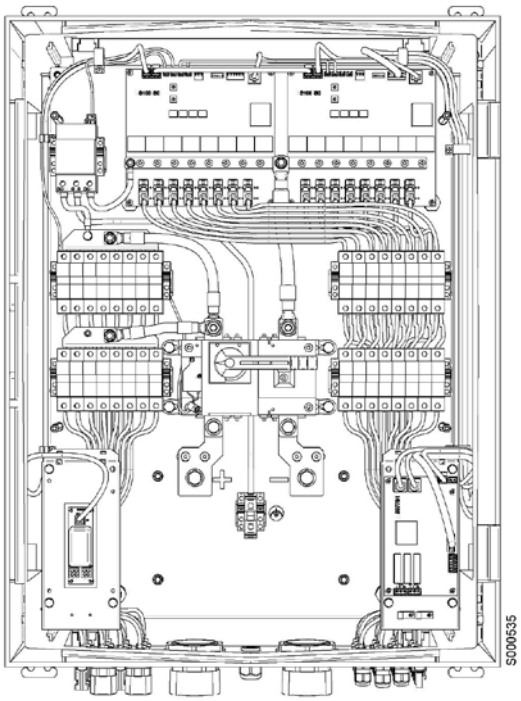


Figure 7: Internal view of a SMART STRING BOX LT

3.2. Measuring the Current and Performance of the Individual Strings

The SMART STRING BOX LT makes it possible to accurately read the current of each individual connected string. The measurements are processed by the internal control board in order to obtain:

- Average measurements of the currents for strings 1 to 8 and 9 to 16, for the purpose of integration with the Santerno remote control service.
- Detection of string opening.
- Detection of performance loss.

For further information, please refer to the “Programming Guide”.

3.3. Environmental Measures

It is possible to connect up to two auxiliary sensors to the board for measuring the ambient temperature, module surface radiation, horizontal radiation, wind speed. The use of these sensors makes it possible to carry out environmental measurements distributed over utility scale PV plants.

Each input can be connected to solarmeters, thermometers with 0-100 mV, 0-10 V, 4-20 mA, PT100 outputs.

For all the details, please refer to section 7.4.

3.4. Monitoring the State of the SPD Disconnect Switch

The control board can monitor the intervention of the Surge Protection Devices and opening of the disconnect switch.

For further information, please refer to the “Programming Guide”.

4. PRODUCT IDENTIFICATION

4.1. Product Part Number

The product Part Number identifies the parallel string box and is indicated on the relevant nameplate. The nameplate also holds all the necessary technical data (please refer to section 12.1).

The product Part Number is made up of the following elements:

XXX-YY-VVWW-ZZZZV-II

Field	Name	Description
XXX	**Model**	**SSB: for SMART STRING BOX**
YY	**N. of strings**	N. of string inputs
VV	**Version**	LT: light
WW	**Optional field**	Identifies product versions
ZZZZ	**Field voltage**	1000: Class 1000V
II	**Insulation class**	If not present: Insulation class I II: Insulation class II

Table 3: Product name

Example: SSB-16_LT03-1000V-II

4.2. Product Revision Index

The product revision index is indicated on the nameplate. Please refer to section 12.1.

4.3. Serial Number

The serial number of each individual module can be found on the lower section of the module itself (on the label and on the inside).

S000165

Figure 8: SMART STRING BOX LT Serial Number

5. STORAGE AND TRANSPORT

The warranty covers manufacturing defects. The manufacturer shall not be held liable for any damage which may have occurred during transport and unpacking. Under no circumstances shall the manufacturer be held liable for damage or faults caused by incorrect use, misuse, incorrect installation or inadequate temperature or humidity conditions or exposure to corrosives nor for faults caused by operation outside the rated values. Nor shall the manufacturer be held liable for consequential or accidental damage.

NOTE

For the terms of warranty, please refer to the warranty certificate supplied with the product.

5.1. Checking the Product on Delivery

On receiving delivery of the equipment make sure that the packaging shows no signs of damage. Check that it complies with your order by referring to the nameplates described below. In the event of any damage, please contact the relative insurance company or the supplier. If the delivery does not match your order, contact the supplier immediately.

NOTE

Check that all relative accompanying materials are present.

5.2. Conditions for Transport

The parallel string boxes are delivered packed to extremely high standards.

To avoid damaging the product, move the package using a pallet jack or a forklift with adequate lifting capacity.

5.3. Storage

If the equipment is to be stored before installation, make sure that the ambient conditions in the warehouse meet the necessary specifications (please refer to section 12.2).

6. HANDLING AND ASSEMBLY

PROHIBITION

It is strictly forbidden to proceed with product handling and assembly operations in adverse weather conditions, in snow, rain or persistent fog. Always check that there is no water or condensate inside the product.

It is strictly prohibited to leave the product outside when its front cover is open, in any kind of weather conditions.

WARNING

The SMART STRING BOX LT must be installed with the cable input/output side pointing downwards.

Avoid installing the product where it may be exposed to direct sunlight.

Do not install the SMART STRING BOX LT upside down or with its front cover turned upwards. Make sure that air can circulate freely around the box.

WARNING

Every time the SMART STRING BOX LT is opened and reclosed, it must be done to the highest working standards, ensuring that the product remains intact and that no damage is caused to the sealing and fixing elements.

Before reclosing the front cover, always check that the inside of the SMART STRING BOX LT is free from condensate or water residues; if this is not the case the product must be placed in safety conditions (please refer to section 2.7) and thoroughly dried out. Make sure that the front cover is properly tightened and that the correct degree of watertightness and IP rating (IP65) is restored.

6.1. Product Handling

Remove the product from the packaging through the sides, keeping it horizontal to the ground.

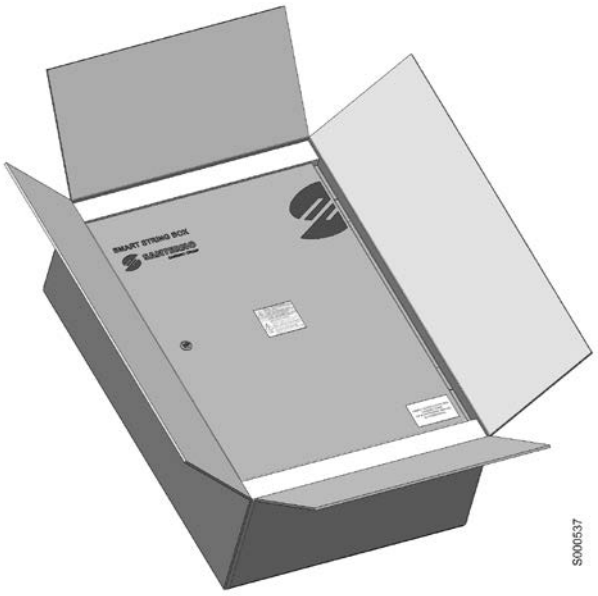


Figure 9: Packaging of the SMART STRING BOX LT

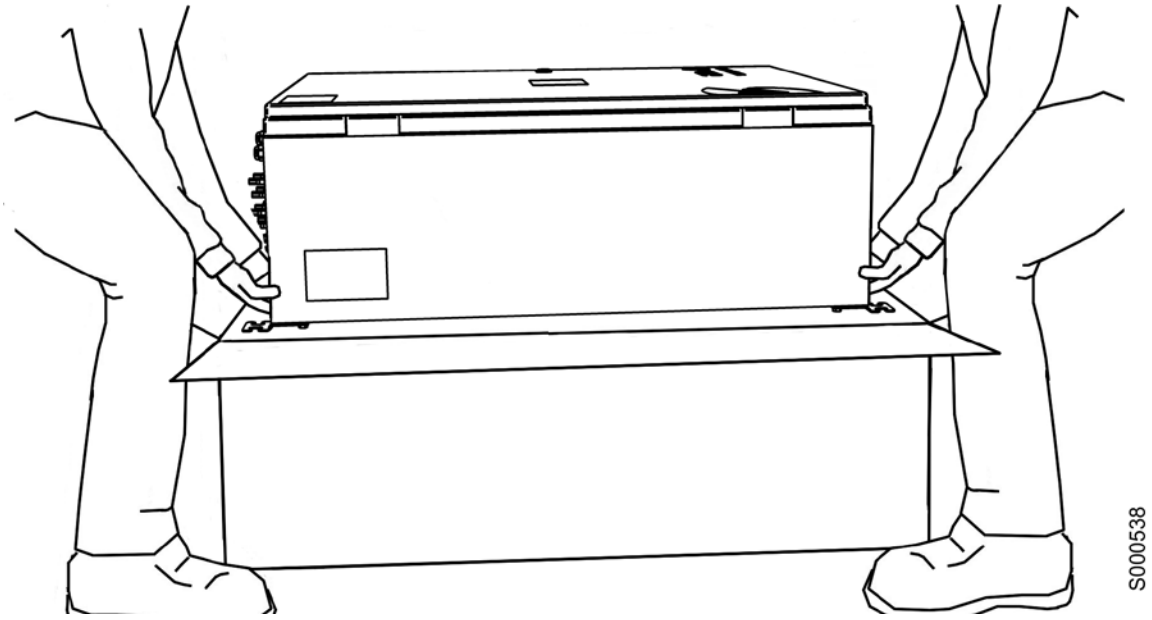


Figure 10: Unpacking the SMART STRING BOX LT

Make sure that the front cover is closed when handling the product. Avoid twisting, bumping or dropping the product. Avoid any mechanical stress.

NOTE

The key to open the front cover is fastened externally to the string box connectors.

6.2. Mounting the Product on the Installation Site

WARNING

Being as the ambient conditions significantly affect the life-expectancy of the product, do not install it where water build-up may be created due to dips in the installation surface or where it may be exposed to constant dripping.

All the parallel string boxes must be installed in upright position as shown in Figure 11. To facilitate installation, the parallel string boxes come supplied with special brackets.

To allow for easy installation and effective air circulation, make sure that there is enough free space around the equipment.

Dimensions, weight and necessary clearance are indicated in section 12.5.

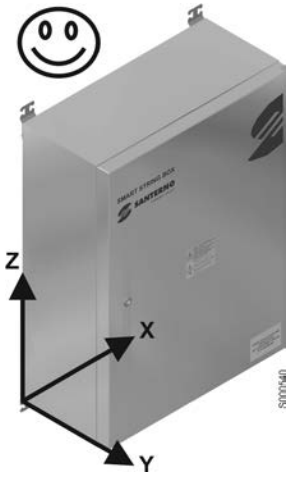


Figure 11: Correct mounting

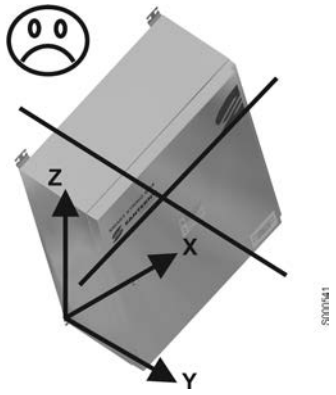


Figure 12: Incorrect mounting

7. ELECTRICAL INSTALLATION AND COMMISSIONING

7.1. Preliminary Notes

WARNING

To carry out the following operations, check that the parallel string box is in safety conditions. Please refer to section 2.7.

The following paragraphs provide information on power and signal cable connection and commissioning.

Each string must be made up of the same number of panels. All panels must have the same nominal characteristics. Failure to observe these specifications will lead to a plant with low performance and possible malfunctions.

Do not install devices and/or components (SPDs, return or switch terminals, joins on the cables) on the wiring between the SMART STRING BOX LT and the modules. As well as lowering the level of plant safety and performance, malfunctions may occur.

DANGER

Before carrying out the electrical installation, make sure that the following conditions are met:

- Auxiliary 230 V~ power supply is cut off (no voltage applied),
- All disconnectors of the other string boxes connected to the same inverter are open,
- No string fuse is inserted.

Follow the sequence below for the electrical installation:

- Connection of the output cable and functional earth bonding
- Connection of the auxiliary power supply
- Connection of the signal cables
- Connection of the strings

Electricians must wear personal protective equipment.

7.2. Connection to the Output Cables and Functional Earth

Proceed as follows:

- Remove the protective cover by loosening the 4 screws and by slightly pressing the box side to pull out the cover (Figure 13).
- Connect the power cables already provided with cables lugs and tubing coming from the inverter onto the bars in the string box by letting the cable go through the tubing joints (Figure 14).
- Connect the cables to the + and - bars in accordance with Table 21.
- Fasten the tubing to the tubing joints, making sure that IP65 degree of protection is not affected.
- Insert the functional earth cable through the dedicated cable-gland (Figure 14).
- Connect the functional earth cable to the relative terminal.
- Reassemble the polycarbonate protective cover by slightly pressing it and tighten its fastening screws.
- Tighten the cable-gland, making sure that IP65 degree of protection is not affected.

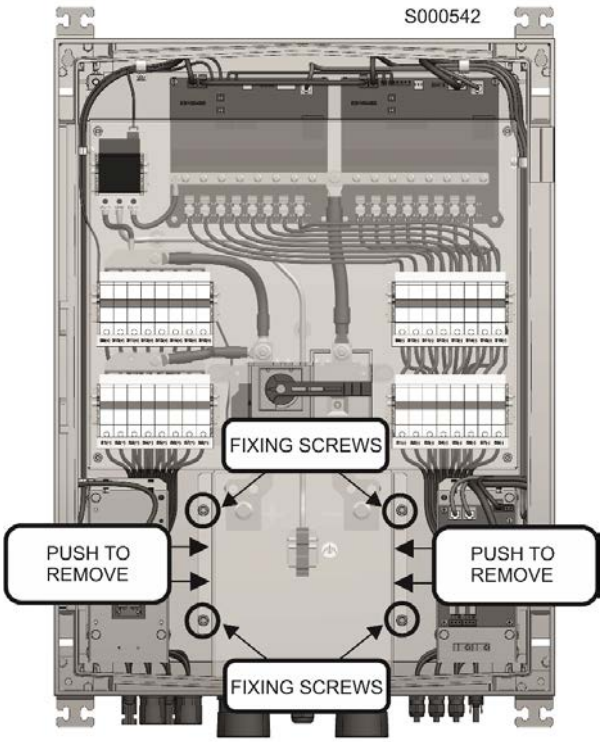


Figure 13: Removing the polycarbonate cover protecting the output cables and the functional earth

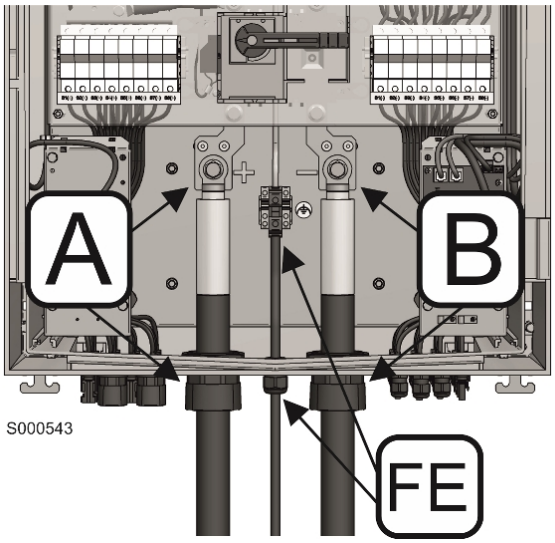


Figure 14: Position of the output cable tubing and functional earth cable gland

Connections	Function	Dedicated cable-gland/tubing
A	Positive pole power cable connection bar to the inverter	A
B	Negative pole power cable connection bar to the inverter	B
FE	Functional earth cable connection terminal	FE

Table 4: Key to the output cable and functional earth connections

WARNING

The cable glands must be correctly tightened once the cable has been inserted. Cable glands which are not used must be plugged. The gable glands and covers must be accurately tightened to prevent water, insects or small animals from getting inside and causing plant malfunctions as well as fire risks.

Make sure that water, condensation, insects or small animals cannot get inside cable tubing, thus avoiding plant malfunctions as well as fire risks.

WARNING

Prevent the cable connected to the string box from being mechanically stressed. It is sometimes necessary to provide special anchoring for the output cable. Cable anchoring is particularly required for cable cross-sections over 240 mm^2 and when the free cable length exceeds 100 cm.

7.3. Connection of the Auxiliary Power Supply

Each SMART STRING BOX LT houses a measurement and supervision circuit that needs power supply.

Each SMART STRING BOX LT requires 230 V~ ±10% buffered via UPS. In order to facilitate on-site wiring, the auxiliary power supply is fed by way of two parallel-connected terminals so that maximum 20 string boxes may be connected with an in-out connection.

WARNING

Before accessing the terminal boards, make sure that the string box is in safety conditions. See section 2.7.

Terminal	Signal	Description
N	NEUTRAL	230 V~ 50/60 Hz power supply input
L	LINE	230 V~ 50/60 Hz power supply input

Table 5: Connections to 230 V~ terminals power supply

Please refer to section 12.3 for the power supply ratings.

Proceed as follows:

- Insert the auxiliary power supply cables, provided with tubing, by letting the cable go through the tubing joints of the string box (Figure 15).
- Connect power supply as shown in Figure 16.
- Fasten the tubing to the joints, making sure that IP65 degree of protection is guaranteed.

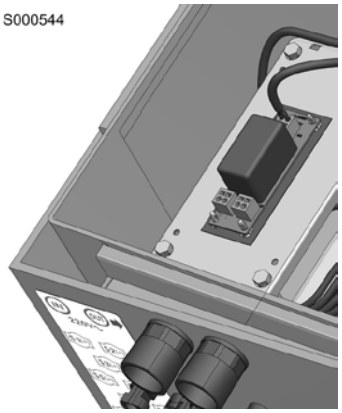


Figure 15: Position of auxiliary power supply tubing joints

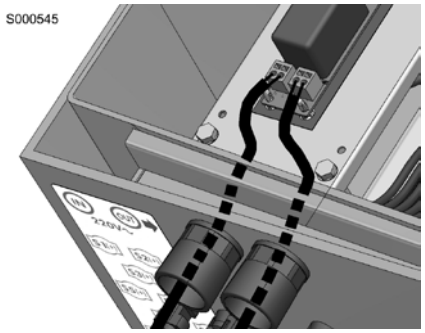


Figure 16: Auxiliary power supply connection to the ES1005 board

Cable specifications are given in section 12.

7.4. Environmental Sensor Configuration and Connections

Each SMART STRING BOX LT has two configurable analogue environmental measurement inputs. Each input can be connected to solarmeters, thermometers with 0-100 mV, 0-10 V, 4-20 mA outputs, PT100 probes.

The M3 terminal board on the ES977 board has three terminals for each analogue measurement: the signal terminal, the common terminal and the excitation terminal for a 3-wire PT100 thermistor measurement.

The figure below shows the box inside and the elements for the connections of the environmental measurement sensors.

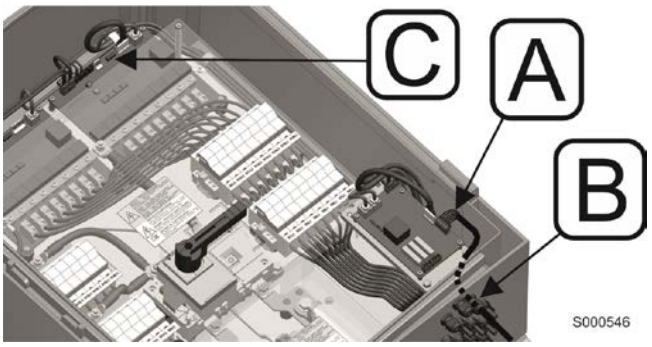


Figure 17: Connection of the SMART STRING BOX LT environmental measurement sensors

Terminal	Description
A	Terminals for environmental measurements
B	Cable-gland for environmental measurement sensors
C	DIP-switch for environmental measurement configuration

Before connecting the signal conductors, it is necessary to set the configuration based on the type of input signal on DIP-switch SW1 in the ES1004 board.

No. of terminals	Signal	Description
11	PT0x	Excitation output for PT100 thermistor channel 0 (connect to AI0 with 2-wire PT100)
12	AI0	Configurable measure input channel ACH0
13	0V	Common measure 0 - Zero volt signal circuits
14	PT1x	Excitation output for PT100 sensor channel 1 (connect to AI1 with 2-wire PT100)
15	AI1	Configurable measure input channel ACH1
16	0V	Common measure 0 – Zero volt signal circuits

Table 6: Environmental measures terminals, M3 connector

Please refer to the following table for setting the DIP-switch, taking into account that contacts 1 - 3 are relevant to channel ACH0 and contacts 4 - 6 are relevant to channel ACH1.

SW1

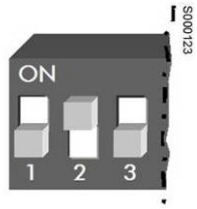
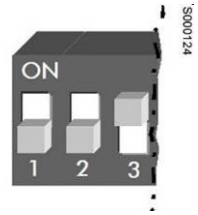
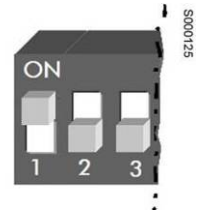
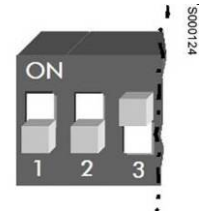
Configuration of analogue input ACH0			
0-10 V f.s. mode	0-100 mV f.s. mode	0-20 mA f.s. mode	PT100 mode (Default configuration)
			

Table 7: DIP-switch Configuration of analogue input ACH0

SW1

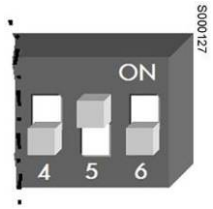
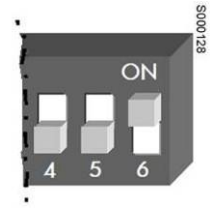
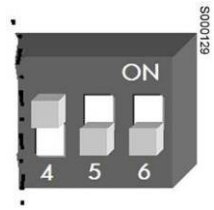
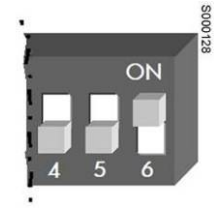
Configuration of analogue input ACH1			
0-10 V f.s. mode	0-100 mV f.s. mode	0-20 mA f.s. mode	PT100 mode (Default configuration)
			

Table 8: DIP-switch Configuration of analogue input ACH1

Configuration of the channel and the measurement unit must be set to correspond by programming the relative board parameters. To carry out correct configuration, please refer to the “Programming Guide”.

Input signal specifications	DIP-switch settings	Type of signal acquisition parameterization
0÷10 V	0-10 V f.s. mode	Voltage 0÷10 V
0÷100 mV	0-100 mV f.s. mode	Voltage 0÷100 mV
0 mA ÷ 20 mA	0-20 mA f.s. mode	Current 0÷20 mA
4 mA ÷ 20 mA	0-20 mA f.s. mode	Current 4÷20 mA
-50 °C ÷ 120 °C	Temperature reading with PT100 thermistor	Temperature

Table 9: Factory settings for environmental measurements

It is preferable to carry out connection of the environmental sensors with a shielded cable, connecting the shield to the GND - 0V terminal and leaving it free on the opposite side.

It is preferable to connect the 3-wire PT100 thermistor to suppress the residual resistance of the wire carrying the excitation current. Correct connection is illustrated in the figure below.

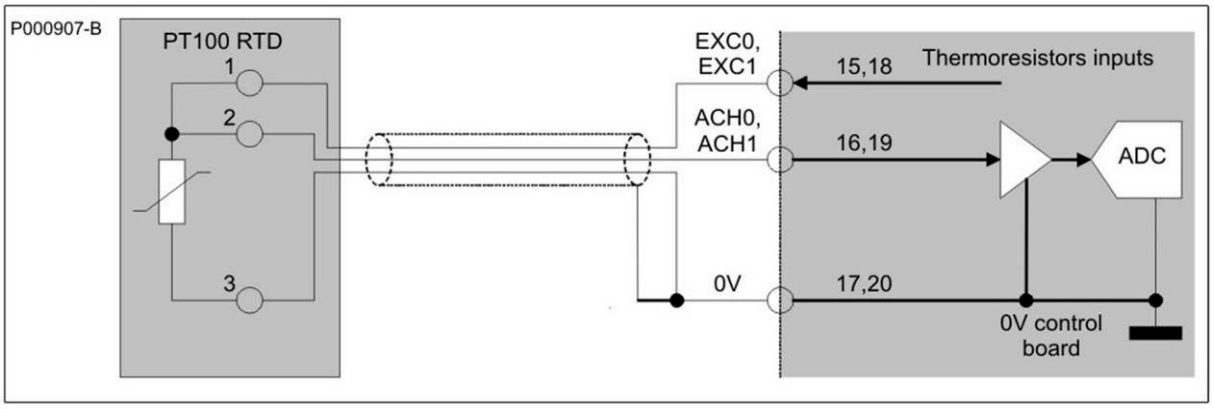


Figure 18: Connection of the 3-wire PT100 thermistor

If 3-wire PT100 sensors are not used, it is still preferable to connect the excitation terminal near the sensor.

NOTE

It is necessary to set the software parameters to match the DIP-switch settings. Hardware configuration settings which do not correspond with the type of acquisition set in the parameters produce results which do not reflect the values actually acquired.

A voltage or current value which exceeds the upper full-scale value or is less than the lower full-scale value produces a saturated acquired value of the maximum and minimum measures respectively.

WARNING

Voltage or current values exceeding the full-scale value may lead to malfunctions of the electronic components.

WARNING

The voltage-configured inputs have high input impedance and must never be left open if active. Isolating a conductor relative to an analogue input configured as a voltage input does not guarantee that the channel reading will be zero. Zero is only correctly detected if the input is wired to a low-impedance or short-circuited signal source. Therefore, do not put relay contacts in series on the inputs to reset the reading.

For the technical characteristics, please refer to section 12.

7.5. Bus Communications Configuration and Connections

Please refer to section 8.4.

7.6. Connection of the String Conductors

The connection of the cables to the panels must be carried out along the shortest possible route in order to minimize loss in resistance in the cables and hence system losses.

The correct method of cabling is shown in the figure below.

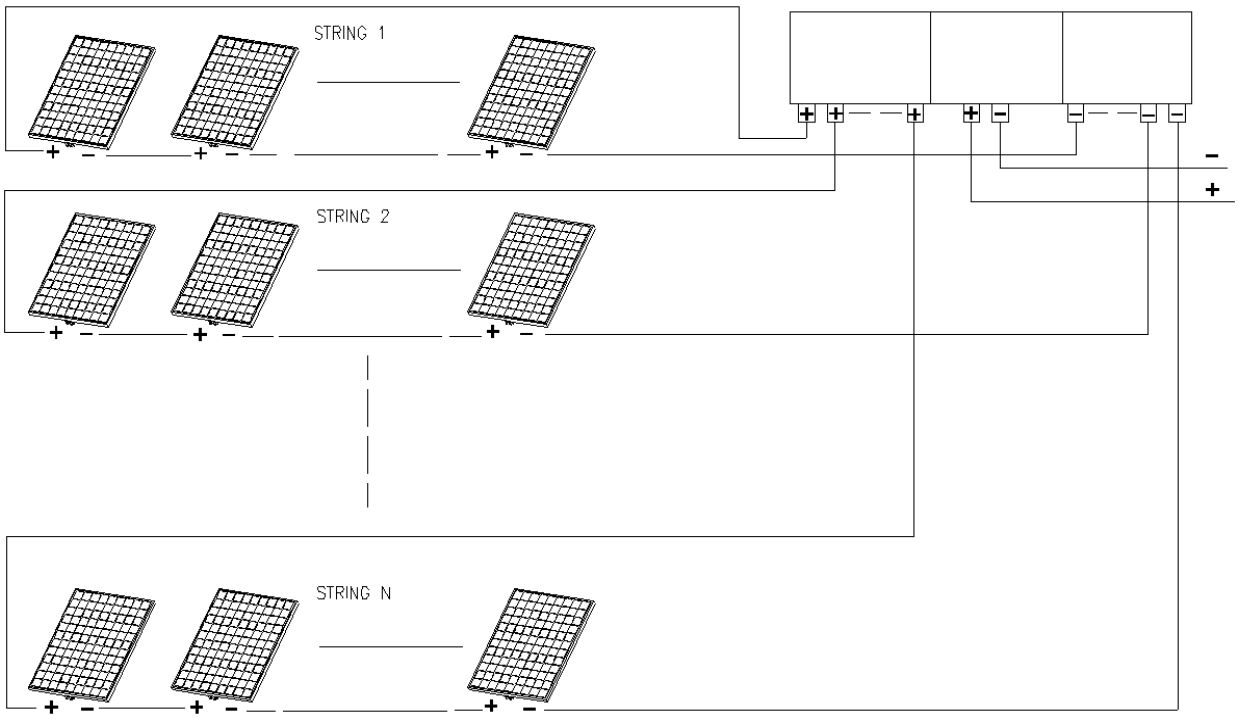


Figure 19: Recommended cabling – SMART STRING BOX LT to PV modules

The SMART STRING BOX LT envisages quick-fit PV connectors as a standard:

- Female connector on the positive pole.
- Male connector on the negative pole.

WARNING

Always use flying connectors of the same brand as the connectors installed on the string box. The use of other connectors may damage the product.

To carry out the following operations, check that the disconnect switch on the DC-SWITCH BOX of the parallel string box in question is open.

Always wear the PPE required by law for working in the presence of live voltage (dielectric gloves with at least 2000 high-voltage insulation).

DANGER

Check polarity of each string before connecting them.

DO NOT CONNECT THE STRINGS IN CASE OF POLARITY MISMATCH.

7.6.1. Connecting the String Boxes

Maximum 16 strings may be connected to each SMART STRING BOX LT.
The drawing below shows the box inside. The string inputs are highlighted.

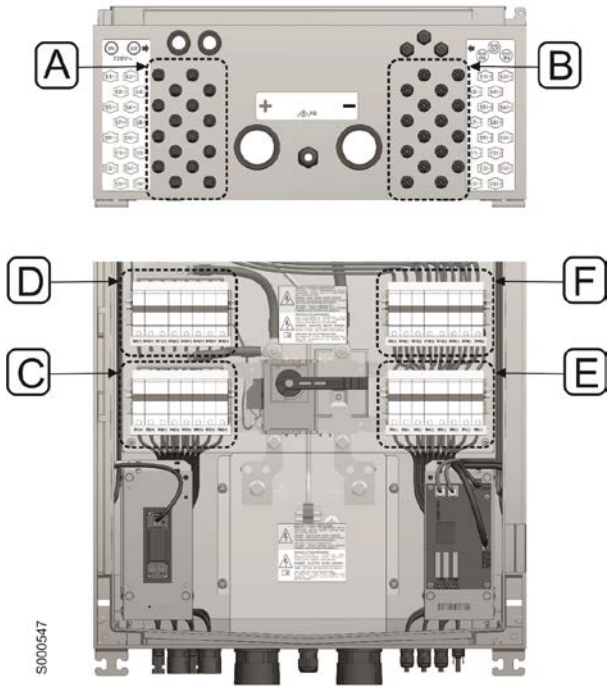


Figure 20: Bottom side view and inside view with string inputs highlighted

Connections	Function	Dedicated connector
A	String positive pole connection	A
B	String negative pole connection	B
C	Fuse block on string 1-8 positive pole	-
D	Fuse block on string 9-16 positive pole	-
E	Fuse block on string 1-8 negative pole	-
F	Fuse block on string 9-16 negative pole	-

Table 1: Key to string connections

The string connections are to be made when the string box is in safe conditions:

- **Disconnector open**
- **Fuse-holders open**
- **Box front cover closed**

Plug the contacts. Pull the connectors to make sure that they are correctly plugged in.

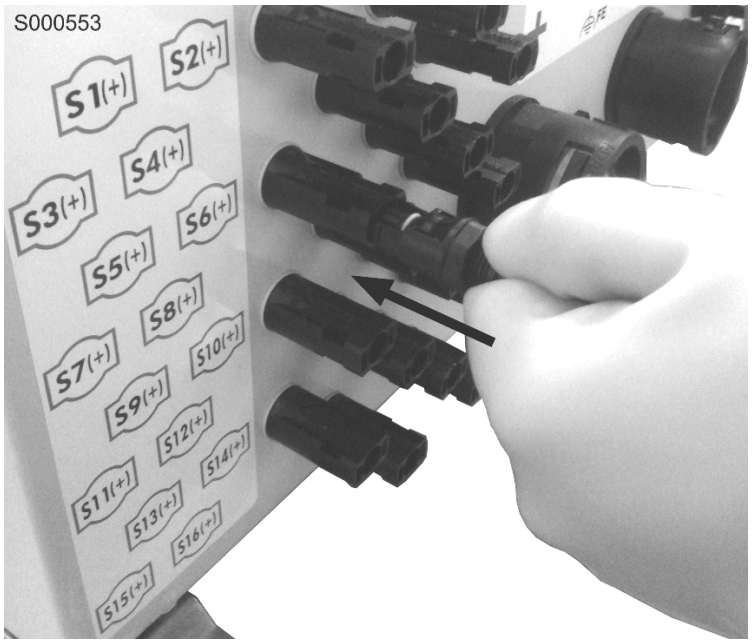


Figure 21: Plugging the string connectors

For all details related to power wiring, see section 12.6.

7.7. Replacing and Inserting the String Fuses

PROCEDURE FOR REPLACING AND INSERTING THE STRING FUSES

Before inserting the fuses inside the string box, check the string polarity by measuring voltage between the positive and negative pole of each string on the connection screws of the relative fuse-holder.

All the strings must have positive voltage values (approx. +/-10% of the average value), unless some strings are in the shadow.

Figure 22: Voltage measurement points (string check 2: correct mounting)

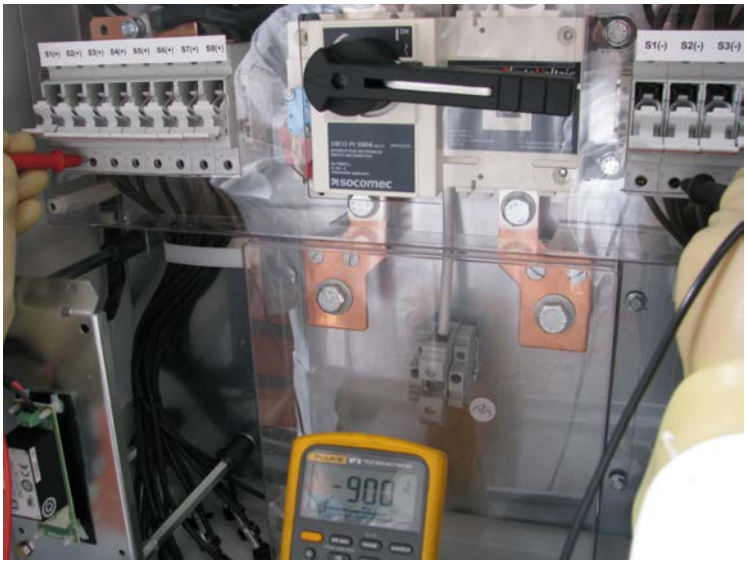


Figure 23: Voltage measurement points (string check 2: string mismatch!!!)

DANGER

Avoid opening and closing the fuse-holders when the string is live. Check string polarity before inserting a fuse. Make sure that no current flows in the string box before removing a fuse. The presence of a short-circuit on the string connected to the fuse to be removed may lead to current flowing in case the safety fuse is not open.

Do the following to remove and insert a fuse:

- Open the inverter DC side switch.
- Open the front cover of the SMART STRING BOX.
- Open the disconnector in the SMART STRING BOX.
- Make sure that no current is flowing.
- Remove or insert the fuse from the fuse-holder.

DANGER

Wear PPE when removing or inserting a fuse; in particular, dielectric gloves are required (see section 2.5), as opening the fuse-holder does not ensure that both fuse contacts are properly cut off (dual voltage power supply).

Restore all operating conditions.

- Close the front cover in the SMART STRING BOX.

7.8. Commissioning

Once all the string boxes have been connected, do the following to carry out the equipment commissioning:

- Close the disconnector in the SMART STRING BOX.
- Close the front cover of the SMART STRING BOX.
- Restore the auxiliary power supply.
- Close the inverter DC side switch.

7.9. Notes on Output Short-Circuit

The SMART STRING BOXES LT are equipped with a suitable under load disconnect device in output but are not fitted with protection against short circuits, such as fuses, in output.

Fault caused by a short circuit on the output cables must be envisaged during the design phase and appropriate protective measures must be adopted.

Some design examples:

1. If the PV field is composed of multiple SMART STRING BOXES LT, the Sunway DC-Parallel effectively solves this problem.
2. If the PV plant is made up of a very small number of SMART STRING BOXES LT, a connection directly to the inverter can be envisaged, without inserting fuses, as long as the cables are sized for the maximum fault current.
3. If the PV plant is made up of just one SMART STRING BOX LT, the problem does not exist.

In the first case, the Sunway DC-Parallel input fuses protect the equipment against short-circuits. In the second case, overdimensioned cables are adopted, that are capable of withstanding the short-circuit fault. In the third case, cable overdimensioning shall make it possible to withstand the short-circuit current of each individual string.

Being as the PV field is a current-limited generator, even in the event of a short circuit the current delivered by this kind of generator cannot exceed the maximum sizing value.

If the PV plant is made up of more than one SMART STRING BOX LT, consider the example of a short-circuit occurring downstream from a SMART STRING BOX LT, but upstream from the connection to the Sunway DC-Parallel, as shown in Figure 24.

When this happens, the current from all the strings but one is localized in the section of cable between the point where the short circuit has occurred and the connection to the Sunway DC-Parallel.

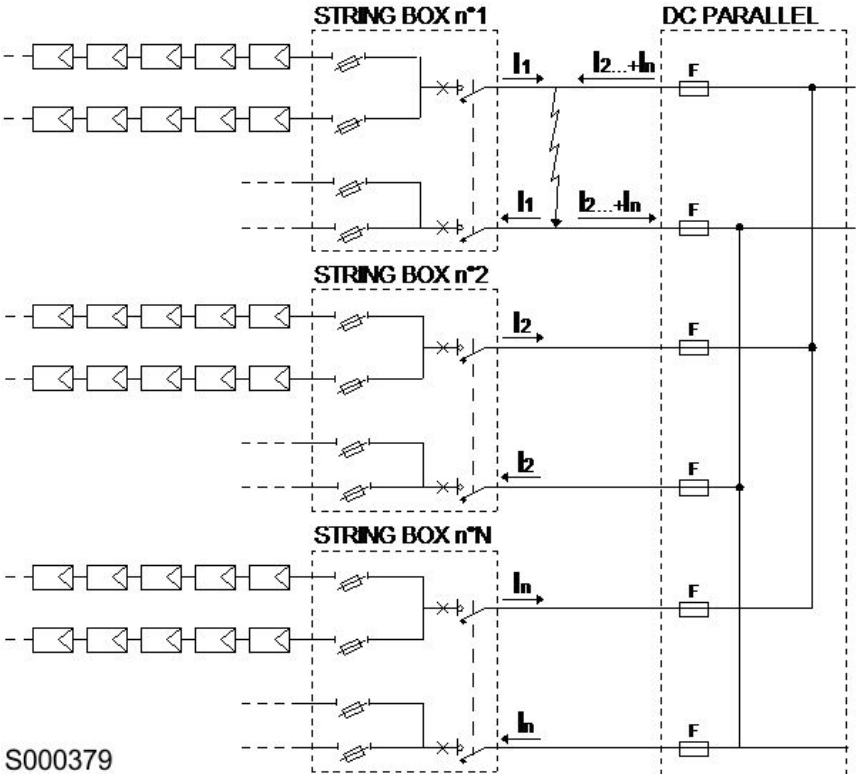


Figure 24: Short-circuit located downstream from the SMART STRING BOX LT

8. COMMUNICATIONS AND REMOTE MONITORING

WARNING

To carry out the following operations, check that the parallel string box is in safety conditions. Please refer to section 2.7.

8.1. General Information

The SMART STRING BOX LT is equipped with a communication port which allows for local and remote connection to a remote monitoring system. This provides the following advantages:

- Full integration with the Santerno remote monitoring system for checking production performance and detecting alarms.
- Complete remote monitoring accessibility in both local and remote mode from PC and SunwayPortal web portal.

By using a PC as a Master device, it is possible to adopt Elettronica Santerno's Remote Sunway software package. This software offers tools such as image capture, keyboard emulation, oscilloscope and multifunction tester functions, operating data history tables compiler, parameter setup and reception-transmission-saving of data to and from PC and scan functions for automatic recognition of connected devices. Consult the specific Remote Sunway manual for use of the software package with Elettronica Santerno products.

8.2. Communication Ports and Protocol Used

The SMART STRING BOX LT serial ports use the 2-wire RS485 electric standard plus a 0 volt reference wire and standard Modbus/RTU protocol.

The SMART STRING BOX LT usually behaves as a Modbus slave, i.e. it responds to requests made by a Modbus Master device. The Master is usually a Sunway series solar inverter, fitted with a Data Logger board, and a PLC with Modbus interface which accompanies the plant, or by a PC equipped with Elettronica Santerno's Remote Sunway software.

The serial port on the SMART STRING BOX LT, available on connectors M1 and M2, implements galvanic isolation of the RS485 signals in relation to the external communication devices.

For specifications concerning the protocol, programming of the serial parameters, the Modbus address etc., please refer to the "Programming Guide".

8.3. Connection Topologies

The SMART STRING BOX LT is usually multidrop connected. The multidrop connection entails the chain connection of multiple devices. In this case, each device is a SMART STRING BOX LT taking 2 addresses.

The RS485 multidrop line to multiple devices must be wired using a linear and not a star topography: each device connected to the line must be connected by an incoming cable from the previous device and have an outgoing cable to connect the next device. The exceptions are obviously the first and last devices in the chain, which will have only an outgoing line and an incoming line respectively.

The reference diagram recommended by the MODBUS-IDA association for the connection of 2-wire devices is illustrated in the figure below.

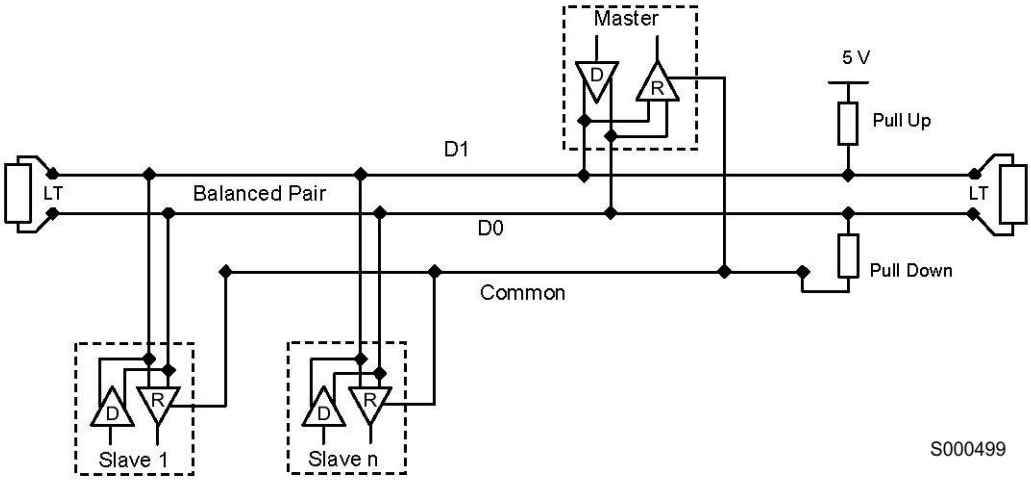


Figure 25: Recommended multidrop connection diagram

The network is made up of the termination resistor and the polarization resistors incorporated for convenience in each SMART STRING BOX LT and which can be turned on by DIP-switch SW1 located on ES977. The figure shows the termination network only for the devices at the ends of the chain. In fact, these are the only ones which need a plugged-in terminator.

Being as one end of the chain is constituted of the Master device, only both contacts of DIP-switch SW1 must be set to ON in the SMART STRING BOX LT located the furthest away (in electrical terms) from the Master, i.e. the one at the end of the multidrop chain. All the DIP-switches in the other SMART STRING BOX LT modules must remain on OFF.

If multiple SMART STRING BOXES LT are multidrop connected, it is necessary to enter and leave with a RS485 cable, which is why there are two cable-glands and two connectors (input and output) for that function.

8.4. Connection

8.4.1. RS485 Bus – Main Principles

The MODBUS-IDA organization (http://www.modbus.org) gives special guidelines on how to create the connection for Modbus communications on RS485 serial link as a 2-wire cable type.

According to the Modbus guidelines, connecting 0V common terminal is required. The connection to a common 0V of the serial link of all devices participating to a comms multidrop network reduces potential differences that may affect communications.

To increase immunity, the serial interface is galvanically isolated with respect to the control board circuits of the string box. The other devices connected to the bus must be provided with a galvanically isolated RS485 comms interface. Otherwise, if communication is established to a laptop, a galvanically isolated RS485/USB converter must be used.

8.4.2. RS485 Cable

For this type of cable, the following MODBUS-IDA specifications are recommended:

Connection cable	
Type of cable	Shielded cable made up of a balanced pair known as D1/D0 + common conductor.
Model	Belden 3106A Paired EIA Industrial RS485 PLTC/CM.
Minimum cross-section of the conductors	AWG22 corresponding to 0.325 mm^2.
Maximum length	500 metres with reference to the maximum distance measured between the two stations furthest apart.
Characteristic impedance	120 Ω.

Table 10: RS485 Connection cable

NOTE

Using a cable other than Belden 3106A must be authorised by Elettronica Santerno.

WARNING

Wiring operations of the module must be carried out when the inverter is NOT powered. Remember to take all the necessary precautions before accessing the connectors and before handling the board.

8.4.3. RS485 Port

SERIAL PORT CONNECTION

Serial port	Optoisolated port	Connectors
RS485	Yes	M1-M2: RS485 field bus connection

Table 11: Serial port connection

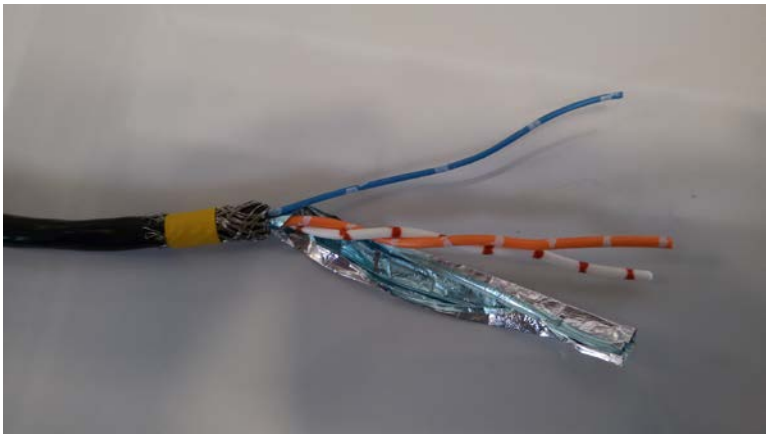
No. of terminals	Signal	Description
1	A (D1)	RS485 Signal D1 (*) INPUT
2	B (D0)	RS485 Signal D0 (*) INPUT
3	0VM	RS485 Signal 0V “Common” (*) INPUT
4	A (D1)	RS485 Signal D1 (*) OUTPUT
5	B (D0)	RS485 Signal D0 (*) OUTPUT
6	0VM	RS485 Signal 0V “Common” (*) OUTPUT

Table 12: Terminals M1 and M2

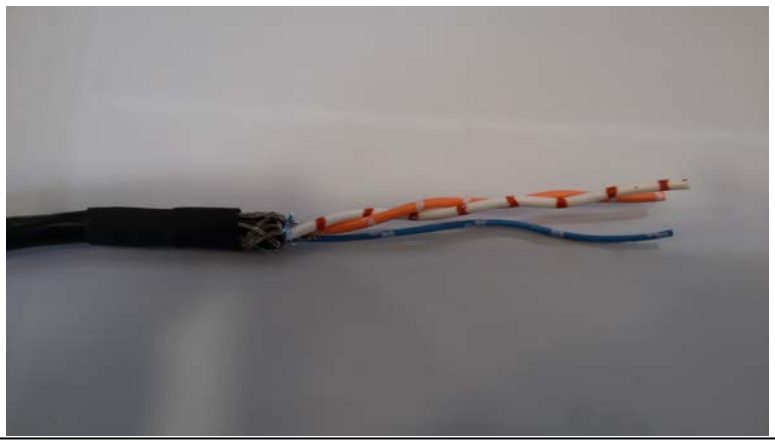
(*) In accordance with the MODBUS-IDA association nomenclature

Do the following to obtain correct wiring of the Belden cable:

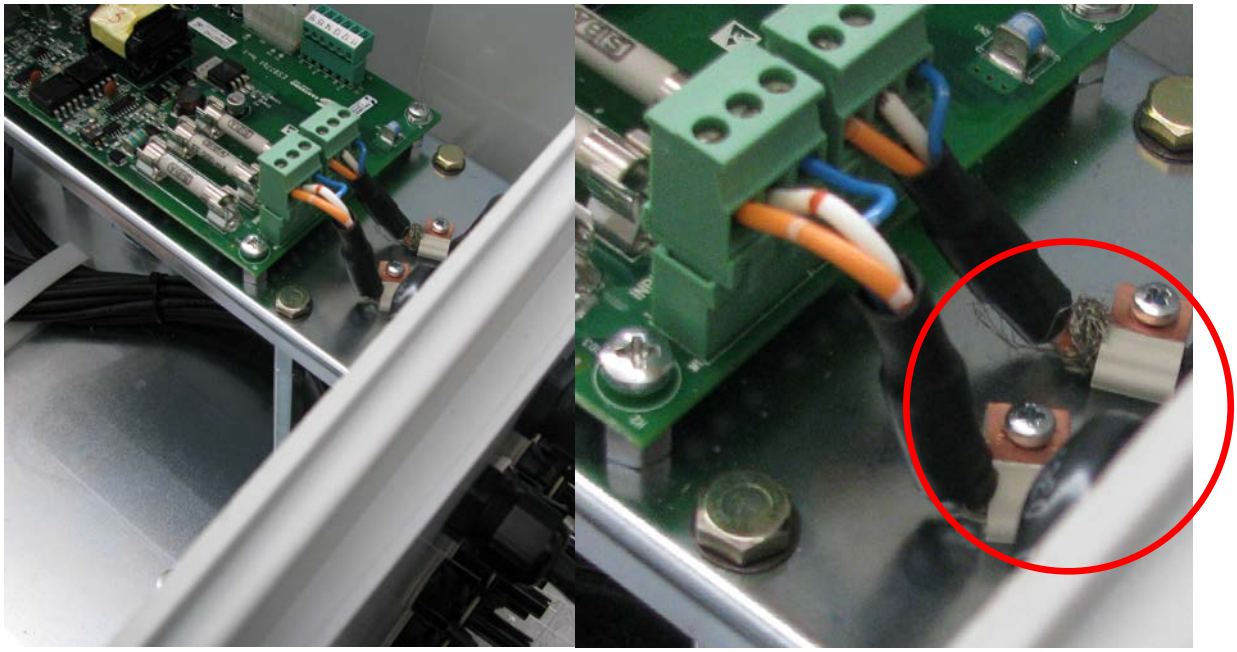
- Strip approx. 100mm
- Bend the cable screening braid backward
- Fix the braid and leave approx. 10mm stripped cable



- Remove the cable screening braid in excess from the twisted cable
- Fasten the braid to the tubing using heat-shrinking tubing



- Insert the cable into the cable-gland and fasten the cable to the copper cable strain relief where the stripped cable begins
- Fasten the cables to the terminals.



- The shielded braid shall be fixed by the copper cable-gland.

Figure 26: Connection of the RS485 cable to the serial port terminals

8.4.4. DIP-switch RS485 Line Termination

DIP-switch	Function	Factory setting	Notes
SW1	RS485 termination	SW1-1 = OFF SW1-2 = OFF Termination and polarization resistors not enabled	SW1-1 and SW1-2 : ON 150 Ω resistor between A and B 390 Ω resistor between A and +5VM1 390 Ω resistor between B and 0VM1 SW1-1 and SW1-2 : OFF no termination and polarization resistor **NO OTHER CONFIGURATION IS ALLOWED**

Table 13: DIP-switch for RS485 line termination

The factory settings of the DIP-switches are indicated in the following figure. The DIP-switches are mounted on the ES977 board.

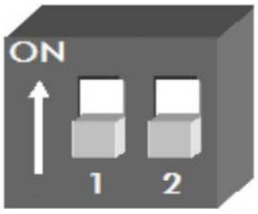


Figure 27: Communication line terminator DIP-switch

NOTE

Incorrect setting of the terminators in a multidrop line may inhibit communication and lead to communication difficulties particularly at high baud rates. If more than the two prescribed terminators have been installed on a line some drivers may enter protection mode for thermal overload thus blocking the communication of some devices.

Elements participating in a RS485 section are called nodes. The maximum number of nodes which can be connected on a section is limited to the following aspects:

- Logic limit of the bus
- Length of the connection
- Transmission rate
- Electronic drivers used

The limit set by the line drivers used in Sunway TG models is 30 devices. It is not advisable to use section lengths exceeding 500m. Should it be necessary to connect more than 30 devices on the same line or over a length exceeding 500 m, it is advisable to break the connection up into more than one section using RS485 repeaters.

NOTE

The RS485 bus default rate is 38400 baud. It is not advisable to exceed this value. In the event of communication disturbances, it is possible to set the rate at a lower value 19200 or 9600 baud.

NOTE

The voltage values for the idle bus are as follows:

2.6 V between line A (D1) and Common

2.4 V between line B (D0) and Common

8.4.5. Board Addressing

For correct communication within the range of the multidrop chain it is necessary to allocate two unique addresses to each SMART STRING BOX LT.

Each SMART STRING BOX LT has two default Modbus addresses, “01” and “02”. Should it be necessary to change them, follow the bus communication installation procedure below.

- Power the board. In that way, the functions of the SMART STRING BOX LT boards are active (the boards can communicate).
- MODIFYING THE ADDRESS: if necessary, act on the Rotary Switches CE1 and CE2 on the ES1004 board by setting the required address between 1 and 99. Figure 28 shows the position of the rotary switches on ES1004 board. The rotary switch HIGH CE1 is for the tens, while the LOW CE2 is for the units. For further information, please refer to the “Programming Guide”.
  - Wait for 15 seconds before sending a query to the new address.

WARNING

The ES1004 board does not acknowledge the Modbus addresses that have been set while the board was off.

NOTE

In the event of serial communication problems, please refer to section 11.

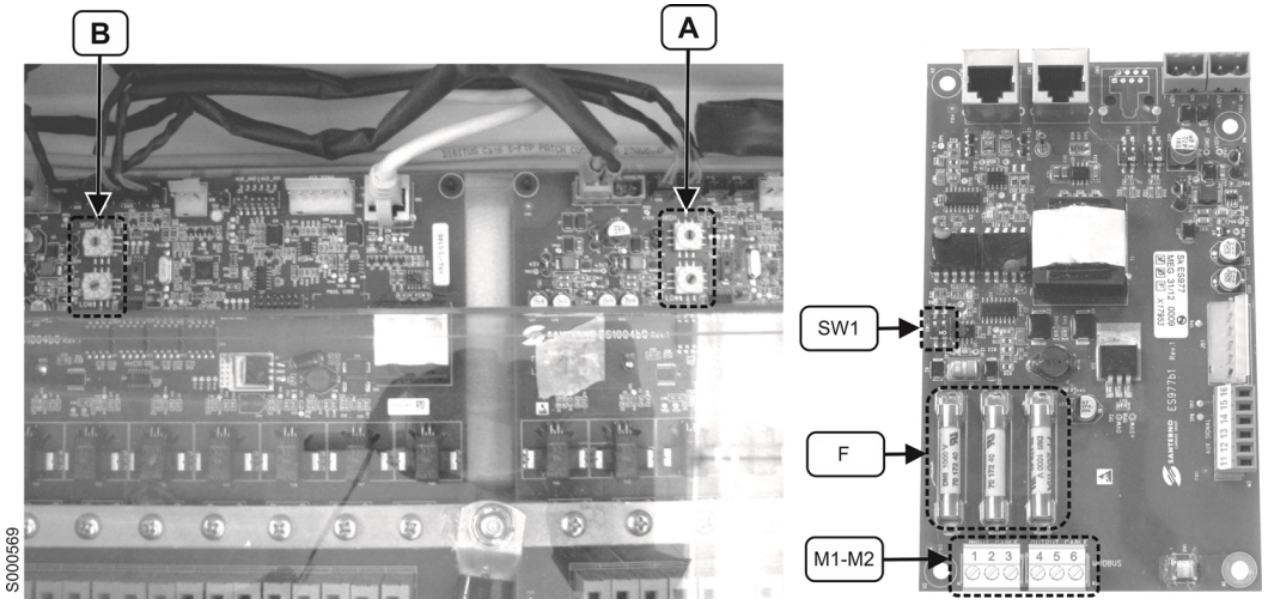


Figure 28: ES1004 and ES977 boards with RS485 terminals, RS485 switch terminators, RS485 safety fuses and environmental sensors terminals

Connections	Function
M1	Connection of serial link M1
M2	Connections of serial link M2
F	Serial link safety fuses
A	Rotary-switch setting RS485 address for strings 1-8 monitoring
B	Rotary-switch setting RS485 address for strings 9-16 monitoring
SW1	DIP-switch for the configuration of the serial link terminators

Table 14: Connections, DIP-switch and rotary switches for the serial link configuration

9. MAINTENANCE

DANGER

Death from electrocution and burns due to contact with live components of the grid and PV field.

Make sure that no voltage is applied to the equipment. Power must be cut off.

DANGER

Before carrying out any kind of operation, please refer to section 2.7.

NOTE

In the event of any fault, please contact the Elettronica Santerno SpA CUSTOMER SERVICE for instructions on the necessary corrective action to be taken.

Adequate maintenance ensures conversion performance and inverter reliability is maintained over time.

This heading describes all the activities required to keep machine parts which are subject to wear and deterioration and/or components which are essential for guaranteeing safety and optimum performance in good condition.

Access to products for the purpose of maintenance, modifications and management involves all persons responsible for production and maintenance. It must be carried out in observance of the health and safety regulations described in section 2.6.

The minimum maintenance interval is indicated in the table below.

Equipment installed in an environment where there is a high concentration of dust requires more frequent maintenance than generally indicated.

The activities described may involve stopping the inverter. Once the maintenance procedure has been completed restart the inverter by pressing the START button.

9.1. Maintenance Sheet

Maintenance tasks	Frequency (recommended)
Box visual inspection and cleaning	Every 6 months
Check the state of connectors	Every 12 months
Check the state of cable glands and tubing joints	Every 12 months
Check the state of fuses	Every 12 months
Check the state of the disconnect switch	Every 12 months
Check SPDs	Every 12 months
Check that cables and bars are securely tightened	Every 12 months
Check the condition of nameplate and warning signs	Every 24 months
The frequency of scheduled maintenance may need to be increased depending on the location in which the equipment is installed and the relevant ambient conditions.	

Table 15: Maintenance sheet

9.1.1. Box Visual Inspection and Cleaning

- Visually inspect the state of cables. Check that cables show no signs of damage caused by rodents and remove any insects.
- Check to see if any condensation has formed inside the equipment. Should this be the case, clean with a cloth, find out where water is getting in and rectify the problem.
- General box cleaning.
- Check the watertightness of the casing and for any signs of damage.
- Check that the front cover, the cable-glands, the tubing joints and each watertight device is correctly positioned and consequently that IP65 protection is guaranteed.
- Check that no wires, clamps or anything else has inadvertently been left inside the string box.

9.1.2. Checking the Connector State

- Check the state of the quick-fit PV connectors.
- Check that connectors are firmly inserted.
- Close off all the unused connectors (ask Elettronica Santerno SpA CUSTOMER SERVICE).

9.1.3. Checking the Cable Glands State

- Check the state of the cable glands.
- Check that cable glands are securely tightened around the cable.
- Close off all the unused cable glands (ask Elettronica Santerno SpA CUSTOMER SERVICE).

9.1.4. Check Tubing State

- Check the state of the cable tubing and make sure that it is properly fastened to the cable gland.

9.1.5. Checking the Fuses

- Routine maintenance entails checking the continuity of the fuses installed (to remove the fuses, see section 7.7).

9.1.6. Checking the SPDs

Inspect the status of the SPDs (Surge Protective Devices) by checking the status of the button/slot on the discharger.

The exact position of the SPDs can be seen on the Electrical and mechanical schematic.

Figure 29: Example of a typical Surge Protective Device

Button/slot status	SPD Status
Button/slot with green indicator visible	SPD in good conditions
Button/slot with red indicator visible	SPD faulty

Please refer to Table 29.

9.1.7. Check Cable Tightening

In order to guarantee correct tightness of the electrical contacts, periodical checking of the tightening torques is to be carried out over the equipment's life cycle.

Pay particular attention to any colour variations or anomalies affecting the terminals and copper bars. Replace any damaged connections or corroded contact elements.

- Check the tightening of all the terminal clamps for connecting the power wiring and tighten if necessary. The tightening torques can be found in section 12.6.

10. UNINSTALLING A SMART STRING BOX LT

This section covers how to uninstall a SMART STRING BOX LT.

CAUTION

Only skilled technicians wearing PPE are authorised to uninstall the product.

DANGER

ELECTRIC SHOCK HAZARD

Carry out all safety procedures described in the following sections before operating on the product and on the connected conductors.

DANGER

ELECTRIC SHOCK HAZARD

DO NOT disconnect the conductors or open the string fuses under operating conditions other than the ones described in this Installation Guide.

Disconnecting the conductors or opening the string fuses when current flows inside the product may cause electric arcs and lead to personal injury or product malfunctions.

10.1. Preliminary Safety Procedures

The SMART STRING BOX LT products are nodes of complex plants. Safety procedures involve both the node concerned and the all the other nodes connected to the system.

The safety procedure also considers the dangers that may be caused by photovoltaic sources, that operate as voltage and current generators when exposed to solar radiation. Voltage generated by those sources may be dangerous for the operators and may cause electric arcs if they are improperly cut off.

Safety procedure to follow in order to uninstall a SMART STRING BOX LT:

- **After sunset and before dawn so that no current flowing is to be found through the string conductors:**
  - Open the front door of the string box to be uninstalled
  - Open the output disconnector;
  - Disconnect all the string conductors;
- Make sure that the inverter connected to the product is STOPPED;
- Open the inverter DC side switch;
- Cut off 230 V auxiliary power supply source;
- Open the output disconnectors of all the string boxes connected to the same inverter as the string box to be uninstalled.

10.2. Uninstallation Procedure

Do the following once the product to be uninstalled is in safety conditions as described in the section above:

- Make sure that no voltage is applied:
  - Between 230 V auxiliary power supply terminals;
  - Between the output negative pole and positive pole, after removing the polycarbonate panel;
- Disconnect 230 V auxiliary power supply terminals;
- Disconnect the output conductors;
- Disconnect any other conductor connected to the product, including the environmental measurement conductors and the RS485 conductors;
- Proceed with the mechanical uninstallation of the product.

Refer to section 7 to replace the SMART STRING BOX LT.

DANGER

ELECTRIC SHOCK HAZARD

If the SMART STRING BOX LT that has been uninstalled and removed from the plant is not immediately replaced, put all the conductors that have been disconnected in safety conditions before restoring the operation of the PV plant section concerned.

11. TROUBLESHOOTING

The SMART STRING BOX LT products are completely protected against short-circuits and overvoltage caused by system failure or temporary phenomena. Furthermore, the control system performs complete self-diagnosis operations to help personnel solve any problems which may occasionally arise. The modular design of Elettronica Santerno inverters makes repair and/or reset operations quick and easy to perform.

This chapter indicates the most likely causes of the most common problems. The steps to be taken to remove these causes are also described.

WARNING

To carry out the following operations, check that the parallel string box is in safety conditions. Please refer to section 2.7.

NOTE

If necessary, please contact the Elettronica Santerno SpA CUSTOMER SERVICE.

11.1. Self-Diagnostics

The SMART STRING BOX LT' self-diagnostics system detects and records most malfunctions and provides technical support elements which are useful for problem solving.

The elements providing support for diagnostic functions which are accessible in remote and/or local remote control are as follows (please refer to the "Programming Guide"):

- Measure and control electronic board power supply indicator LED.
- Output disconnect switch status.
- SPD status.
- String current verification.
- Alarms history for the SMART STRING BOX LT accessible in remote and/or local remote control.

When an alarm occurs, the SMART STRING BOX LT records it in the Alarms history list together with the time of occurrence (Supply Time and Operation Time), the status of the SMART STRING BOX LT and the value of certain sampling measurements taken at the time of alarm tripping. The stored data is very useful in helping to determine the cause which triggered the alarm and consequent removal of the alarm condition.

11.2. General Principles in the Event of Failure

Access to the PV system components for the purpose of maintenance, modifications and management involves all persons responsible for production and maintenance. It must be carried out in observance of the health and safety regulations described in section 2.6.

11.2.1. Fault Containment

The following prescriptions are of a general nature.

- Place the equipment affected by the fault in safety conditions. This operation may involve stopping and disconnecting all the up- and downstream devices. Please refer to section 2.4.

- If the fault has occurred inside an inverter, press an emergency stop button to cut the inverter off up- and downstream. Open the disconnect switches of all the string boxes so that the entire DC input section is safe, including the DC-Parallel (if installed).
- In multi-inverter systems it is usually sufficient to cut off the inverter affected by the fault both up- and downstream so that the other inverters can remain in operation.
- If the fault has occurred in one of the components downstream from the inverter (AC parallel cabinet, external transformer, metering cabinet etc.) STOP all the machines and then press the emergency stop button to cut off the inverter both up- and downstream.
- If the fault has occurred in one of the components upstream from the inverter (DC-parallel, String Box, etc.) STOP all the machines and then press the emergency stop button to cut off the inverter both up- and downstream. Open the disconnect switches of all the String Boxes so that the entire DC input section is safe, including the DC-Parallel (if installed).
- If the fault has occurred in one of the String Boxes, open all the strings connected in input and open the disconnect switches of all the String Boxes in order to place all the equipment in safety conditions, including the cable output section.
- Proceed with analysis of the causes and consequences of the fault.

NOTE

If necessary, please contact Elettronica Santerno SpA CUSTOMER SERVICE.

11.2.2. Fault Analysis

This section covers the main principles to be observed when analysing the causes and consequences of faults.

A PV inverter usually operates as part of an overall system. All the components adopt various protective measures therefore, in general, the consequences of a generic fault affecting an upstream component or element does not extend to other components downstream.

However, the causes and the consequences of any faults which may arise need investigating on the plant as a whole.

Fault investigation and analysis activities represent one of the most hazardous tasks assigned to maintenance technicians. This manual only provides indications of an extremely generic nature concerning the precautions which must be adopted when fault investigation and analysis activities need to be carried out on live components.

In the event of a fault, before proceeding to resolve the problem, the following tasks must be performed to evaluate:

- The state of components and the system as a whole:
  - Check the state of the contacts.
  - Check the state of cables.
  - Check the state of any interface protection installed in the system.
  - Check the state of all protective elements installed in the system.
  - Check the state of any auxiliary power supplies.
  - Check the level of humidity present on system components.
- If faults have occurred on each box, inverter and/or the system:
  - Check for any earth faults on the DC side and the AC side.
  - Make sure that all prescriptions have been observed relative to the neutral connection or those relative to field configuration (floating, Positive Earthed, Negative Earthed).
  - Check the state of the SPDs.

Once all the aforementioned steps have been performed, proceed with evaluating:

- The causes of faults.
- The consequences of faults on the electrical, electromechanical and electronic components.
- The steps to be taken to remove the cause of the fault.

Once all the aforementioned steps have been performed, proceed with rectifying the causes of the fault.

NOTE

If necessary, please contact Elettronica Santerno SpA CUSTOMER SERVICE.

11.3. Current Measurement Failure

11.3.1. No Current Measurement is Performed

- Check fuses.
- Make sure that the output disconnect switch is closed.
- Make sure that no short-circuit is occurring in the string.
- Make sure that string polarity is correct.
- Make that the cable continuity is ensured in the string.

NOTE

If the problem persists, please contact Elettronica Santerno SpA CUSTOMER SERVICE.

11.3.2. The Expected Current is not Measured

- Make sure that the quick-fit connectors are in the correct position.
- Make sure that no short-circuit is occurring in the string.

11.4. Communications Failures

11.4.1. Serial Communications Failures

- Check that all the programming parameters are correct.
- Check the voltage values for the idle bus: please refer to section 8.4.3.
- Check fuses in ES977.
- Check the state of the gas discharge tube (GDT) in ES977.

11.5. Safety Devices Tripped

11.5.1. SPDs Tripped

- If the SPDs have tripped, replace the cartridges after placing the string box in safe conditions.

PROHIBITION

It is forbidden to use cartridges different from the ones installed (same brand and model required).

Please refer to section 12.7.

11.5.2. String Fuse Blown

This section describes faults relevant to one or more SMART STRING BOX LT fuses blowing. If a fuse blow, procedures cannot be limited to simply replacing the fuse. Suitable analysis of the fault which caused the problem must be also carried out.

NOTE

Should the fuse blow again, please contact Elettronica Santerno SpA CUSTOMER SERVICE.

Before replacing a blown fuse, all the tasks described in section 11.2.1 and 11.2.2 must be performed.

11.6. Revision of a String with Inverted Polarity

Correct connection of the strings must be checked in the presence of live voltage, hence in the daytime.

DANGER

Correct connection of the strings must be checked by expert personnel only using all the necessary safety devices and precautions.

Do not insert or remove fuses in the event of a string with inverted polarity or unchecked polarity.

Connecting a string with inverted polarity may damage the product.

Place the string box in safe conditions by opening the on-load circuit breaker and all the string fuses at night.

- Make sure that the inverter connected to the SMART STRING BOX LT is NOT running, i.e. that it is STOPPED.
- Open the inverter DC side switch.
- Remove auxiliary voltage from the aux source, without operating on the string box.
- Wait for the field voltage on the inverter side to reach safety values, in compliance with the applicable safety standards.
- Open the string box.

- Make sure that the on-load disconnector is open.
- Make sure that the fuse-holders in the string box concerned are open.
- Make sure that fuses are intact.
- Disconnect the PV connectors of the string (see section below).
- Check the product status as described in the sections above.
- With the aid of a multimeter check the polarity of the strings (between the positive pole input terminal of each individual string and a negative pole input terminal).
- Rectify cabling, if polarity mismatch is detected.
- Connect the string again.
- Check string polarity (section 7.7).

11.7. Disconnecting a String

DANGER

Disconnecting a string is allowed only if no current flows in the relative cable, as it is forbidden to open the fuse-holders, remove the connectors both in the string box and the live PV modules. If the safety fuse has not blown, current may flow if a short-circuit is to be found in the string to be removed. Check polarity of each string before connecting it to the product.

Carry out step 2 below at night if you are not sure that no current is flowing.

Procedure:

1- Open the disconnector inside the string box.
2- Open the fuse-holders inside the string box.
3- Use the special tool to compress the two snaps. Pull out the connector.

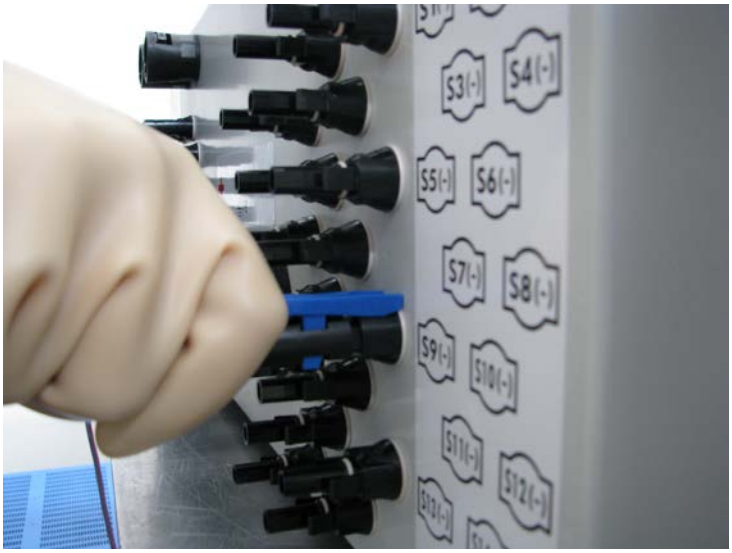


Figure 30: Disconnecting a string connector

Once the string cabling has been rectified, restore the conditions for the plant operation (section 7.8).

11.8. How to Contact the CUSTOMER SERVICE

Should it be necessary to contact the Elettronica Santerno SpA CUSTOMER SERVICE, please provide the following data:

- Equipment model
- Serial Number
- Date of commissioning
- Order confirmation reference, if available

It is advisable to recover the following information from the product memory:

- Operation time (please refer to the “Programming Guide”)
- Alarms history (please refer to the “Programming Guide”)

This operation can be carried out using the Remote Sunway program with local or remote connection.

NOTE

Should it be necessary to send the equipment in for repair or to return the equipment, contact the Elettronica Santerno SpA CUSTOMER SERVICE, to agree upon the terms.

12. TECHNICAL DATA

WARNING

Power supply must be ensured by an external, 230 Vac ~ power supply source.

12.1. Nameplate

Each nameplate indicates the product's technical data and identification details:

- 1- Name of the product.
- 2- Part Number assigned to the product by Elettronica Santerno.
- 3- Technical data (rated input/output voltage and current, rated power, etc.)
- 4- CE marking and indications of the relative reference Standards applied in the construction of the equipment.
- 5- Product revision index.
- 6- Serial Number: identifies the product serial number

The nameplate measures 110 x 70 mm and is silver in colour.

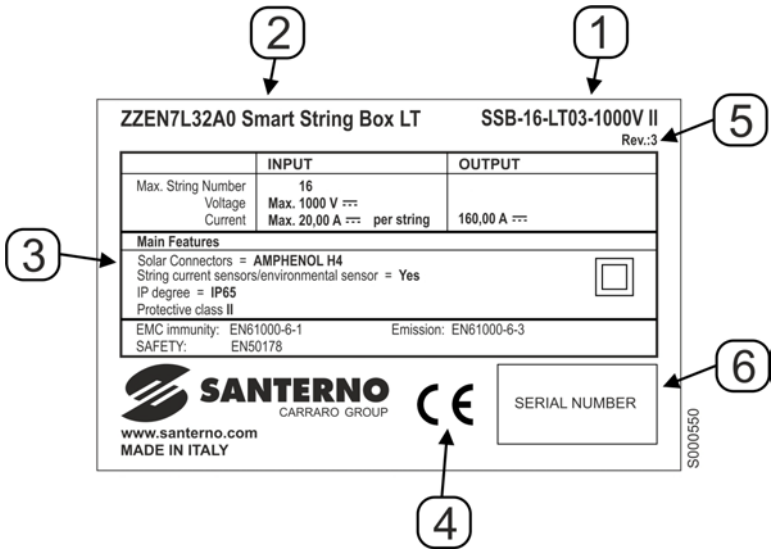


Figure 31: SMART STRING BOX LT nameplate

12.2. Environmental Requirements for Storage and Transport

Required conditions	
Ambient temperature for storage	-25 °C ÷ +65 °C (the product must be clean, dry, closed and packed) (class 1k4 in compliance with EN 60721-3-1).
Ambient humidity for storage	From 5% to 95%, from 1 g/m^3 to 25 g/m^3, with no condensation or ice formation (class 1k3 in compliance with EN 60721-3-1).
Ambient temperature during transport	25 °C to +70 °C (the product must be clean, dry, closed and packed) (class 2k3 in compliance with EN 60721-3-2).
Ambient humidity during transport	Maximum 95% up to 60 g/m^3. Slight condensation may occur when the equipment is not running (category 2k3 in compliance with EN 60721-3-2).
Atmospheric pressure for storage	From 86 to 106 kPa (class 1k4 in compliance with EN 50178).
Atmospheric pressure during transport	From 70 to 106 kPa (class 2k3 in compliance with EN 60721-3-2).

Table 16: Environmental requirements for storage and transport

12.3. Installation Requirements

Installation specifications for SMART STRING BOX LT	
Operating ambient temperature	-25 °C ÷ +45 °C
Operating ambient humidity	From 4% to 100%, from 0.9 g/m^3 to 36 g/m^3, with no condensation or ice formation (category 4K4H in compliance with EN 50178)
Altitude	Up to 2000 m ASL For higher altitudes, please contact Elettronica Santerno
Installation site	Do not install the equipment where it is exposed to direct sunlight or where it is exposed to conductive dust, corrosive gases, vibrations, water spray or dripping. Do not install in salty environments
Degree of protection	IP 65
Degree of pollution (IEC/EN 60721-3-4)	Class 4C2 for chemically active substances Class 4S3 for mechanically active substances

Table 17: Installation specifications for SMART STRING BOX LT

12.4. Electrical Specifications

	Feature	Unit of measure	SSB-16-LT03-1000V II
INPUT	Maximum DC input voltage (V)	V	1000
	DC String Fuses		PV rated (10x38) not included
	Impp input current (Impp) @ ambient 45°C per string (A)	A	20
	Max. input current (Isc) @ ambient 45°C per string (A)	A	22
	Maximum number of connectable strings		16
	Uc Pulse withstanding voltage (kV)	kV	4
OUTPUT	Rated output current @ ambient 45°C (A)	A	160
	Uc Pulse withstanding voltage (kV)	kV	4

Table 18: Electrical specifications of the SMART STRING BOX LT

12.4.1. Choosing the String Fuse Size

The fuse size is to be chosen based on the string short-circuit current. Please refer to the table below. Fuse brands other than those in the table are to be explicitly authorized by Elettronica Santerno.

Maximum Input Current Isc @ ambient 45°C (A)	Fuse Size	Type of fuse (Bussmann)	Type of fuse (Mersen)	Type of fuse (SIBA)
Up to 5.5	8	PV-8A10F	HP 10M 8	---------
5.5 to 7.1	10	PV-10A10F	HP 10M 10	--------
7.1 to 8.8	12	PV-12A10F	HP 10M 12	--------
8.8 to 11	15	PV-15A10F	HP 10M 15	URZ 50 215 26.15
11 to 14.3	20	PV-20A10F	HP 10M 20	------
14.3 to 17.6	25	PV-10M25	HP 10M 25	-------
17.6 to 22	30	PV-10M30	HP 10M 30	-------

Table 19: Fuses recommended based on Isc

WARNING

The maximum number of strings connected to the product shall be calculated based on the allowable output rated power, as well as on the ambient temperature and the product configuration.

Auxiliary Power Supply Specifications	Unit of measure	Min.	Typ	Max.
Applicable operating voltage range (Vac)	V~	195	230	264
Frequency	Hz	47	50	63
Power absorbed from the grid	W		18	23
Current absorbed from the grid	A			0.3
Peak inrush current (1ms)	A			40

Table 20: Auxiliary power supply specifications

12.4.2. Load Curve

In order to calculate the deliverable current (Iout), a normalized coefficient at rated conditions (Inom=160Amp@45°C) is given.

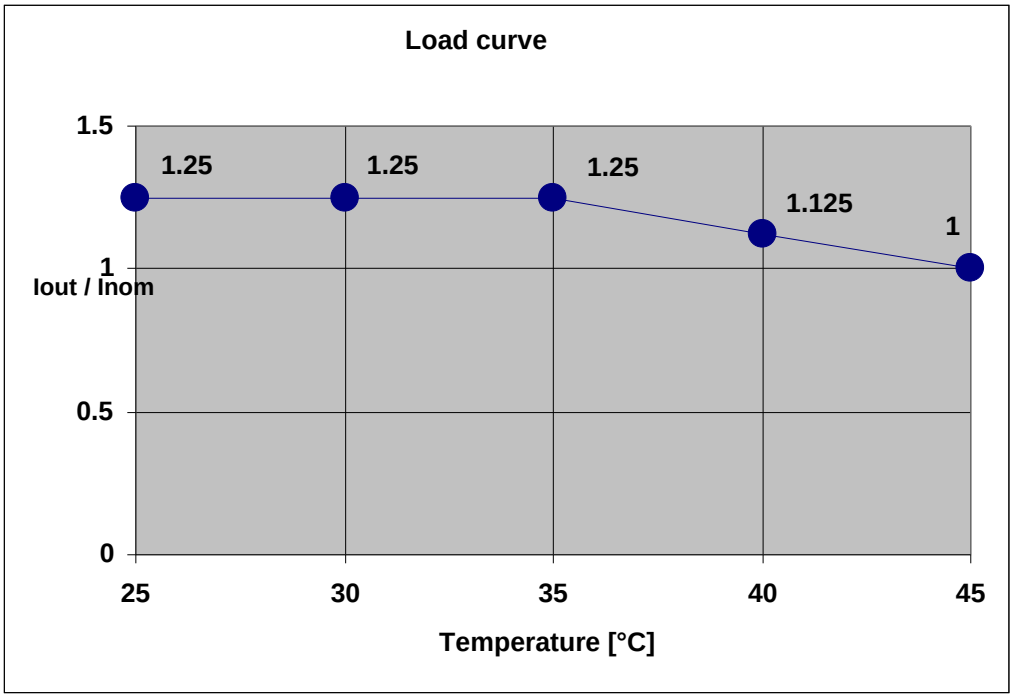


Figure 32: Load coefficient based on temperature

12.5. Mechanical Specifications

Product	Dimensions WxHxD [mm]	Weight [kg]
SSB-16-LT03-1000V-II	635x890*300	32.5

Table 21: Dimensions and weight of the SMART STRING BOX LT

12.5.1. Mechanical Dimensions

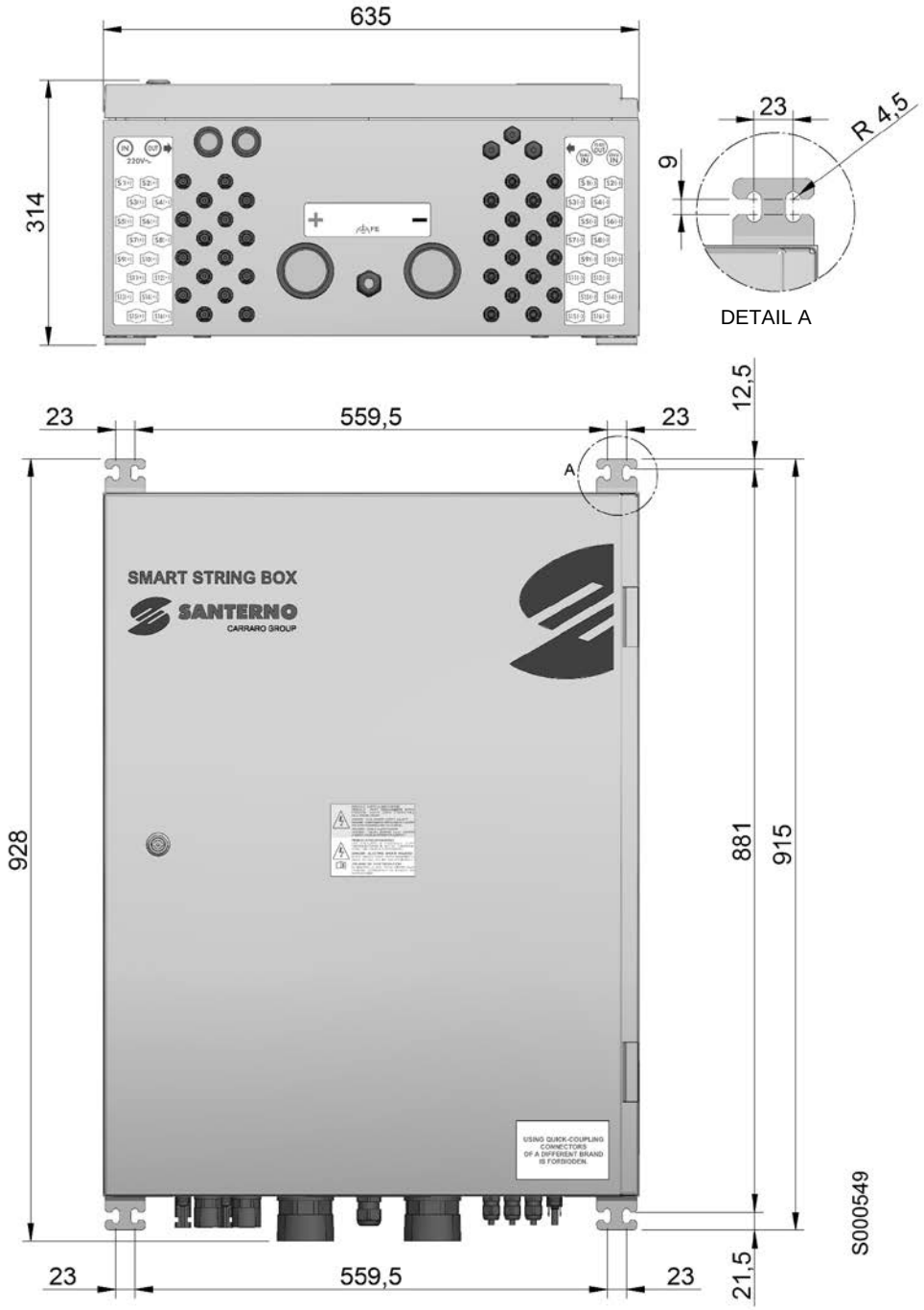


Figure 33: 16-string SMART STRING BOX LT

12.5.2. Clearance Values

It is necessary to observe the following minimum distances from walls, other equipment and objects in order to ensure safety of access and adequate heat dispersion.

SMART STRING BOX LT	Front [mm]	RH/LH side [mm]	Back [mm]	Top [mm]	Bottom [mm]
SSB-16-LT03-1000V-II	700	120	--	350	450

Table 22: Minimum clearance values

See section 6.

12.5.3. Fastening the Box

Fasten the box with at least N.4 screws M8 in the corners.

12.6. Connections

12.6.1. DC Connection – String Cables

Quick-coupling connectors

String cable header	Min/max Conductor [mm^2]	Notes
Quick-coupling connectors type Amphenol Helios H4	4/6	Always use flying connectors of the same brand as the connectors installed on the string box. The use of other connectors may damage the product.

Table 23: String cable connections with PV quick-fit connector

WARNING

To get even temperature inside the string box components, adopt string inputs as per the table below.

Max. input current Isc@ ambient 45°C (A)	Max. input current Isc@ ambient 35°C (A)	Number of connected strings	Input to be used
Up to 11.7	Up to 14.7	15-16	No limitation
From 11.7 to 13.5	From 14.75 to 16.9	13-14	Do not connect inputs 4 and 12
From 13.5 to 16.7	From 16.9 to 18.4	11-12	Do not connect inputs 3,6,11, and 14
From 16.7 to 19.6	From 18.4 to 24.5	9-10	Do not connect inputs 2,4,6,10,12 and 14
From 19.6 to 22	From 24.5 to 27.5	8	Do not connect inputs 2,4,6, 8, 10,12,14,16

Table 24: Inputs to be used based on the string current

12.6.2. DC Connections - Output Cables

DESCRIPTION	Unit of measure	SSB-16-LT03-1000V II
Cables per pole	n	1
Tightening torque for bolt M12 (see note below)	Nm	From 27 to 30
Max. cross-section of the conductor	mm^2	300
Min/max outer diameter of the cable	mm	14/40
Cable gland	-	M63
Compatible spiral tubing		Adaptaflex 54mm type PA, PI, CP, PR and PF
Max. dimensions of cable lug	See Table 26	
Suggested cable lug for copper cable	-	Cembre Series A-M contained palm
Cable lug compatible for aluminum cable (see note below)		Cembre Series CAA

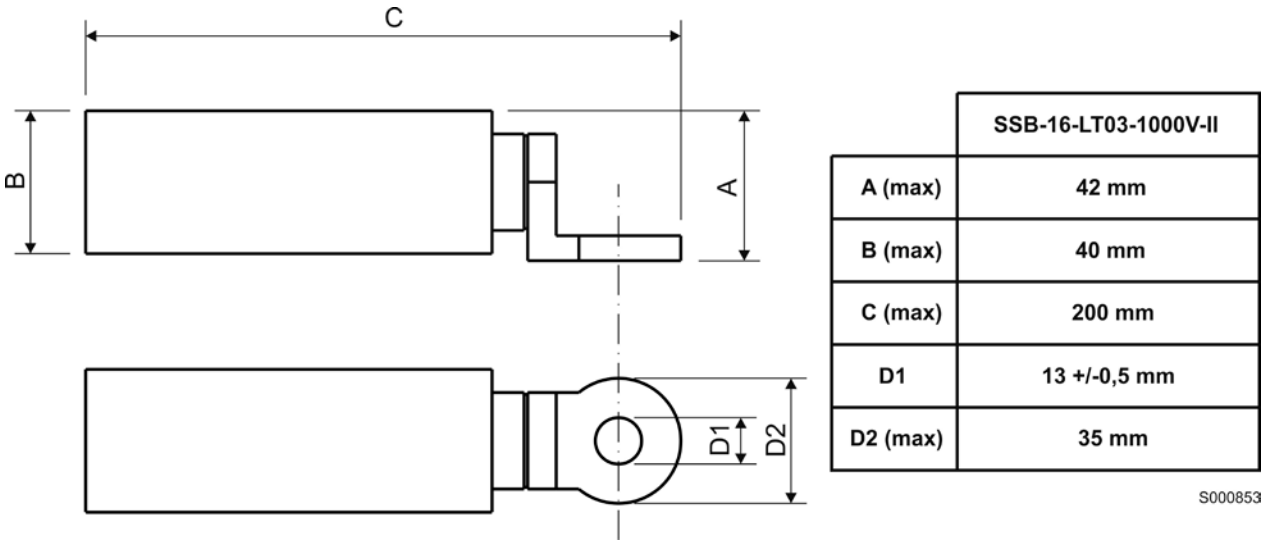
Table 25: Power cables connection

NOTE

*Use the bolts supplied (M12*25); if they are to be replaced, use screws having the same length.*

NOTE

Use bimetal copper-aluminum cable lugs.



	SSB-16-LT03-1000V-II
A (max)	42 mm
B (max)	40 mm
C (max)	200 mm
D1	13 +/-0,5 mm
D2 (max)	35 mm

Figure 34: Dimensions of the cable lugs to be used for the output cables

12.6.3. Connection of Functional Earth Cables

DESCRIPTION	UNIT OF MEASURE	SSB-16-LT03-1000V II
Cables per pole	N.	1
Tightening torque	Nm	3.2-3.7
Max cross-section of the conductor (minimum | maximum)	-	1.5 | 35
Cable stripping	mm	18
Outer diameter of the cable (minimum | maximum)	mm	9 | 17
Cable gland	-	M25

Table 26: Functional earth cable

12.6.4. Connection of RS485 Signal Cables and Analogue Inputs

DESCRIPTION	UNIT OF MEASURE	SSB-16-LT03-1000V II
Cables per pole	N.	2 x RS485 1 x analogue input
Cross-section of the conductor (minimum | maximum)	mm^2	0.2 | 2.5
Tightening torque	Nm	0.5-0.6
Outer diameter of the cable (minimum | maximum)	mm	3.5 | 10
Cable gland per pole	-	M16
Suggested cable lug for copper cable	-	CEMBRE, tube cable lug/tip

Table 27: RS485 cable section and auxiliary analogue inputs

12.6.5. Connection of 230Vac ~ Aux Power Supply Cables

Description	Unit of measure	SSB-16-LT03-1000V II
Cables per pole (*)	N.	2
Type of terminal		Spring
Screwdriver blade as per DIN5264-A	mm	0.4*2.5
Cross-section of the conductor (minimum | maximum)	mm^2	0.13 | 2.5
Cable stripping	mm	6
Conductor cross-section with terminal (maximum)	mm^2	1.5
Outer diameter of the cable (maximum)	mm	16
Tubing gland		2*M25
Dimensions and types of compatible tubing		Adaptaflex 28mm type PA, PI, CP, PR and PF

Table 28: Connection of the power supply cables

NOTE

The connector is provided with N.2 spring terminals which are parallel-connected to create a 230Vac in-out circuit.

12.7. SPDs

Technical specifications for SPDs are provided in the table below.

Technical Specifications	
Rated voltage of system	1000 V
Maximum voltage of system	1000 V
Rated discharge current	12.5 kA
Response time	25 ns
Residual current	< 1 mA
Configuration	Y connection of three SPDs to varistor
UP level of protection (L-L / L-PE)	3.5 kV
General Specifications	
Removable cartridges	Yes
UL94 Fire resistance	V-0

Table 29: SPD technical specifications

12.8. Environmental Sensors Specifications

The nominal specifications for the environmental measures analogue inputs are indicated in the table below.

WARNING

If the maximum/minimum input or output voltage ratings are exceeded, irreparable damage to the equipment may occur.

Analogue inputs configured in 0-20 mA mode	Unit	Rating		
		Min	Typ	Max
Input impedance	kΩ		40	
Cumulative offset and gain error in relation to full scale value	%		0.5	
Temperature coefficient of the offset and gain error	ppm/°C			200
Digital resolution	bit			12
Voltage LSB value	mV/LSB		2.44	
Permanent overload on the inputs without causing damage	V	-30		+30
Input filter cut-off frequency (low-pass first order filter)	Hz		1	

Table 30: Analogue inputs configured in 0-10 V mode

Analogue inputs configured in 0-100 mV mode	Unit	Rating		
		Min	Typ	Max
Input impedance	MΩ	1		
Cumulative offset and gain error in relation to full scale value	%		0.2	
Temperature coefficient of the offset and gain error	ppm/°C			50
Digital resolution	bit			12
Voltage LSB value	µV/LSB		24.7	
Permanent overload on the inputs without causing damage	V	-30		+30
Input filter cut-off frequency (low-pass first order filter)	Hz		1	

Table 31: Analogue inputs configured in 0-20 mA mode

Analogue inputs configured as temperature measurement with PT100	Unit	Rating		
		Min	Typ	Max
Type of probe	2-wire connection PT100 thermistor			
Measurement range	°C	-50		125
PT100 element polarization current	mA		0.67	
Temperature measurement coefficient	ppm/°C			50
Digital resolution	bit			12
Maximum cumulative measurement error over -40 °C ÷ +50 °C temperature range	°C		0.5	1.5
Mean value of temperature LSB (SW linearization function)	°C/LSB		0.098	
Permanent overload on the inputs without causing damage	V	-10		+10
Input filter cut-off frequency (low-pass first order filter)	Hz		1	

Table 32: Analogue inputs configured as temperature measurement with PT100

13. ANNEXES

13.1. Revision Index

Revision 01:

- Section 12.6.2.: Tightening torque for M12 bolts changed from “18 to 20” to “27 to 30”.
- Figure 34: Dimensions of the cable lugs to be used for the output cables updated.