Treetech

Product Manual

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1.1 Legal information

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1.1.1 Disclaimer

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1.2 Presentation

This manual presents all the recommendations and instructions for the installation, operation, and maintenance of the Smart Device Bushing - SDB**.**

1.3 Typographical conventions

Throughout this text, the following typographical conventions have been adopted:

Bold: Symbols, terms, and words in bold have greater contextual importance. Therefore, pay attention to these terms.

Italic: Foreign language terms, alternative terms, or terms used outside of formal contexts are italicized.

Underlined: References to external documents.

1.4 General and safety information

This section will present relevant aspects regarding the security, installation, and maintenance of the SDB**.**

1.4.1 Safety symbols

This manual uses three types of risk classification, as shown below:

Warning:
This symbol is used to highlight certain observations, alerting the user to a potentially dangerous operational or maintenance procedure that requires greater care in its execution. Minor to moderate injuries may occur, as well as damage to equipment.

Caution:
This symbol is used to alert the user to a potentially dangerous operational or maintenance procedure where extreme caution must be taken. Serious injury or death may occur. Possible damage to equipment will be irreparable.

Risk of electric shock:
This symbol is used to alert the user to an operational or maintenance procedure that, if not strictly followed, could result in electric shock. Mild, moderate, or severe injury or death may occur.

1.4.2 General symbols

This manual uses the following general-purpose symbols.:

Important
This symbol is used to highlight information.

Tip
This symbol represents instructions that facilitate the use of or access to functions in the SDB**.**

1.4.3 Minimum recommended profile for the SDB operator and maintainer

The installation, maintenance, and operation of equipment in electrical substations require special care; therefore, all recommendations in this manual, applicable standards, safety procedures, safe work practices, and good judgment must be used during all stages of handling the Smart Device Bushing – SDB.

Only authorized and trained personnel, operators and maintenance staff, should handle this equipment.

To handle the SDB, the professional must:

1. Be trained and authorized to operate, ground, power on, and power off the SDB, following maintenance procedures in accordance with established safety practices, which are the sole responsibility of the SDB operator and maintainer;
2. Be trained in the use of PPE, CPE, and first aid;
3. Be trained in the operating principles of the SDB, as well as its configuration;
4. Follow the regulatory recommendations regarding interventions on any type of equipment within an electrical power system.

1.4.4 Environmental and voltage conditions required for installation and operation

The following table lists important information regarding environmental and voltage requirements.

Table 1 - Operating conditions

Condition	Range/description
Supply voltage	85~250 Vac/Vdc
Application	Equipment for indoor use in substations, industrial environments and similar settings.
Indoor/outdoor use	Indoor use
Protection rating (IEC 60529)	IP20
Altitude* (IEC EN 61010-1)	2000 m
Temperature (IEC EN 61010-1)	
Operation	-40...+85 °C
Storage	-50...+95 °C
Relative humidity (IEC EN 61010-1)	
Operation	5...90% - Non-condensing
Storage	5...90 % - Non-condensing
Overvoltage (IEC EN 61010-1)	Category II
Pollution level (IEC EN 61010-1)	Grau 2
Atmospheric pressure** (IEC EN 61010-1)	80...110 kPa

*Altitudes above 2000 m already have successful applications.
** Pressures below 80 kPa already have successful applications.

1.4.5 Instructions for testing and installation

This manual should be available to those responsible for the installation, maintenance, and users of the Smart Device Bushing - SDB.

To ensure user safety, equipment protection, and proper operation, the following minimum precautions must be followed during the installation and maintenance of the SDB.

1. Read this manual carefully before installing, operating, and maintaining the SDB. Errors in the installation, maintenance, or adjustments of the SDB may cause false alarms, failure to issue relevant alarms, and thus lead to a misunderstanding of the true health and operational status of the transformer or application, since the SDB is designed to withstand electrical substation environments, also encompassing industrial and commercial environments.

2. The installation, adjustments, and operation of the SDB must be performed by trained personnel familiar with power transformers, control devices, and substation equipment control circuits, or by individuals familiar with and trained to implement the Smart Device in their application.

3. Special attention should be given to the installation of the SDB, including the type and gauge of the cables, the installation location and commissioning, as well as the correct parameterization of the equipment.

The SDB must be installed in a sheltered environment (a doorless panel in a control room or an enclosed panel in the case of outdoor installation) that does not exceed the temperature and humidity specified for the equipment.

Do not install the SDB near heat sources such as heating resistors, incandescent lamps, and high-power devices or devices with heat sinks. Installation near ventilation openings or where it may be exposed to forced airflow, such as the inlet or outlet of cooling fans or forced ventilation ducts, is also not recommended.

If the panel where the SDB is installed has a window, use a G20 or higher quality film to prevent direct sunlight (ultraviolet rays) from reaching the equipment. If the window glass is dark, this procedure is not necessary.

1.4.6 Instructions for cleaning and decontamination

Be careful when cleaning the SDB. Use **only** a damp cloth with soap or detergent diluted in water to clean the housing, faceplate, or any other part of the equipment. Do not use abrasive materials, polishes, or harsh chemical solvents (such as alcohol or acetone) on any of its surfaces.

Turn off and unplug the equipment before cleaning any parts of it.

1.4.7 Inspection and maintenance instructions

For inspection and maintenance of the SDB, the following observations must be followed:

Do not open your equipment. There are no user-serviceable parts inside. This must be done by Treetech technical support or technicians accredited by them. This equipment is completely maintenance-free, and visual and operational inspections, periodic or not, can be performed by the user. These inspections are not mandatory.

All parts of this equipment must be supplied by Treetech, or one of its authorized suppliers, according to its specifications. If the user wishes to acquire them in another way, they must strictly follow Treetech's specifications for this. This will ensure that the performance and safety of both the user and the equipment are not compromised. Failure to follow these specifications may expose the user and the equipment to unforeseen risks.

Opening the SDB at any time will void the product warranty. In cases of improper opening, Treetech will also not be able to guarantee its correct functioning, regardless of whether the warranty period has expired or not.

1.5 Customer service

Are you already familiar with our online customer service platform?

CS

SAC

On the CS page, you'll find a quick and direct communication channel with our support team. Get your questions answered, resolve problems, and keep your Treetech product application up-to-date.

The Treetech knowledge base is also available, including catalogs, manuals, application notes, frequently asked questions, and more.

In some cases, it will be necessary to send the equipment to Treetech's Technical Assistance. Our Customer Service department will explain the entire procedure and provide the necessary contact information.

1.6 Warranty Terms

The Smart Device Bushing - SDB will be guaranteed by Treetech for a period of 2 (two) years, starting from the date of purchase, exclusively against any manufacturing defects or quality flaws that render it unsuitable for regular use.

The warranty will not cover damage to the product resulting from accidents, misuse, incorrect handling, incorrect installation and application, inadequate testing, or if the warranty seal is broken.

Any need for technical assistance should be communicated to Treetech or its authorized representative, presenting the equipment along with the corresponding proof of purchase.

Treetech provides no express or implied warranty other than those stated above. Treetech does not provide any warranty of the suitability of the SDB for a particular application.

The seller shall not be liable for any property damage or for any losses or damages arising from, connected with, or resulting from the purchase of the equipment, its performance, or any service possibly provided in conjunction with the SDB.

Under no circumstances shall the seller be liable for any losses incurred, including but not limited to: loss of profits or income, inability to use the SDB or any associated equipment, capital costs, costs of purchased energy, costs of substitute equipment, installations or services, downtime costs, claims from the buyer's customers or employees, regardless of whether such damages, claims or losses are based on contract, warranty, negligence, tort or otherwise. Under no circumstances shall the seller be liable for any personal injury of any kind.

2 Introduction

2.1 Intended use

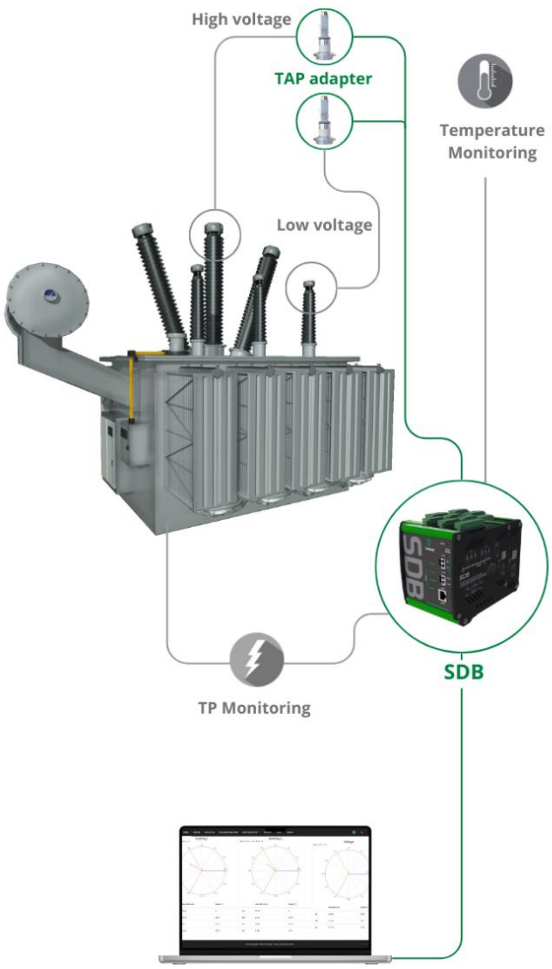


Figure 1 - System topology

Bushings are fundamental components in high-voltage equipment, being widely used in power transformers and shunt reactors. Their main function is to enable the passage of electric current between the external environment and the interior of the equipment, while simultaneously ensuring the necessary electrical insulation from the casing.

Due to this essential function, bushings are subject to high dielectric stresses, making any insulation failure a critical factor for the integrity of the equipment. A problem in this structure can result in severe damage and, in extreme situations, cause the total destruction of the equipment. In the case of power transformers, for example, the financial losses resulting from a dielectric failure can be hundreds of times greater than the cost of the bushing that caused the problem itself.

To mitigate these risks, the SDB (Smart Device Bushing) was developed, an advanced monitoring system capable of detecting variations in leakage current, tangent delta, and capacitance. This continuous monitoring allows for the identification of potential insulation faults at an early stage, contributing to the reliability and longevity of high-voltage equipment. It is performed in an integrated manner, analyzing all three bushings in the three-phase system. By comparing the measurements between them, the SDB can detect even subtle changes, making the maintenance process safer, more efficient, and more reliable.

2.2 Features

Robust hardware

The SDB design meets EMC (Electromagnetic Compatibility) standards to withstand harsh electromagnetic conditions in substations and operating temperatures from -40 to 85°C.

Compact and versatile

The SDB has compact dimensions, providing space savings and reduced installation costs.

International standards met

IEEE C57.91:2011 and IEC 60076-7:2018; UL-508.

National standards met

ABNT NBR 5416:1997 and ABNT NBR 5356-7:2017.

Expertise in embedded systems

Treetech has specialists in embedded operating systems with extensive experience in the field. This knowledge has been incorporated into SDB, making it an extremely secure and stable product, while remaining easy to operate.

2.3 Functions

Monitoring sets

Monitoring of 3 or 6 bushings.

Alarms:

- Emission of alarms in case of abnormalities with indication from relays;
- Adjustable timing, allowing identification of fast or very fast evolving faults.

Self-diagnoses

They detect internal faults with indication from a relay.

PT monitoring

In addition to current measurement, the SDB also measures voltage and makes the data available for analysis on its web interface.

Temperature measurement

The SDB features a PT100 input, enabling temperature measurement for various applications.

TRIP relay

Relay equipped with TRIP function triggered by alarms due to currents.

2.4 Inputs, outputs and communication

2.4.1 Inputs

- ✓ 2 Current input sets for two three-phase bushing sets (primary and secondary);
- ✓ 1 Three-phase voltage input set.
- ✓ 1 PT100 sensor input.

2.4.2 Outputs

- ✓ 4 configurable output contacts (NO) for alarms due to absolute values, high evolution trends, or high or very high bushing leakage currents;
- ✓ 1 fixed output contact (NC) for self-diagnosis;

2.4.3 Communication

The SDB offers three models with varying Ethernet communication ports; all support the Modbus RTU/TCP and DNP3 RTU/TCP communication protocols, as well as IEC Goose Publisher and IEC MMS Server.

- ✓ **FO FO:** 2 Ethernet Fiber Optics (UL)

Figure 2 - SDB FO FO

✓ **FO SR:** 1 Ethernet Fiber Optic + 1 Serial Fiber Optic

Figure 3 - SDB FO SR

✓ **RJ45:** 2 Ethernet RJ45

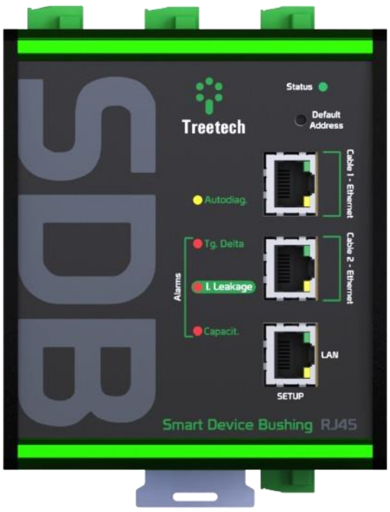


Figure 4 – SDB RJ45

In addition to these, the SDB also has:

✓ 1 RS-485 for communication via Modbus/DNP3 RTU protocols;

✓ 1 RS-485/RS-232 for communication via Modbus/DNP3 RTU protocols;

✓ 1 Ethernet RJ45 port for **parameterization.**

3 Design and installation

3.1 Installation and removal of terminals

The terminals have screws to ensure better fixation, so care must be taken during installation and removal:

- ✓ Use a 2.5 mm flathead screwdriver;
- ✓ Before removing the terminals, check that the screws are completely loosened;
- ✓ Forcing removal with the screws tightened may damage the SDB.

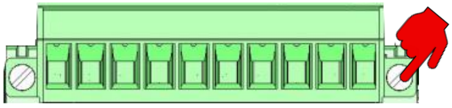


Figure 5 - Terminal with screws

3.2 Mechanical installation

3.2.1 Standard DIN rail installation

This equipment is compatible with standard DIN rail mounting and can be located on mounting plates inside panels. It is important to ensure that the SDB is securely attached to the rail; if there are no other IEDs nearby, the use of a rail lock is also recommended. After mounting, proceed with the electrical installation.

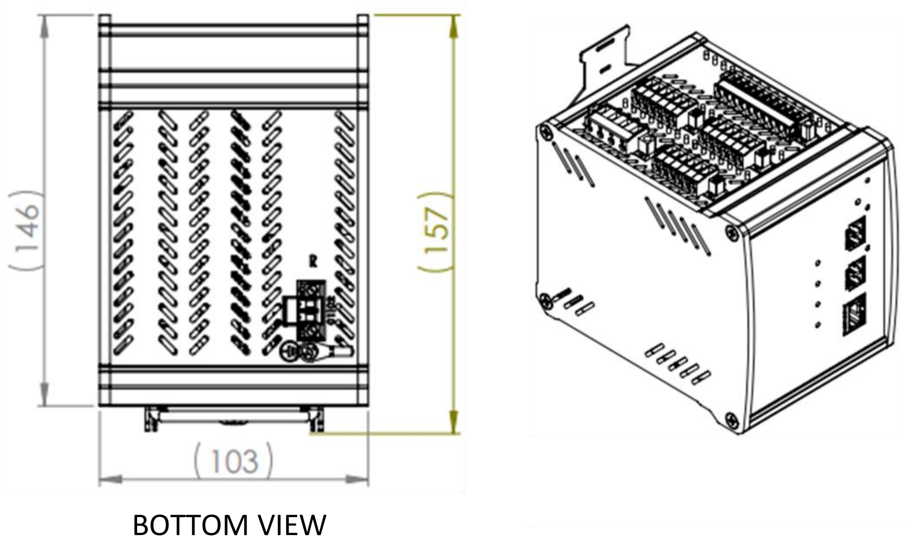


Figure 6 - DIN rail installation

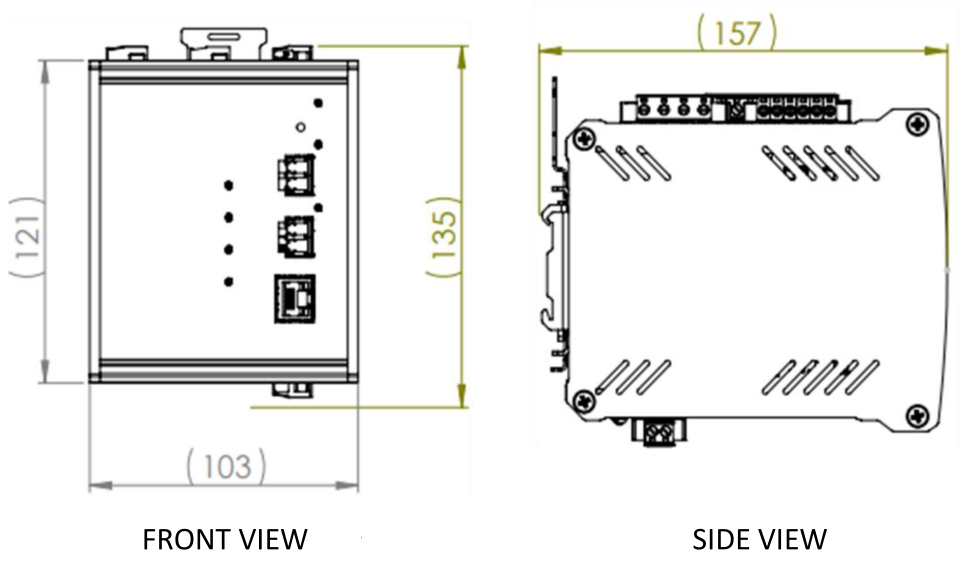


Figure 7 - DIN rail installation, front and side views

3.2.2 Panel-mounted installation

The equipment can be installed fitted into panels, such as doors or front panels. It is important to observe the thickness of the panel's paint, as very thick layers can hinder insertion. It is also essential to ensure a firm fixation before carrying out the electrical installation. The dimensions of the equipment and the cutout required for mounting are presented below.

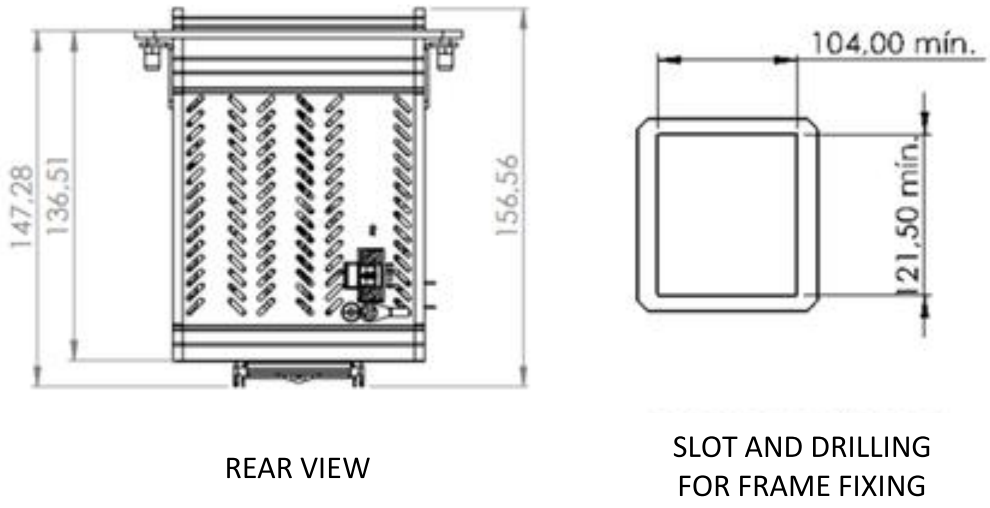


Figure 8 - Panel installation, bottom view and slot

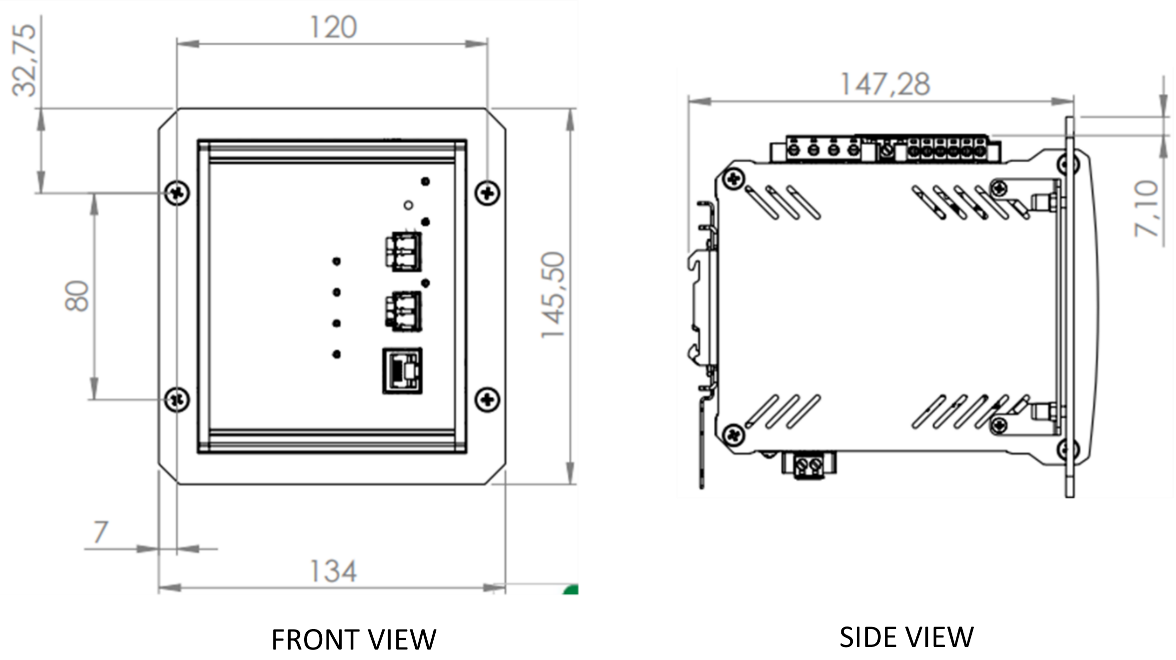


Figure 9 - Panel installation, front and side views

3.3 Electrical installation

Some special precautions must be taken for the design and installation of the SDB, as described below:

The connection terminals are installed on the top of the SDB, in three removable connectors, to facilitate installation. Cables from 0.3 to 2.5 mm² can be used, following good installation practices.

Study and understand the application in which you intend to use the SDB, and learn about its functional, electrical, and configuration characteristics. This way you will be able to take full advantage of the equipment and minimize risks to your safety.

The following circuit breaker specification is recommended when used exclusively for the SDB:

• AC/DC Power Supply, Phase-Neutral: Single-pole circuit breaker, 1 A ≤ In ≤ 2 A, curve B or C, standards NBR/IEC 60947-2, NBR/IEC 60898 or IEEE 3004.5;
• AC/DC Power Supply, Phase-to-Phase: Bipolar circuit breaker, 1 A ≤ In ≤ 2 A, curve B or C, standards NBR/IEC 60947-2, NBR/IEC 60898 or IEEE 3004.5.

A circuit breaker should be used immediately before the power input (Universal power supply - 85 ~ 250 Vdc/Vac, <12 W, 50/60 Hz).

The circuit breaker must have the number of poles corresponding to the number of phases used in the power supply, and the poles must only interrupt the phases, never the neutral or ground. It must provide thermal and electrical protection to the conductors supplying the equipment and must be located near the equipment and easily maneuverable by the operator.

Additionally, it must have indelible identification showing that it is the SDB's electrical disconnect device.

3.3.1 Table for Cable Specifications

Tabela 2 - Cable Specifications

Cable specifications		
Function	***Specification***	***Observation***
Power supply	1.5mm^2 to 2.5mm^2	-
TAP adapter	**Exposed to the weather:** Shielded cable (BTC), 2 x 18 AWG, EPR 90°C insulation, 0.6/1 kV. **Protected from the weather:** Shielded cable (BTC), 2 x 18 AWG, PVC insulation.	Mandatory, referring to NBR7286
Three-phase voltage signal	1.5mm^2	-
PT100	**Exposed to the weather:** 3x16 AWG cable with EPR insulation **Protected from the weather:** 3x18AWG cable with PVC insulation	This specification is mandatory and covers distances up to 265m. For greater distances, cables sized according to the installation requirements must be used. If you have any questions, contact the Treetech team; see Error! Reference source not found.
Relays	**1.5 mm²:** Minimum gauge for signaling (self-diagnoses, alarms...) **2.5 mm²:** Minimum gauge for power circuits (TRIP relay)	Recommended according to the specification in NBR5410

RS485/232	2x18AWG PVC Cable	It is recommended to consult the topic Error! Reference source not found. for installation

3.3.2 Wiring diagram

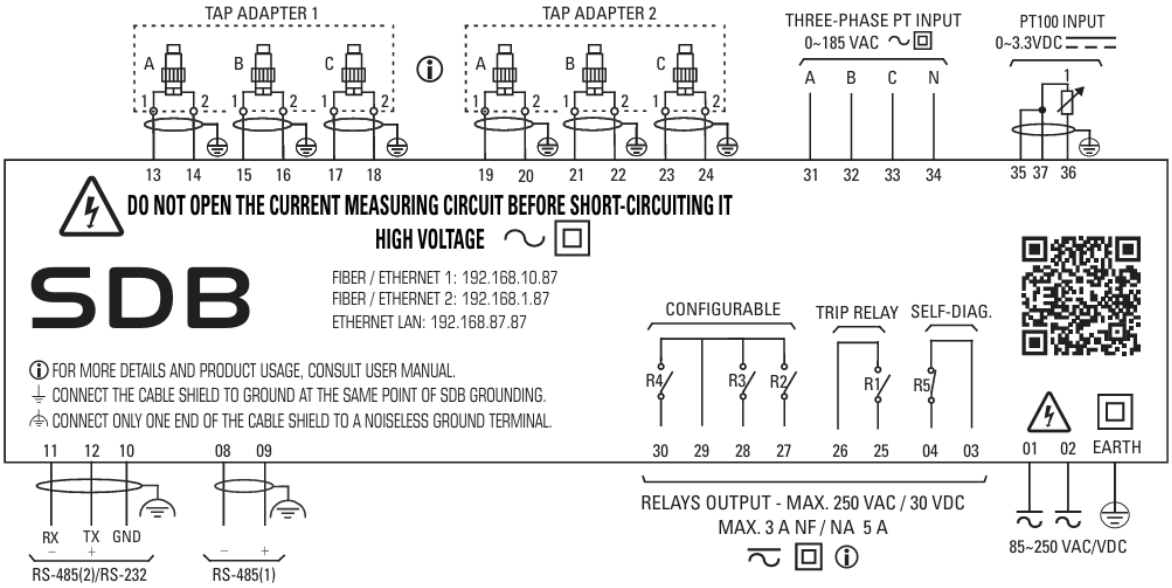


Figure 10 - SDB wiring diagram

3.3.3 Input terminals

Table 3 - Input terminals

Inputs	
Power supply Universal power input – 85 ~250 Vac/Vdc, 50/60Hz, 12 W	01 – Vac/Vdc 02 – Vac/Vdc
Bushing set (1)	13 – Signal input (Adapter A) 14 – Common input (Adapter A) 15 – Signal input (Adapter B) 16 – Common input (Adapter B) 17 – Signal input (Adapter C) 18 – Common input (Adapter C)
Bushing set (2)	19 – Signal input (Adapter A) 20 – Common input (Adapter A) 21 – Signal input (Adapter B) 22 – Common input (Adapter B) 23 – Signal input (Adapter C) 24 – Common input (Adapter C)
Three-phase voltage input This is a three-phase voltage input, where each of the three inputs corresponds to	31 – Phase A 32 – Phase B

phases A, B, and C of a set of three-phase bushings. This input allows the measurement of amplitudes and phase shift angles between the phases.	33 – Phase C 34 – Neutral
Input for PT100 Input for direct connection of a PT100 Ω sensor at 0 °C, in a three-wire measurement configuration.	35 – Common 36 – VM 37 – VR

3.3.4 Output terminals

Table 4 - Output terminals

Outputs	
Self-diagnosis relay Relay (NC), signals internal faults, power supply issues, or problems with the connection cables.	03 – Common 04 – Relay 5 (NC)
TRIP Relay This normally open (NO) relay has the function of switching off the transformer and is activated when an alarm is triggered by high or very high leakage current.	25 – Relay 1 (NO) 26 - Common
Programmable signaling relays Normally Open (NO) relay with programmable function. Programming instructions for these relays can be found in Error! Reference source not found..	27 – Relay 2 (NO) 28 – Relay 3 (NO) 29 – Common 30 – Relay 4 (NO)

3.3.5 Communication

Table 5 - Communication terminals

Communication	
RS-485 Connection to data acquisition system, Modbus RTU or DNP3 protocols, using shielded twisted-pair cable.	08 – (-) 09 – (+)
RS-485 or RS-232 The SDB also has an RS-232 communication port for connection to any control, supervisory, or monitoring system; use a shielded, three-wire twisted-pair cable.	10 – GND (RS-232) 11 – RX (RS-232) / - (RS-485) 12 – TX (RS-232) / + (RS-485)

Ethernet Communication port via RJ45 or SC multimode fiber optic cable for communication between the SDB and the control/supervisory system or communication with the IEDs. Output protocols: Modbus® TCP (slave), Modbus® TCP/RTU (slave), DNP3 TCP (outstation), and IEC 61850 (server and publisher). Connection to data acquisition system, Modbus RTU or DNP3 protocols.	Available on all models, see Communication section.
Serial fiber optic port Multimode fiber optic communication port (SC) for communication between the SDB and the control/supervisory system or communication with the IEDs. Output protocols: Modbus® RTU (slave), DNP3 RTU (outstation).	Available only in the FOSR model, see models in Communication.
Ethernet port for configuration (setup) The RJ45 (LAN/setup) port is present on all models and is intended exclusively for equipment configuration; it is not used for collecting or transmitting operational data.	

Communication with the data acquisition system

Up to 31 devices can be interconnected on the same communication network. The communication protocols available for this connection are Modbus® and DNP3.

The connection between the SDB and the data acquisition system must be made using a shielded twisted-pair cable, maintaining an uninterrupted shield throughout the entire length. If intermediate terminals are needed for serial communication interconnection, the cable shield should also pass through the terminal to avoid interrupting the connection.

In conjunction with the termination resistors, pull-up and pull-down resistors should be used at only one point in the network, as shown in Figure 11.

The 5V DC power supply for the pull-up and pull-down resistors can be internal to the data acquisition system. Note that some communication equipment may already have these resistors installed internally, eliminating the need for external resistors. A maximum distance of 1200 m between the ends of the communication network must be observed.

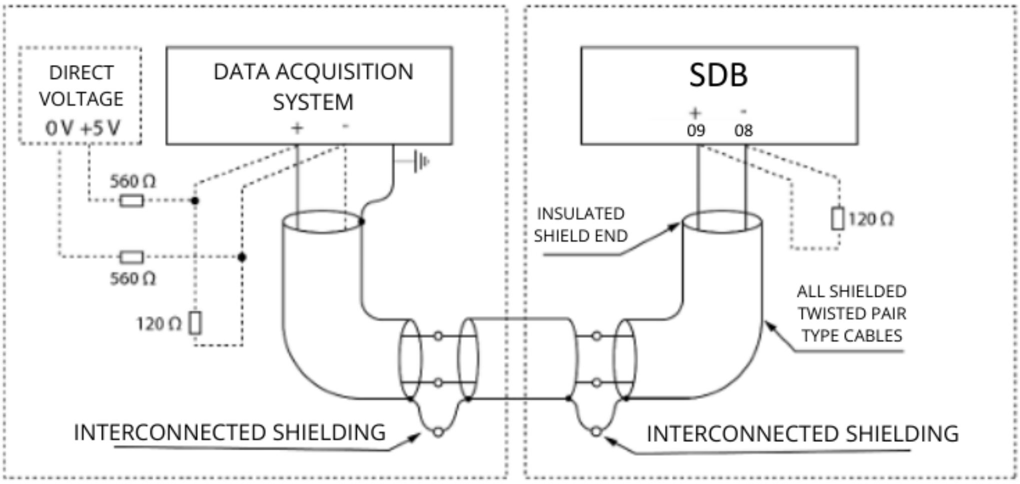


Figure 11 - Connection and grounding of the RS-485 serial communication shield

3.3.1 Temperature sensor

The SDB has an input for a Pt100 Ω at 0 °C RTD temperature sensor. The sensor must be connected to the SDB with shielded cables, maintaining a continuous shield and grounding only at the end connected to the equipment. If intermediate terminals are used, the shielding must pass through them without interruption, and the unshielded sections should be as short as possible. The maximum permissible resistance per path is 3 Ω (6 Ω in the total path between the PT100 and the SDB).

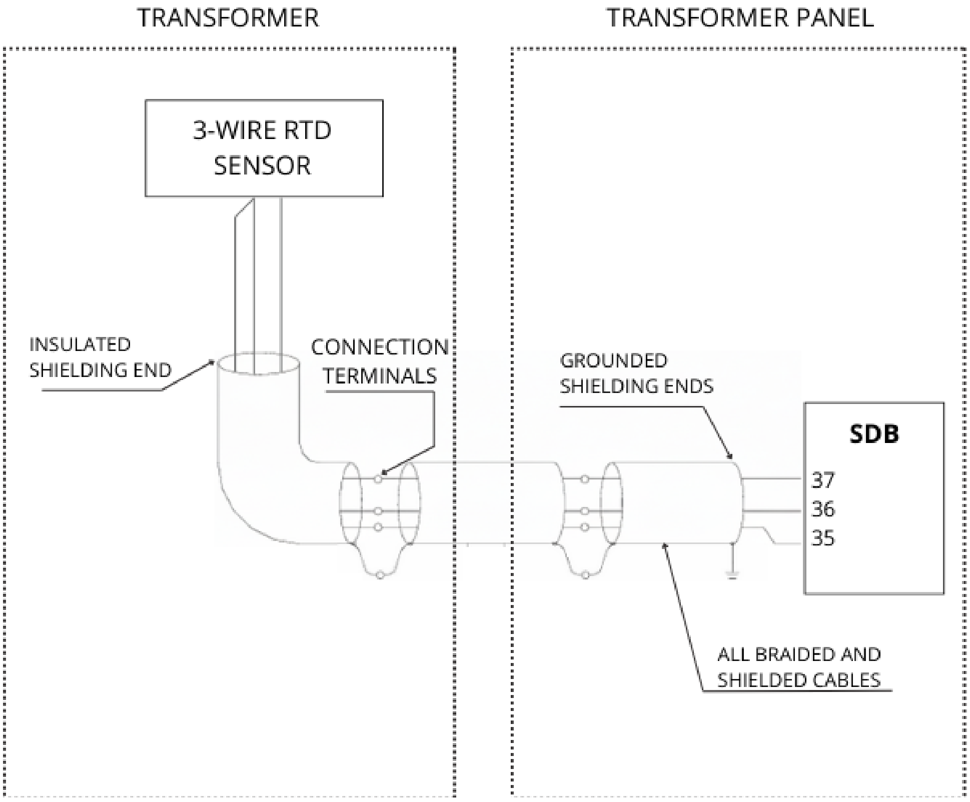


Figure 12 - Cable and shield connection and grounding details

3.4 TAP adapter

The tap adapter is an essential accessory for the operation of the SDB; it is responsible for establishing the electrical connection with the bushing tap, and also ensures mechanical rigidity and sealing against weathering. This equipment has internal protections against overvoltages and overcurrents resulting from transient phenomena, and also has a safety system against accidental opening of the measuring circuit, the tap-opening protection. This protection directs the leakage current through a low-impedance path, allowing the system to continue operating indefinitely, although it is advisable to take immediate action.

Figure 13- DP-141 TAP Adapter

3.4.1 Mechanical installation

Mechanical installation of the TAP adapter requires the transformer to be de-energized. Carefully remove the capacitive TAP cover and connect the adapter manually, without using tools, to avoid damage to the terminal. It is essential to secure it firmly, but without applying excessive force, and anchor the cables or conduits to nearby structures to reduce stress on the adapter.

3.4.2 Electrical installation

Electrical installation involves connecting the shielded cable between the TAP adapter and the equipment, ensuring effective grounding of the shielding at a single point. A continuity test must be performed on the contact pin to ensure the integrity of the ground connection, verifying the drainage of leakage currents through the common terminal. The entire process must follow electrical safety recommendations and Treetech installation specifications. To learn how to perform the continuity test, see Tap Adapter Installation Procedure.

To ensure the cable's mechanical strength, the use of very small gauges is not recommended, in order to reduce the possibility of accidental opening of the bushing's TAP. The shielding of the connecting cables between the TAP adapters and the SDB should also pass through terminals, avoiding any interruption. The unshielded cable section, due to the splice, should be as short as possible, and the shielding should be grounded at only one end, preferably at the TAP adapter.

ATTENTION: Under no circumstances should the bushing TAP remain open while the bushing is energized. Therefore, it is highly recommended that the cables from the TAP adapters not be connected directly to the measuring modules, but that short-circuitable intermediate terminals (such as those used for current transformer circuits) be used. See Figure 14. This makes it possible to short-circuit the intermediate terminals and divert leakage currents, allowing the measuring module to be taken out of operation even with the bushings energized.

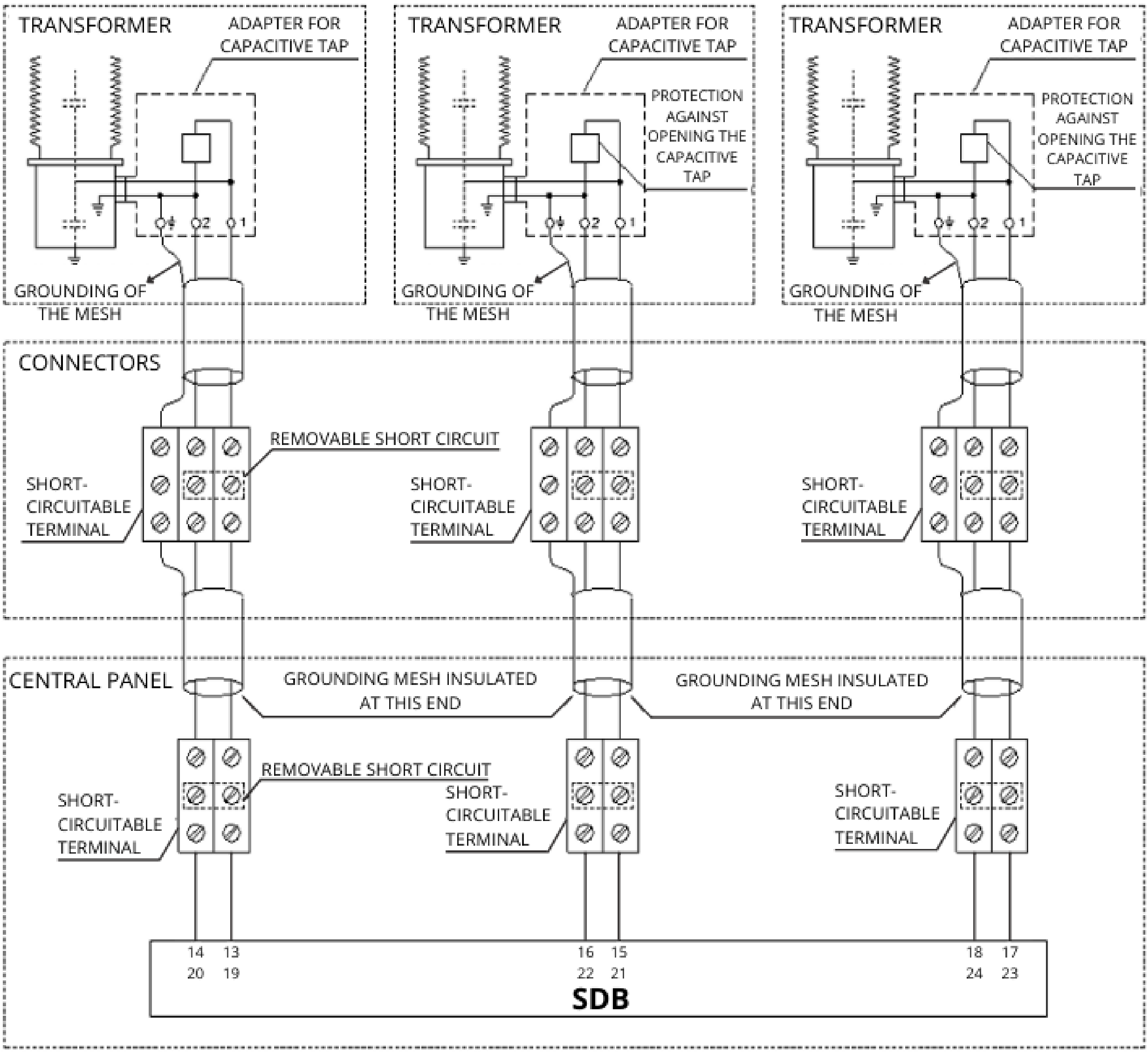
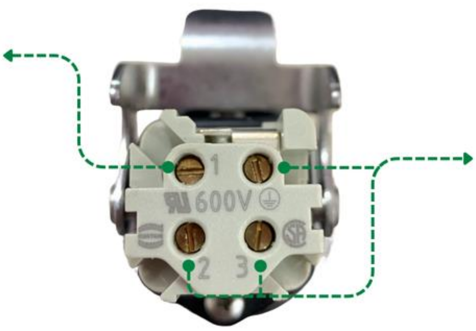


Figure 14 - Wiring and grounding details

3.4.3 TAP adapter socket terminal layout

Terminal 1: Signal terminal, connected to the SDB signal input, see Error! Reference source



Terminals 2, 3 and ground: Connected to each other and to the common SDB, see Error! Reference source not

Figure 15 - TAP adapter socket terminal

4 Operation

All functionalities of the Smart Device Bushing (SDB) are accessed exclusively through its web interface, which provides real-time information regarding measurements, operational status, alarms, and self-diagnosis procedures. The equipment does not have a display or physical keys on its front panel for navigation; the only operation that can be performed directly on the front panel is changing the IP address via the "Default Address" button. Status, alarm, and internal fault signaling is performed simultaneously by the web interface and by indicator lights (LEDs).

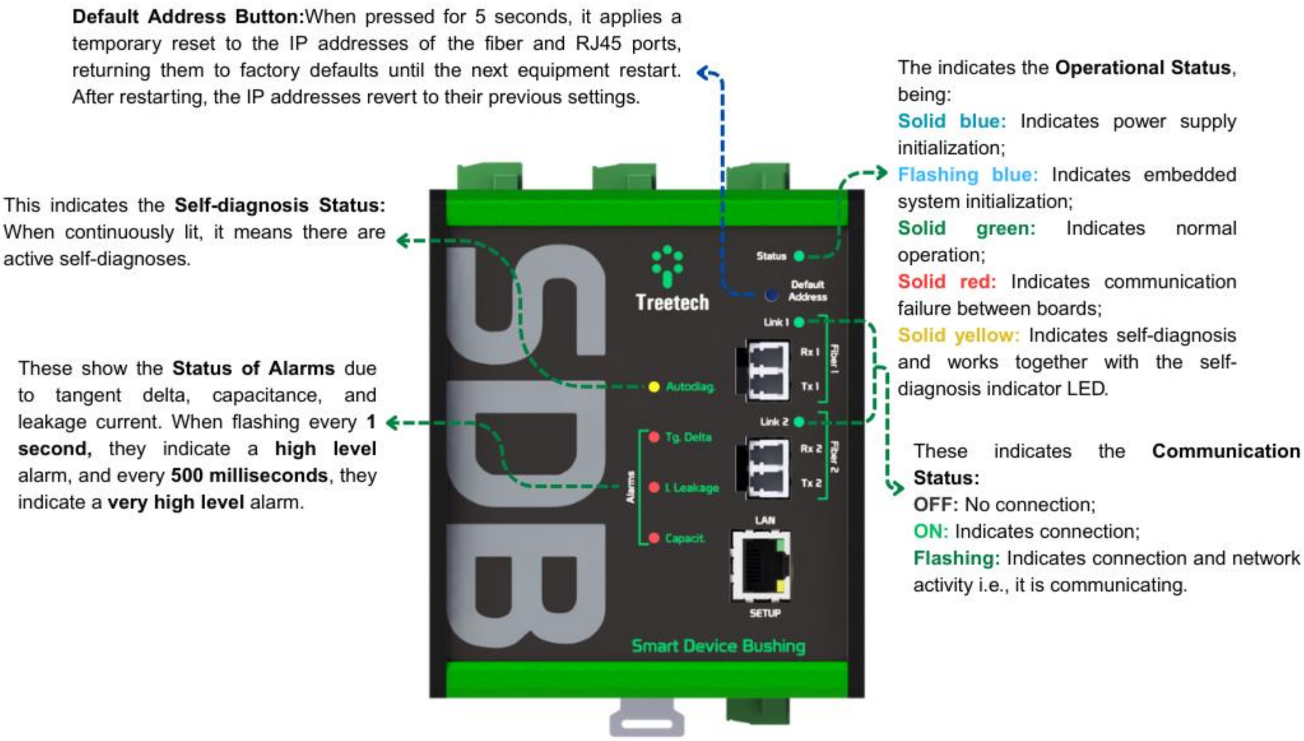


Figure 16 - Arrangement and function of LEDs

4.1 General information about the Web Interface

The Smart Device Bushing (SDB) web interface provides access to all the equipment's functionalities. Through it, it is possible to view real-time measurements, operational status, alarms, and self-diagnoses, whether logged in or not. This tool centralizes the monitoring and configuration of the SDB in a practical and secure way.

Figure 17 - Home screen

4.1.1 Navigation

To facilitate navigation within the SDB web interface, a standardized symbology is used, present in various sections of the system. The display of certain fields and functionalities may vary before and after login, and according to the user's access profile, restricting views or adjustments to those with the appropriate permissions.

Language

The SDB web interface is available in three languages: Portuguese, English, and Spanish. Users can select their preferred language, ensuring greater accessibility and understanding of information during equipment operation and configuration.

Figure 18 - Language tab

Information

This icon provides contextual information about the page and is primarily displayed in settings areas. It is useful for quickly clarifying questions while adjusting parameters.

Figure 19 - Information icon

Status

This indicates the quality of the SDB's internal communication. Using color-coded legends, it's possible to quickly identify if the communication is faulty or unstable. This signaling contributes to rapid diagnosis and greater reliability in equipment monitoring. The following icons are also present in the Online tab and represent the status of the elements displayed in that area.

Poor communication: Communication failure with the equipment;

Unstable communication: Unreliable communication status.

4.1.2 Login

Username and password

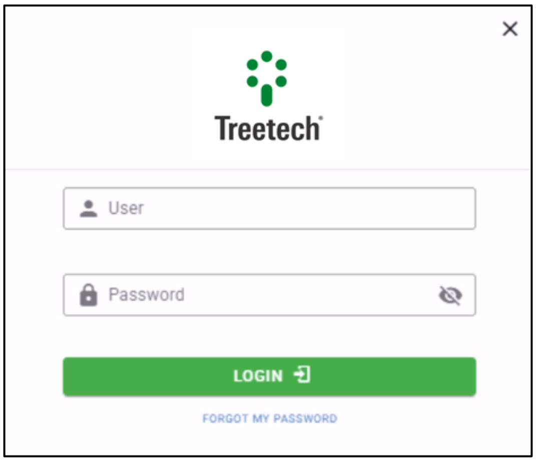


Figure 20 - Login screen

To access more details about the IED and acquire data online through the web page, you need a valid username and password. To do this, simply click the green "Login" button located in the upper right corner of the screen.

A window will appear with fields for user identification and password. After filling in the fields, simply click the green "Login" button again to access the system. The default login details are:

Username: default | **Password:** Default123

User settings

This tab allows you to configure the profile, create users, and restart the device. It becomes available after logging in, and to access it, simply click on the user icon.

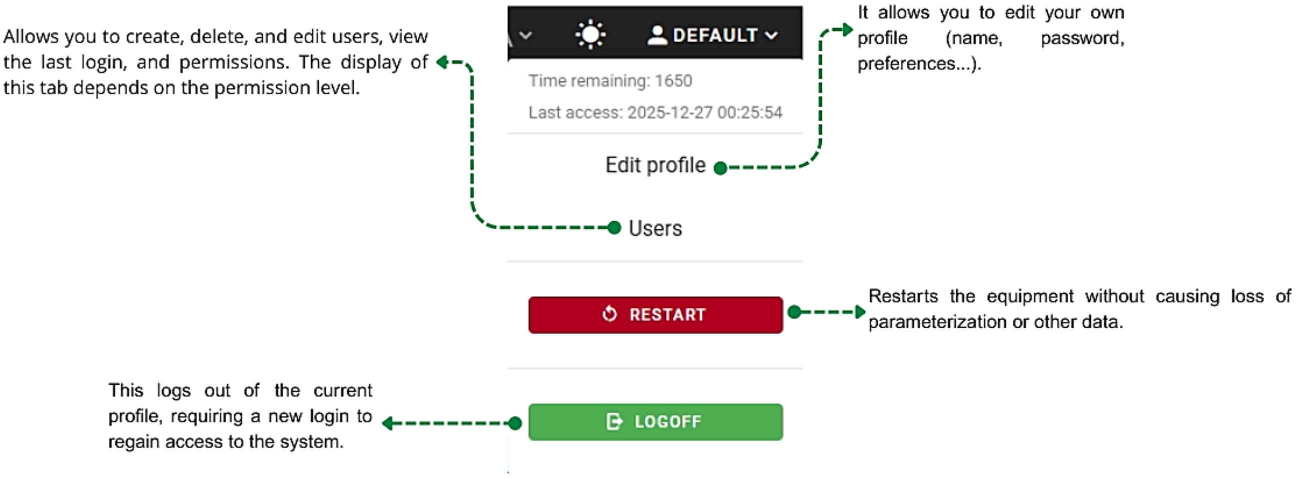


Figure 21 - User tab

Incorrect username and/or password

If the username and/or password are incorrect, a message in a red box will be displayed informing you of the error and the number of attempts remaining. If you exceed the allowed number of attempts (up to 3), your login will be temporarily blocked for approximately 1 minute; you will still be able to log in with another profile if necessary.

Time limit

If the user logs in but remains inactive on the system, the session will expire after ten minutes. In the last thirty seconds, a countdown window will alert them that the session is about to end.

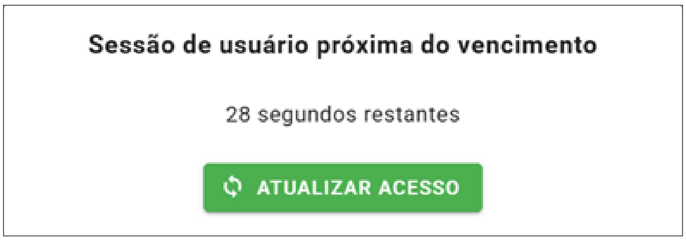


Figure 22 - Time limit

4.1.3 Configuration

The "Configuration" tab, available after login, brings together the general settings of the equipment, allowing the user to define essential parameters for its operation. Here, it is possible to configure the application used, adjust the date and time, define network information, and perform firmware updates. These settings ensure the system aligns with the specific needs of each installation.

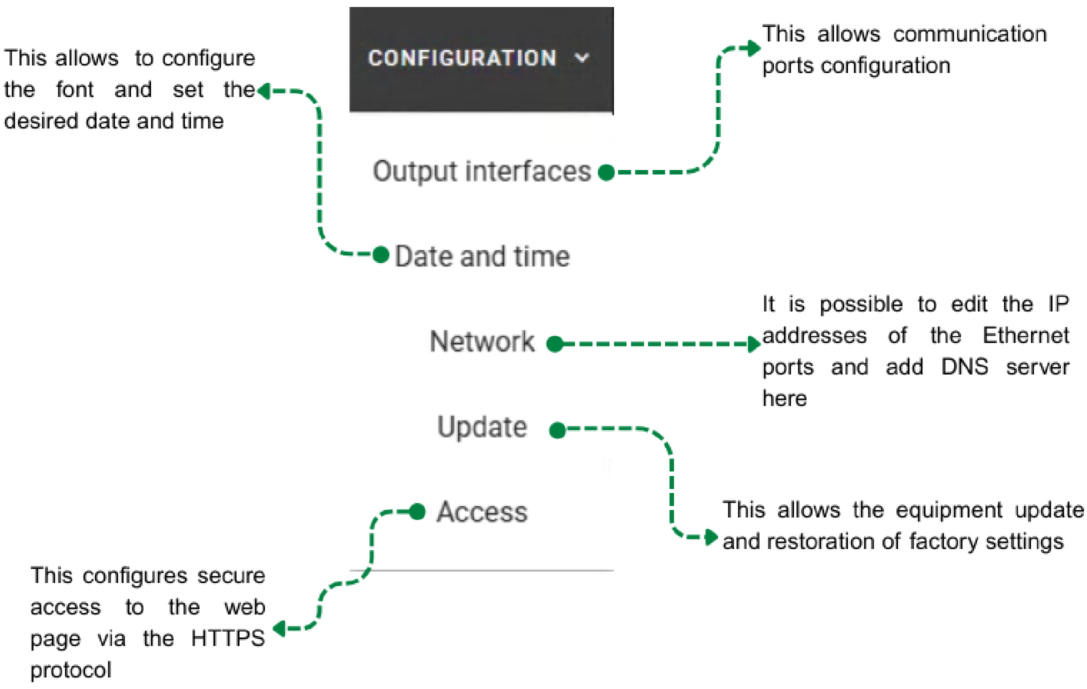


Figure 23 - Configuration tab

4.1.4 Monitoring screen

Display of measurements

The SDB web interface homepage displays, in real time, the currents of the circuits and the phase voltages, with RMS values and angles. Leakage currents are displayed in graphs per phase, as are the A, B, and C voltages. This structure allows for quick and technical monitoring of the system conditions.

Clicking on the measurements applies a zoom feature to the summation, available in factors of 10x, 100x, or 1000x.

Display of alarms and self-diagnoses

The home page also displays alarm and self-diagnosis alerts, which indicate signal abnormalities or internal faults automatically detected in the monitored systems. These alerts are highlighted at the top of the screen for quick identification. Each event is accompanied by the exact date and time it was recorded.

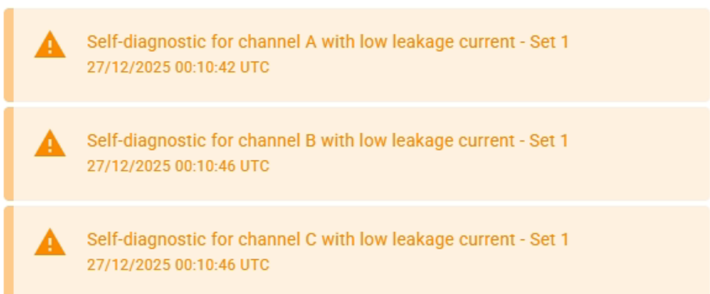


Figure 24 - Display of alarms and self-diagnoses

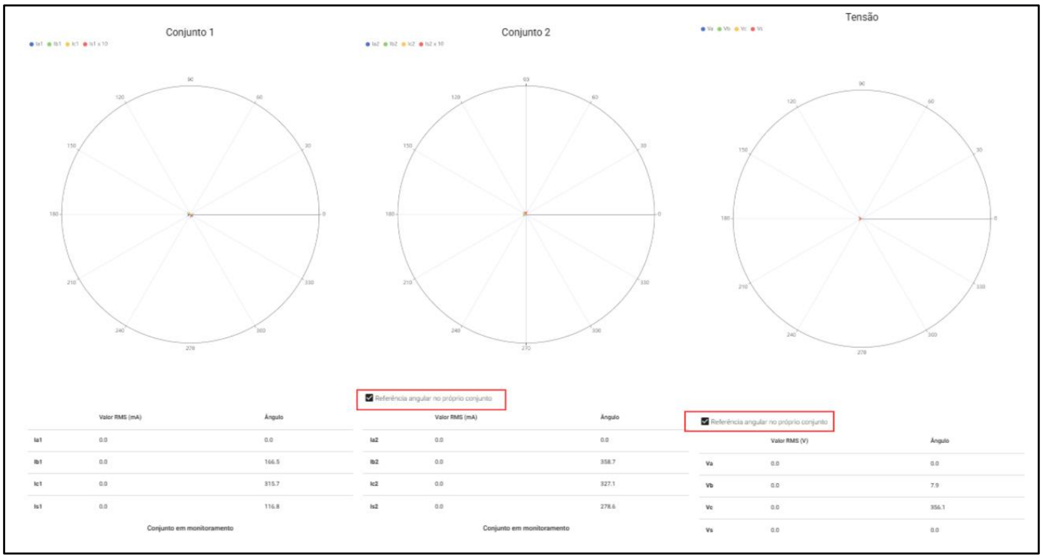


Figure 25 - Display of measurements

On the measurement display screen, two checkboxes associated with the angular reference are also available. Enabling them makes it possible to view the angular reference directly from the set itself, instead of using the general angular reference.

4.2 Application and communication

4.2.1 Application configuration

The application tab can be found in Configuration; clicking on it will display the following screen:

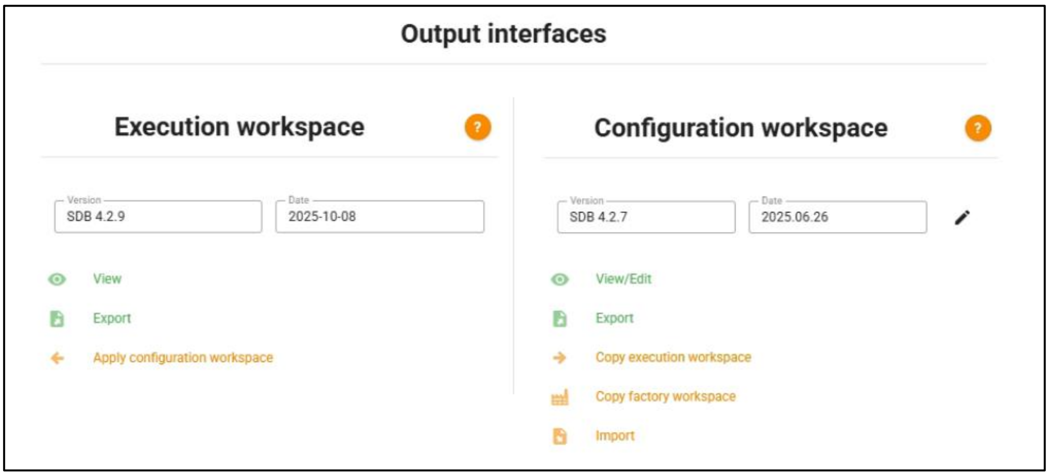


Figure 26 - Application

Running area

Stores the current data being used by system processes and cannot be edited at runtime.

- **View:** Allows observation of the data that is being processed;
- **Export:** Downloads a copy of the current data and serves as a backup for future updates;
- **Apply configuration area:** Applies the settings defined in the "Configuration Area".

Configuration area

This is the area where data can be changed and edited at any time; as long as this data is not applied, it does not interfere with the system's operation.

- **View/Edit:** Allows data observation and enables the user to make changes to the system. Any changes will only take effect after applying the modifications from the configuration area to the running area.
- **Export:** Downloads a copy of the configuration area data, which serves as a backup for any future updates;
- **Copy running area:** Copy to the configuration what is being used in the running area;
- **Copy factory area:** Clears the current configuration and restores the factory settings;
- **Import:** Allows importing the (.back) file; for security reasons, it is encrypted.

4.2.2 How to configure communication

Configuration area

In the settings area, click on “View/edit”, then click on “add”.

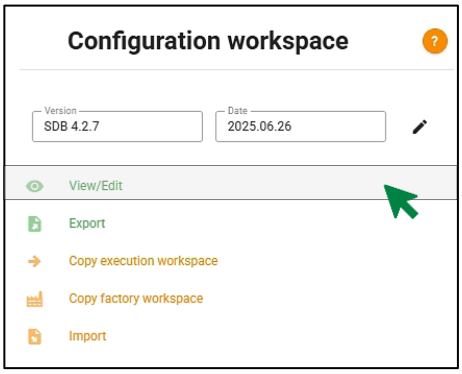


Figure 27 - Configuration area

Configuring the output

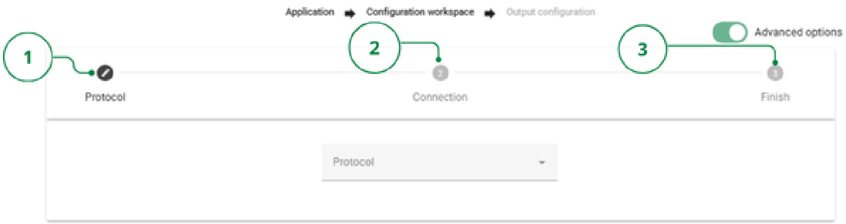


Figure 28 - Output configuration

1. **Protocol selection**

   To begin the configuration, first select one of the following available protocols:

   - Modbus;
   - DNP3;
   - IEC;
   - Other.

2. **Connection configuration**

   After choosing the protocol, the next step is to adjust the connection parameters, which vary depending on the selected protocol.

3. **IED**

   Finally, select the SDB, configure the name, and set the address, if applicable.

4.3 Online tab

The Online tab displays active alarms, self-diagnoses, voltage and temperature measurements, and bushing measurements such as capacitance and tangent delta, allowing for centralized monitoring and rapid response to anomalies.

4.3.1 Data status

As described in the Error! Reference source not found. section, it is possible to track the communication status of the equipment. Similarly, the displayed parameters can also be monitored in real time, as demonstrated below.

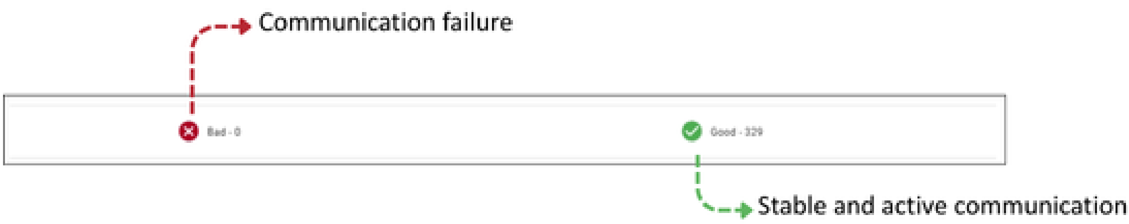


Figure 29 - Data communication status

4.3.2 Data layout

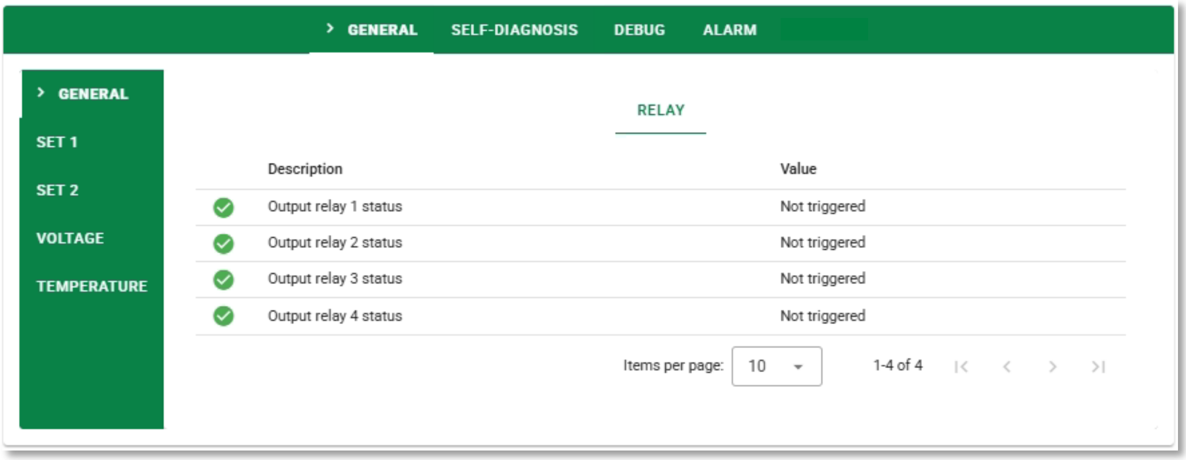


Figure 30 - Information panel

The online tab has a panel that organizes alarms, self-diagnoses, measurements, and debug information, allowing for continuous and efficient monitoring of operating conditions. The following image shows what each tab contains horizontally.

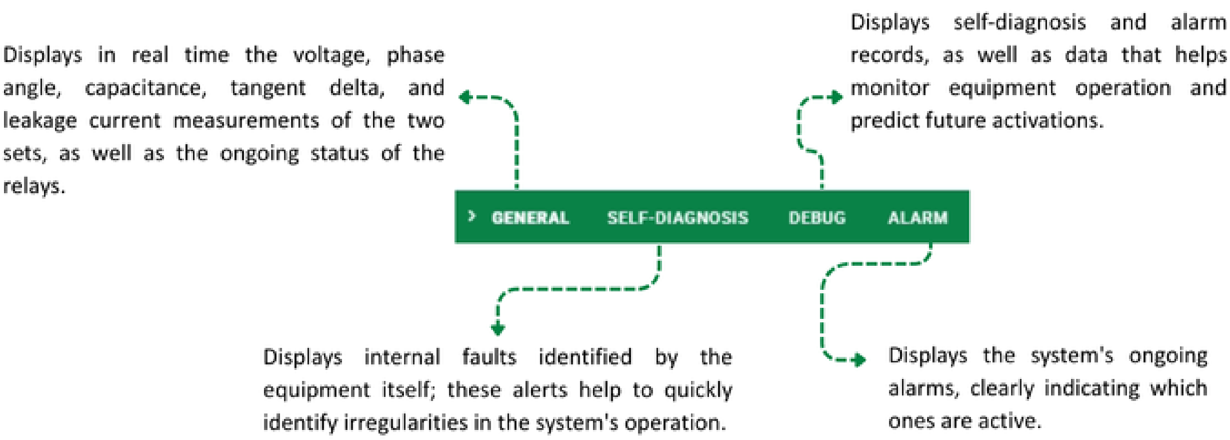


Figure 31 - Horizontal guides for the Online tab

In the vertical part of the panel, the sections are divided as follows:

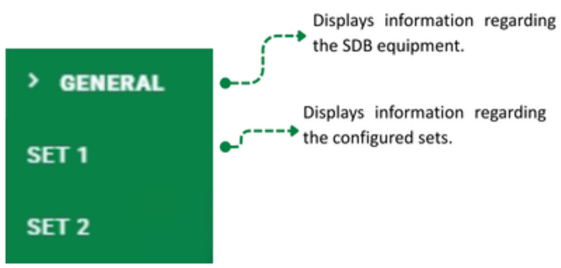


Figure 32 - Vertical guides for the Online tab

It is also possible to use filters to find the desired data more quickly and efficiently.

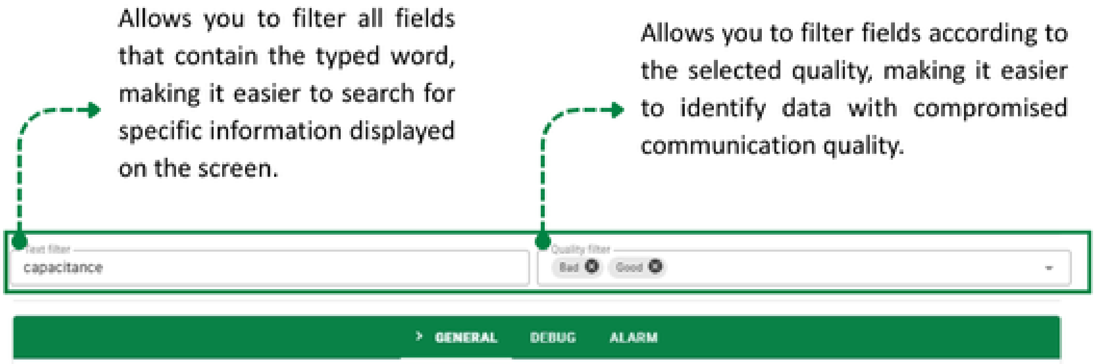


Figure 33 - Filters by text and quality

4.4 Analysis tab

This tab allows for graphical visualization of the data recorded in sets 1 and 2, as well as voltage measurements. The user can select and explore the desired variables within a maximum interval of 31 days. It is also possible to download the information and graphs presented. If no data is available for the selected period, the message "no data to display" will be shown.

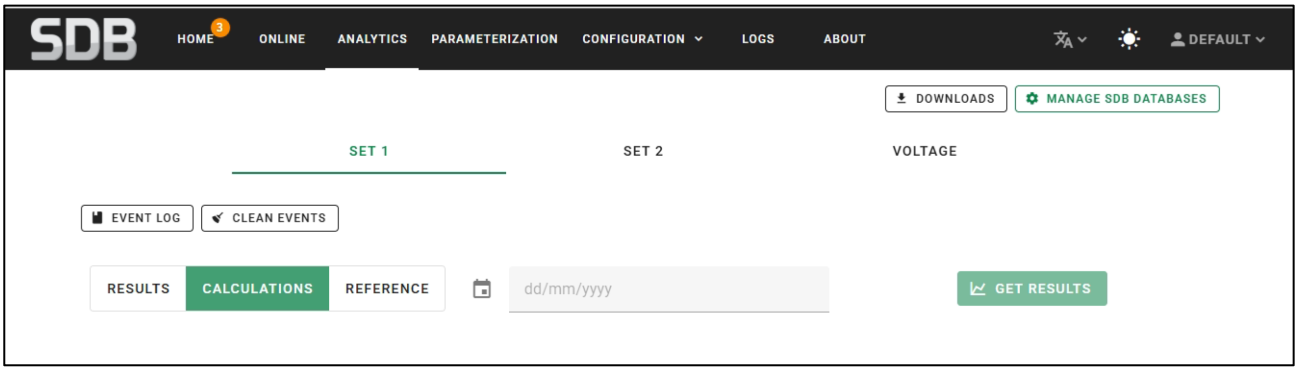


Figure 34 - Analysis tab

4.4.1 Downloads

For a more detailed analysis, the user can download the available records; simply select the desired item and start exporting the data.

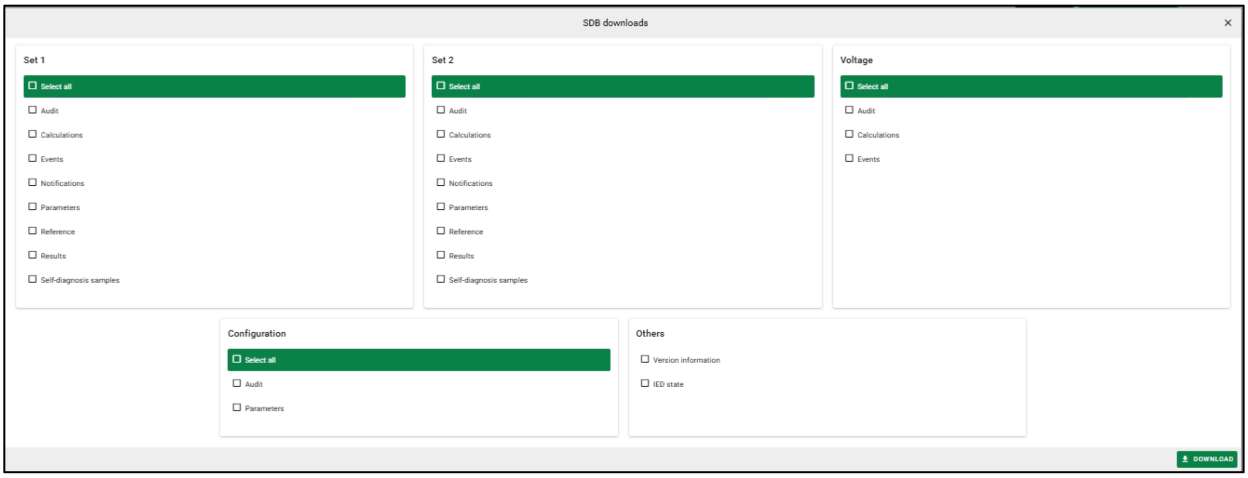


Figure 35 - Downloads area

- **Audit**: Contains detailed records of operations performed on the equipment, allowing for the tracking of actions performed by users over time;
- **Calculations**: Stores the values of measurements taken by the equipment, used for analysis and verification of the behavior of the monitored sets;
- **Events**: Gathers records automatically generated by the system, such as alarms, self-diagnoses, and other events relevant to the equipment's operation;
- **Notifications**: Contains records of notifications for alarms, self-diagnoses, and their respective memories;
- **Parameters**: Contains the ongoing values of the equipment parameters, allowing you to monitor configured settings;
- **Reference**: Stores previously saved reference values in the system, serving as a comparative basis for measurement and calculation results of the sets;
- **Results**: Combines the calculated values of tangent delta and capacitance for evaluating the dielectric condition of the monitored sets;
- **Self-diagnosis samples**: Contains detailed records captured at the moment a self-diagnostic tool is activated, allowing for analysis of the equipment's operational status at the time of the event;
- **Version information**: Displays the version history of middleware used on the device, facilitating the control of updates and the traceability of changes in the system.

4.4.2 Managing SDB databases

If necessary, it is possible to transfer databases from one device to another by exporting or importing, thus preserving the learning history, configurations, and user-defined settings.

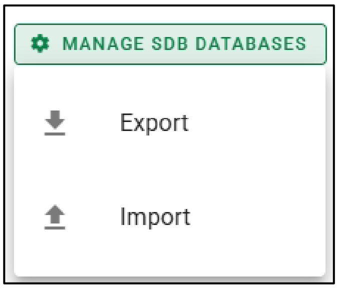


Figure 36 - Manage database

4.4.3 Analysis of sets

It allows you to graphically obtain the calculations and results for a given period, provided that this period does not exceed 31 days.

Event log

It displays messages related to events that occurred in the sets, such as self-diagnoses, alarms, reading errors, commands, among others, also indicating the date and time they occurred.

Figure 37 - Event log button

Results

It graphically displays the results of the calculations (tangent delta and capacitance), allowing you to analyze their evolution over time.

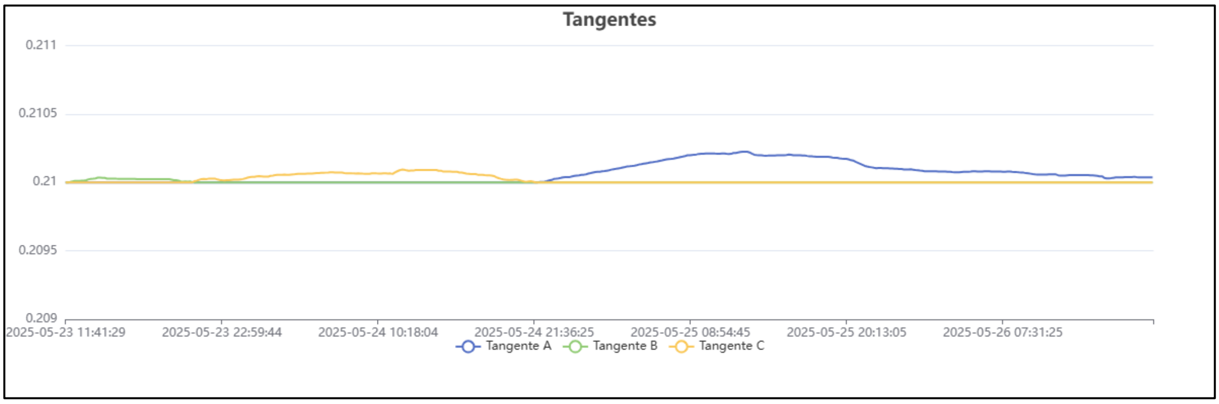


Figure 38 - Result of the evolution of the tangent delta displayed in a graph

Calculations

It graphically displays current sum measurements, phase currents, and frequency, allowing for analysis of variations over time.

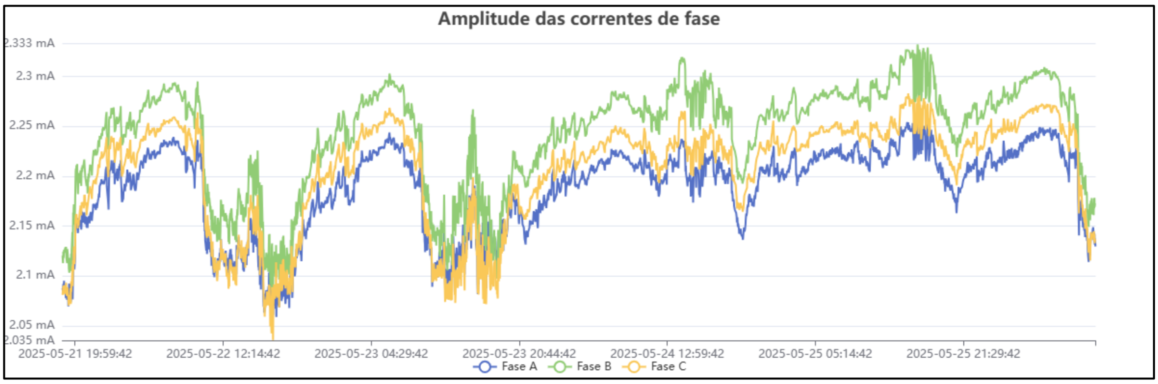


Figure 39 – Measurement of phase currents displayed in a graph

Reference

Displays the signals measured by the SDB during the learning period.

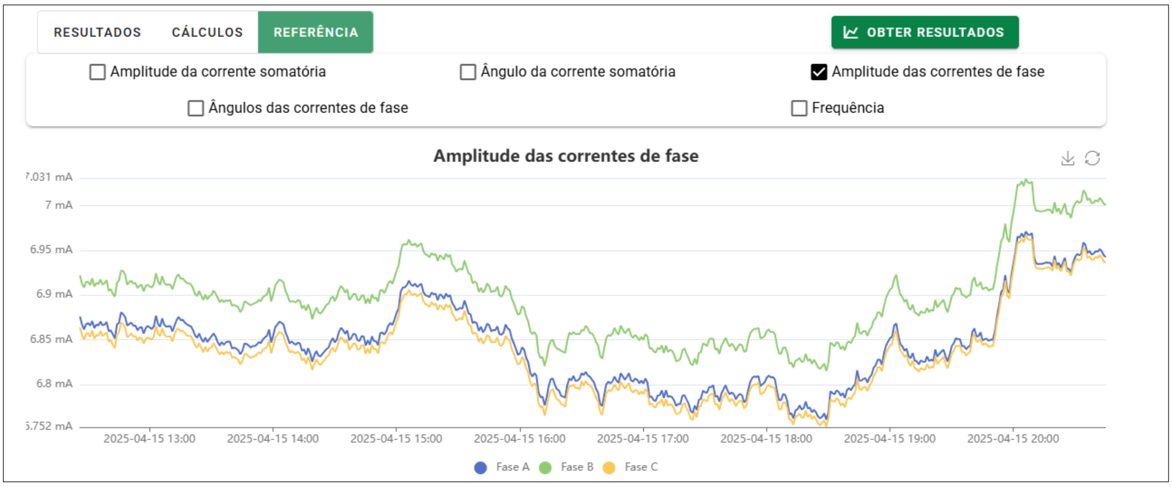


Figure 40 – Measure of reference values

It is possible to compare the calculations with the reference values, allowing you to validate whether the values presented in the measurements and the SDB activations (such as alarms) are consistent.

Figure 41 - Comparison of reference value measurements

4.4.4 Analysis of voltage

In this tab, it is possible to graphically analyze the voltage values of phases A, B, and C, as well as the variation and phase shift over time.

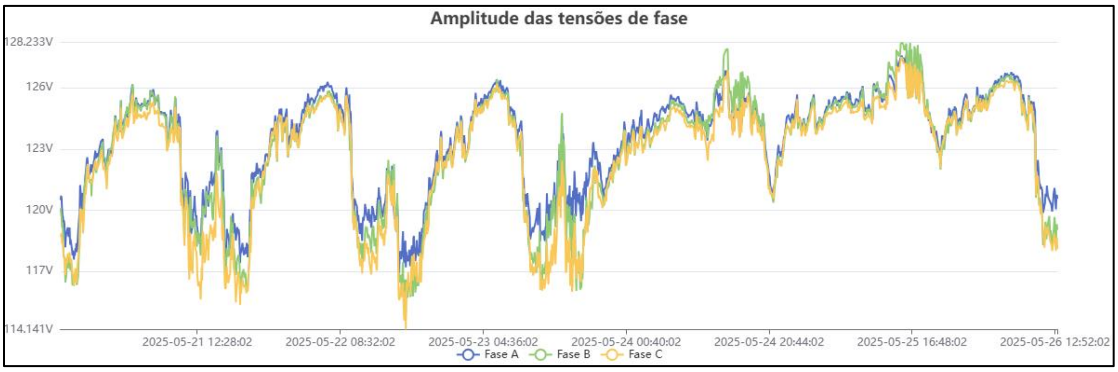


Figure 42 - Amplitude of phase voltages displayed in a graph

In both the voltage analysis and set analysis tabs, if no data is available for the specified period, the message below will be displayed.

Figure 43 - Message displayed

5 Parameterization

To ensure the correct operation of the system, the Smart Device Bushing (SDB) requires the adjustment of several parameters, which provide the necessary information for its proper functioning and continuous monitoring. All adjustments and configurations are performed exclusively through its web interface; to access it, follow these steps:

- ✓ Connect the SDB to the network through any of its communication ports;
- ✓ Type the device's IP address into any browser; it's important to verify that the device used for access is connected to the same network as the SDB;
- ✓ Log in with your username and password (see Error! Reference source not found.) and access the settings tab, highlighted in the image below.

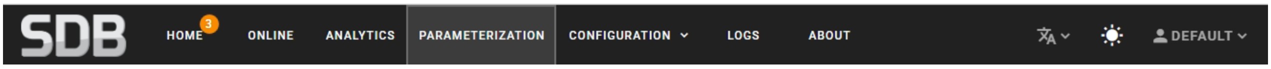


Figure 44 - Parameterization tab

For the first access to the web interface, use the default IP address, being:

- **RJ45:** 192.168.87.87
- **Fiber 1:** 192.168.10.87
- **Fiber 2:** 192.168.1.87

After the first access, if desired, it is possible to change the device's IP address (see Error! Reference source not found.).

5.1 Submitting and validating parameters

Submitting parameters

For a parameter change to take effect in the SDB, it is necessary to click the "Submit" button on each screen where the modification is made. The system saves parameters individually per screen, not globally. This means that if you navigate to a new tab without clicking "Submit," the previously made changes will not be saved.

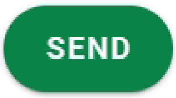


Figure 45 Submit button

Validating parameters

All changes must respect the limits previously defined for each parameter. If the entered value is outside the allowed range, the system will not allow the configuration to be sent. This validation prevents operational errors and ensures the safety and stability of the equipment's operation.

This icon is common on configuration screens and is a visual indicator that there are parameters pending submission, meaning they have been changed but not yet saved.

5.2 General parameterization

The general parameterization of the SDB encompasses the essential adjustments for the proper functioning of the system, bringing together the basic operating configurations, criteria for automatic alarm activation, and guidelines for general diagnoses. These parameters define the equipment's behavior in response to operating conditions, events, and faults, allowing the user to customize monitoring according to the transformer's characteristics and requirements.

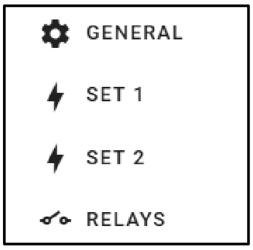


Figure 46 - General parameterization

5.2.1 Basic

Basic parameter settings allow you to configure essential commands for the sets, such as resetting alarm and self-diagnosis memories, restarting the learning process, activating the automatic alarm mode, and adjusting the hysteresis. These settings ensure flexibility and precision in system monitoring.

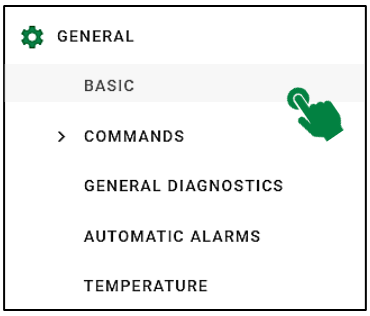


Figure 47 - Basic parameterization

Enable monitoring of set 'x'
Parameter that enables monitoring of the sets.
Adjustment range: Enabled, disabled
Default: Disabled

Enable automatic alarm mode (Leakage current/Capacitance/Tangent delta)
Parameter that enables the automatic alarm mode.
Adjustment range: Enabled, disabled
Default: Disabled
If all these parameters are disabled, the **The self-diagnosis** for inconsistent sum will only be triggered when the parameterized values for self-diagnosis of proportion inconsistency and sum disparity are reached simultaneously.
Automatic alarms_screen will not be displayed. To manually configure the alarms, it is necessary to disable automatic mode.

Time constant for calculating evolution trends
Defines the time constant of the digital filter that smooths temporary variations in capacitance and tangent delta, preventing unwanted trend alarms.
Adjustment range: 0 to 120 days
Default: 30 days

Alarm hysteresis
Parameter that allows the definition of a hysteresis value, preventing alarms from constantly triggering.
Adjustment range: 0 to 20%
Default: 5%

Number of samples of Tangent Delta
Parameter that allows the definition of a value for calculating tangent delta samples.
Adjustment range: 10 to 2600
Default: 2520

Number of samples of Capacitance
Parameter that allows the definition of a value for calculating capacitance samples.
Adjustment range: 10 to 2600
Default: 2520

Time to alarm due to leakage current – High – Set "x"
Parameter that defines a time to trigger the high leakage current alarm.
Adjustment range: 30 to 1800s
Default: 60s

Time to alarm due to leakage current – Very high – Set "x"
Parameter that defines a time to trigger the very high leakage current alarm.
Adjustment range: 30 to 1800s
Default: 60s

5.2.2 Commands

It brings together the functions of direct control over the monitored sets, allowing the resetting of learning and the execution of resets in alarm and self-diagnosis memories.

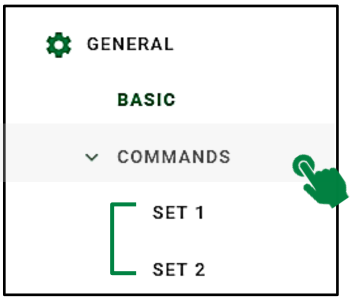


Figure 48 - Commands

Reset of set ‘x’ learning

This parameter sends a command to reset the learning of the sets.
Adjustment range: No command, perform reset.
Default: No command

Reset of averages for the calculation database of set 'x'

When activated, this parameter resets the average calculations for the sets.
Adjustment range: No command, perform reset
Default: No command

Reset of self-diagnosis memory of set ‘x’

When activated, this parameter resets the self-diagnosis memory of the sets.
Adjustment range: No command, perform reset
Default: No command

Reset of alarm memory of set ‘x’

When activated, this parameter resets the alarm memory of the sets.
Adjustment range: No command, perform reset
Default: No command

Reset of tangent delta trend of phase ‘A/B/C’ – Set ‘x’

When activated, this parameter resets the tangent delta trend of the sets.
Adjustment range: No command, perform reset
Default: No command

Reset of capacitance trend of phase ‘A/B/C’ – Set ‘x’

When activated, this parameter resets the capacitance trend of the sets.
Adjustment range: No command, perform reset
Default: No command

Reset of general tangent delta trend

When activated, this parameter resets the tangent delta trend for all phases and sets.
Adjustment range: No command, perform reset
Default: No command

Reset of general capacitance trend

When activated, this parameter resets the capacitance trend of all phases and sets.
Adjustment range: No command, perform reset
Default: No command

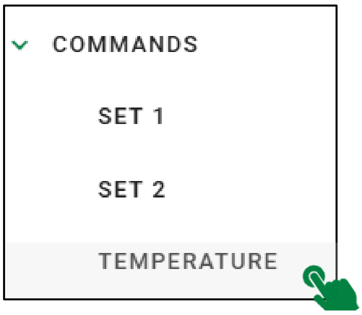


Figure 49 - Temperature command

Reset of self-diagnosis of temperature jump

When enabled, the parameter resets the temperature jump self-diagnosis.
Adjustment range: No command, perform reset.
Default: No command

5.2.3 General diagnoses

This tab allows you to configure limits for anomaly detection, such as deviation from nominal frequency, disparity, offset, inconsistency in the proportion of sums, and operational discrepancies between sets. These settings ensure greater reliability in identifying internal faults and monitoring system conditions.

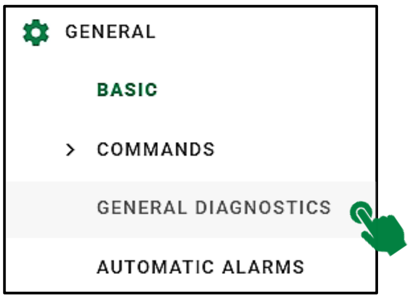


Figure 50 - General diagnoses

Self-diagnosis of maximum nominal frequency

Defines the deviation value that the nominal frequency must reach to trigger self-diagnosis.
Adjustment range: 0.01 to 5.00 Hz
Default: 0.3 Hz

Self-diagnosis of maximum frequency disparity
Defines the disparity value that must be reached to trigger self-diagnosis.
Adjustment range: 0.001 to 5000 Hz
Default: 0.1 Hz

Self-diagnosis of maximum offset
Defines the offset value that must be reached to trigger self-diagnosis.
Adjustment range: 0.1 to 6553.5 mA
Default: 1000 mA

Self-diagnosis of inconsistency in sum ratio
Defines the value that, when reached, triggers the self-diagnosis. This value is the ratio between the sums.
Adjustment range: 0.00 to 655.35
Default: 10
The self-diagnosis for inconsistent sum will only be triggered when the parameterized values for self-diagnosis of proportion inconsistency and sum disparity are reached simultaneously.

Self-diagnosis of inconsistency in sum disparity
Defines the value that, when reached, triggers the self-diagnosis. This value is the difference between the sums.
Adjustment range: 0 to 65535 mA
Default: 1000 mA
The self-diagnosis for inconsistent sum will only be triggered when the parameterized values for self-diagnosis of proportion inconsistency and sum disparity are reached simultaneously.

5.2.4 Automatic alarms

This tab allows you to configure percentage limits for automatic alarm generation, based on deviations from reference values. Settings include alarms for leakage current (high and very high), capacitance (high and very high), and tangent delta (high and very high), as well as hysteresis adjustments to prevent activations due to momentary variations.

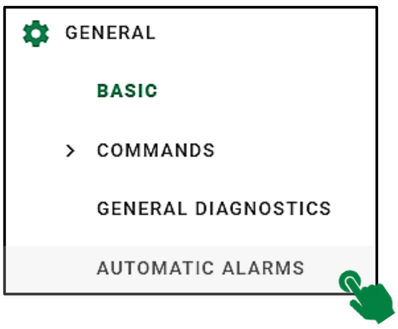


Figure 51 - Automatic alarms

Percentage value for automatic alarms due to leakage current – High
Defines the percentage value for the automatic leakage current alarm – High.

Adjustment range: 1 to 2000 %
Default: 150%
It will only be displayed if the automatic alarm mode for leakage current is enabled.

Percentage value for automatic alarms due to leakage current – Very high
Defines the percentage value for the automatic leakage current alarm – Very high.
Adjustment range: 1 to 2000 %
Default: 200%
It will only be displayed if the automatic alarm mode for leakage current is enabled.

Percentage value for automatic alarms due to leakage current – Hysteresis
Defines the percentage value for hysteresis.
Adjustment range: 1 to 50 %
Default: 10%
It will only be displayed if the automatic alarm mode for leakage current is enabled.

Automatic alarm due to capacitance – High – General
Defines the percentage value to trigger the automatic alarm for high capacitance.
Adjustment range: 0.00 to 320.0%
Default: 3%
It will only be displayed if the automatic alarm mode for capacitance is enabled.

Automatic alarm due to capacitance – Very high – General
Defines the percentage value to trigger the automatic alarm for very high capacitance.
Adjustment range: 0.00 to 320.0%
Default: 5%
It will only be displayed if the automatic alarm mode for capacitance is enabled.

Automatic alarm due to tangent delta – High – General
Defines the percentage value to trigger the automatic alarm for high tangent delta.
Adjustment range: 0 to 32000 %
Default: 100%
It will only be displayed if the automatic alarm mode for tangent delta is enabled.

Automatic alarm due to tangent delta – Very high – General
Defines the percentage value to trigger the automatic alarm for very high tangent delta.
Adjustment range: 0 to 32000 %
Default: 200%
It will only be displayed if the automatic alarm mode for tangent delta is enabled.

5.2.5 Temperature

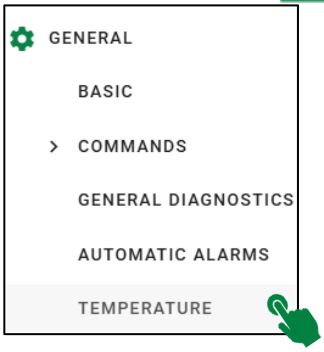


Figure 52 - Temperature parameterization

Enabling the temperature sensor

When enabled, the parameter enables temperature measurement.
Adjustment range: Enable, disable
Default: Disable

5.3 Set parameterization

The parameterization of the sets allows for the individual configuration of the limits and behaviors of each of the modules monitored by the SDB. In this tab, the user adjusts the reference values and criteria that guide the monitoring of capacitance, tangent delta, and leakage current, ensuring that each set operates according to the specific characteristics of the transformer.

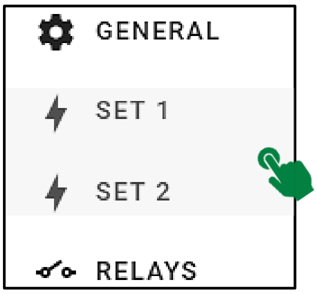


Figure 53 - Set parameters

5.3.1 Initial values

This tab allows you to parameterize the initial reference values for capacitance and tangent delta of sets 1 and 2, broken down by phase (A, B, and C). This data serves as a basis for comparison during continuous monitoring, allowing the detection of deviations and trends over time.

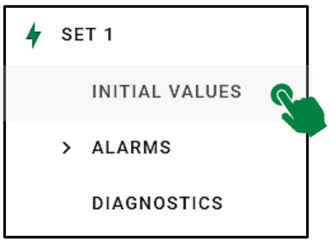


Figure 54 - Initial values

Initial capacitance value – Set 'x' – Phase A, B or C
Capacitance initial value.
Adjustment range: 50.0 to 3200.0 pF
Default: 500 pF

Initial tangent delta value – Set 'x' – Phase A, B or C
Delta tangent initial value.
Adjustment range: 0.01 to 3%
Default: 0.3%

5.3.2 Alarms due to leakage current

This screen will only be displayed if the automatic alarm mode for leakage current is disabled, see Basic.

It allows the configuration of percentage limits for alarm issuance based on the variation of leakage current relative to the reference value.

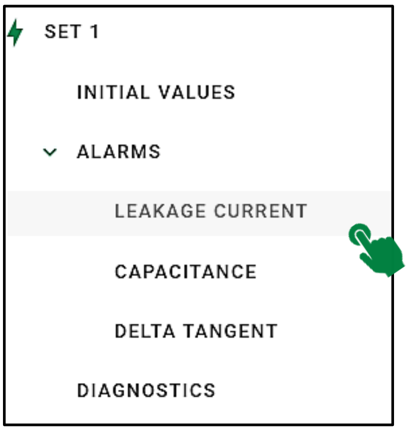


Figure 55 - Leakage current alarms

Alarm due to leakage current – High – Set 'x' – Phase A, B or C
Defines the value at which the high leakage current alarm should be triggered.
Adjustment range: 0.01 to 150.00 mA
Default: 80 mA

Alarm due to leakage current – Very high – Set 'x' – Phase A, B or C
Defines the value at which the very high leakage current alarm should be triggered.
Adjustment range: 0.01 to 150.00 mA
Default: 90 mA

5.3.3 Alarms due to capacitance

This screen will only be displayed if the automatic alarm mode for capacitance is disabled, see Basic.

It defines the activation thresholds for alarms triggered by variations in measured capacitance, with adjustable levels for alert and fault situations.

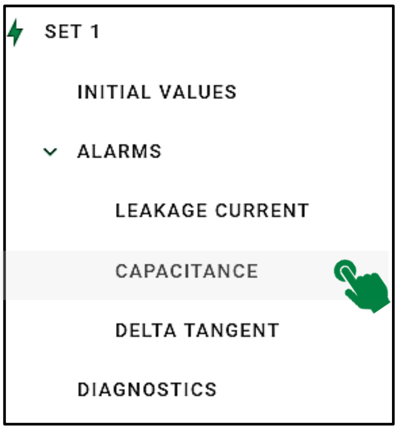


Figure 56 - Capacitance alarms

Alarm due to capacitance – High – Set 'x' – Phase A, B or C
Defines the value at which the high capacitance alarm should be triggered.
Adjustment range: 50.0 to 3200.0 pF
Default: 515 pF

Alarm due to capacitance – Very high – Set 'x' – Phase A, B or C
Defines the value at which the very high capacitance alarm should be triggered.
Adjustment range: 50.0 to 3200.0 pF
Default: 525 pF

Alarm due to capacitance evolution trend – High – Set 'x' – Phase A, B or C
Defines a value for the high capacitance trend alarm; it is triggered when the projection indicates that the limit will be reached in fewer days than the defined value.
Adjustment range: 0 to 365 days
Default: 30 days

5.3.4 Alarms due to tangent delta

This screen will only be displayed if the automatic alarm mode for tangent delta is disabled, see Basic.

It enables alarm parameterization based on the increase in tangent delta, indicating possible deteriorations in insulation.

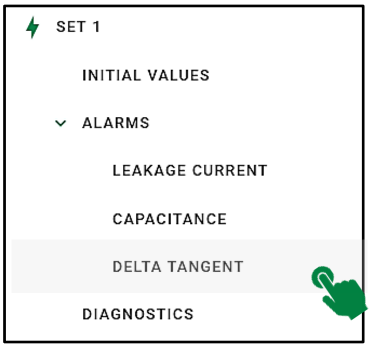


Figure 57 - Delta tangent alarms

Alarm due to tangent delta – High – Set 'x' – Phase A, B or C
The value that must be considered for the alarm to be triggered by a high tangent delta.
Adjustment range: 0.01 to 32.0%
Default: 0.7 %

Alarm due to tangent delta – Very high – Set 'x' – Phase A, B or C
The value that must be considered for the alarm to be triggered by a very high tangent delta.
Adjustment range: 0.01 to 32.0%
Default: 1.8 %

Alarm due to tangent delta evolution trend – High – Set 'x' – Phase A, B or C
Sets the value for the high delta tangent trend alarm, triggered when the projection indicates that the limit will be reached in fewer days than the defined value.
Adjustment range: 1 to 365 days
Default: 30 days

5.3.5 Diagnoses

Configures the operating criteria for the self-diagnosis related to low leakage current.

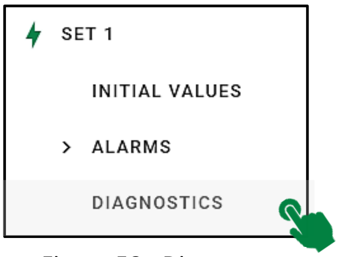


Figure 58 - Diagnoses

Minimum leakage current – Set 'x' – Phase A, B or C
Defines the minimum leakage current value for the diagnosis to be triggered.
Adjustment range: 0.08 to 100.0 mA
Default: 10 mA

Percentage value for leakage current – Low
Defines the percentage value for leakage current diagnosis – Low.
Adjustment range: 20 to 80%
Default: 50%

5.4 Relay parameterization

The relay parameterization tab allows the configuration of the behavior of the SDB's physical outputs associated with specific alarm events. The user can define the operating mode (pulsed or sustained), the retention times, and the relay mapping for different alarm conditions, ensuring an appropriate and personalized system response to identified events.

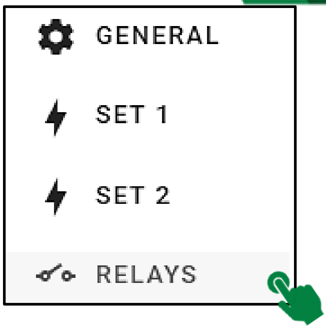


Figure 59 - Relay parameterization

Selection of relay ‘x’ operation

Changes the relay's operating mode.
Adjustment range: NO (Normally Open), NC (Normally Closed)
Default: NO (Normally Open)

Selection of phase – Relay ‘x’

Defines a phase for the relay.
Adjustment range: Not selected, Phase A, B or C
Default: Not selected

Selection of set – Relay ‘x’

Defines a set for the relay.
Adjustment range: Not selected, Set 1 or 2
Default: Not selected

Selection of alarm – Relé ‘x’

Defines an alarm for the relay.
Adjustment range:

- Not selected;
- High Capacitance;
- Very High Capacitance;
- High Capacitance Trend;
- High Tangent Delta;
- Very High Tangent Delta;
- High Tangent Delta Trend;
- High Leakage Current;
- Very High Leakage Current.

Default: Not selected

6 Commissioning for entry into service

Once the equipment has been installed in accordance with this manual, commissioning should follow the basic steps below.

- Verify the electrical installation according to the recommendations in this manual. Check the correctness of the electrical connections (for example, through continuity tests);
- Ensure that no contact operations will interact with other systems during this phase. If necessary, isolate all control, alarm, and shutdown contacts;
- Perform all SDB parameterization according to the instructions in this manual;
- Reconnect any contacts that may have been isolated;
- After installation, it is important to check the operation of the LEDs, especially the equipment status via its respective LED (see Error! Reference source not found.).

7 Troubleshooting

7.1 Self-diagnosis

The following table contains recommended solutions for self-diagnostics. If the warning persists or reappears after some time, contact Treetech technical support (see Error! Reference source not found.).

Table 6 - Self-diagnosis

Self-diagnosis	Recommendation
Self-diagnosis of phase sequence	Check the installation; this self-diagnosis indicates that there may be a phase reversal, meaning the cables may be reversed.
Self-diagnosis of channel current with high frequency difference	Check the installation; it could also indicate an internal fault.
Self-diagnosis of channel current with low leakage current	Check the installation; this self-diagnosis indicates that there may be an error in the installation or loose cables.
Self-diagnosis of channel current with offset outside limits	Check the TAP adapter; the display of this self-diagnosis may indicate a fault in the TAP adapter.
Self-diagnosis of calculated current sum with high frequency difference	Check the installation; it could also indicate an internal fault.
Self-diagnosis of calculated current sum with low leakage current	Check the installation; this self-diagnosis indicates that there may be an error in the installation or loose cables.

Self-diagnosis of calculated current sum with offset outside limits	Check the TAP adapter; the display of this self-diagnosis may indicate a fault in the TAP adapter.
Self-diagnosis of measured current sum with high frequency difference	Check the installation; it could also indicate an internal fault.
Self-diagnosis of measured current sum with low leakage current	Check the installation; this self-diagnosis indicates that there may be an error in the installation or loose cables.
Self-diagnosis of measured current sum with offset outside limits	Check the TAP adapter; the display of this self-diagnosis may indicate a fault in the TAP adapter.
Self-diagnosis of disparity between frequencies	Check the installation; it could also indicate an internal fault.
Self-diagnosis of RTD calibration Self-diagnosis of RTD reading Self-diagnosis of RTD cable reading Self-diagnosis of temperature jump	a) Check for poor connections or disconnections throughout the entire cable path connected to terminals 1 and 2 of the temperature sensor, including the connection to the SDB, the feed-through terminals, and the connection to the sensor. b) Check if shielded cable is being used to connect the temperature sensor to the SDB. c) Verify that the shielding of the SDB-to-temperature sensor cable is grounded only on one side of the connection and the other end is insulated. d) Replace the faulty temperature sensor.

7.2 Self-diagnosis of internal fault

If any of the self-diagnosis issues listed below occur, it is necessary to restart the SDB. This can be done by removing and reconnecting the power supply or, alternatively, using the “restart” button available in the login tab of the web interface (see **Error! Reference source not found.**). If the self-diagnosis issue persists or recurs after some time, it is recommended to contact Treetech technical support (see **Error! Reference source not found.**) for analysis and appropriate guidance.

Table 7 - Self-diagnosis of internal fault

Internal fault
Self-diagnosis of communication failures between microcontrollers

Self-diagnosis of general inaccuracy in phase angles
Self-diagnosis of inconsistency in the sum
Self-diagnosis of measurement failure
Self-diagnosis of channel current with indeterminate waveform
Self-diagnosis of channel current near ADC saturation
Self-diagnosis of channel current with angular inaccuracy
Self-diagnosis of calculated current sum with indeterminate waveform
Self-diagnosis of calculated current sum near ADC saturation
Self-diagnosis of calculated current sum with angular inaccuracy
Self-diagnosis of measured current sum with indeterminate waveform
Self-diagnosis of measured current sum near ADC saturation
Self-diagnosis of measured current sum with angular inaccuracy

8 Technical data and type tests

8.1 Technical data

Table 6 - Technical data

HARDWARE	
Supply voltage	85...250 Vac/Vdc
Frequency	50/60 Hz
Maximum consumption	<12 W
Operating temperature – IEC/UL	-40...+85 °C
Protection rating	IP20
Mounting	Panel DIN Rail
Box material	Aluminum
Humidity	5% to 90%condensation humidity
Altitude	2000 meters
Pollution rating	II
Overvoltage category	II
Open equipment	Yes
Cabling	Wire Gauge: 12 to 30 AWG / 0.2 - 2.5 mm² Tightening Torque (Fixing): 0.2 to 0.25 Nm Tightening Torque (Wire): 0.4 to 0.5 Nm Material: Copper Compliance: UL508 – use only with wires rated for 60/75 °C
INPUTS	
Current inputs (2 sets)	0...100mA

Three-phase voltage inputs (1 set)	0...185 Vac
1 RTD	PT100 Ω at 0°C, 3 wires, range: -55...200°C
OUTPUTS	
1x Self-diagnosis relay	NC Contact (Normally Closed) Dielectric strength: 4000Vrms 3 A at 125 VAC (NF) 3 A at 250 VAC (NF) 3 A at 30 VDC (NF)
1x TRIP relay	NO Contact (Normally Open) Dielectric strength: 4000Vac 5 A at 125 VAC (NA) 5 A at 250 VAC (NA) 5 A at 30 VDC (NA)
3x Signaling relays	NO Contacts (Normally Open) 5 A at 125 VAC (NA) 5 A at 250 VAC (NA) 5 A at 30 VDC (NA) The common terminal current-carrying capacity is 10A. Therefore, if multiple relays are used simultaneously the sum of their currents must remain within this limit to prevent connection overload and overheating.
COMMUNICATION INTERFACE	
Communication protocols	DNP3 Modbus® RTU IEC MMS Server IEC GOOSE Publisher
Communication ports	1 RS-485 (based on TIA-485-A standard), 1 RS-485 (TIA-485-A) or 1 RS-232 (TIA-232-F)
IEEE 802.3 (10/100 Mbps) communication ports[1]	Available models: RJ45: 2 Ethernet RJ45 (10/100BASE-T), FOFO: 2 Ethernet Fiber Optic (10/100BASE-FX; MM 1310nm LC connector) (UL Certified), FOSR: 1 Ethernet Fiber Optic (10/100BASE-FX; MM 1310nm LC connector) + 1 Serial Fiber Optic (MM 850nm SC connector).
Parameterization port	RJ45: 1 Ethernet RJ45 (10/100BASE-T)
Master/Slave Protocol	Modbus® (RTU and TCP) and DNP3 (RTU and TCP)
Client/Server Protocol	Modbus® (RTU and TCP) and DNP3 (RTU and TCP) IEC 61850 (MMS server / GOOSE Publisher)
DIMENSIONS AND WEIGHT	**DESCRIPTION**
Dimensions	156x134x103
Weight	1000g

8.2 Type tests

Table 7 - Type tests

IMMUNITY TO HIGH-ENERGY SURGES (IEC 60255-26:2023)	
Differential mode	2 kV (+/-)
Common mode	4 kV (+/-)
IMMUNITY TO ELECTRICAL TRANSIENTS (1 MHZ BURST, IEC 60255-26:2023)	
Peak value 1st cycle	2.5 kV (common mode), 1 kV (dif. mode)
Frequency	1 MHz
Repetition rate	200 bursts/s
APPLIED VOLTAGE (IEC 60255-26:2023)	
Dielectric strength	2 kV at 60 Hz for 1 minute
Voltage impulse	5 kV (+/-)
IMMUNITY TO RADIATED ELECTROMAGNETIC FIELDS (IEC 60255-26:2023)	
Frequency	80...2500 Mhz
Modulation index	80% and 1 kHz sinusoidal
Field intensity	10 V/m
Power supply	220 V / 60 Hz
IMMUNITY TO CONDUCTED ELECTROMAGNETIC DISTURBANCES (IEC 60255-26:2023)	
Field intensity	10 Vrms
Frequency	0.15 a 80 MHz
Modulation index	80% and 1 kHz sinusoidal
Scan frequency	150 kHz to 80 MHz
Fixed frequencies	27
Duration	20 s
Power supply	220 V / 60 Hz
IMMUNITY TO INDUSTRIAL FREQUENCY MAGNETIC FIELDS (IEC 61000-4-8)	
Magnetic field intensity and direction	30 A/m 3 orthogonal axes
ELECTROSTATIC DISCHARGES (IEC 60255-26:2023)	
Air discharge	15 kV
Contact discharge	220 V / 60 Hz
IMMUNITY TO FAST ELECTRICAL TRANSIENTS (IEC 60255-26:2023)	
Power, inputs and outputs (Class A)	4 kV (+/-)
Current output	2 kV (+/-)
CONDUCTED EMISSION (IEC 60255-26:2023)	
Conducted emission limits (Class A)	79 dB (uV) @ 150 kHz...500 kHz (QP) 73 dB (uV) @ 500 kHz...30 MHz (QP) 66 dB (uV) @ 150 kHz...500 kHz (AV) 60 dB (uV) @ 500 kHz...30 MHz (AV)
RADIATED EMISSION (IEC 60255-25)	
Radiated emission limits (Class B)	50 dB (uV/m) @ 30 MHz...230 MHz (QP) 57 DB (uV/m) @ 230 MHz...1 GHz (QP)
POWER FAILURE (IEC 61000-4-11)	
Amplitude variation	0...80% amplitude
Affected cycles	½...300 cycles
Power supply	85 V...265 V - 50/60 Hz
Short interruptions	5 seconds 85 V and 265 V 50/60 Hz
COLD TOLERANCE (IEC 60068-2-1)	
Temperature	-40°C
Test time	16 hours

DRY HEAT TOLERANCE (IEC 60068-2-2)	
Temperature	+85 ºC
Test time	16 hours
HUMID HEAT TOLERANCE (IEC 60068-2-78)	
Temperature and relative humidity	+40 ºC...85% UR
Test time	24 hours
THERMAL CYCLE (IEC 60068-2-14)	
Temperature range	-40...85 ºC
Total test time	120 hours
RESPONSE TO VIBRATION (IEC 60255-21-1)	
Application mode	Sinusoidal
Amplitude and frequency range	0.075 mm (10...59 Hz) 1 G (59...150 Hz)
Duration	8 min/eixo
VIBRATION DURABILITY (IEC 60255-21-1)	
Application mode	Senoidal
Amplitude and frequency range	2G (10...150 Hz)
Duration	160 min/axis

9 Specifications for ordering

In the product purchase order, it is necessary to specify:

- ✓ Product name;
- ✓ Quantity;
- ✓ Model:
  - **FO FO:** 2 Ethernet Fiber Optics;
  - **FO SR:** 1 Ethernet Fiber Optic + 1 Serial Fiber Optic;
  - **RJ45:** 2 Ethernet RJ45.
- ✓ Accessories.

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