MANUAL DO PRODUTO

Treetech

SDV

SMART DEVICE FOR VOLTAGE REGULATION

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1 Foreword

1.1 Legal information

Information in this document is subject to change without notice.

1.1.1 Disclaimer

Treetech Sistemas Digitais reserves the right to make changes without prior notice to all products, circuits and functionalities described herein in order to improve their reliability, function or design. Treetech Sistemas Digitais does not assume any responsibility resulting from the application or use of any product or circuit described herein, nor does it transmit any licenses or patents under its rights, nor the rights of third parties.

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1.2 Presentation

This manual presents all recommendations and instructions for installation, operation and maintenance of the Smart Device for Voltage Regulation - SDV.

1.3 Typographic conventions

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

Bold: Symbols, terms and words that are in bold have greater contextual importance. Therefore, pay attention to these terms.
Italics: Terms in a foreign language, alternatives or with their use out of the formal situation are placed in italics.
Underlined: References to external documents.

1.4 General and safety information

In this section, relevant aspects of safety, installation and maintenance of the SDV will be presented.

1.4.1 Safety symbology

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

Warning
This symbol is used to alert the user to a potentially dangerous operating or maintenance procedure, which demands greater care in its execution. Minor or moderate injuries may occur, as well as equipment damage.

Caution
This symbol is used to alert the user to a potentially dangerous operating or maintenance procedure, and extreme care must be taken. Severe injury or death may occur. Possible damage to the equipment will be irreparable.

Risk of electric shock
This symbol is used to alert the user to an operating or maintenance procedure which, if not strictly observed, could result in electric shock. Minor, moderate, severe injuries or death may occur.

1.4.2 General symbology

This manual uses the following general-purpose symbols:

Important
This symbol is used to highlight information.

Tip
This symbol represents instructions that make usage or access to functions easier on the SDV.

1.4.3 Recommended minimum profile for SDV operator and maintainer

The installation, maintenance and operation of equipment in electrical power substations require special care and therefore all recommendations in this manual, applicable standards, safety procedures, safe work practices and good judgment must be used during all steps of handling the Smart Device for Voltage Regulation - SDV.

> Only authorized and trained personnel - operators and maintainers - should handle this equipment.

To handle the SDV, the professional must:

- ✓ Be trained and authorized to operate, ground, turn on and off the SDV, following the maintenance procedures in accordance with established safety practices, which are under the sole responsibility of the operator and maintainer of the SDV;
- ✓ Be trained in the use of PPEs, CPEs and first aid;
- ✓ Be trained in the operating principles of the SDV, as well as its configuration;
- ✓ Follow the normative recommendations regarding interventions in any type of equipment inserted in an electrical power system.

1.4.4 Environmental and voltage conditions required for installation and operation

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

Table 1 - Operating conditions

Condition	Range/Description
Application	Equipment for indoor use in substations, industrial and similar environments.
Indoor/outdoor use	Indoor use
Degree of protection (IEC 60529)	Front panel IP50, backside IP20
Height* (IEC EN 61010-1)	Up to 2000 m
Temperature (IEC EN 61010-1)	
Operation	-40...+85 °C
Storage	-50...+95 °C
Relative humidity (IEC EN 61010-1)	
Operation	5...95 % - uncondensed
Storage	3...98 % - uncondensed
Supply voltage fluctuation (IEC EN 61010-1)	Up to ±10 % of rated voltage
Overvoltage (IEC EN 61010-1)	Category II
Pollution degree (IEC EN 61010-1)	Degree 2
Atmospheric pressure ** (IEC EN 61010-1)	80...110 kPa

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

1.4.5 Testing and installation instructions

This manual must be available to those responsible for the installation, maintenance and users of the Smart Device for Voltage Regulation - SDV.

In order to ensure user safety, equipment protection and correct operation, the following minimum precautions must be followed during the SDV installation and maintenance:

1. Read this manual carefully before installing, operating and maintaining the SDV. Errors in installation, maintenance or adjustments of the SDV may cause improper operations of the on-load tap changer, unsatisfactory voltage regulation, undue alarms or shutdowns, or relevant alarms may not be issued;

2. Installation, adjustments and operation of the SDV must be done by trained personnel familiar with electric motors, power transformers, on-load tap changers or voltage regulators, control devices and control circuits of substation equipment;

3. Special attention must be given to the installation of the SDV, including the type and gauge of the cables and terminals used, as well as the procedures for putting into service, including the correct parameterization of the equipment.

The IED must be installed in a sheltered environment (a panel without doors in a control room or a closed panel, in case of outdoor installation) that does not exceed the temperature and humidity specified for the equipment.

Do not install the IED near heat sources such as heating resistors, incandescent lamps and high-power devices or with heat sinks. It is also not recommended to be installed near ventilation holes or where it can be reached by forced air flow, such as the exit or entry of cooling fans or forced ventilation ducts.

1.4.6 Cleaning and decontamination instructions

Be careful when cleaning the SDV. Use **only** a damp cloth with soap or detergent diluted in water to clean the cabinet, front mask or any other part of the equipment. Do not use abrasive materials, polishers or aggressive chemical solvents (such as alcohol or acetone) on any of its surfaces.

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

1.4.7 Inspection and maintenance instructions

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

Do not open your equipment. There are no user serviceable parts in it. This must be done by Treetech technical assistance, or technicians accredited by it.
This equipment is completely maintenance free, and visual and operational inspections, periodic or not, can be carried out by the user. These inspections are not mandatory.

Opening the SDV at any time will result in loss of the product's warranty. In cases of improper opening of the equipment, Treetech cannot guarantee its correct functioning, regardless of whether the warranty period has expired or not.

All parts of this equipment must be provided by Treetech, or one of its accredited suppliers, according to their specifications. If the user wishes to purchase them in any other way, Treetech specifications for this must be strictly followed. Thus, the performance and safety for the user and the equipment will not be compromised. If these specifications are not followed, the user and the equipment may be exposed to unforeseen risks.

1.5 Technical assistance

Treetech has a wiki where several frequently asked questions and guides are made available to clarify customer questions. It is worth performing a search by accessing the link below.

Wiki
wiki.treetech.com.br

If you can not find a solution by accessing our service portal, you can open a call so our SOS team will assist you.

Service desk
http://sos.treetech.com.br/

In some cases, it is advisable to send the equipment to our technical assistance. To do this, follow the steps also described on our wiki.

Shipping procedure for technical assistance
https://treetech.atlassian.net/wiki/x/AgCuNQ

For more information, please contact us through one of the options available at the link below.

Contacts
http://treetech.com.br/contato/assistencia-tecnica/

1.6 Warranty term

The Smart Device for Voltage Regulation - SDV will be guaranteed by Treetech for a period of 2 (two) years, counted from the date of purchase, exclusively against any manufacturing defects or quality defects that make it unfit for regular use.

The warranty will not cover damage suffered by the product as a result of accidents, mistreatment, incorrect handling, incorrect installation or application, improper tests or in the event of breach of the warranty seal.

Any need for technical assistance should be communicated to Treetech or its authorized representative, with the presentation of the equipment accompanied by the respective proof of purchase.

No express or implied warranty other than those mentioned above is provided by Treetech. Treetech does not provide any warranty of suitability of the SDV to a particular application.

The seller shall not be attributable to any kind of damage to property or for any loss and damage arising, connected to, or resulting from the acquisition of the equipment, the performance of the same or any service possibly provided together with the SDV.

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

2 Introduction

Figure 1 - Smart Device for Voltage Regulation - SDV

The quality of voltage and thermal management of electrical equipment, such as transformers, are essential for its safe operation, allowing to obtain from these assets the maximum use of the investment without endangering their lifespan.

The **Smart Device for Voltage Regulation - SDV**, is an equipment that brings together the main functionalities of a voltage regulator relay combined with thermal control and protection. During its operation, the SDV aims to maintain the quality of the voltage in the load, that is, within a given range of values, programmed by the user. For this, in addition to performing the ANSI 90 function, the SDV presents a series of applications to meet the most demanding regulations of the electricity sector.

In addition, based on the temperature readings of the insulating oil and one or more transformer load currents, the SDV performs the temperature calculations (thermal image) of one or more windings and acts on the machine's temperature management (ANSI 26 and 49 functions).

Finally, Treetech's SDV is specially designed to integrate harmoniously and completely with any product that supports Modbus®, DNP3 and IEC 61850 protocols.

2.1 Features and functions

MULTIMETER FUNCTION

Indications of voltages in the transformer and load, voltage deviation, current, active, reactive and apparent powers, load percentage, power factor and frequency.

TAP CHANGER BLOCK (INTRINSIC PROTECTION)

The OLTC is blocked in case of overcurrent, undervoltage, or tap changer triggered. For cases of overvoltage, the actuation is selectable: tap changer block or rapid voltage decrease.

ADJUSTABLE PT/CT PHASE DIFFERENCE

Adjustments between 0 and 330°, allowing any type of PT/CT connection.

LINE DROP COMPENSATION

The SDV performs this function in two ways: Resistance and Reactance (RX) adjustments or by the simplified voltage drop percentage method (Z compensation).

ROBUST HARDWARE

The Design of the SDV exceeds EMC (*Electromagnetic Compatibility)* standards to withstand severe electromagnetic conditions of substations and operating temperature from -40 to +85 °C.

VFD (*VACUUM FLUORESCENT DISPLAY*)

High brightness, readable under any lighting and temperature conditions.

INTERNATIONAL STANDARDS COMPLIED

IEEE C57.91:2011 and IEC 60076-7:2018 (international); ABNT NBR 5416:1997 and ABNT NBR 5356-7:2017 (Brazilian).

10 REGULATION SETS

Ten independent sets of voltage regulation parameters, activated by programming an internal clock, which allows the adjustment of month, day and time, or by communication.

TAP CHANGER COMMAND

The user selects the tap changer command mode between local/remote, and manual/automatic.

MEASUREMENT OF TWO TEMPERATURES

Measurement of up to two temperatures between: ambient, transformer oil and tap changer oil.

FINAL GRADIENT FORECAST

Calculation of the oil-winding temperature final gradient forecast for the present load.

REDUNDANT MEASUREMENT OF OIL TEMPERATURE

Function that prevents the measurement from being unavailable in the event of a Pt100 sensor failure.

LOCAL COOLING CONTROL

Two options for performing this function: automatic or manual - via front keyboard, and remote - via communication port.

SELF-DIAGNOSIS

Self-diagnostic relays to indicate internal failures and integration failures with peripheral equipment such as other sensors.

REDUCED SIZE

Extremely reduced dimensions: 96x96x125 mm

EVEN USE OF FANS AND PUMPS

Automatic switching of forced cooling groups.

INTERNAL CLOCK

Adjustment maintained for 48 hours in case of power failure, without the use of batteries - maintenance-free equipment.

2.1.1 Inputs

- ✓ An input for measuring the voltage of one of the transformer phases using the auxiliary regulation PT;
- ✓ Three inputs for true-rms AC current measurement from a split-core window type external clip-on CT;
- ✓ Two inputs for temperature measurement using 3-wire Pt100 Ω 0°C RTD sensors with self-calibration, ensuring high accuracy and stability over the entire ambient temperature range;
- ✓ An input for a potentiometric transmitter, which allows measuring the tap position (tap) of the tap changer (available if the **TAPP** option is enabled);
- ✓ Two dry contact inputs (available if the **DIGI** option is enabled) for remote commands, such as automatic/manual, local/remote changeover, increase/decrease tap (available if the **TAPP** option is enabled) and enable/disable the parallelism concentrator (available if the **CONC** option is enabled).

2.1.2 Outputs

- ✓ Display indication of measured currents, temperatures and voltages;
- ✓ Up to 14 signaling relays, 3 reversible ones and 11 normally open (NO);
- ✓ Output relays for alarm and self-diagnosis indications;
- ✓ Output contacts in sufficient quantity for individualized indication of alarms and shutdowns for each oil and winding temperature measured;
- ✓ Shutdown contacts with adjustable timing from 0 to 20 minutes, with countdown indication on the display and via serial communications;
- ✓ Output contact for signaling the countdown to shutdown in progress;

- Reversible output contacts for activating up to two forced cooling groups: safe activation of cooling in case of power failure, sensor failure, wiring failure or internal failure, triggered by the self-diagnostic function;
- Reversible output contact for signaling power failure, sensor, wiring or internal failure detected by self-diagnostics;
- Up to four current loop outputs for remote indications of temperatures in the ranges 0... 1, 0... 5, 0... 10, 0...20, 4...20, -1...+1, -5...+5, -10...+10, -20...+20 mA.[1]

2.1.3 Communication

- 1 RS-485 serial communication port;
- 1 RS-485 or RS-232 serial communication port;
- 2 RJ45 Ethernet ports (RJ45 model) *;
- 2 fiber optic Ethernet ports (FOFO model) *;
- 1 fiber optic Ethernet port and 1 serial fiber optic port (FOSR model) *;
- 1 RS-485 port dedicated to the parallelism concentrator (only if the **CONC** option is enabled);
- Modbus®, DNP3 and IEC 61850 communication protocol, with support for timestamp, capable of signaling events such as alarms, shutdowns, cooling activation, etc., with 1 ms accuracy.

* Customer must choose only one of the 3 configurations.

[1] In case the user chooses the range options with negative values, mA outputs 3 and 4 will be unavailable.

2.2 System features

EMBEDDED OPERATING SYSTEM

The SDV has an embedded operating system, customized by Treetech. This ensures greater stability and operational reliability of the product firmware, as well as being future proof.

ACCESS SECURITY

To guarantee access and data security, the SDV works with profiles of different levels of operation access, with remote settings and administration.

REMOTE UPDATE

Through the web interface, the firmware update process becomes extremely simple and intuitive.

CLOCK SYNC

SDV allows clock synchronism configuration via NTP protocol.

COMMUNICATION LOG DOWNLOAD

The SDV provides in its interface the download of the communication log to facilitate network diagnosis.

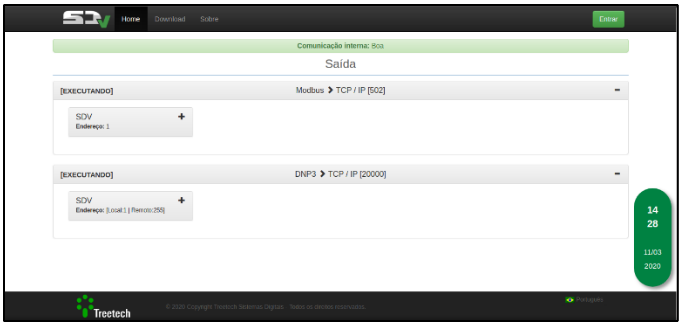
EXPERTISE IN EMBEDDED SYSTEMS

Treetech has specialists in embedded operating systems with extensive experience in the area. This knowledge has been added to the SDV, making it an extremely safe and stable product while remaining easy to operate.

2.3 Website

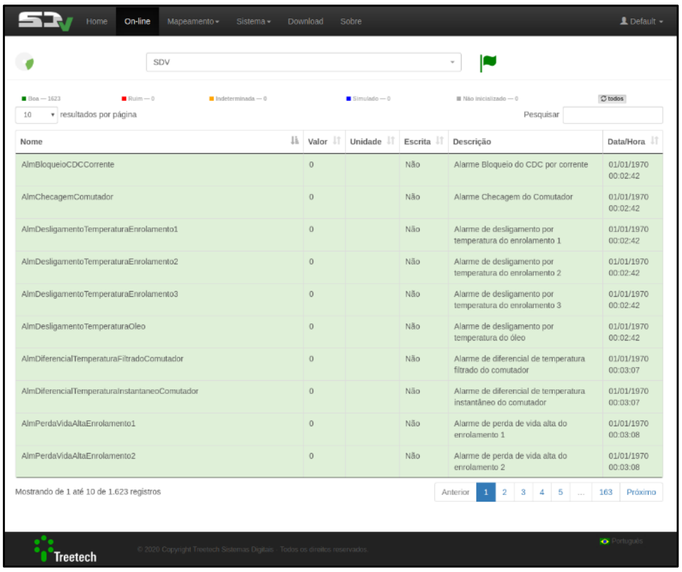
FRIENDLY WEB INTERFACE

Using the latest HTML5 and Bootstrap technologies, all communication management and visualization of SDV's information are done directly on the equipment's web interface, without the need for a license or installation of proprietary software.



REMOTE NETWORK SUPERVISION

It is possible to supervise the communication status and error statistics of the SDV.
Access to the details of the IED allows tracking of measurement values in real time.



2.4 Optional functions

According to the order, the SDV can be provided with one or more of the optional functions listed below:

MMEM - Mass storage

Non-volatile memory for storing measurements and events of alarms, shutdowns and others, with a capacity greater than 10 months recording every 15 minutes. Programming of the interval between recordings and temperature and voltage variation for recording is customized by the user. Information is downloaded via Treetech download software.

PCOL - Pre-cooling

Extends insulation lifespan by triggering cooling groups when user-selected load levels are reached. Taking advantage of the oil's large thermal inertia, forced cooling is activated before the temperature rises excessively, reducing exposure of the windings to high temperatures and increasing the lifespan of the insulation. Are programmed by the user:

- ✓ Percentage of loading for individual activation of each forced cooling stage;
- ✓ Hysteresis to turn off the forced cooling stages when decreasing loading.

FEXC - Daily cooling activation

This function prevents fans and/or pumps from remaining idle for long periods in transformers with low load or during periods of low ambient temperature. This prevents shaft blockage due to dirt accumulation or grease drying. The cooling equipment is activated daily, according to the equipment's internal clock, as selected by the user:

- ✓ Hour and minute of fan operation start;
- ✓ Total daily fan operation time, from 0 to 999 minutes.

The daily cooling activation function can also be used with the purpose of pre-cooling in transformers subject to cyclical loads, by scheduling the cooling start-up for a time before the daily peak load, with user-selectable advance.

INAG - Insulation aging monitoring

This function performs the online monitoring of the loss of life of the winding insulation, providing important information for the diagnosis and prognosis of the equipment's condition:

- ✓ Current percentage of lifespan remaining, from 100 % (new insulation) to 0 % (end of life of insulation);
- ✓ Average insulation loss of life rate, in % per day, calculated over a user-selectable time period;
- ✓ Extrapolation of the remaining lifetime for the insulation, calculated as a function of the above variables (percentage of remaining life and average loss of life rate).

OLTD – Tap changer temperature differential

This function allows comparing the transformer oil temperature with that of the tap changer, so that abnormal temperature differentials can be detected, and maintenance teams are alerted to the development of tap changer failures.

As the temperature differential is subject to the influence of external variables, monitoring is carried out in two different modes, in order to raise the diagnostic efficiency and avoid false alarms:

- ✓ Instantaneous Differential Monitoring - Provides quick response alarms in case of high intensity defects, even if of short duration;
- ✓ Filtered Differential Monitoring - By submitting the Instantaneous Differential to a low-pass filter, it is possible to detect trends in the evolution of the differential that indicate permanent defects of small intensity, although with a longer detection time.

DIGI - Digital inputs

Two digital inputs for switching the OLTC command mode between manual/automatic and local/remote. They can also be used to command raise tap/decrease tap if the **TAPP** option is enabled or enable/disable the parallelism concentrator if the **CONC** option is enabled.

TAPP – Tap changer position measurement

One input for measuring the position of the OLTC by potentiometric transmitter, with cable resistance compensation and error detection. Associated functions:

- ✓ Current output programming for remote tap indication;
- ✓ Manual command of the local OLTC (front panel), by serial communication or Ethernet;
- ✓ Limitation of the OLTC excursion range (minimum and maximum taps allowed) and memorization of the minimum and maximum positions reached by the SDV since the last reset;
- ✓ Protection against improper tap changer operations: tap changer block in case of operations not initiated by the SDV.

OLMT – Tap changer maintenance assistant

Allows the measurement of position in the molds of the **TAPP** option presented in the item above and adds:

- ✓ OLTC operation counter, with maintenance warning by number of operations;
- ✓ Integration of squared switched current, with high I^2 sum maintenance warning;
- ✓ Remaining time forecast for maintenance;
- ✓ Maintenance alarms are issued with programmable advance.

OLCK - Verification of successful tap changing

Enabled, this function allows the SDV to verify the tap changing success by means of voltage changes after the regulation command (increase/decrease voltage), without the need to measure the tap position.

The algorithm applied to this verification method performs the comparison between the initial voltage levels and the one presented after the command for tap changing. Once the difference between the measured voltages is less than the deviation, OLTC inactivity is identified, generating tap changing failure warnings.

In some cases, it is necessary more than one tap changing to return the voltage to acceptable limits. In order to avoid error indication in the first tap changing, the parameter “OLTC Limit Check” is used. This parameter defines the limit amount of voltage rereadings, in order to cover the subsequent tap changings. Only after checking up to the established limit, if the voltage difference remains below the deviation, alarms will be issued.

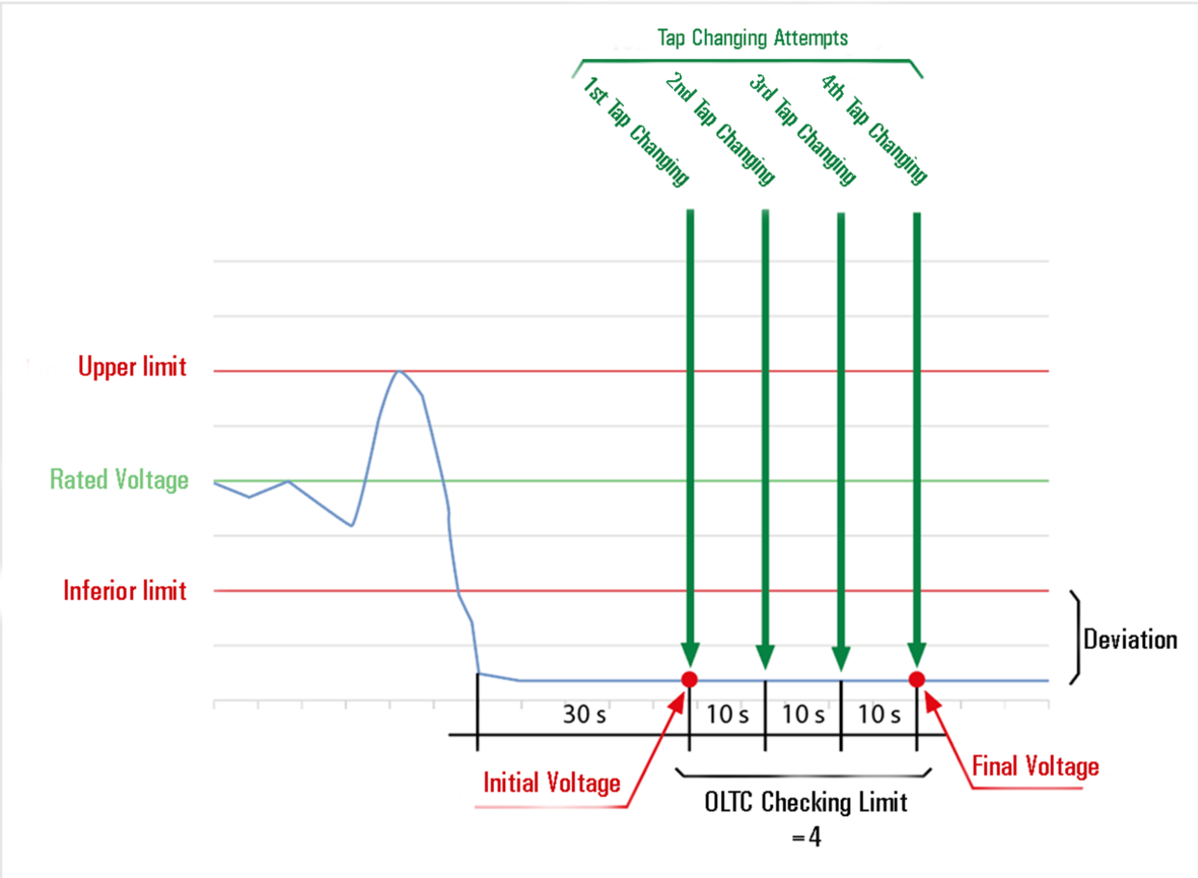


Figure 2 - Graph representing the OLTC checking limit

CONC - Parallelism concentrator

It interfaces between Treetech's Synchronous Parallelism Supervisor - SPS and a data acquisition system, adding the functionality of other Treetech equipment: the Serial Communication Module - COMM-04.

2.5 Basic operating philosophy

The **Smart Device for Voltage Regulation - SDV** is an equipment that combines the functionalities of temperature monitors and voltage regulators such as the **TM**, **AVR**, in addition to the **COMM-04** parallelism concentrator by Treetech. Thus, to facilitate understanding, the basic operating of its functions will be explained in two parts: one referring to temperature monitoring and the other to voltage regulation.

2.5.1 Temperature monitoring

2.5.1.1 Oil and winding temperatures

Based on the temperature readings of the insulating oil and one or more transformer load currents, the SDV performs temperature calculations (thermal image) of one or more windings, depending on the application. Transformer data that are programmed by the user, adapting the model to its characteristics, are part of the thermal image calculation.

The measurement of oil temperature is done directly, using resistive sensors, type Pt100 Ω at 0 °C. The measurement of transformer load currents is carried out through a measurement current transformer (CT), connecting its secondary to the SDV via external split-core window type CTs (required accessory, supplied separately).

2.5.1.2 Forced cooling control

The SDV can command up to 2 groups of forced cooling, in manual or automatic mode. In automatic mode, the forced cooling groups are controlled based on the highest measured value among the temperatures of windings 1, 2 and 3 or based on the oil temperature, depending on the parameterization. In manual mode, forced cooling groups are driven directly by the operator.

If the optional pre-cooling function is available, forced cooling can also be commanded based on the percentage loads of the windings, considering the highest measured load. The pre-cooling function makes that, due to the thermal inertia of the oil and the windings, the cooling groups are activated before the transformer reaches the pre-set temperature levels in the automatic control settings, thus reducing the average temperature of transformer operation.

The optional daily cooling activation function allows the daily activation of the fans and/or oil circulation pumps, in order to avoid mechanical failures due to long periods of non-use, with start time and exercise time programmed by the user.

2.5.1.3 Multigradient function

The SDV has a multigradient function, as the thermal behavior of a transformer varies according to the activation of its cooling stages.

This functionality allows the equipment to vary the thermal parameters according to the active cooling stage. The winding temperature is calculated with greater precision, according to the operation of the transformer, ensuring greater reliability in the thermal management of the asset.

2.5.1.4 Transformer - tap changer temperature differential

The on-load tap changer (OLTC) is one of the main sources of failures in power transformers, mainly due to the existence of moving parts that conduct and interrupt high currents while subjected to high electrical potentials.

Some of the most common failure modes in OLTC are related to deteriorated contacts or mechanical misadjustments that cause the contact resistance to rise and lead to significant heating, which tends to further raise this resistance, in a cascade effect that leads to complete failure, in general with a high degree of severity.

Under normal operating conditions, the OLTC is a minor heating source compared to the heat generated by transformer losses, so the oil temperature in the tap changer tank is mainly influenced by the temperature of the transformer oil. The graph in Figure 3, drawn from real measurements, exemplifies this situation. It shows, in addition to the individual temperatures of the transformer and the tap changer, the temperature difference between tap changer and transformer, which is monitored to detect defects such as those mentioned above.

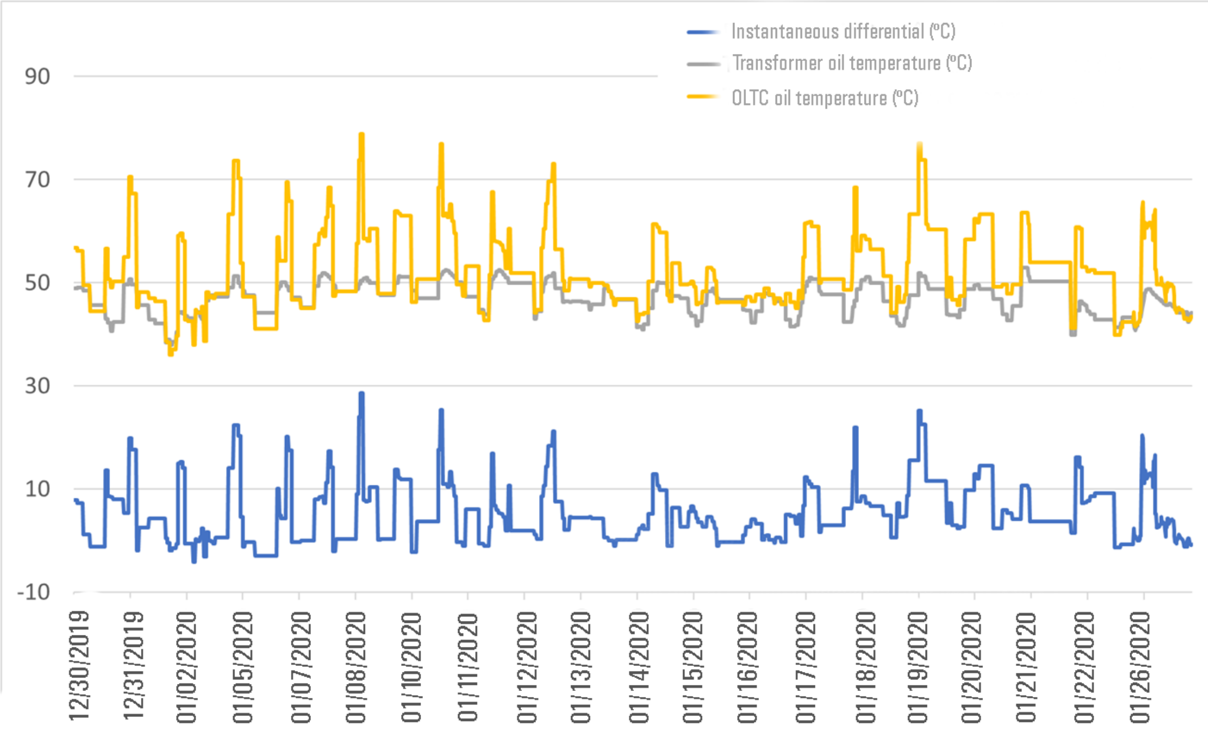


Figure 3 – Temperature measurements of the OLTC, transformer and tap changer temperature differential

As the temperature differential is subject to the influence of external variables, such as the activation of forced cooling, rapid variations in atmospheric conditions and others, monitoring is carried out in two distinct modes, illustrated in Figure 4, to raise the efficiency of the diagnosis and prevent false alarms.

2.5.1.4.1 Monitoring the instantaneous differential

The monitoring of the instantaneous temperature differential provides alarms with fast response in case of high intensity defects, even if of short duration.

2.5.1.4.2 Monitoring the filtered differential

The filtered temperature differential is obtained by subjecting the instantaneous differential to a low-pass filter with a user-adjustable time constant. Its monitoring makes it possible to detect trends in the evolution of the differential that indicate permanent defects of small intensity, although with a longer detection time.

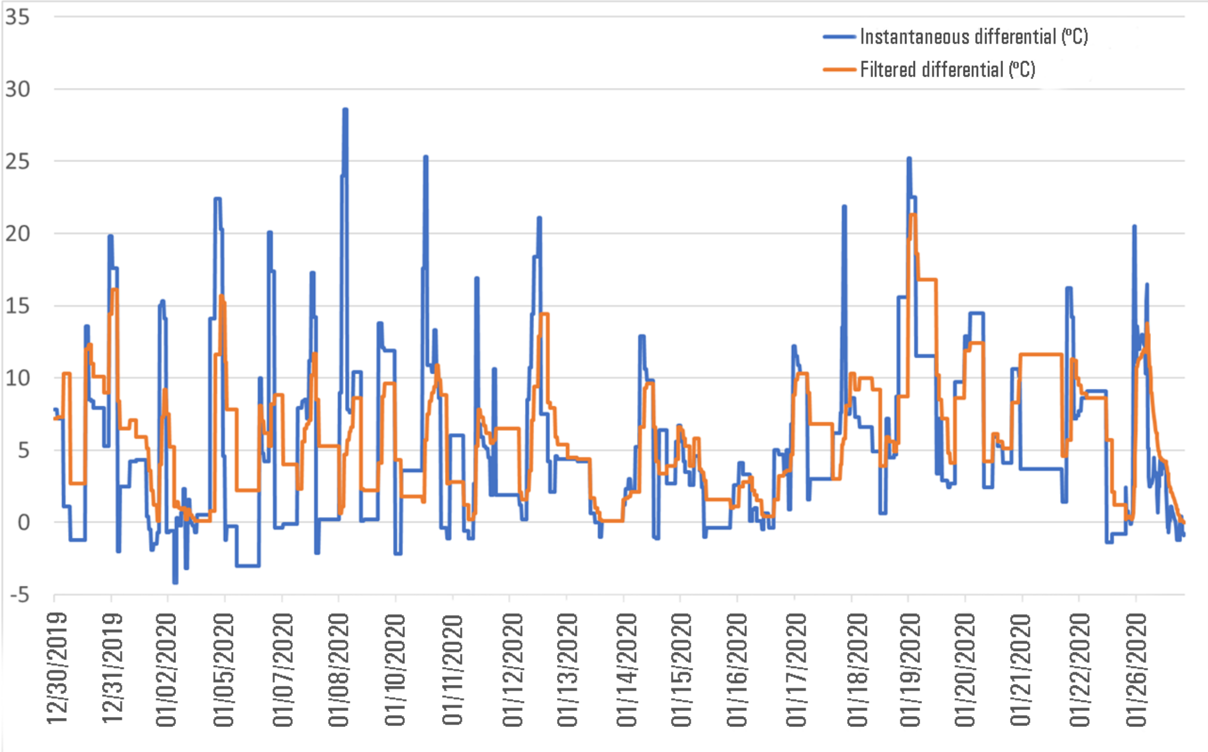


Figure 4 - Instantaneous and filtered temperature differentials

The instantaneous and filtered temperature differential alarm settings can be determined automatically by the SDV, through a period of learning the normal behavior of the tap changer. These alarms can later be changed manually by the user.

The duration of this learning period can be adjusted by the user, typically the value of one week is used. During this period, the maximum values reached by the instantaneous and filtered temperature differentials are recorded, and to these maximum values a programmed tolerance margin is added, thus obtaining the alarm values by instantaneous and filtered differential respectively.

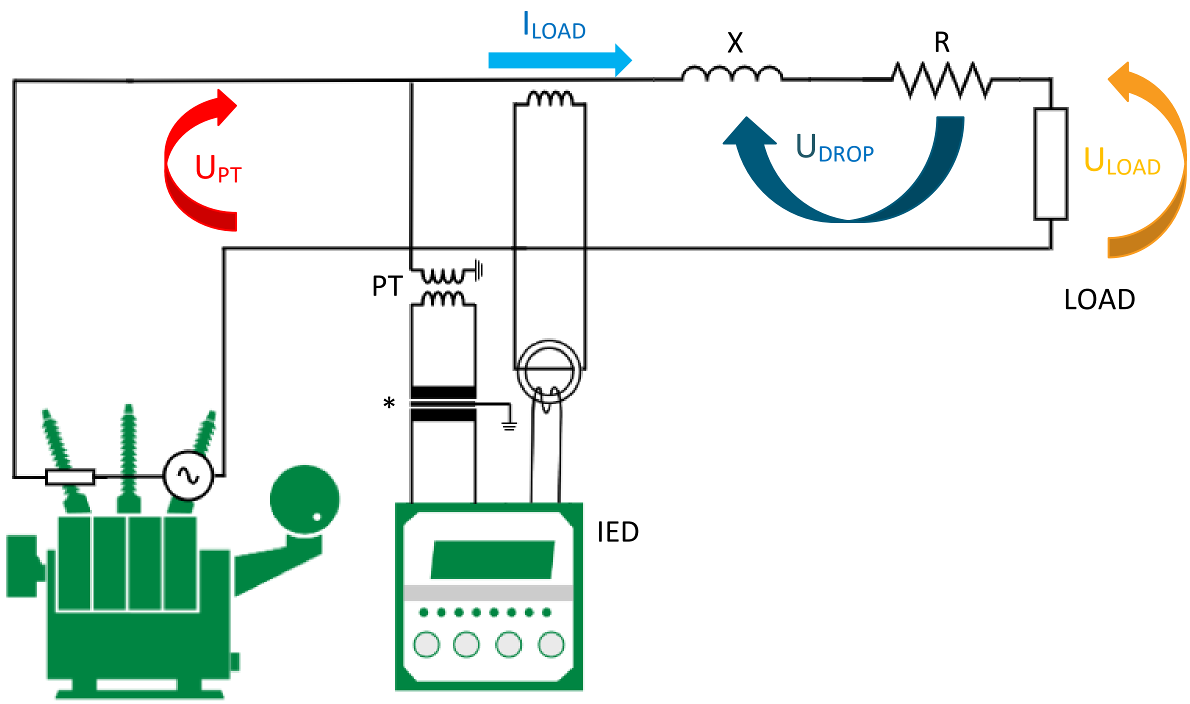
If the measured values for the instantaneous or filtered temperature differentials exceed their respective alarm values, the SDV will signal the alarm with the corresponding code on the display and, if programmed in this way, it will trigger an output contact.

As with the transformer oil temperature, the on-load tap changer oil temperature is measured using a Pt100 Ω sensor at 0 °C, which is connected to one of the inputs available on the Smart Device for Voltage Regulation.

2.5.2 Voltage regulation

During its operation, the SDV aims to maintain the load voltage within a range of values determined by the parameters programmed by the user.

The SDV measures the voltage at the transformer’s output and the load current and uses them together with the programmed line voltage drop parameters to calculate the voltage at the load, which in turn is the voltage that must be effectively maintained within the desired limits as shown in Figure 5.



*Treetech auxiliary PT: 138.580.01

Figure 5 - Smart Device for Voltage Regulation - SDV

For more detailed information on how the SDV acts during voltage regulation, see chapter 5.5. In addition to the basic voltage regulation function, the SDV also performs protection functions for the on-load tap changer, blocking its operation in adverse conditions, such as a short circuit in the line (overcurrent and undervoltage) and protection for the load (overvoltage).

2.5.3 Parallelism

One of the main concerns when operating power transformers in parallel is to avoid the occurrence of circulating currents between the parallel windings. Since the transformers in parallel have the same vector group, compatible voltage, power and impedance levels and the primary windings are supplied by the same source, the main requirement to avoid current circulation is that the transformation ratios are equal.

In transformers with an on-load tap changer (OLTC), which change their transformation ratio during operation, this condition can be fulfilled by several methods. If the transformers in parallel have the same number of taps, it is enough that they all operate in the same tap position for the circulating current to be minimal.

One of these methods is the master-follower method, the Synchronous Parallelism Supervisor - SPS operating philosophy, in which the master bank will adjust the tap of its transformer, or transformers, according to the detected need, then the followers will copy the master's movement and switch to the same position.

The SDV can act as a parallelism concentrator if the **CONC** option is enabled, managing the parallelism of the SPS, thus replacing the COMM-04 communication module.

2.5.4 Application examples

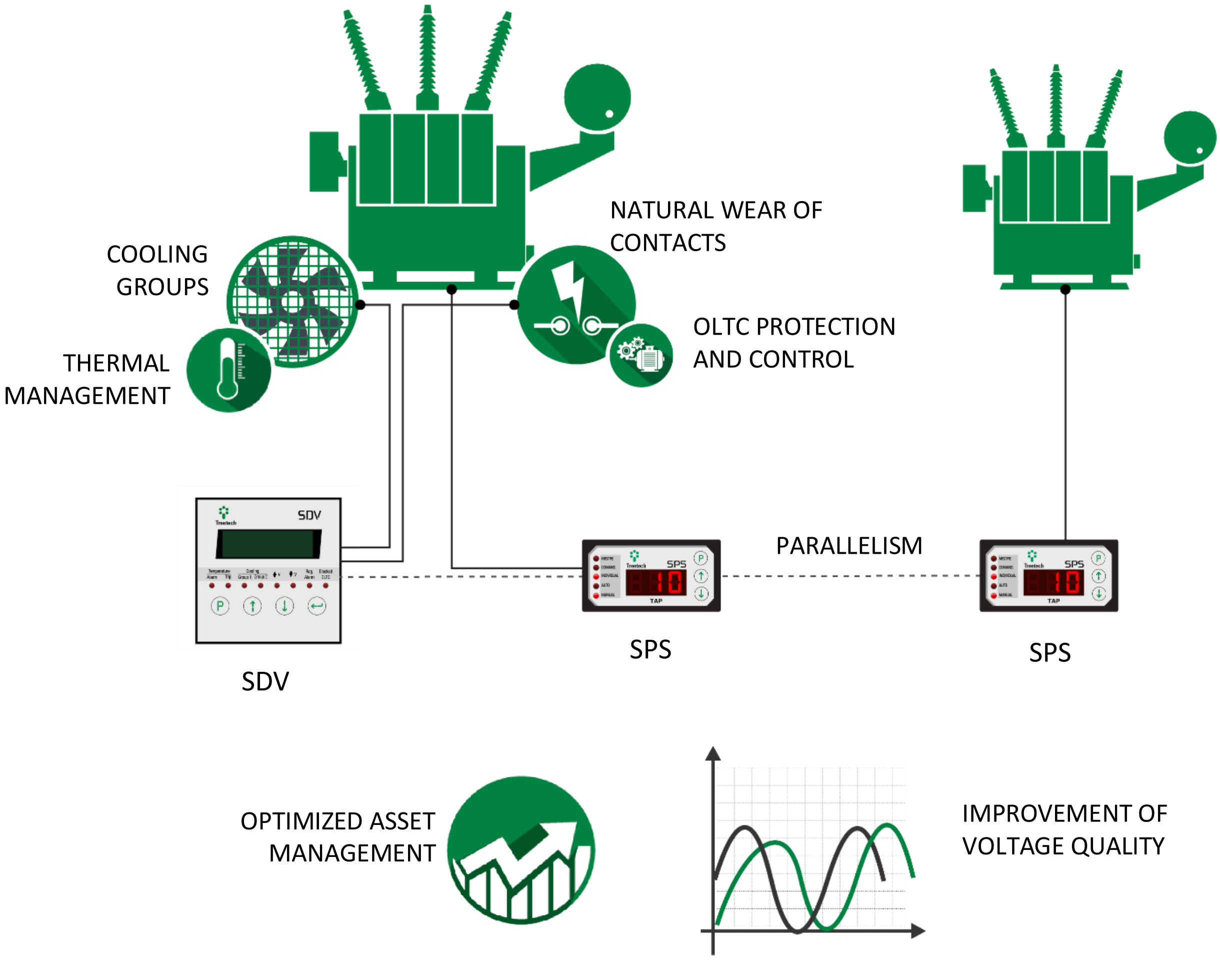


Figure 6 – Application example of the Smart Device for Voltage Regulation - SDV

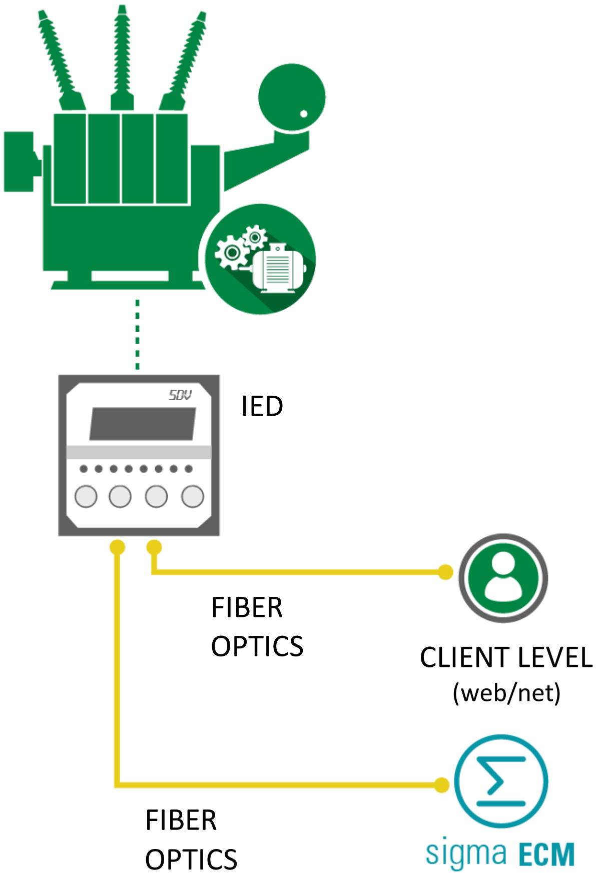


Figure 7 - Application example of the Smart Device for Voltage Regulation – SDV with fiber optics

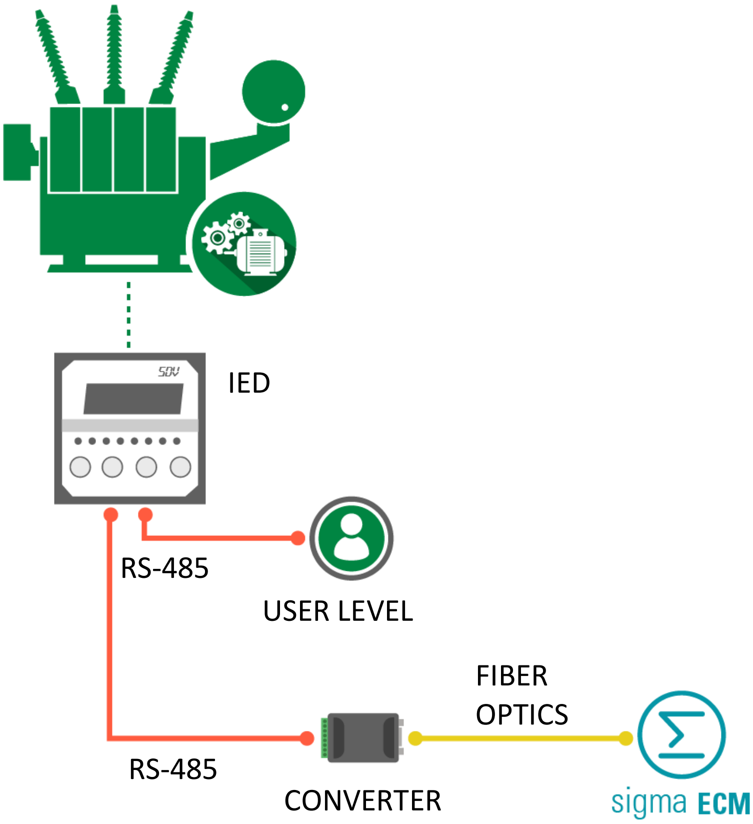


Figure 8 - Application example of the Smart Device for Voltage Regulation – SDV with RS-485

3 Design and installation

3.1 System topology

The SDV has a basic topology, relating its inputs to its outputs, but depending on whether the associated optional functions exist, this topology may have some elements included in its scope. It is worth adding that not all options can be active at the same time.

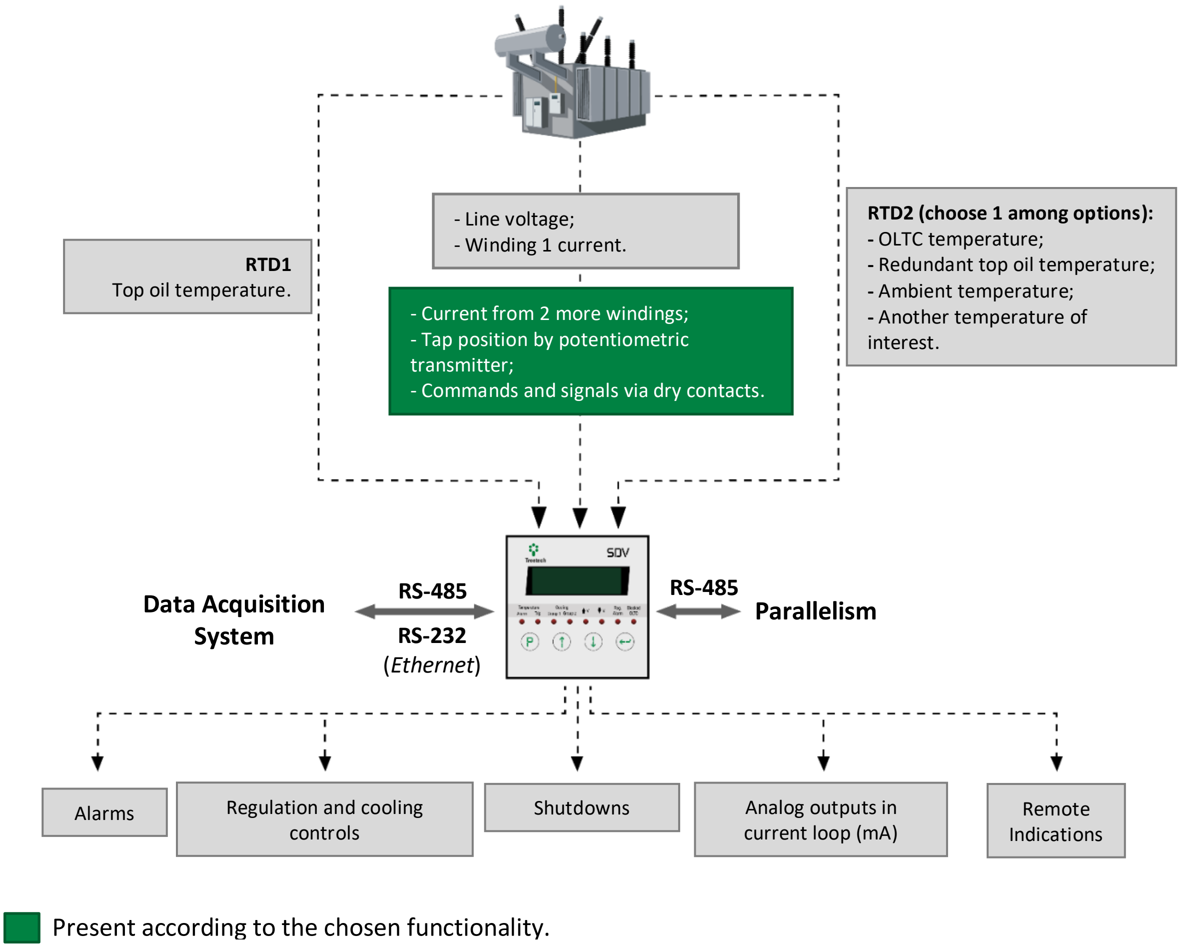


Figure 9 - System Composition of the Smart Device for Voltage Regulation - SDV

The required items for the installation and operation of the Smart Device for Voltage Regulation - SDV are:

- Smart Device for Voltage Regulation - SDV;
- External window CT which is required by the SDV to measure the current for regulation. This item must be specified in the purchase order when the SDV model has regulation;
- External PT for measuring the system voltage that is required by the SDV. This is an item that must appear in the purchase order;

- External split-core window CTs (clip-on) that are required by the SDV for current measurement for thermal imaging. The quantity varies according to the thermal monitoring application (1 or 3 windings) and must be included in the purchase order;
- RTD type Pt100 Ω at 0 °C for temperature measurement by the SDV. The quantity can vary between 1 and 2 and must be included in the purchase order according to the quantity of temperatures to be measured;
- Weatherproof cabinet for outside installation (accessories);
- Three-way shielded cables for connecting the RTD type sensor;
- Two-way shielded twisted-pair cables for serial communication;

3.2 General considerations

The temperature sensor (RTD) must be connected to the Smart Device for Voltage Regulation - SDV through a shielded cable, without interruption of the mesh, which must be grounded only at the end connected to the SDV.

The RS-485 serial communication must be interconnected through a shielded twisted pair cable, keeping the mesh uninterrupted until its termination, grounding only one of the ends. The maximum distance allowed for this type of serial communication is 1200 meters, according to the TIA-485-A-1998 standard.

The first three output relays, in addition to being reversible, can be configured to work in normally closed (NC) or normally open (NO) mode in the "
Relays" menu, section 5.9.2. In this way, it is possible to obtain several advantages arising from this flexibility. One of them is the duplication of contacts, just considering an inverse operating logic in the final application, without any harm to the safety or speed of action of the contact for the critical application.

Details on how to carry out the electrical installation can be found in section 3.4.

3.2.1 Communication port topology

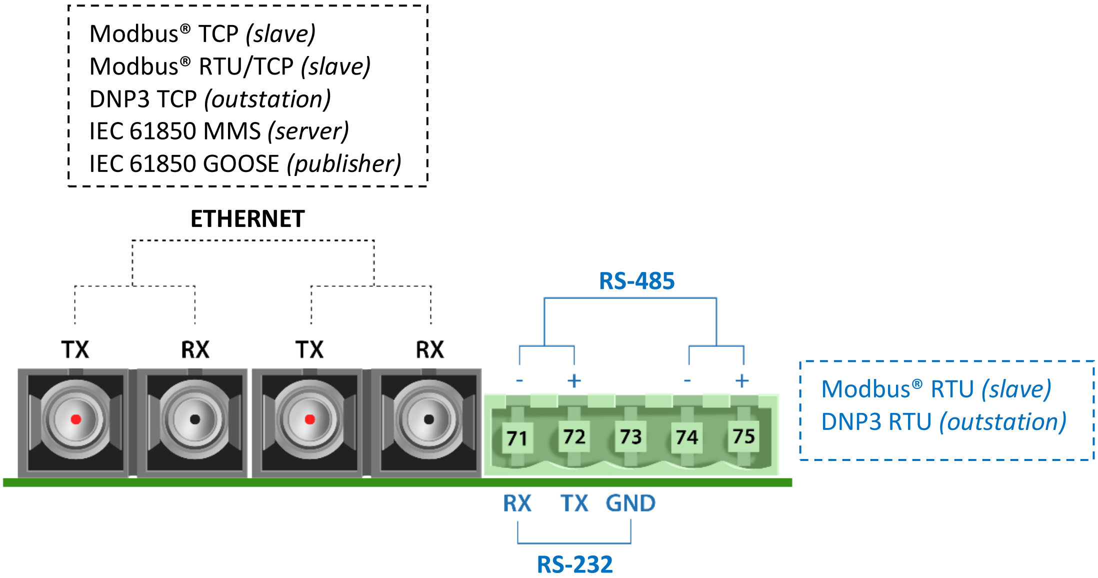


Figure 10 - Topology of ports available on fiber optic Ethernet model (FOFO)

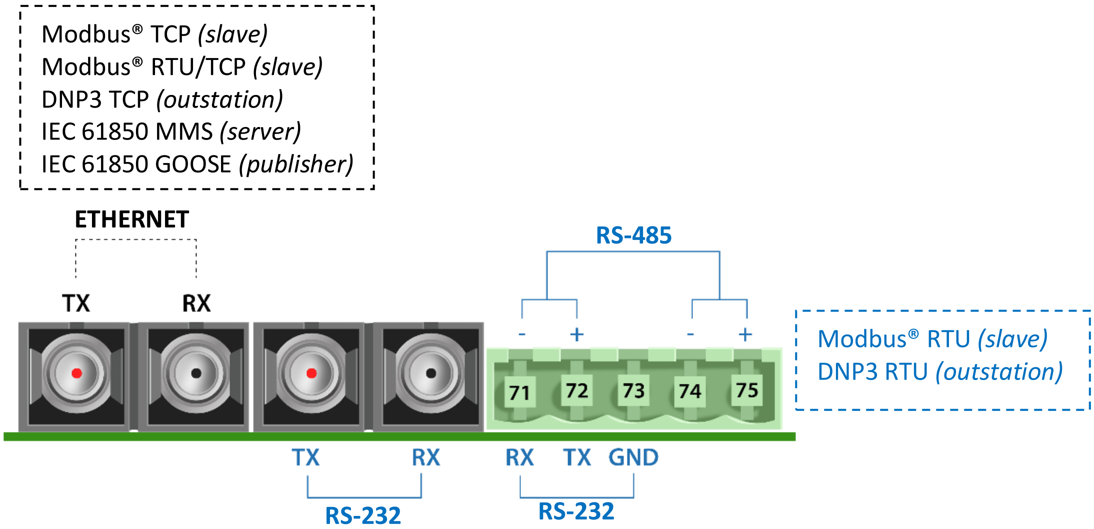


Figure 11 - Topology of ports available on fiber optic Ethernet + serial model (FOSR)

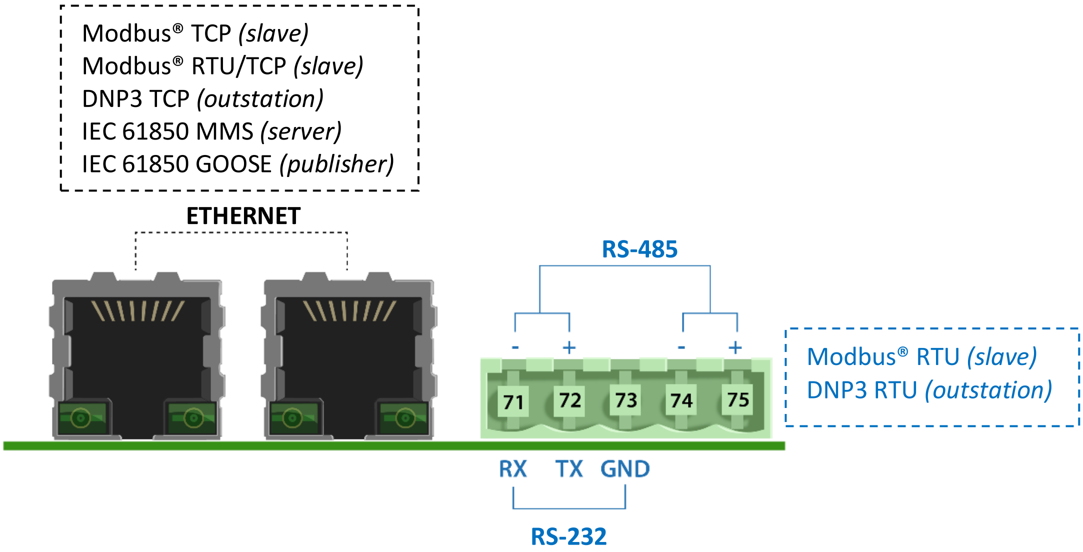


Figure 12 - Topology of ports available on the RJ45 (RJ45) model

3.3 Mechanical installation

The Smart Device for Voltage Regulation - SDV must be installed protected from the weather, inside panels or sheltered in a control room, for example. In either case, there must be an anti-condensation system.

The SDV is suitable for flush-mounted installation and can be fixed, for example, on doors or front plates of panels. Fastening clips are supplied with the equipment.

The following figure shows the main dimensions of the equipment, as well as the dimensions of the cutout in the plate for inserting it.

Special attention must be given to the thickness of the paint layers of the plate where the cut is made, because in some cases, when high thickness paint is used, the reduction of the cut area can even prevent the insertion of the equipment. The connection terminals are installed on the rear of the SDV, in three removable connectors, in order to facilitate the connections. Cables from 0.3 to 2.5 mm^2 can be used, following good installation practices.

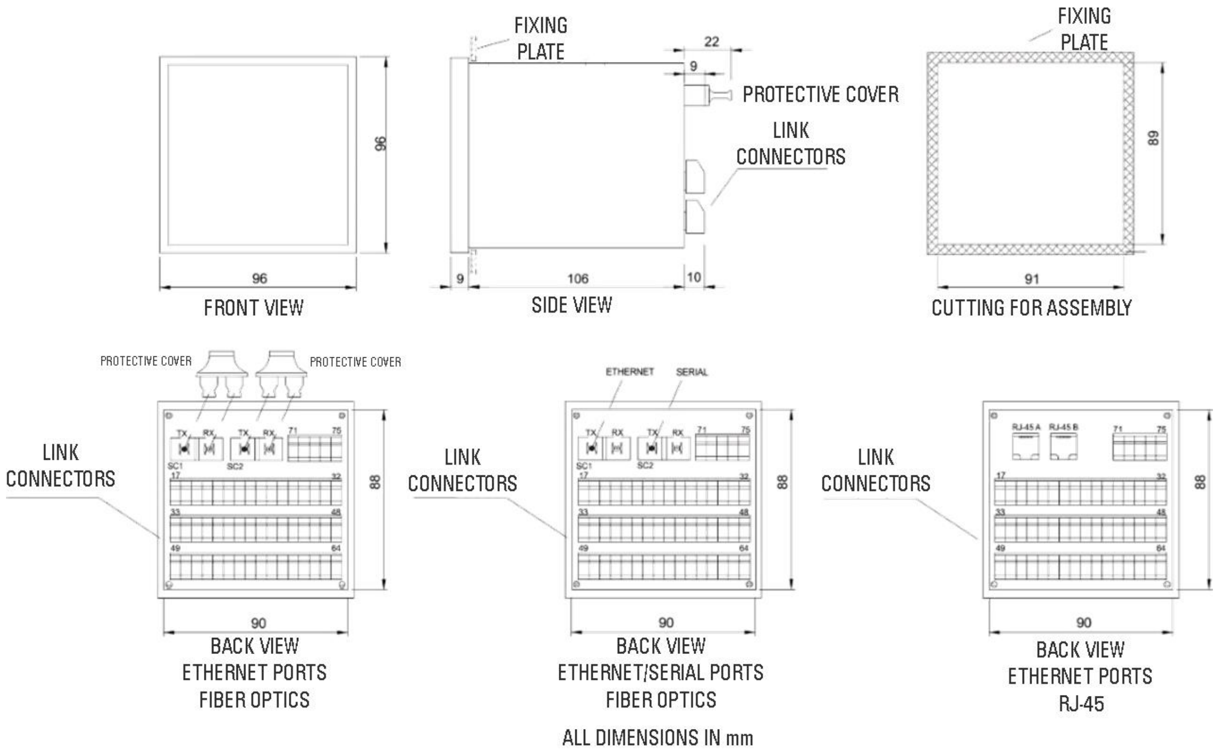


Figure 13 - Dimensions of the SDV

3.4 Electrical installation

The SDV is a versatile equipment that can meet many different types of applications.

Thus, its installation requires a higher level of study and care than equipment dedicated exclusively to a single application or task.

The SDV has different electrical installation configurations. These settings are determined if the application in question uses the available features and options.

Study and understand the application in which you want to use the SDV. Learn about the functional, electrical and configuration characteristics of the SDV. In this way you will be able to take full advantage of the equipment and minimize the risks to your safety.

This equipment operates at dangerous supply voltage levels, which could result in death or serious injury to the operator or service provider.

Some special care must be taken for the design project and installation of the SDV, as described below.

A circuit breaker must be used immediately before the power input (universal power supply - 85 to 265 Vac/Vdc, ≤ 13 W, 50/60 Hz), which corresponds to pins 33 and 34 of the SDV. This circuit breaker must have the number of poles corresponding to the number of phases used in the supply - the poles must only interrupt the phases, and never the neutral or ground - and provide thermal and electrical protection to the conductors that supply the equipment. The circuit breaker must be close to the equipment and easily maneuvered by the operator. Additionally, it must have an indelible identification showing that it is the electrical disconnect device of the SDV.

The following circuit breaker specification is recommended when used exclusively for the SDV:
AC/DC Power, Phase-Neutral: Single-pole circuit breaker, 1 A ≤ In ≤ 2 A, curve B or C, NBR/IEC 60947-2, NBR/IEC 60898 or IEEE 1015:2006 standards;
AC/DC Power, Phase-Phase: Bipolar circuit breaker, 1 A ≤ In ≤ 2 A, curve B or C, NBR/IEC 60947-2, NBR/IEC 60898 or IEEE 1015:2006 standards.

The minimum insulation for the circuits connected to the SDV is 300 V_{rms} for equipment and auxiliary transducers, such as Pt100 Ω at 0 °C and for equipment with its own power supply up to 50 V_{rms}
The minimum insulation is 1.7 kV_{rms} for equipment powered up to 300 V_{rms}, according to IEC 61010-1.
These values are related to the intrinsic insulation of the devices connected to the SDV. Cases where this value does not apply to equipment or devices connected to the SDV will be explicitly informed in this manual.

The standard schematic diagram of the SDV connections shows all the possibilities of connections that the SDV provides, identifying them, as shown in the figure below.

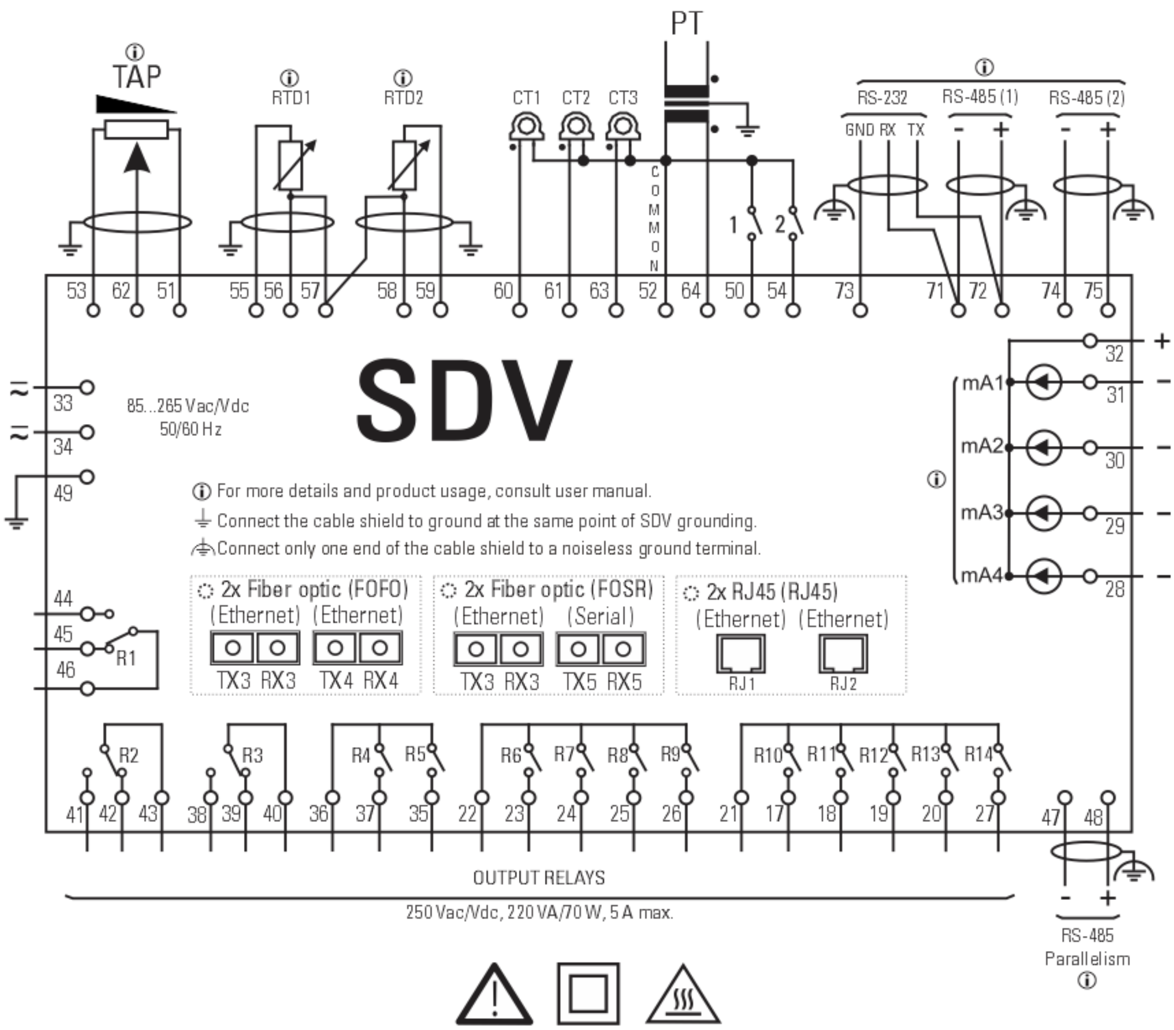


Figure 14 - Electrical connection diagram showing SDV input and output terminals

The use of several inputs depends on the application of the SDV and, therefore, on the parameterizations (Chapter **Error! Reference source not found.**), and on the active options (item 2.2):

- • The second Pt100 sensor can be used as a tool for the redundancy functions for measuring the oil temperature, for calculating the tap changer temperature differential, or for measuring another temperature of interest, such as ambient temperature. However, only one of these functions can be used;
- Terminals for current input 61 and 63 will only be used if the **3-winding temperature supervision** functionality is chosen;
- The potentiometric transmitter, installed on terminals 51, 53 and 62, depends on the **TAPP** option to work;
- Finally, the **DIGI** option enables the use of terminals 50 and 54 to receive the signal from two dry contacts, used for parallelism.

The functions assigned to the outputs in the electrical connection diagram are just suggestions and can be freely configured by the user during parameterization, as seen in subchapter 5.9.

Since the SDV offers a wide variety of warnings, alarms and commands, it will also be necessary to choose the use of the outputs according to the priorities of the application.

Special attention must be paid to the correct connection of components to the SDV at all stages of installation. Errors in connecting the equipment can cause risks or evenirreversible damage to the operator. Damage from misuse is not covered under the warranty.

In the following sections, the connections and functions of the equipment's inputs, outputs and communications will be presented in more detail.

3.4.1 Input terminals

The SDV can be divided, to simplify understanding, into input, output and communication terminal blocks. These blocks will be explained individually. The input block is shown in the table below. It contains a brief description of the items, which are numbered for further detail.

Table 2 - SDV input terminals

Inputs	Terminals
POWER AND GROUND Inputs for universal power 85 to 265 Vac/Vdc, 50/60 Hz, ≤ 13 W.	33 - dc/ac 34 - dc/ac 49 - ground
DRY CONTACT INPUTS These are the inputs for dry contacts that can receive various signals, such as receiving a command to raise or lower tap, change the tap changer command mode between local/remote and manual/automatic or enable the parallelism concentrator. These inputs can only be used if the **DIGI** option is enabled.	50 - C1 54 - C2 52 - common
TAP MEASUREMENT BY POTENTIOMETRIC TRANSMITTER To measure the tap position, a potentiometric transmitter must be connected to the SDV. This table indicates the inputs used by the transmitter. Later, its installation will be explained in more detail. These inputs can only be used if the **TAPP** option is enabled.	62 - *cursor* 51 - minimum tap 53 - maximum tap
TEMPERATURE SENSORS In order to monitor the transformer oil temperature and other temperature required by the application, the Smart Device for Voltage Regulation - SDV has two inputs for Pt100 Ω at 0 °C type sensors.	55 - VR RTD 1 56 - VM RTD 1 57 - VM common 58 - VM RTD 2 59 - VR RTD 2
CURRENT INPUTS The measurement of transformer currents is important to calculate the temperature of the windings, wear of the tap changer contacts due to switched current, the minimum circulating current, etc. The SDV does this by using external split-core window CTs (clip-on) and external regulation CTs with a non-sectionable core. The measurement range **on the primary of the CTs** is 0 to 10 Aac, 14 A peak, and 1% error of the measurement in the range 0.5 to 10 Aac for the clip-on CT and measurement range of 0 to 10 Aac with maximum error of 1% of measurement with loads up to 300 Ω for the external regulation CT.	60 - Ien1 61 - Ien2 63 - Ien3 52 - common
VOLTAGE INPUT The input for measuring one of the transformer's voltages is important for performing the functions related to voltage regulation and parallelism. The measurement range of the SDV is from 0 to 185 Vac at the primary of the regulation PT, with an error of 1% in the range of 80 to 160 Vac.	64 - V_L 52 - common

POWER AND GROUND

The SDV has a universal power input (85 to 265 Vac/Vdc 50/60 Hz). Powering the SDV through the substation's auxiliary services is particularly advisable when it is integrated into a serial communication network for data collection purposes for supervisory or monitoring systems.

DRY CONTACT INPUTS

If the **DIGI** option is enabled, the SDV will be able to receive information through two dry contacts to be connected to terminals 50 and 54 with pin 52 in common.
These contacts are especially useful for the device's regulation functions, allowing it to receive the following instructions and information from a remote source:

- Command for switching between automatic/manual mode;
- Command for switching between local/remote mode;
- Command for increasing/decreasing tap (available if the **TAPP** option is enabled);
- Command for enabling/disabling the parallelism concentrator (available if the **CONC** option is enabled).

The electrical connection of these contacts is very simple, just connecting the contacts to the appropriate inputs. The parameterization of their functions is described in chapter **Error! Reference source not found.**.

TAP MEASUREMENT BY POTENTIOMETRIC TRANSMITTER

With the TAPP option, the SDV can measure the tap position. It is carried out through a specific input for connecting a potentiometric position transmitter of the on-load tap changer.

CONNECTION CABLES FOR TAP MEASUREMENT

The connection potentiometric position transmitter of the tap changer to the SDV is made through three wires: the cursor, the start and the end of the potentiometric transmitter. The three wires must have the same length and gauge. Shielded-type cable must be used for this connection along the entire path from the tap changer cabinet to the SDV, with the shield grounded at a single point.

If a single shielded cable is not used for the entire route, due, for example, to intermediate connection terminals, the continuity of the shield must be ensured by connecting the ends of the shields of the different cables, as can be seen in the following figure. The unshielded cable run due to the splice must be as short as possible.

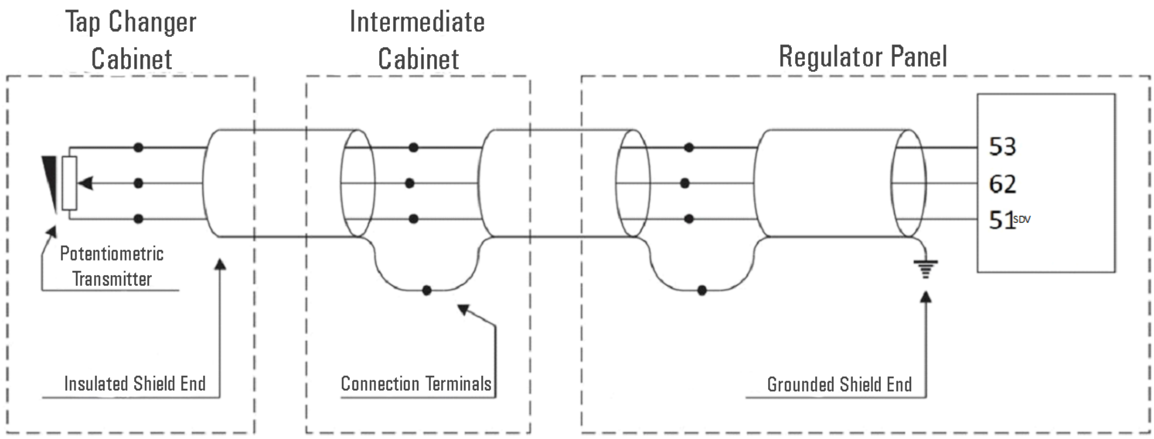


Figure 15 - Connecting the shield of the tap measurement cables

The automatic resistance compensation of the connection cables is made from the potentiometric transmitter to the SDV, and for this the three wires must have the same length and gauge, with the maximum allowable resistance for each wire being 8 Ω. Depending on this maximum resistance and the gauge of the cables used, the maximum permitted length for these can be obtained. Considering non-tinned cables, stranding class 4, we have the maximum lengths shown in the following table.

Table 3 - Maximum length for the gauges of the tap measurement cables

Cable gauge	Typical resistance	Max length
0.5 mm^2	39.0 Ω/km	200 m
0.75 mm^2	26.0 Ω/km	300 m
1 mm^2	19.5 Ω/km	400 m
1.5 mm^2	13.3 Ω/km	600 m
2.5 mm^2	7.98 Ω/km	1000 m
4 mm^2	4.95 Ω/km	1600 m

TAP POSITION TRANSMITTER REQUIREMENTS

The tap position transmitter of the on-load tap changer must be of the potentiometric type, with its resistance varying increasingly. In the parameters related to tap measurement (available if the **TAPP** option is enabled), it is possible to configure the initial and final offset, and the step of the resistor in the tap change. In addition, it is also possible to adjust the tap changing time, maximum and minimum tap and parameters related to the intermediate taps.

In the case of tap changers with intermediate positions, that is, transition positions that have the same voltage as other adjacent positions, it is possible to parameterize the number of transitions with intermediate taps found on the tap changer, the number of intermediate positions in each transition, and if these positions have resistance or are short circuited.

Next, the configuration of each parameter is shown, based on the example potentiometric transmitter in Figure 16, with its data in the table below. All intermediate positions (in the example, 6A, 6, 6B and 6C) will be indicated as tap “6” since they have the same voltage.

Table 4 - Resistance of the cursor indicating the tap position

Tap position	Voltage (V)	Current (A)	Measured resistance between cursor and starting position
1	12420	3220.6	10
2	12696	3150.6	20
3	12972	3083.6	30
4	13248	3019.3	40
5	13524	2957.7	50
6A	13800	2898.6	60
6			70
6B			80
6C			90
7	14076	2841.7	100
8	14352	2787.1	110
9	13800	2734.5	120
10	14904	2683.8	130

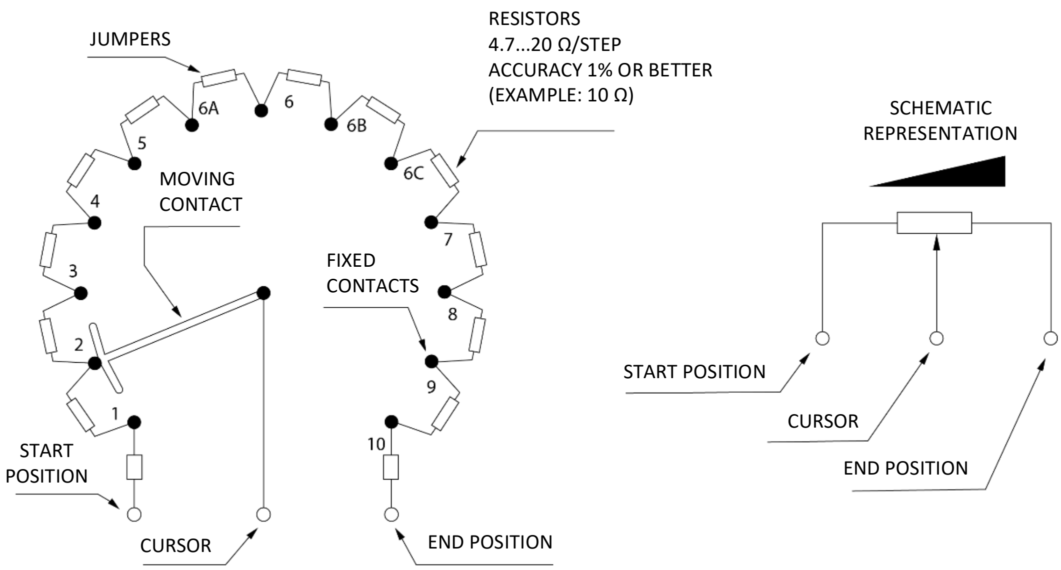


Figure 16 - Configuration of the potentiometric transmitter resistors in the intermediate positions of the OLTC

The SDV assumes that the resistance per step of the potentiometric transmitter is in the range from 4.7 to 20 Ω, and the total resistance of the transmitter from 4.7 to 1400 Ω. The value of each individual resistor is shown in Figure 17, at the RS value. The moving contact (cursor) of the potentiometric transmitter can be either “close before open” or “open before close” type, regardless. The potentiometric transmitter resistors must be precision ones, that is, with error tolerances of at most 1%.

In this case, the SDV parameterization about the OLTC must be done considering the resistance value per step (RS). The parameter “Initial Offset” must be parameterized with the value of the initial resistance (IR). The final resistance (FR) can be entered in the parameter “Final Offset”. Remember that if there are no initial and final resistances, the corresponding offset values must be set to 0.

Furthermore, it is necessary to add the number of monitored tap positions, which in this case is 10, and the number of minimum tap and maximum tap that can be reached by the tap changer, which in the example is 1 and 10, respectively. The tap changing time must also be entered.

For the case of parameterization of the intermediate transition, the SDV requires the adjustment of each one of the existing intermediate transitions, there being a maximum of three different intermediate positions, with up to 5 jumps between them. In the example, we have two intermediate transitions, from tap 5 to tap 6 and from tap 6 to tap 7.

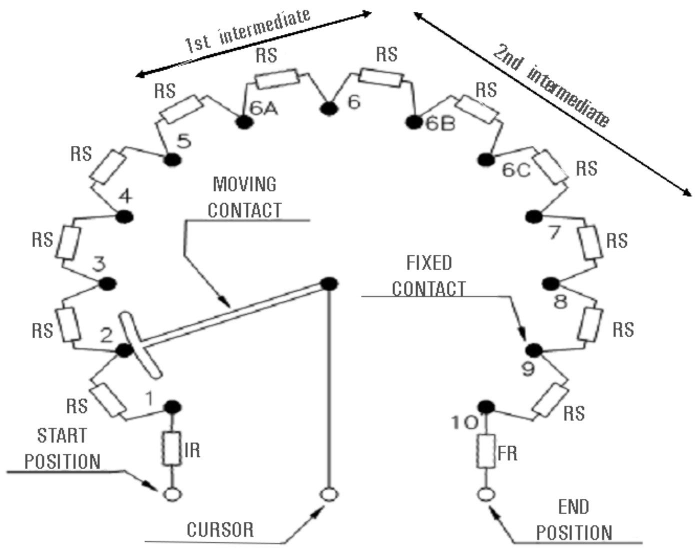


Figure 17 - Illustration of intermediate taps

To parameterize the first intermediate transition, the SDV needs the indication of the tap passage of that transition, which in this case is from tap 5 to tap 6. In addition, it is necessary to enter the number of intermediate steps until the transition is complete. In this case, we have two steps (5 - 6A and 6A - 6). Finally, it is necessary to indicate whether this transition has resistance or not. Some manufacturers and some installations have short-circuited intermediate taps. In these cases, the parameterization must indicate that the intermediate taps do not have resistance. In the example in this manual there is resistance, which must be indicated on the SDV.

In the second intermediate transition, parameterization is done in a similar way. The tap step indication must be from tap 6 to tap 7, the number of steps is 3 (6 - 6B, 6B - 6C, 6C - 7), and the resistance indication must be "YES" in the parameter of presence of resistance in the intermediate taps.

For more details on the parameterization of each of these parameters, such as the initial and final *offset*, resistance per step and settings about the intermediate taps, see item 5.7 of the manual, remembering that these parameters will only be enabled if the **TAPP** option is enabled.

The ongoing tap position of the associated on-load tap changer can be entered in the formats: simple numeric (1...17), bilateral numeric (-8...0...+8) or alphanumeric (8L...N...8R).

If the number of taps is 10, for example, and the representation is not simple numeric, it will be necessary to additionally inform the central tap, which will be the tap considered as 0 in the bilateral classification, or N in the alphanumeric scale. From this value, the SDV corrects the tap indication according to the set central tap value.

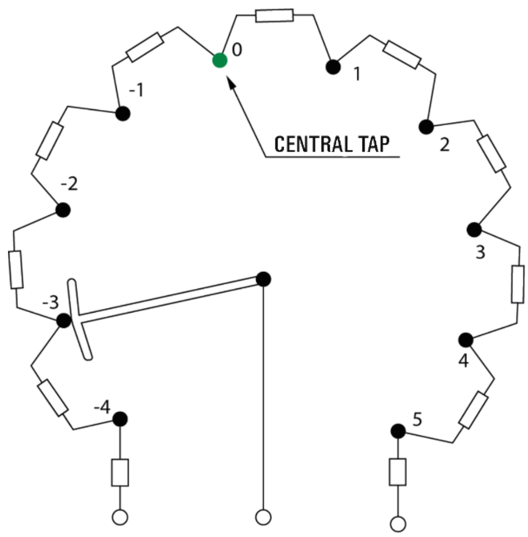


Figure 18 - Central tap indication

TEMPERATURE SENSORS

The SDV has two inputs for RTD Pt100 Ω at 0 °C type temperature sensors. One of them must be used to measure the temperature of the top of the transformer oil; the other can be used to measure ambient temperature, transformer oil temperature redundancy, tap changer oil temperature, or to another desired temperature. The choice of the function of the second sensor is up to the user and, depending on the application, it may be necessary to activate some options. More details on the description of the sensor usage programming can be found in chapter 5.4.

The temperature sensor must be connected to the SDV through shielded cables, without interrupting the mesh, which must be grounded only at the end connected to the SDV, as close as possible to it. If there is a need for intermediate terminals for interconnecting the RTD sensor, the cable shield must pass through the terminal, preventing its interruption. The unshielded cable run due to the splice must be as short as possible.

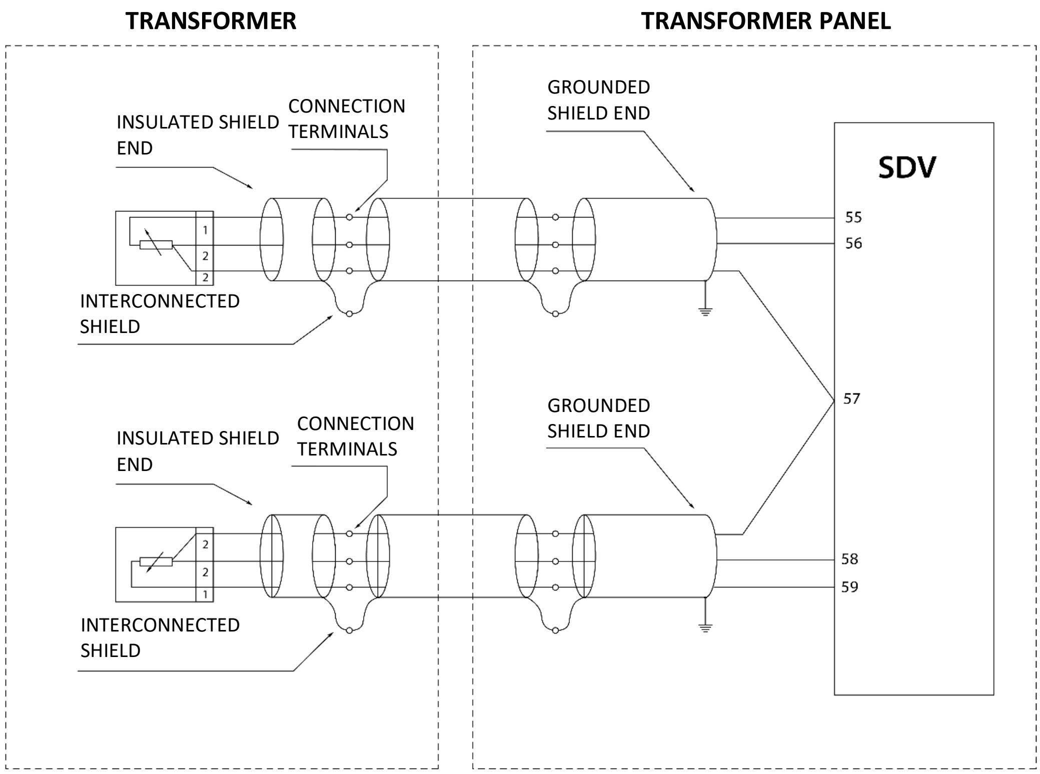


Figure 19 - Connecting the shield in the interconnection between RTD sensors and the SDV

CURRENT AND VOLTAGE INPUTS

There are enough inputs on the SDV to measure the current of three windings of a transformer. Terminals 60, 61 and 63 receive the signals of currents Iwin1, Iwin2 and Iwin3 respectively, while pin 52 is the common one between measurements. If only one winding of the transformer is monitored, the CT used to calculate the thermal image must be connected to terminals 52 and 60 and the one for regulation can also be used, or another input can be used to connect the regulation CT.

The equipment measures winding currents for thermal imaging calculation using external split-core window CTs (clip-on). The measuring range in the primary of the CTs is from 0 to 10 Aac RMS, with a maximum error of 0.5% of the measurement. It is important that the external CT primary rated current (the current coming from the transformer CT) is less than 10 Aac. If this is not possible, it is necessary to use a shunt resistor or some other method to reduce the current to a suitable value.

Care must be taken to connect the transformer CT input to ensure that it does not remain open during asset operation. If interventions are carried out on this circuit with the transformer energized, check that the instrument CT of the equipment is short-circuited and grounded in the panel terminals.

If the SDV has the regulation functionality, the input where the external CT for regulation is located must be informed in the configuration. This external CT is a window type with a non-sectionable core, unlike the clip-on CT that is normally used for thermal imaging. The measuring range at the CT primary is 0 to 10 Aac RMS, with 1% measurement error with loads up to 300 Ω. It is noteworthy that, if the winding in which the regulation is made is also being monitored for the calculation of the thermal image, the current measured by the external regulation CT is already sufficient for the calculation, and it is not necessary to place a clip-on CT in this winding.

The measuring range in the primary of the regulation PT is from 0 to 185 V, with a maximum error of 0.5%, in the operating range from 80 to 160 V. Both PT (potential transformer) and CT (current transformer) inputs take measurements in true RMS mode.

There are several possible combinations for the connection of the PT and the CT, and each combination produces a phase angle between the voltage and current signals. In the SDV programming, the phase difference between the signals is adjusted, from 0° to 330° in 30° steps, which will be used in the compensation for the correct calculation of the power factor.

Below are examples of some possible combinations of TP and TC connections. Other combinations are possible, and the phase difference can easily be determined by drawing the phasor diagram as indicated in the examples.

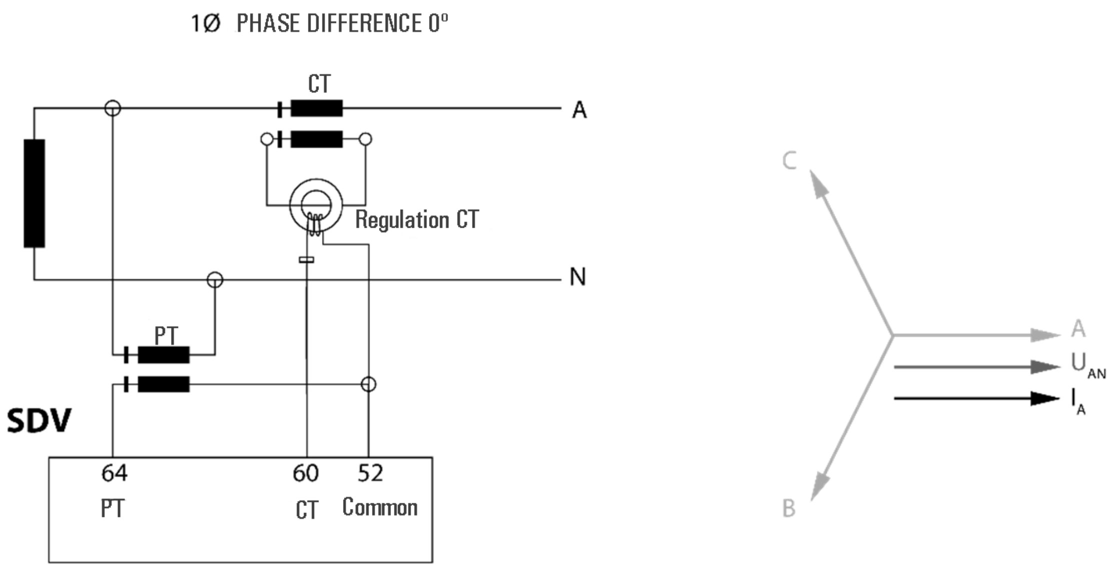


Figure 20 - Connection for single-phase transformer, 0° phase difference

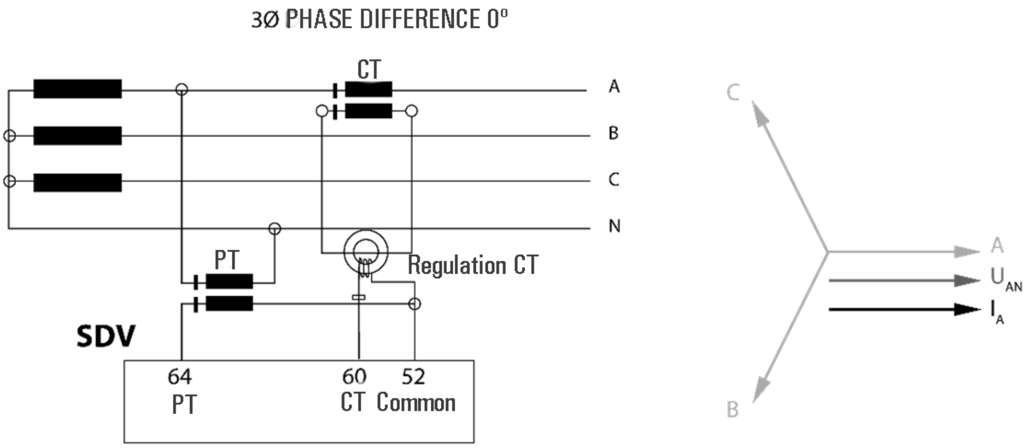


Figure 21 - Phase-neutral PT connection, 0° phase difference

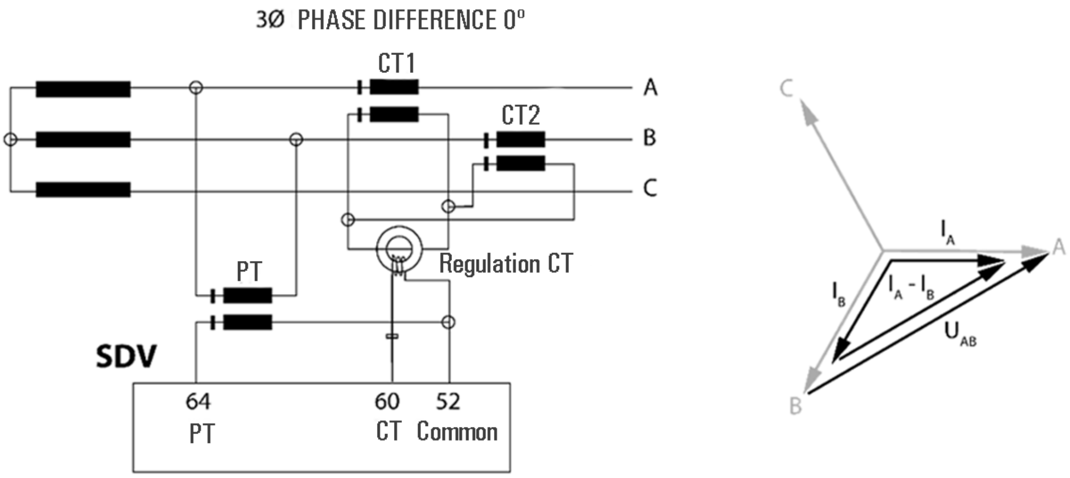


Figure 22 - Phase-to-phase PT connection, 0° phase difference

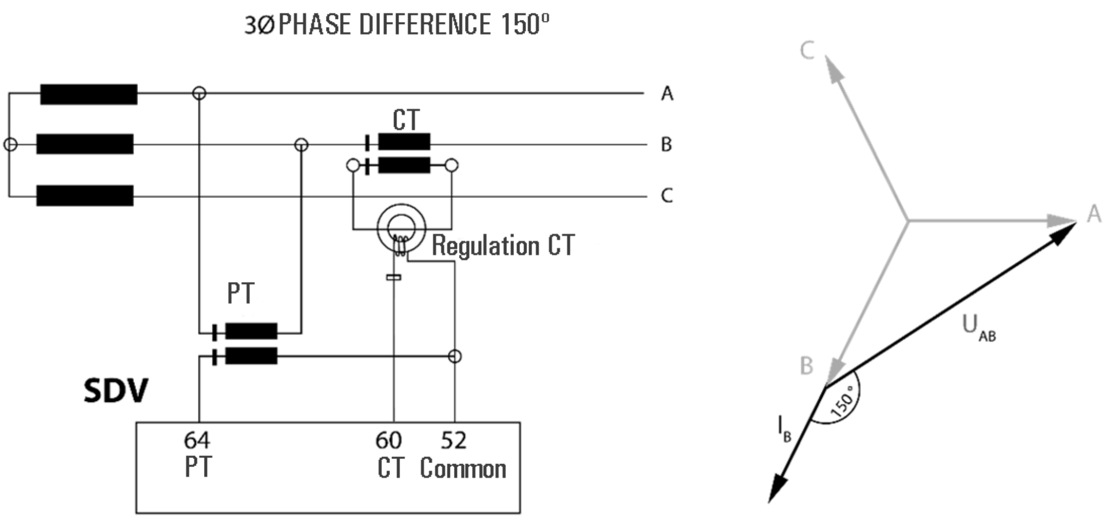


Figure 23 - Phase-to-phase PT connection, 150° phase difference

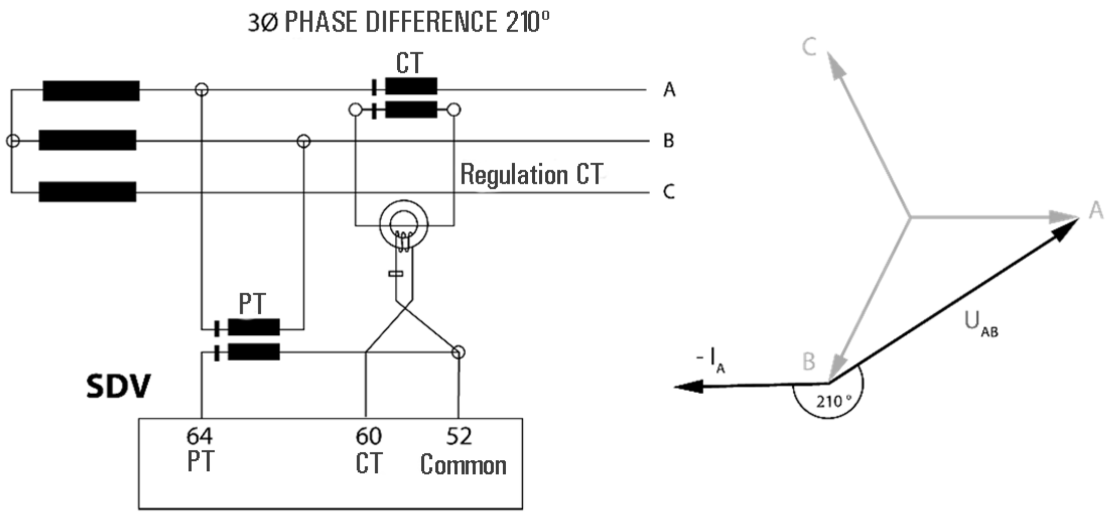


Figure 24 - Phase-to-phase PT connection, 210° phase difference

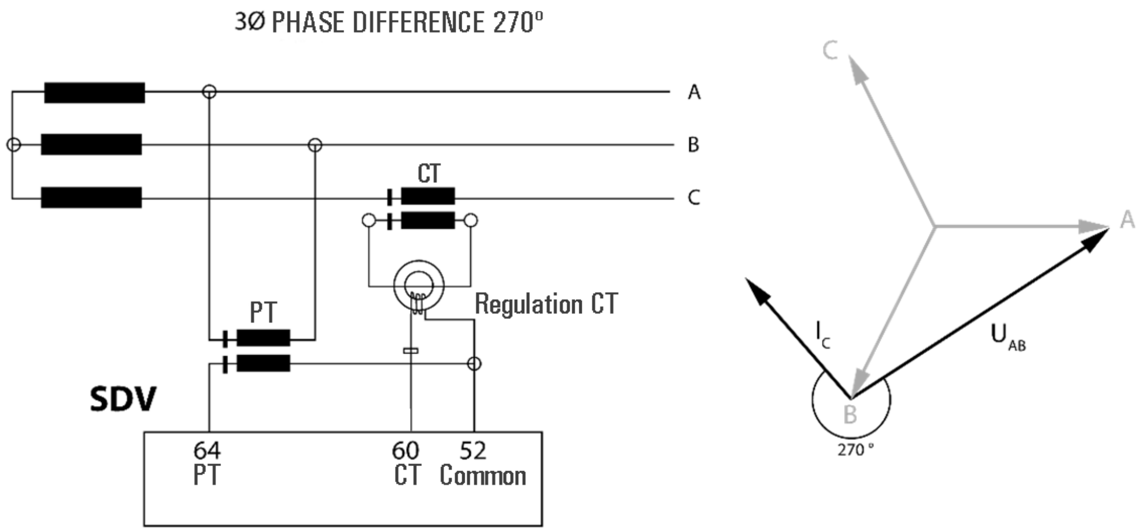


Figure 25 - Phase-to-phase TP connection, 270° phase difference

3.4.2 Output terminals

Table 5 - SDV output terminals

Outputs	Terminals	
REVERSIBLE LOGIC RELAYS	R1	44 - NO 45 - NC 46 - common

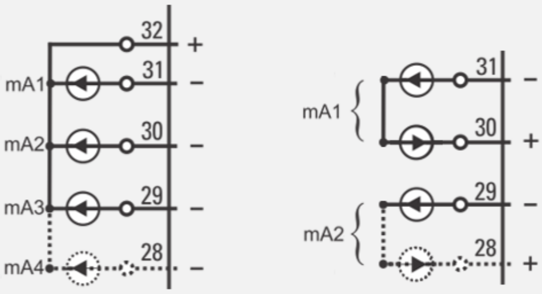
<table>
<tr><td rowspan="2">The SDV has three reversible output relays being NO or NC.

R1 - Self-diagnostic signaling relay
R2 - Forced ventilation group 1 activation relay
R3 - Forced ventilation group 2 activation relay</td><td>R2</td><td colspan="2">41 - NO
42 - NC
43 - common</td></tr>
<tr><td>R3</td><td colspan="2">38 - NO
39 - NC
40 - common</td></tr>
<tr><td rowspan="11">SIMPLE CONTACT RELAYS

The SDV also has another eleven normally open (NO) output relays. Relays 6 to 10 are configurable by the user from a list of possibilities described in Table 6 and the others have a fixed function.

R4 - Command relay to raise voltage
R5 - Command relay to lower voltage
R6 - Configurable
R7 - Configurable
R8 - Configurable
R9 - Configurable
R10 - Configurable
R11 - Oil temperature shutdown relay
R12 - Winding 1 temperature shutdown relay
R13 - Winding 2 temperature shutdown relay
R14 - Winding 3 temperature shutdown relay</td><td>R4</td><td colspan="2">37 - NO
36 - common</td></tr>
<tr><td>R5</td><td colspan="2">35 - NO
36 - common</td></tr>
<tr><td>R6</td><td colspan="2">23 - NO
22 - common</td></tr>
<tr><td>R7</td><td colspan="2">24 - NO
22 - common</td></tr>
<tr><td>R8</td><td colspan="2">25 - NO
22 - common</td></tr>
<tr><td>R9</td><td colspan="2">26 - NO
22 - common</td></tr>
<tr><td>R10</td><td colspan="2">17 - NO
21 - common</td></tr>
<tr><td>R11</td><td colspan="2">18 - NO
21 - common</td></tr>
<tr><td>R12</td><td colspan="2">19 - NO
21 - common</td></tr>
<tr><td>R13</td><td colspan="2">20 - NO
21 - common</td></tr>
<tr><td>R14</td><td colspan="2">27 - NO
21 - common</td></tr>
<tr><td>CURRENT LOOP ANALOG OUTPUTS

There are four outputs for remote indication of several values, such as voltage, temperature or tap position. Their functions are selectable in the programming menu.</td><td>mA1</td><td>31 - (-)
32 - (+)</td><td>31 - (-)
30 - (+)</td></tr>
</table>

The output standard is also selected by the user from the options: 0 to 1, -1 to +1, 0 to 5, -5 to +5, 0 to 10, -10 to +10, 0 to 20, -20 to +20 or 4 to 20 mA. (If a measuring range with negative values is selected, the rear channel will be used as the positive of the analog output, and pin 32 will not be used). Below is an example of the connections for each option. The connection on the left shows the diagram for options 0 to 1, 0 to 5, 0 to 10, 0 to 20 and 4 to 20. The connection on the right shows the diagram for the remaining options, -1 to +1, -5 to +5, -10 to +10, -20 to +20. 	mA2	30 - (-) 32 - (+)	29 - (-) 28 - (+)
	mA3	29 - (-) 32 - (+)	
	mA4	32 - (+) 28 - (-)	

REVERSIBLE LOGIC RELAYS

They are relays that can work as NO or NC depending on the output the user chooses to connect to their application.

The relay contacts can switch loads up to 250 Vdc/Vac, with a maximum power of 70 W/250 VA, considering resistive loads. Their conduction capacity (limit due to the Joule effect) is 5 A, without interruption.

SIMPLE CONTACT RELAYS

There are eleven of these relays on the SDV, R4 through R14. Relays 6 to 10 can be configured to work in normal (NO) or inverted (NC) mode while the others have fixed NO operation.

CONFIGURABLE FUNCTION RELAYS

Configurable relays can be parameterized to operate for any condition among the options shown in the table below.

Table 6 - Configurable relays

Setting range of configurable relays	Description
Class. Green Color	The relay will operate for Green classification alarms
Class. Yellow Color	The relay will operate for Yellow classification alarms
Class. Blue Color	The relay will operate for Blue classification alarms

Class. Red Color	The relay will operate for Red classification alarms
Tap Reading Error	The relay will operate tap reading error
Automatic Mode	The relay will operate when the SDV is in Automatic mode
Manual Mode	The relay will operate when the SDV is in Manual mode
Local Mode	The relay will operate when the SDV is in Local mode
Remote Mode	The relay will operate when the SDV is in Remote mode
Alm. Oil Temp.	The relay will operate when the oil alarm temperature is reached
Delay SD. Oil	The relay will operate when the oil shutdown temperature is reached, with a parameterizable delay
Alm. Temp. Win.1	The relay will operate when winding 1 alarm temperature is reached
Delay SD. Win.1	The relay will operate when the winding 1 shutdown temperature is reached, with a parameterizable delay
Alm. Temp. Win.2	The relay will operate when winding 2 alarm temperature is reached
Delay SD. Win.2	The relay will operate when the winding 2 shutdown temperature is reached, with a parameterizable delay
Alm. Temp. Win.3	The relay will operate when winding 3 alarm temperature is reached
Delay SD. Win.3	The relay will operate when the winding 3 shutdown temperature is reached, with a parameterizable delay
Inst. Differential	The relay will operate when the limit temperature of the instantaneous differential between OLTC oil and transformer oil is reached
Filt. Differential	The relay will operate when the limit temperature of the filtered differential between OLTC oil and transformer oil is reached
Low Lifespan 1	The relay will operate when the remaining lifespan as a percentage of winding 1 insulation is low
Low Lifespan 2	The relay will operate when the remaining lifespan as a percentage of winding 2 insulation is low
Low Lifespan 3	The relay will operate when the remaining lifespan as a percentage of winding 3 insulation is low
Low Lifetime 1	The relay will operate when the remaining lifetime in years of winding 1 insulation is low
Low Lifetime 2	The relay will operate when the remaining lifetime in years of winding 2 insulation is low
Low Lifetime 3	The relay will operate when the remaining lifetime in years of winding 3 insulation is low
High Loss Life 1	The relay will operate when the loss of lifespan exceeds the high alarm for winding 1
High Loss Life 2	The relay will operate when the loss of lifespan exceeds the high alarm for winding 2
High Loss Life 3	The relay will operate when the loss of lifespan exceeds the high alarm for winding 3
Alarm U<	The relay will operate when an undervoltage occurs in the system
Alarm U>	The relay will operate when an overvoltage occurs in the system

Alarm I>	The relay will operate when an overcurrent occurs in the system
OLTC Block	The relay will operate when the OLTC blocking command is issued
OLTC Check	The relay will operate when there is an OLTC check error
OLTC Operations	The relay will operate when OLTC operations exceed the set limit value
OLTC Sum Ipu²	The relay will operate when the OLTC Ipu² sum exceeds the set limit value
Warning Oper.	The relay will operate when OLTC operations reach the set maintenance value
Warning Ipu²	The relay will operate when the OLTC Ipu² sum reaches the set maintenance value

It is noteworthy that some configurable relay parameterization options will only exist if the related option is enabled. Also, the alarms related to winding 2 and 3, regulation and temperature, will only be present if the SDV functionality for these alarms is present.

A configurable relay can be operated by more than one of the settings shown in Table 6, in which case the operation will take place when any of the alarms is triggered.

ANALOG OUTPUTS IN CURRENT LOOP

The SDV has four analog current loop outputs (mA), which can be programmed by the user to remotely indicate the measured voltage, current or tap position value. The output current range is also user selectable from 0 to 1, -1 to +1, 0 to 5, -5 to +5, 0 to 10, -10 to +10, 0 to 20, - 20 to +20 or 4 to 20 mA. The maximum voltage at the current loop output is 10 V, which results in the maximum loads in ohms (Ω) shown below:

Table 7 - Maximum load of current loop output

Output option	Max. load	Output option	Max. load
0...1 mA	10000 Ω	-1...+1 mA	10000 Ω
0...5 mA	2000 Ω	-5...+5 mA	2000 Ω
0...10 mA	1000 Ω	-10...+10 mA	1000 Ω
0...20 mA	500 Ω	-20...+20 mA	500 Ω
4...20 mA	500 Ω	-	-

It is advisable to use shielded twisted pair cable, grounded at only one end, to minimize interference.

The complete list of information that these outputs can send can be found in their parameterization section.

When you want a standard mA output with currents that vary over a range that includes negative values, such as -5 to +5 mA, it is necessary to use two outputs. Together the **mA1** and **mA2** outputs can form a pair in which **mA1** behaves as the most negative pole and **mA2** the most positive. Likewise, the **mA3** and **mA4** outputs can form a second pair, in which **mA3** is the negative pole. In such cases, the number of available analog outputs is naturally smaller.

3.4.3 Communication ports

Table 8 - SDV communication terminals

Communication	Purpose	Terminals
***ETHERNET* PORT** Communication port via RJ45 or SC multimode fiber optics for communication between SDV and control/supervisory system or communication with IEDs. Modbus® TCP (*slave*), Modbus® RTU/TCP (*slave*), DNP3 TCP (*outstation*) and IEC 61850 (*server* and *publisher*) output protocols.	User	RJ45 - 1 RJ45 - 2 TX/RX - 3 TX/RX - 4
SERIAL FIBER OPTIC PORT SC multimode fiber optic communication port for communication between SDV and control/supervisory system or communication with IEDs. Modbus® RTU (*slave*), DNP3 RTU (*outstation*) output protocols.	User	TX/RX - 5
RS-485 COMMUNICATION PORTS Two of them, located at terminals 71 and 72, and 74 and 75, are intended to allow the connection between the SDV and some supervision or monitoring system owned by the user. The third port is dedicated to parallelism and is located at terminals 47 and 48. Communication is done using Modbus® or DNP3 protocol via shielded twisted-pair cable.	User	71 - (-) 72 - (+) 74 - (-) 75 - (+)
	Parallelism	47 - (-) 48 - (+)

RS-232 COMMUNICATION PORT The SDV has an RS-232 communication port for connection to any control, supervisory or monitoring system. Communication is done using the Modbus® or DNP3 protocol, using a shielded and twisted 3-way cable.	User	71 - RX 72 - TX 73 - GND

3.4.3.1 Cautions when installing the RS-485 network

3.4.3.1.1 Communication with the data acquisition system

The SDV can be connected to a data acquisition system (supervisory or monitoring system) via the RS-485 serial communication ports located on terminals 71 and 72, and 74 and 75.

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

The interconnection between the SDV and the data acquisition system must be carried out through a shielded twisted-pair cable, maintaining the mesh without interruption throughout the entire route. If there is a need for intermediate terminals for interconnecting the serial communication, also pass the cable shielding through a terminal, avoiding its interruption. The unshielded cable run due to splicing should be as short as possible, and it is advisable that the cable shield be grounded at only one end. It is advisable to use a 120 Ω terminating resistor at each end of the serial communication network to attenuate signal reflections. In conjunction with the termination resistors, *pull-up* and *pull-down* resistors must be used at only one point of the network, as indicated in the figure below. The 5V direct voltage for supplying 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, dispensing with the use of external resistors. The maximum distance of 1200 m between the ends of the communication network must be obeyed.

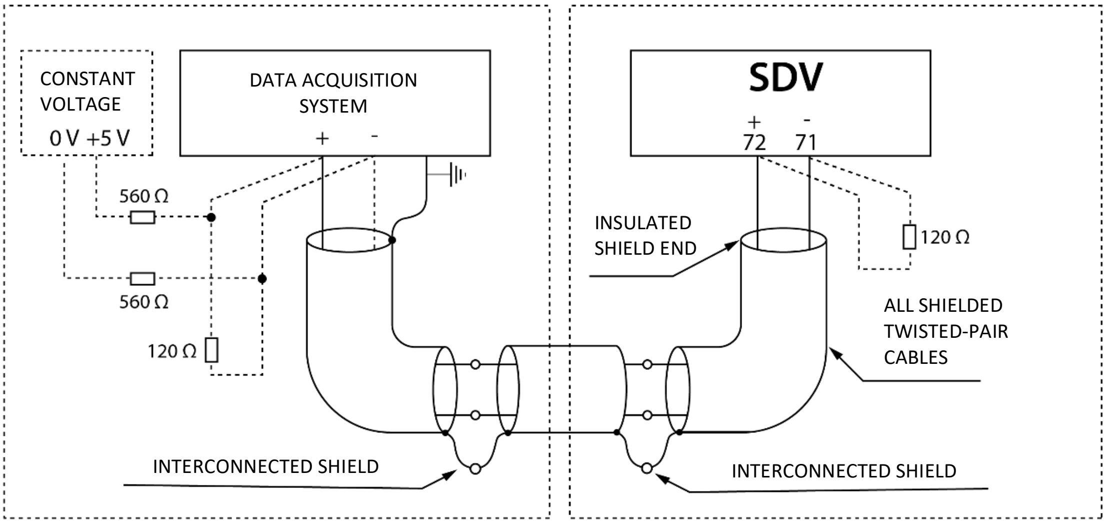


Figure 26 - RS-485 serial communication shield connection and grounding

3.4.3.1.2 Parallelism communication

For the SDV to act as a parallelism concentrator, the SDV and all SPSs that participate in parallelism must be interconnected by connecting their RS-485 ports in parallel, as shown in Figure 27. If there is a need for intermediate terminals for interconnecting the serial communication, also pass the cable shielding through a terminal, avoiding its interruption. The unshielded cable run due to the splice must be as short as possible. It is recommended that the cable shield be grounded at only one end and that a 120 ohm termination resistor be installed at each end of the serial communication, as shown in Figure 27:

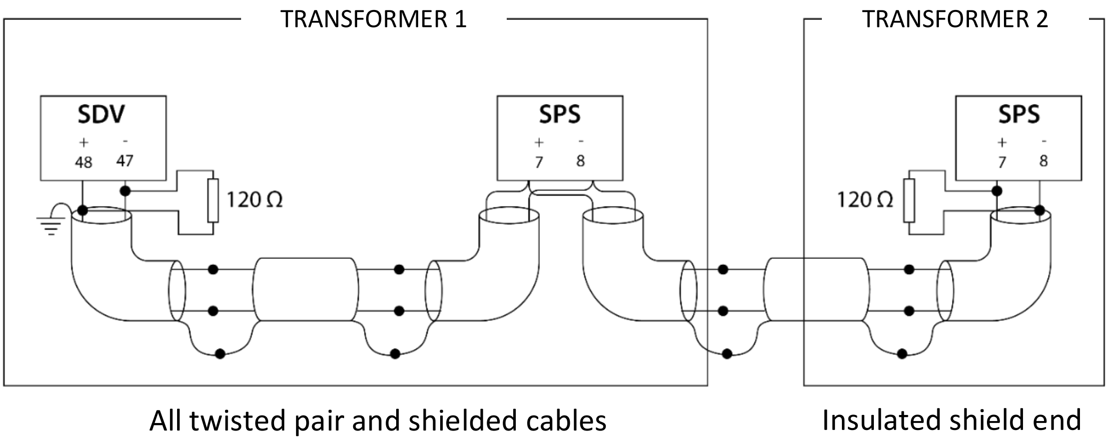


Figure 27 - SDV interconnection as parallelism concentrator

4 Operation

All operations on the Smart Device for Voltage Regulation - SDV can be performed through the keyboard on its front panel. The voltages, currents and other measured quantities are indicated on the display, and the alarm conditions, by the signaling LEDs.

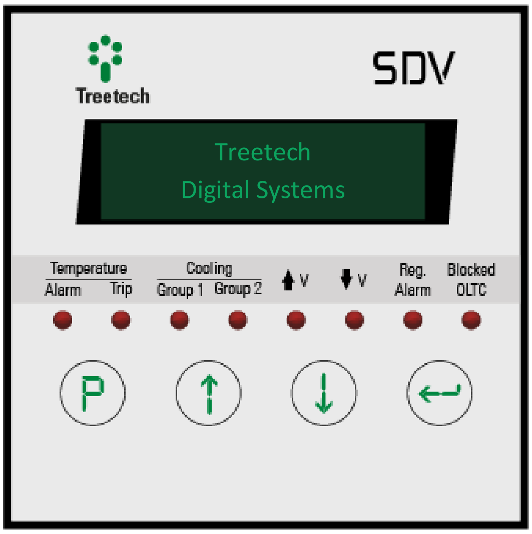


Figure 28 - SDV front display

The LEDs on the front of the SDV are divided into the categories "Temperature", "Cooling" and LEDs related to regulation, which have the following functions:

Temperature
- **Alarm:** Lit when an oil or winding temperature alarm occurs. It will blink when the screen shown on the display refers to the measurement causing the alarm.
- **Trip:** Lit when the transformer is switched off due to oil or winding temperature. It will blink when the screen shown on the display refers to the measurement causing the alarm.
Cooling
- **Group 1**: Lit while cooling group 1 is active.
- **Group 2**: Lit while cooling group 2 is active.
- **V↑**: Blinks while action is required to raise the voltage.
- **V↓**: Blinks while action is required to lower voltage.
- **Reg. Alarm**: Lit when one of the following alarms occurs: I>, U<, U> or Ic>. The display will indicate the specific alarm.
- **Blocked OLTC**: Blocked tap changer alarm.

4.1 Key functions

The function of each key on the front panel can be described as follows in most situations:

Key	Function
	Programming key: allows access to the password to enter the configuration menus. In these, it leaves the current menu and returns to the previous level menu. If activated while changing a parameter, it returns to the previous level menu without saving the change made.
	Up key: navigation to menus and increases programmed values.
	Down key: navigation to menus and decreases programmed values.
	Enter key: selects the menu option and parameters shown on the display, saves programmed values.

4.2 Contrast adjustment

In the initial measurement screen, press and hold the key : the contrast adjustment screen will be shown.

Use the keys: and to raise and lower the brightness, respectively.

Press the key to save the new setting and the key to return to the indication screens.

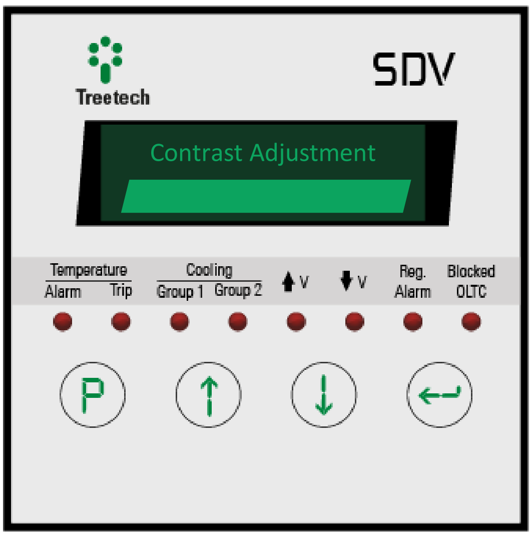
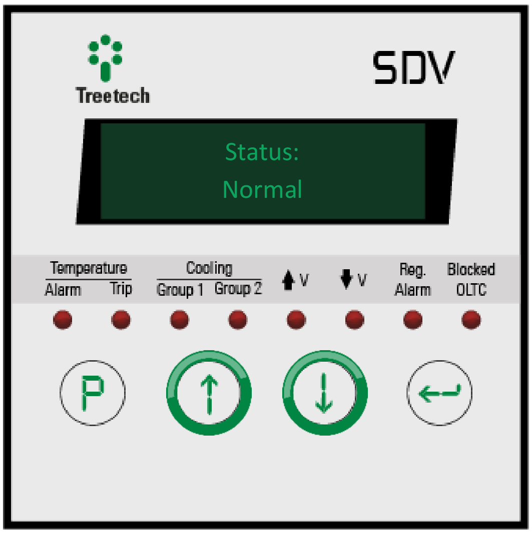


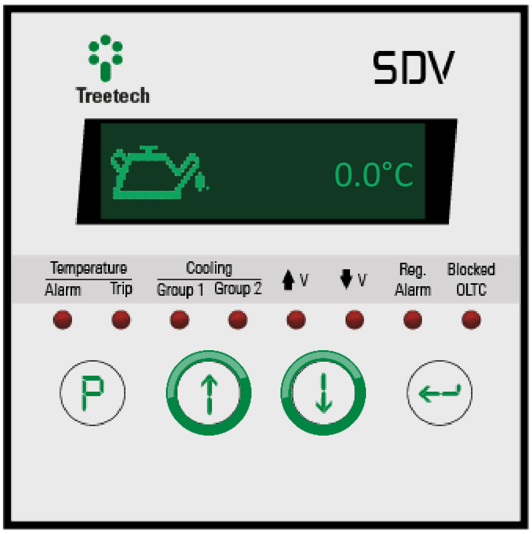
Figure 29 - SDV contrast adjustment

4.3 Query screens

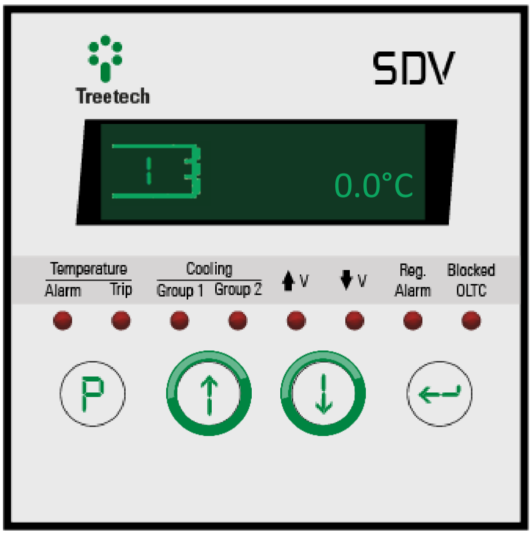
The Smart Device for Voltage Regulation - SDV display presents some screens just for reference. Information such as date, time, time zone and measurements. Use the arrows and to navigate through the screens shown below:



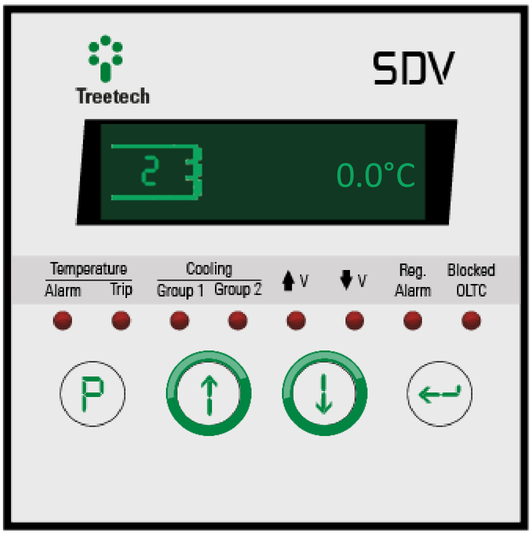
STATUS: Indicates the general status of the monitored equipment.



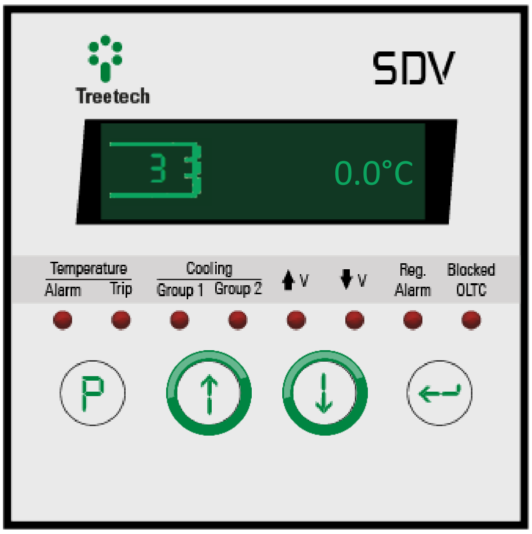
OIL TEMPERATURE: Indicates the temperature of the transformer oil.



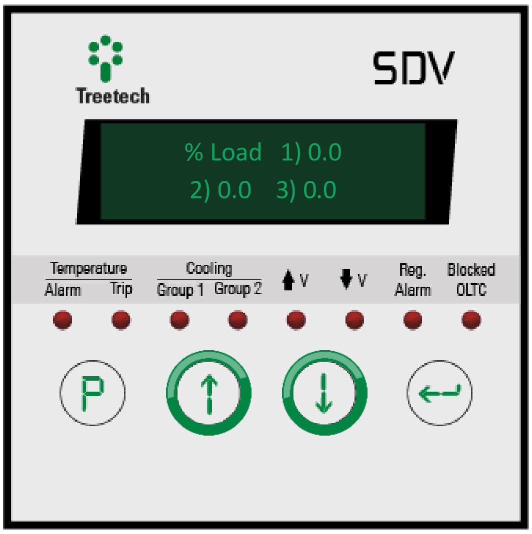
TEMP. WIN. 1: Indicates the temperature of the first winding of the transformer.



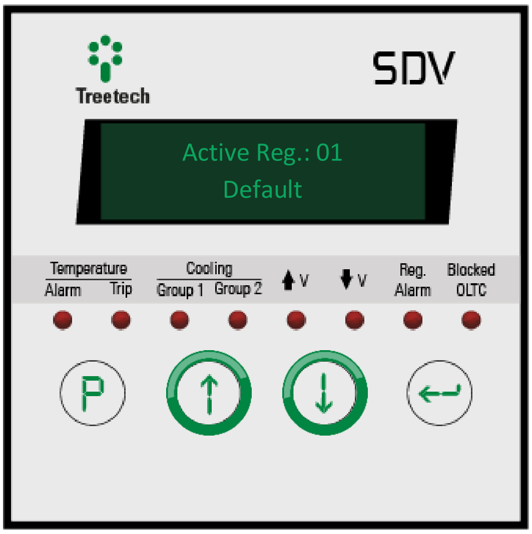
TEMP. WIN. 2: Indicates the temperature of the second winding of the transformer.



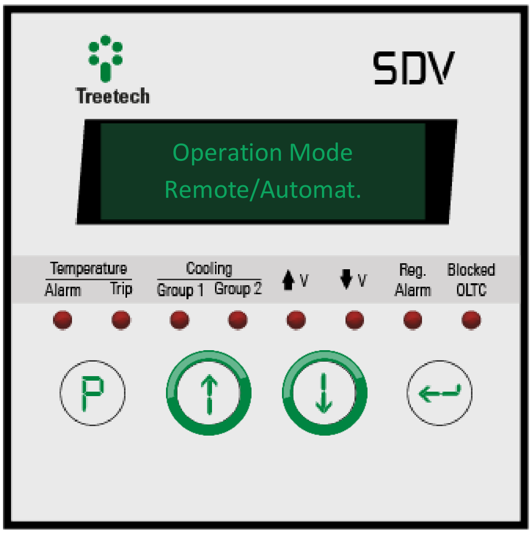
TEMP. WIN. 3: Indicates the temperature of the third winding of the transformer.



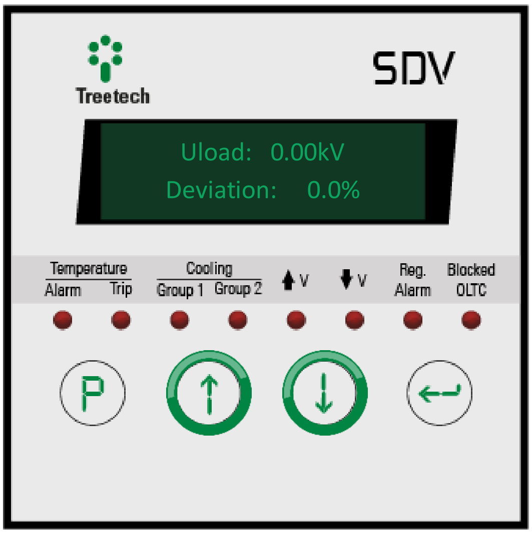
LOADING: Shows, in relation to the rated load, the percentage loading of each transformer winding.



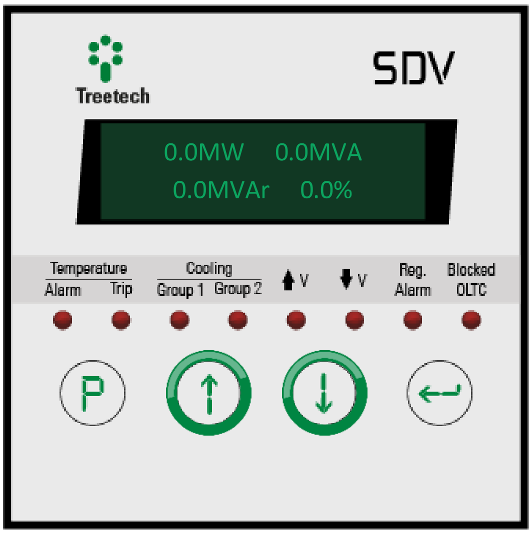
ACTIVE REGULATION SET: Indicates which regulation set is currently active.



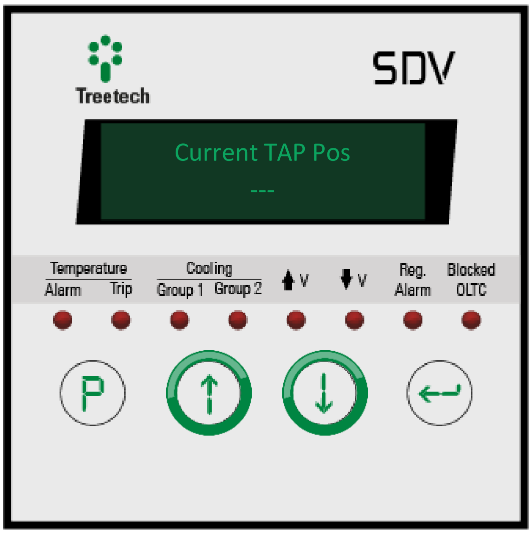
OPERATION MODE: Indicates the SDV operation mode (automatic or manual) and the command mode (local or remote).



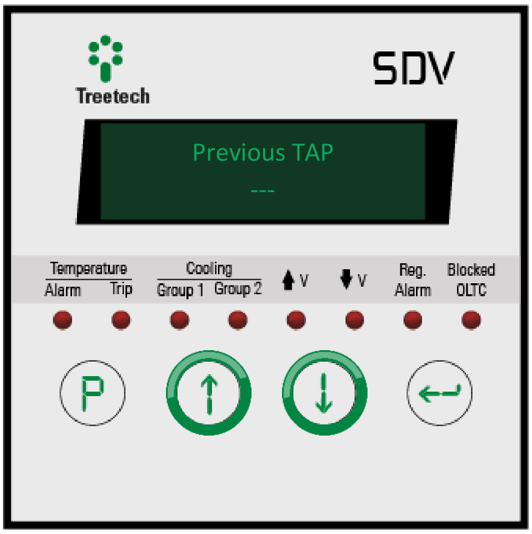
LOAD VOLTAGE AND DEVIATION: Indicates the load voltage and its deviation from the rated voltage.



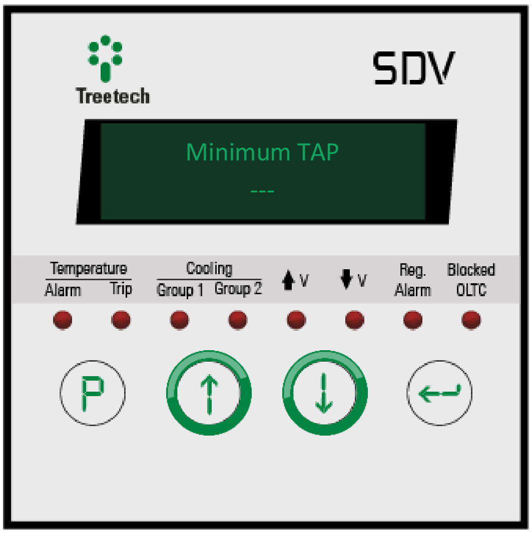
POWER: Indicates active and reactive power, apparent and percentage of the transformer load.



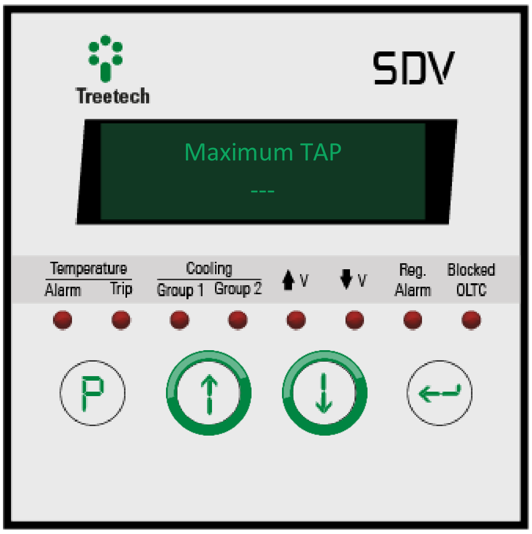
TAP POSITION: Indicates the position the tap is presently in.



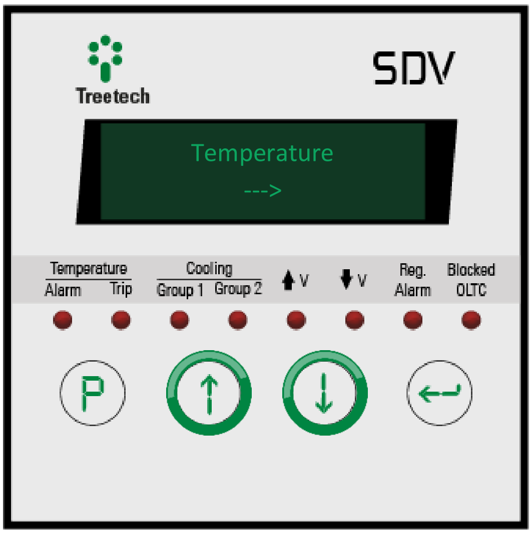
PREVIOUS TAP: Indicates the last tap position before the present one.



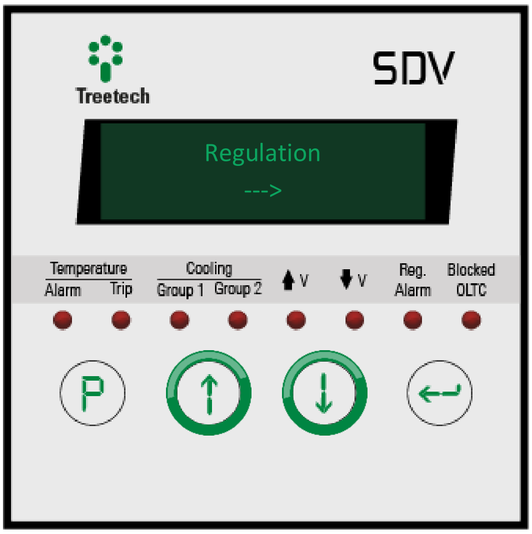
MINIMUM TAP: Indicates the minimum position reached by the tap after the last reset. To reset this value, see item 4.4.



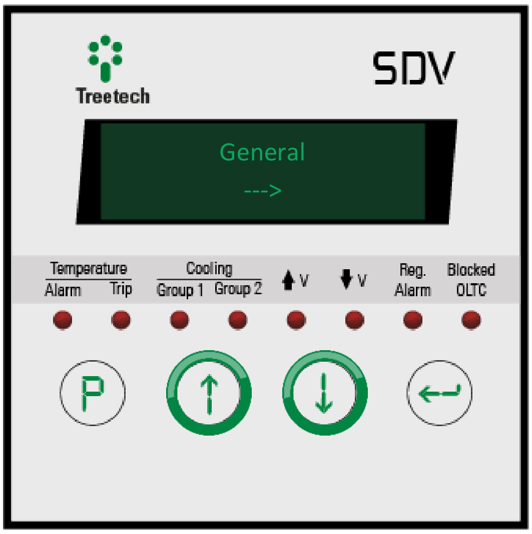
MAXIMUM TAP: Indicates the maximum position reached by the tap after the last reset. To reset this value, see item 4.4.



TEMPERATURE MENU: Press the key and access the advanced query screens for temperature.



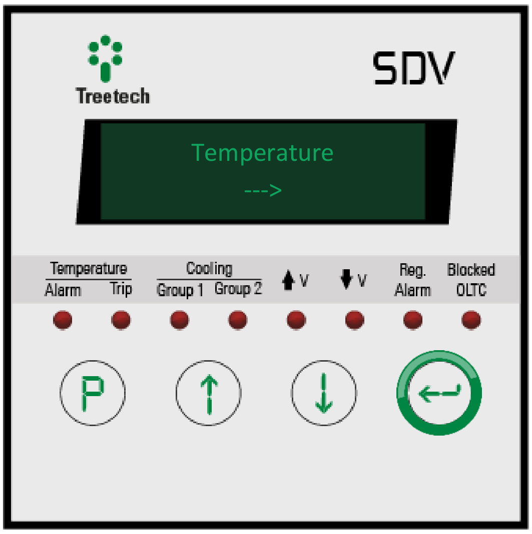
REGULATION MENU: Press the key and access the advanced query screens for regulation.



GENERAL MENU: Press the key and access the general advanced query screens.

4.3.1 Advanced temperature query

See in detail aspects of temperature measurement and engineering function results relating to temperature and load measurement by pressing the key on the screen to the side.
To navigate through the advanced query screens for temperature, use the and keys. At any time, press the key to return. To reset the maximums shown in the following menus, press the key on the measurement you want to reset for approximately 3 seconds.



Max. Oil Temp.
49.6 °C

MAXIMUM TEMPERATURE OF OIL: Indicates the maximum temperature reached by the transformer oil since the last time this marker was reset.

Max. WindTemp. 1
49.6 °C

MAXIMUM TEMPERATURE OF WINDING 1: Indicates the maximum temperature reached by transformer winding 1 since the last time this marker was reset.

Max. WindTemp. 2
49.6 °C

MAXIMUM TEMPERATURE OF WINDING 2: Indicates the maximum temperature reached by transformer winding 2 since the last time this marker was reset.

Max. WindTemp. 3
49.6 °C

MAXIMUM TEMPERATURE OF WINDING 3: Indicates the maximum temperature reached by transformer winding 3 since the last time this marker was reset.

Final Grad. 1
0.0 °C Stg.(1)

FINAL GRADIENT 1: Indicates what the final temperature gradient between oil and winding 1 will be if the present loading is maintained. It also shows the active cooling stage.

Final Grad. 2
0.0 °C Stg.(1)

FINAL GRADIENT 2: Indicates what the final temperature gradient between oil and winding 2 will be if the present loading is maintained. It also shows the active cooling stage.

Final Grad. 3
0.0 °C Stg..(1)

FINAL GRADIENT 3: Indicates what the final temperature gradient between oil and winding 3 will be if the present loading is maintained. It also shows the active cooling stage.

Wind. Curr. 1
0.00 kA

WINDING 1 CURRENT: The current flowing through winding 1 of the transformer.

Wind. Curr. 2
0.00 kA

WINDING 2 CURRENT: The current flowing through winding 2 of the transformer.

Wind. Curr. 3
0.00 kA

WINDING 3 CURRENT:
The current flowing through winding 3 of the transformer.

Sec. Curr. 1
0.00 A

CURRENT IN THE SECONDARY OF THE CT OF WINDING 1:
Indicates the current in the CT secondary of winding 1.

Sec. Curr. 2
0.00 A

CURRENT IN THE SECONDARY OF THE CT OF WINDING 2:
Indicates the current in the CT secondary of winding 2.

Sec. Curr. 3
0.00 A

CURRENT IN THE SECONDARY OF THE CT OF WINDING 3:
Indicates the current in the CT secondary of winding 3.

Pt 1 Sensor
0.0 °C

TEMPERATURE 1:
Shows the temperature measured by the Pt100 sensor #1, usually the temperature of the transformer oil thermowell.

Pt 2 Sensor
0.0 °C

TEMPERATURE 2:
Shows the temperature measured by the Pt100 sensor #2, which can be the redundant one (oil), ambient, tap changer, etc.

Maxim. Temp. Pt1
49.6 °C

MAXIMUM TEMPERATURE 1:
Shows the maximum temperature measured by the Pt100 sensor #1 since the last time this marker was reset.

Maxim. Temp. Pt2
102.8 °C

MAXIMUM TEMPERATURE 2:
Shows the maximum temperature measured by Pt100 sensor #2 since the last time this marker was reset.

OLTC Temp. Dif.
--->

OLTC TEMPERATURE DIFFERENTIAL ADVANCED QUERY:
By pressing , enter the advanced query menu related to the tap changer temperature differential.

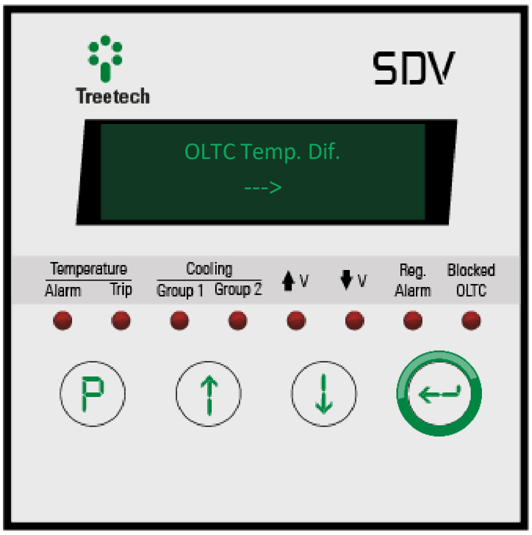
INSULATION AGING ADVANCED QUERY:

By pressing (enter key), enter the advanced query menu related to the insulation aging.

4.3.1.1 Advanced query of the tap changer temperature differential

By using a second Pt100 to measure the tap changer temperature, various relationships between this and the transformer oil temperature can be established; press the key (enter key) on the screen to the side to consult these values.

To navigate through the tap changer temperature differential advanced query screens, use the (up key) and (down key) keys. At any time, press the key (P key) to return.



OLTC Status
Monitoring

OLTC TEMPERATURE DIFFERENTIAL STATUS:
Indicates the present status of the monitoring of the tap changer temperature differential.

Inst. Temp. Dif.
0.0 °C

INSTANTANEOUS TEMPERATURE DIFFERENTIAL:
Instantaneous temperature differential between transformer oil and tap changer oil. It tracks the most sudden and ephemeral variations in the temperature differential and detects faults that develop more quickly.

Filt. Temp. Dif.
0.0 °C

FILTERED TEMPERATURE DIFFERENTIAL:
The filtered temperature differential between transformer oil and tap changer oil. Because it is filtered, it will be less influenced by passing situations, making it better for detecting persistent differentials and long-lasting trends in temperature difference.

Min. Inst. Dif.
0.0 °C

MINIMUM INSTANTANEOUS DIFFERENTIAL:
Displays the smallest instantaneous temperature differential since the last time this pointer was reset.

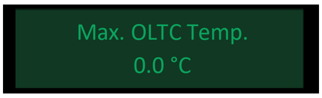
Min. Filt. Dif.
0.0 °C

MINIMUM FILTERED DIFFERENTIAL:
Displays the smallest filtered temperature differential since the last time this pointer was reset.

Max. Inst. Dif.
0.0 °C

MAXIMUM INSTANTANEOUS DIFFERENTIAL:
Displays the largest instantaneous temperature differential since the last time this pointer was reset.

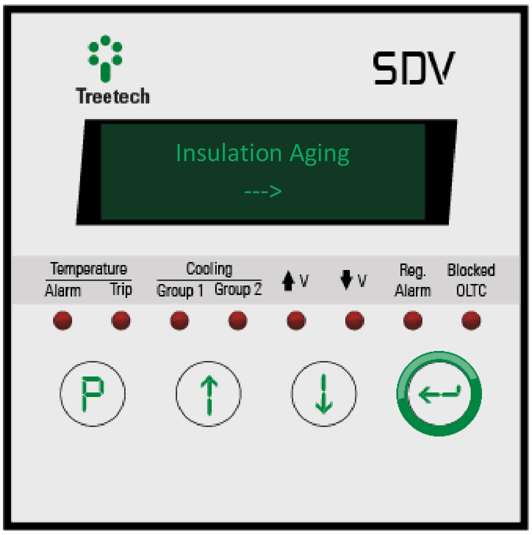
MAXIMUM FILTERED DIFFERENTIAL:
Displays the largest filtered temperature differential since the last time this pointer was reset.



MAXIMUM OLTC TEMPERATURE:
Displays the highest temperature measured on the tap changer since the last time this pointer was reset.

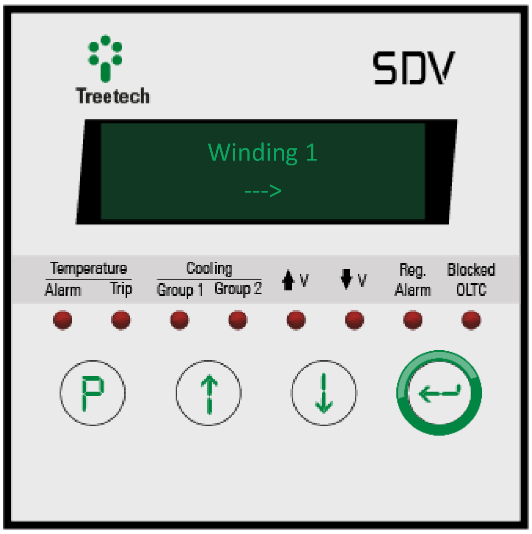
4.3.1.2 Advanced query of the insulation aging

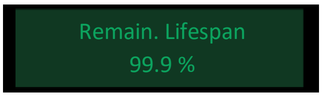
View the insulation aging status and progression, calculated based on the transformer's temperature and load, by pressing the key on the screen to the side.
To navigate through the insulation aging advanced query screens, use the and keys. At any time, press the key to return.



WINDING SELECTION

See information on the insulation aging of each winding (1, 2 or 3) individually. Use and to find the desired winding and press to select.
Then, navigate through the menus described below:





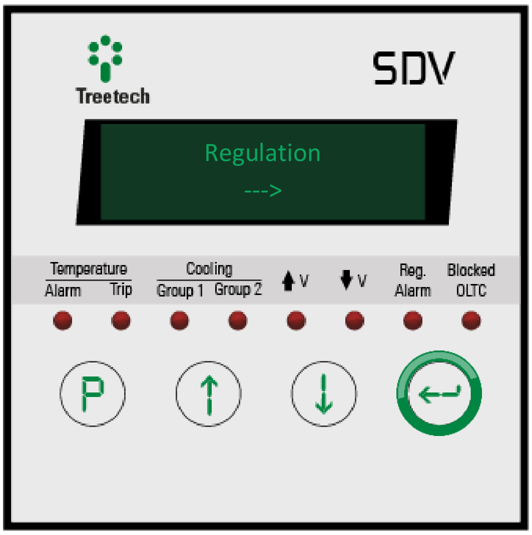
WINDING LIFESPAN: Indicates the remaining insulation lifespan of the selected winding.

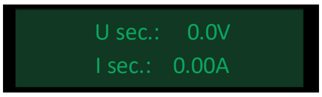
LOSS OF LIFETIME: Shows the average lifespan loss per day.

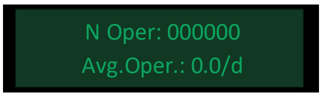
LIFETIME: Shows the projection of the remaining lifetime of the insulation, in years.

4.3.2 Advanced query of regulation

Consult in detail aspects of regulation and engineering functions arising from regulation by pressing the key on the screen to the side.
To navigate through the regulation advanced query screens, use the keys and . At any time, press the key to return.







VOLTAGE AND CURRENT: Displays the line voltage and current of the transformer on the top row. On the bottom row, it displays the frequency and capacitive power factor (c) or inductive power factor(i).

VOLTAGE AND CURRENT IN THE SECONDARY OF PT AND CT: Displays the voltage at the secondary of the transformer's PT. In the lower row, it shows the current in the secondary of the measuring CT.

NUMBER OF OPERATIONS: Shows the number of operations already performed by the tap changer and the average of daily operations.

Oper. Since Last
Maint.: 000000

OPERATIONS AFTER LAST MAINTENANCE: Indicates the number of operations performed by the tap changer after the last maintenance.

I^2: 0.00x10^3
Avg. I^2: 0.0/d

SWITCHED CURRENT: Displays the accumulated of the switched current in the upper row. Below, it shows the average daily increment of the switched current.

I^2 since Maint.
0.00x10^3

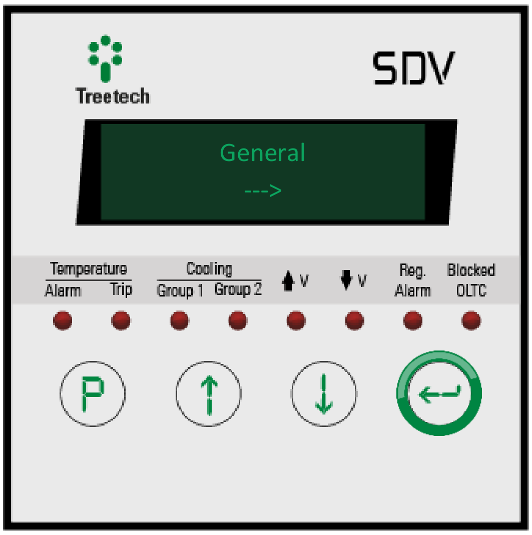
SWITCHED CURRENT AFTER LAST MAINTENANCE: Indicates the accumulated switched current after the last maintenance.

Warn I^2: >999d
Operations:>999d

REMAINING DAYS: Indicates the number of days left for the alarm due to I^2 or due to operations, considering the I^2 accumulation trends or the daily present switching average, respectively.

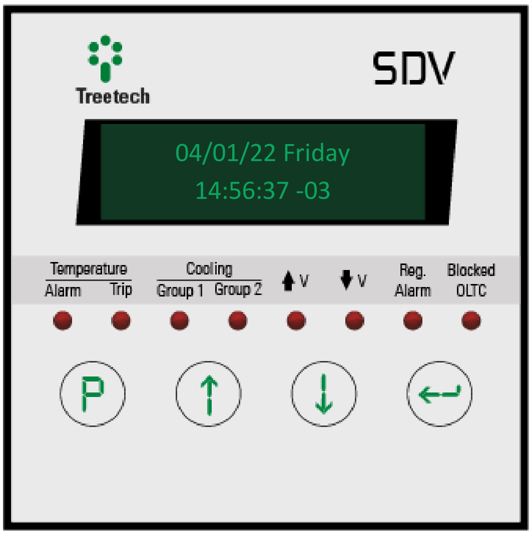
4.3.3 General advanced query

Consult in detail the general aspects of the IED by pressing the key on the screen to the side.
To navigate through the general advanced query screens, use the and . At any time, press the key to return.



CLOCK

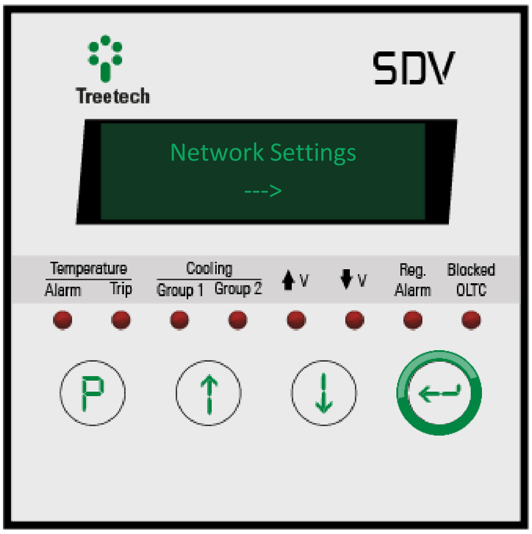
This screen shows date, day of week, time and GMT (time zone). If during parameterization the SDV is programmed in English, this screen will be presented in the form mm/dd/yy. Otherwise, dd/mm/yy.



NETWORK SETTINGS

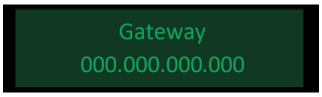
Press to view network settings. This query screen shows the IP address and subnet mask of the SDV primary and secondary network, gateway, preferred and alternate DNS.

Use the keys and navigate through information.



IP ADDRESS 1:
SDV primary IP address.

SUBNET MASK 1:
Subnet mask associated with SDV primary IP.



GATEWAY:
Gateway address.

PREFERRED DNS ADDRESS:
Preferred DNS server address.

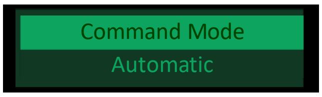
ALTERNATIVE DNS ADDRESS:
Alternate DNS server address.

IP ADDRESS 2:
Secondary IP address of the SDV.

SUBNET MASK 2:
Subnet mask associated with SDV secondary IP.

4.4 Regulation command modes

The SDV allows the user to select a series of characteristics of the regulation's operation. To access this menu, press the key . To navigate through the options and confirm the selection, use the keys , and , respectively .



TAP CHANGER OPERATION: This screen allows the user to choose the OLTC operation mode between “Local” or “Remote”. If the first option is chosen, the source of commands for the OLTC will be the equipment itself. Otherwise, commands will come from an external source, such as other networked equipment or signals at some input contact.

COMMAND MODE: It defines if the commands to raise and lower tap will be given automatically according to some criterion evaluated by the equipment's algorithms, or if they will come from manual commands. The source of the commands can be from a local or remote source in both “Automatic” and “Manual” modes.

RESET TAP: Resets the recorded minimum and maximum tap historical values. Consequently, in the query screen, the current tap value will be shown as maximum tap and minimum tap until new changes occur.

4.4.1 Interlock conditions

There are, however, some interlocking conditions between the above settings. The tables below show where the commands to perform a specific action should come from according to the way the SDV is configured.

Table 9 - Command conditions

Increase/Decrease tap commands				
	Front	External Contact	SDV Regulation	Serial
Manual/local	Allowed	Not allowed	Not allowed	Not allowed
Manual/remote	Not allowed	Allowed	Not allowed	Allowed
Automatic/local	Not allowed	Not allowed	Allowed	Not allowed
Automatic/remote	Not allowed	Not allowed	Allowed	Not allowed

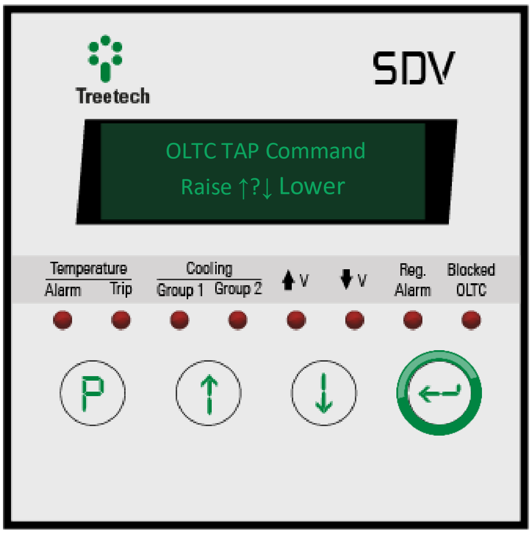
Table 10 - Command conditions - Part II

Choose the command mode between automatic and manual:				
	Front	External Contact	SDV Regulation	Serial
Local	Allowed	Not allowed	Not applicable	Not allowed
Remote	Not allowed	Allowed	Not applicable	Allowed

Caption:	
(green)	Allowed
(light grey)	Not allowed
(black)	Not applicable

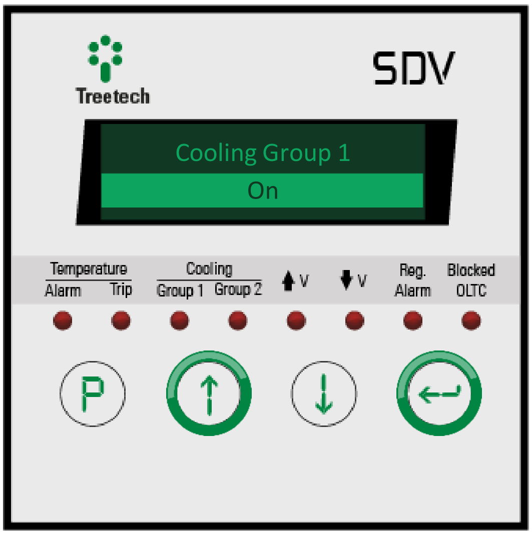
4.5 Commands to OLTC

By pressing the key P and ↑ at the same time, the user has access to the OLTC tap command screen.
Use one of the arrows on the front of the equipment to command increasing or decreasing of the tap, press ↵ to confirm the operation.
As seen in the tables in the previous section, it will only be possible to do this if the SDV is configured in local and manual mode.



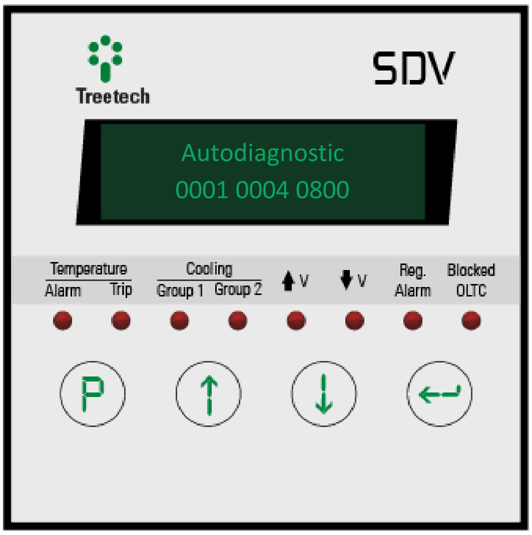
4.6 Commands to cooling groups

The SDV has two contacts for commanding ventilation or cooling groups in general.
However, it may be in the user's interest to turn on the ventilation at any time from the equipment 's display.
To do this, press the ↵ and ↑ keys at the same time.
To navigate through the options “Automatic” and “On”, and to confirm the selection, use, respectively, the keys ↑, ↓ and ↵.

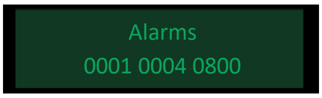


4.7 Warnings

The Smart Device for Voltage Regulation - SDV is capable of detecting and predicting a series of faults that may occur in the transformer, the tap changer, or in itself. When such irregularities are detected, warning texts automatically appear on the equipment screen, as in the example on the right - in this case, the SDV has detected a self-diagnosis and displays the self-diagnosis code for identification.



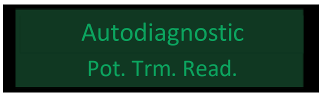
SELF-DIAGNOSIS:
This screen is displayed when the IED has internal or connection anomalies. One or more codes are displayed on the line below for self-diagnosis identification, according to the table available in chapter 7.1 of this manual.



ALARMS:
This screen is displayed when the IED identifies external anomalies. As in the self-diagnosis screen, one or more codes are shown to identify the self-diagnosis, according to the table available in chapter 7.2 of this manual.

FACTORY MENU LOCKED:
This screen will be displayed when the user enters the wrong password to access the "Factory" menu five times. With this message displayed, this menu is automatically locked. User prompts and menus continue to function normally.

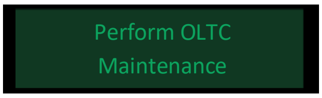
POTENCIOMETRIC TRANSMITTER READING ERROR I:
This screen is displayed when the IED is unable to read the tap position on the potentiometric transmitter. For more details of this error, refer to the table available in chapter 7.1 of this manual (Code 0001).



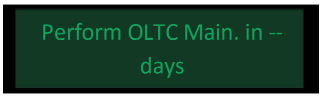
SELF-DIAGNOSIS OF POTENCIOMETRIC TRANSMITTER READING ERROR II:
This screen is displayed when the IED is unable to read the tap position on the potentiometric transmitter. For more details of this error, refer to the table available in chapter 7.1 of this manual (Code 0002).

OLTC BLOCKED I:
This screen is displayed to advise the user that the OLTC has been blocked due to the reverse power flow error.

OLTC BLOCKED II:
This screen is displayed to advise the user that the OLTC has been blocked due to an error other than reverse power flow.



OLTC MAINTENANCE WARNING:
This screen is displayed to advise the user that tap changer maintenance is due soon. To inform the SDV that the maintenance has been carried out, press simultaneously  and , the message “OLTC Maintenance carried out?” will appear on the screen, then press the key  and then  to confirm.



MAINTENANCE WARNING IN DAYS:
This screen notifies the user of the need for OLTC maintenance, establishing an ideal time (in days).

Perform Maintenance
Ipu^2 in -- days

SUM OF INTEGRAL CURRENT HIGH:
This screen is displayed when the sum of the integral current reaches the user-selected alarm value, indicating wear on the tap changer contacts.

Oil Trip Delay
--.-- min

SHUTDOWN TIME DUE TO OIL TEMPERATURE:
The user can program the timing for shutdown when the oil temperature reaches the programmed level. This screen indicates the time, in minutes, for this action.

Wind1 Trip Delay
--.-- min

SHUTDOWN TIME DUE TO TEMPERATURE OF WINDING 1:
The user can program the timing for the shutdown when the temperature of winding 1 reaches the programmed level. This screen indicates the time, in minutes, for this action.

Wind2 Trip Delay
--.-- min

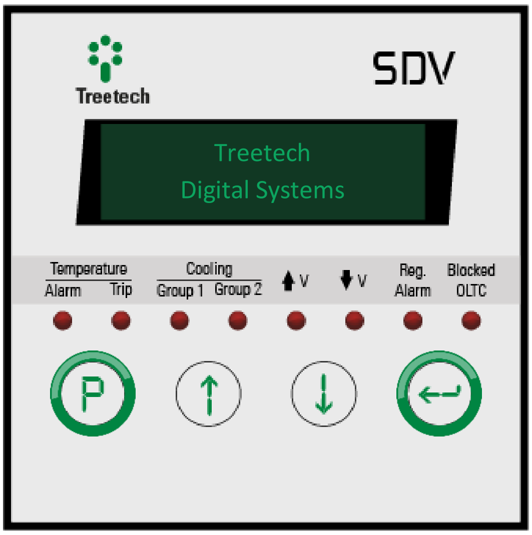
SHUTDOWN TIME DUE TO TEMPERATURE OF WINDING 2:
The user can program the timing for the shutdown when the temperature of winding 2 reaches the programmed level. This screen indicates the time, in minutes, for this action.

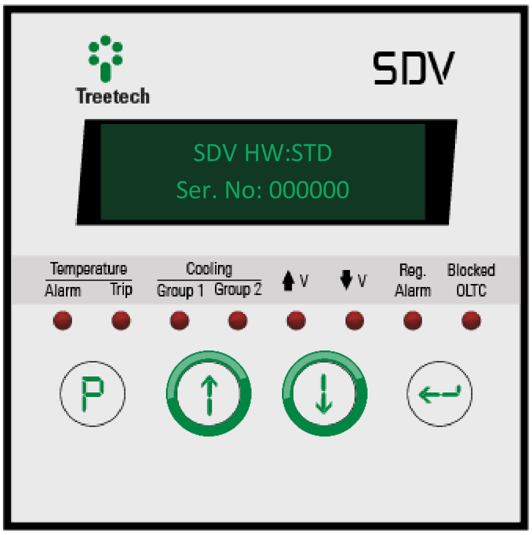
Wind3 Trip Delay
--.-- min

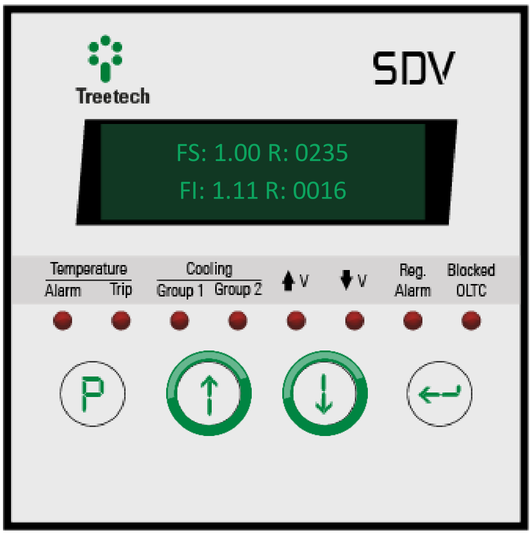
SHUTDOWN TIME DUE TO TEMPERATURE OF WINDING 3:
The user can program the timing for the shutdown when the temperature of winding 3 reaches the programmed level. This screen indicates the time, in minutes, for this action.

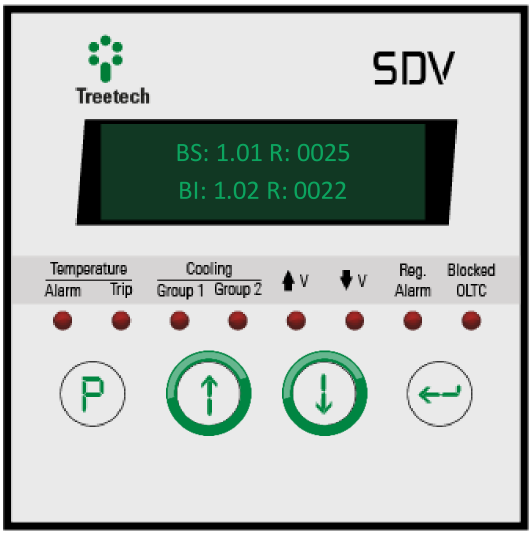
4.8 Firmware, bootloader and other SDV information

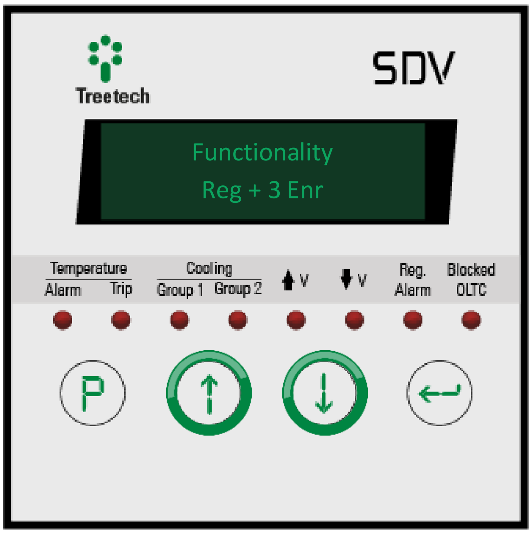
To consult versions and releases of the firmware and bootloader of the equipment's upper and lower board, serial number, functionality and enabled options, press keys P and ↵ at the same time. The screens below will be presented in sequence. Press the key ↵ on the "Options" screen to access it and navigate using the keys ↑ and ↓ to view the enabled options.

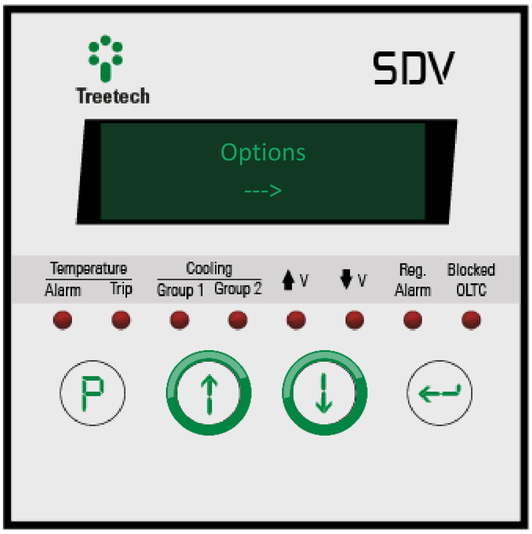









Treetech
SDV
Functionality
Reg + 3 Enr
Temperature
Alarm
Trip
Cooling
Group 1
Group 2
V
V
Reg.
Alarm
Blocked
OLTC
P


Treetech
SDV
Options
--->
Temperature
Alarm
Trip
Cooling
Group 1
Group 2
V
V
Reg.
Alarm
Blocked
OLTC
P

5 Parameterization

To guarantee its correct operation, several parameters must be adjusted in the SDV that will provide the equipment with the necessary information for its operation.

Programmable parameters are organized in menus with password-protected access. In the main menu, the user will have access to the programming submenus, where it is possible to navigate and adjust the values according to the characteristics of the transformer and users' needs.

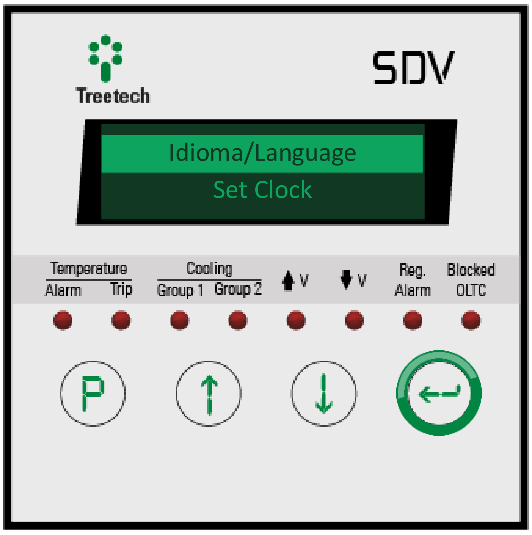
To access the Smart Device for Voltage Regulation - SDV programming menu, press the key for 5 seconds. The password screen will be displayed. Using the keys and set the password (range: 0 to 8191). If the initial indication is 4210, then the password is “0000” - which is the factory default value. This password can be changed by the user After setting the password, press the key to enter the programming menu.

To navigate through the menus, use the keys and . Press the key to select the menu to be programmed. At any time press the key to return to the main menu.

Once inside a menu, use the and keys to navigate through the parameters. Press the key to select the parameter to be changed. When editing parameters, the keys and are used to increment and decrement values, or to switch between the available parameterization options. When you reach the desired value or option, press the key to confirm your choice. At any time, press the key to exit parameter editing without saving changes. Parameters relating to optional items will only be shown if they are available.

5.1 Language

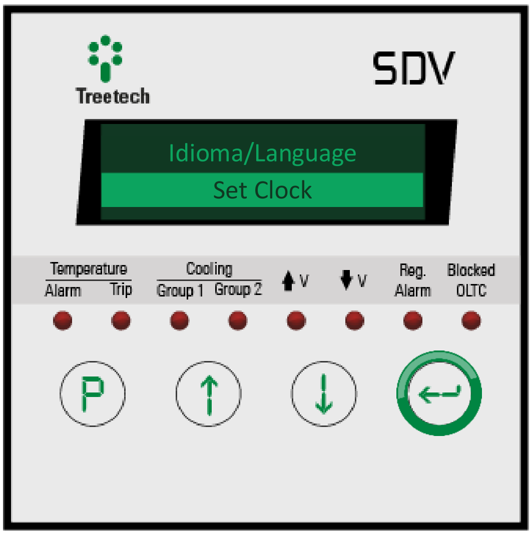
To access the language selection menu, navigate with the arrow keys until the "Idioma/Language" line is highlighted, then press .

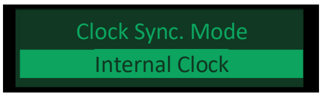


LANGUAGE DISPLAY:
Select the default SDV display language.
SETTING RANGE: Portugues, English, Espanol.
DEFAULT VALUE: Portugues.

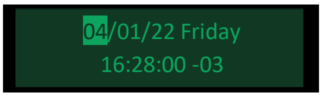
5.2 Set clock

To access the date and time setting menu, navigate with the arrow keys until the "Set Clock" line is highlighted, then press .





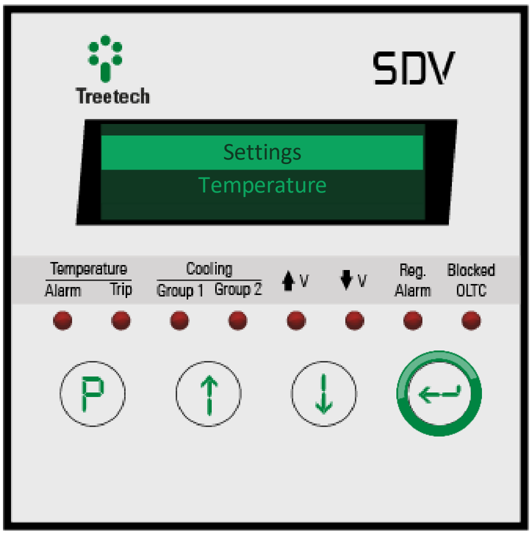
CLOCK SYNCHRONIZATION MODE:
Select whether the SDV date and time will be based on the NTP/SNTP protocol or the internal clock. If the first option is chosen, by pressing the key the clock will be set by the network according to NTP/SNTP and the menu will return to the previous level. The IP address of the NTP/SNTP server must be configured via the website.
If the second option is chosen, the next screen will be as described in the next item.
SETTING RANGE: Internal Clock, NTP/SNTP.
DEFAULT VALUE: Internal Clock.



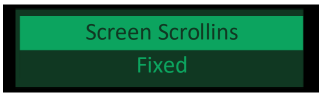
CLOCK SETTING:
First, set the day of the month. Press to confirm and proceed to month setting. Then choose the year, hour, minutes and time zone (UTC). The day of the week will be set automatically. If the selected language is English, the date format will be mm/dd/yy.

5.3 Settings

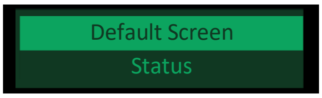
To access the general settings menu, navigate with the arrows until the "Configuration" line is highlighted, then press .
In this menu there is only the "General" submenu, which can be accessed by pressing the key .



5.3.1 General

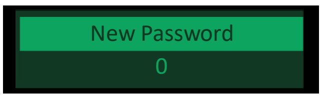


SCREEN SCROLL:
Choose whether, during normal operation, the device will always display the same indication or whether the main information should be presented cyclically, with an interval of a few seconds between them.
SETTING RANGE: **Fixed, Alternate.**
DEFAULT VALUE: **Alternate.**



DEFAULT SCREEN:
Choose which home screen the IED will display when it is running. This parameter appears when the screen scroll mode is set to fixed.
SETTING RANGE: **----, Status, Oil Temp., Temp. Wind. 1, Temp. Wind. 2, Temp. Wind. 3, % Load, Active Regulation Set, Operation Mode, Uload/Deviation, Power, Present TAP.**
DEFAULT VALUE: **Status.**

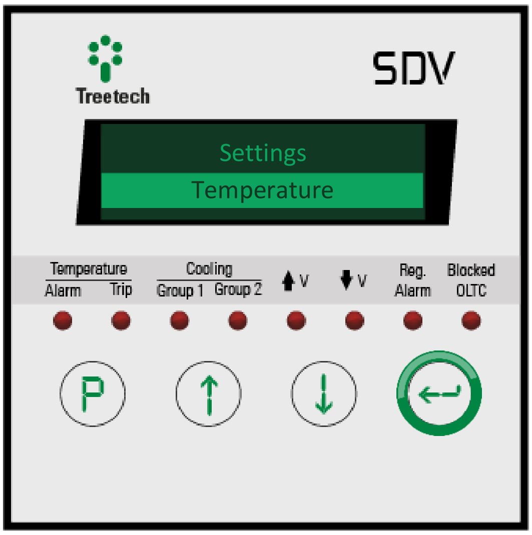
SCREEN SAVER:
Select the time for the device to return to the home screen when not in use. After this time, the IED will also automatically reduce the screen brightness for energy saving.
SETTING RANGE: **1 to 15 min.**
DEFAULT VALUE: **5 min.**



NEW PASSWORD:
Choose a new password to access the parameterization menu.
SETTING RANGE: **0 to 8191.**
DEFAULT VALUE: **0**

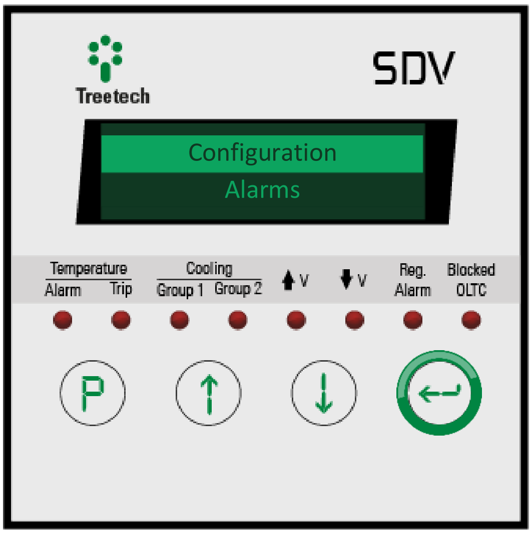
5.4 Temperature

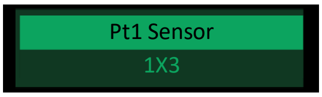
To access the parameterization menu related to temperature monitoring, navigate with the arrows until the "Temperature" line is highlighted, then press ↵.



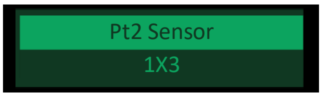
5.4.1 Configuration

Submenu for configuration of the functions of the Pt100 Ω temperature sensors. The following parameters can be configured from this submenu:

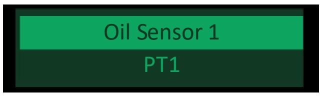




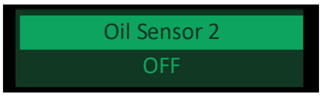
RTD 1 SENSOR ACTIVATION:
Choose to turn the first of the two Pt100 temperature sensors on or off. Later it will be possible to assign functions to temperature sensors. If the sensor is already assigned to some function, it will not be possible to disable it. If active but not assigned to any function, it will measure ambient temperature.
SETTING RANGE: **1X3, OFF.**
DEFAULT VALUE: **1X3.**



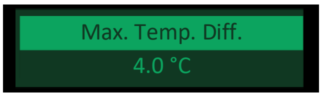
RTD 2 SENSOR ACTIVATION:
Choose to turn the second of the two Pt100 temperature sensors on or off. Later it will be possible to assign functions to temperature sensors. If the sensor is already assigned to some function, it will not be possible to disable it. If active but not assigned to any function, it will measure ambient temperature.
SETTING RANGE: 1X3, OFF.
DEFAULT VALUE: 1X3.



OIL TEMPERATURE SENSOR 1:
Choose the sensor to be used when measuring the transformer oil temperature. Only sensors that have not yet been assigned to another task will appear as an option.
SETTING RANGE: PT1, PT2, OFF.
DEFAULT VALUE: PT1.



OIL TEMPERATURE SENSOR 2:
Choose the second sensor to be used to measure the transformer oil temperature in the case where it is intended to create a measurement redundancy. Only sensors that have not yet been assigned to another task will appear as an option.
SETTING RANGE: PT1, PT2, OFF.
DEFAULT VALUE: OFF.

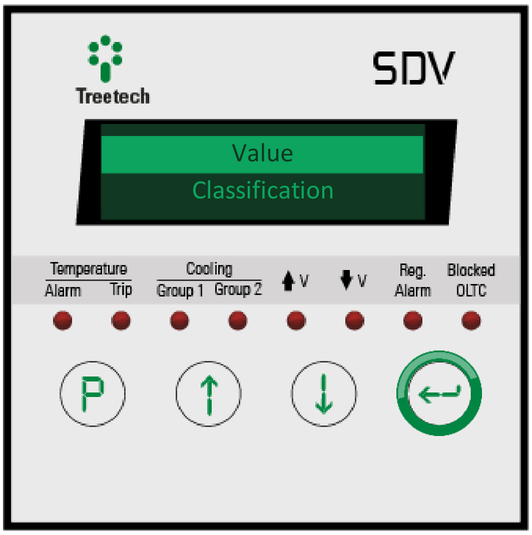


MAXIMUM TEMPERATURE DIFFERENTIAL:
Set the largest tolerable difference between the temperatures measured by the redundant sensors. A difference greater than the one defined here will generate the self-diagnosis “Max Difference Error”.
SETTING RANGE: 1.0 to 6.0 °C.
DEFAULT VALUE: 4.0 °C.

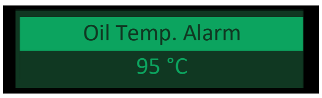
SIMULATOR:
In case of any test or experiment that involves connecting a temperature sensor simulator to the SDV, indicate here which input will be used for this purpose.
SETTING RANGE: PT1, PT2, OFF.
DEFAULT VALUE: OFF.

5.4.2 Alarms

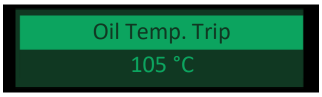
The alarm configuration submenu is subdivided into two other submenus. The first is where the threshold values for temperature-related alarms are defined. The second submenu is where the priority level of temperature alarms is classified according to the color coding explained in the section 7.2.



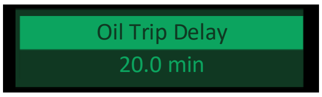
5.4.2.1 Value



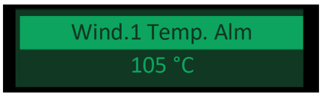
ALARM DUE TO TOP OIL TEMPERATURE:
Alarm activation temperature for high oil temperature. Once triggered, the alarm is only disabled if the temperature drops 1 °C or more below the trigger value.
SETTING RANGE: -55 to 200 °C.
DEFAULT VALUE: 95 °C.



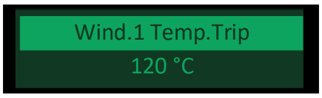
SHUTDOWN DUE TO TOP OIL TEMPERATURE:
Transformer shutdown temperature due to high oil temperature. Once triggered, the shutdown signal is only deactivated if the temperature drops 1 °C or more below the trigger value.
It can also be used as a second level alarm if automatic transformer shutdown is not desirable.
SETTING RANGE: -55 to 200 °C.
DEFAULT VALUE: 105 °C.



DELAY OF SHUTDOWN DUE TO OIL TEMPERATURE:
Allows a delay to be entered between the moment when the oil temperature reaches the shutdown value and when the shutdown signal and associated output relays are actually activated.
SETTING RANGE: 0.0 to 20.0 min.
DEFAULT VALUE: 20.0 min.



ALARM DUE TO TEMPERATURE OF WINDING 1:
Alarm triggering temperature due to high winding 1 temperature. Once triggered, the alarm is only disabled if the temperature drops 1 °C or more below the trigger value.
SETTING RANGE: -55 to 200 °C.
DEFAULT VALUE: 105 °C.



SHUTDOWN DUE TO TEMPERATURE OF WINDING 1:
Transformer shutdown temperature due to high winding 1 temperature. Once triggered, the shutdown signal is only deactivated if the temperature drops 1 °C or more below the trigger value. It can also be used as a second level alarm if automatic transformer shutdown is not desirable.
SETTING RANGE: -55 to 200 °C.
DEFAULT VALUE: 120 °C.

Wind1 Trip Delay
20.0 min

DELAY OF SHUTDOWN DUE TO TEMPERATURE OF WINDING 1:
Allows a delay to be entered between the moment when the winding 1 temperature reaches the shutdown value and the time the shutdown signal and associated output relays are actually activated.
SETTING RANGE: 0.0 to 20.0 min.
DEFAULT VALUE: 20.0 min.

Wind.2 Temp. Alm
105 °C

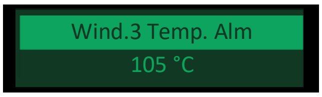
ALARM DUE TO TEMPERATURE OF WINDING 2:
Alarm triggering temperature due to high winding 2 temperature. Once triggered, the alarm is only disabled if the temperature drops 1 °C or more below the trigger value.
SETTING RANGE: -55 to 200 °C.
DEFAULT VALUE: 105 °C.

Wind.2 Temp.Trip
120 °C

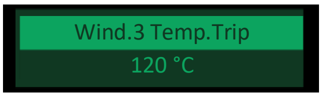
SHUTDOWN DUE TO TEMPERATURE OF WINDING 2:
Transformer shutdown temperature due to high winding 2 temperature. Once triggered, the shutdown signal is only deactivated if the temperature drops 1 °C or more below the trigger value. It can also be used as a second level alarm if automatic transformer shutdown is not desirable.
SETTING RANGE: -55 to 200 °C.
DEFAULT VALUE: 120 °C.

Wind2 Trip Delay
20.0 min

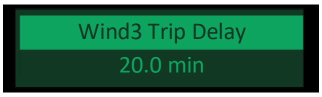
DELAY OF SHUTDOWN DUE TO TEMPERATURE OF WINDING 2:
Allows a delay to be entered between the moment when the winding 2 temperature reaches the shutdown value and the time the shutdown signal and associated output relays are actually activated.
SETTING RANGE: 0.0 to 20.0 min.
DEFAULT VALUE: 20.0 min.



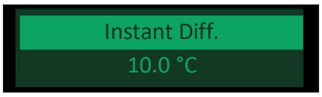
ALARM DUE TO TEMPERATURE OF WINDING 3:
Alarm triggering temperature due to high winding 3 temperature. Once triggered, the alarm is only disabled if the temperature drops 1 °C or more below the trigger value.
SETTING RANGE: -55 to 200 °C.
DEFAULT VALUE: 105 °C.



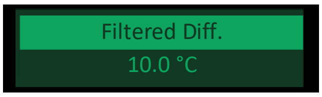
SHUTDOWN DUE TO TEMPERATURE OF WINDING 3:
Transformer shutdown temperature due to high winding 3 temperature. Once triggered, the shutdown signal is only deactivated if the temperature drops 1 °C or more below the trigger value. It can also be used as a second level alarm if automatic transformer shutdown is not desirable.
SETTING RANGE: -55 to 200 °C.
DEFAULT VALUE: 120 °C.



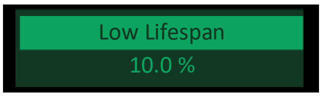
DELAY OF SHUTDOWN DUE TO TEMPERATURE OF WINDING 3:
Allows a delay to be entered between the moment when the winding 3 temperature reaches the shutdown value and the time the shutdown signal and associated output relays are actually activated.
SETTING RANGE: 0.0 to 20.0 min.
DEFAULT VALUE: 20.0 min.



MAXIMUM INSTANTANEOUS DIFFERENTIAL:
Instantaneous temperature differential between transformer and tap changer above which the “Instantaneous Temperature Differential Alarm” (alarm panel 2, code 0001) must be activated.
SETTING RANGE: -40.0 to 40.0 °C.
DEFAULT VALUE: 10.0 °C.



MAXIMUM FILTERED DIFFERENTIAL:
Filtered temperature differential between transformer and tap changer above which the "Filtered Temperature Differential Alarm" (alarm panel 2, code 0002) must be activated.
SETTING RANGE: -40.0 to 40.0 °C.
DEFAULT VALUE: 10.0 °C.



LOW LIFESPAN:
The SDV constantly calculates the wear of the winding insulation. When its lifespan is below the threshold parameterized here, the alarm will be issued.
SETTING RANGE: 0.0 to 99.9 %.
DEFAULT VALUE: 10.0 %.

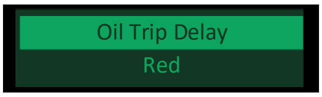
LOW REMAINING LIFETIME:
Based on the load and wear history, the SDV calculates the remaining lifetime for the transformer. If the projected remaining lifetime is less than what is set here, an alarm will be activated.
SETTING RANGE: 0.0 to 39.9 years.
DEFAULT VALUE: 1.0 year.

HIGH LOSS OF LIFESPAN:
If the calculated loss of lifespan rate exceeds the daily limit set here, this alarm will be activated.
SETTING RANGE: 0.000 to 9.999 %.
DEFAULT VALUE: 0.007 %.

5.4.2.2 Classification

ALARM DUE TO TOP OIL TEMPERATURE:
Classify this alarm into one of the categories listed in the setting range or disable the alarm classification.
SETTING RANGE: Red, Yellow, Blue and Disabled.
DEFAULT VALUE: Red.

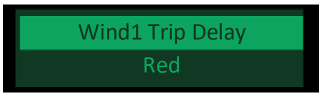
SHUTDOWN DUE TO TOP OIL TEMPERATURE:
Classify this alarm into one of the categories listed in the setting range or disable the alarm classification.
SETTING RANGE: Red, Yellow, Blue and Disabled.
DEFAULT VALUE: Red.



DELAY OF SHUTDOWN DUE TO OIL TEMPERATURE:
Classify this alarm into one of the categories listed in the setting range or disable the alarm classification.
SETTING RANGE: Red, Yellow, Blue and Disabled.
DEFAULT VALUE: Red.

ALARM DUE TO TEMPERATURE OF WINDING 1:
Classify this alarm into one of the categories listed in the setting range or disable the alarm classification.
SETTING RANGE: Red, Yellow, Blue and Disabled.
DEFAULT VALUE: Red.

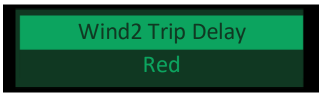
SHUTDOWN DUE TO TEMPERATURE OF WINDING 1:
Classify this alarm into one of the categories listed in the setting range or disable the alarm classification.
SETTING RANGE: Red, Yellow, Blue and Disabled.
DEFAULT VALUE: Red.



DELAY OF SHUTDOWN DUE TO TEMPERATURE OF WINDING 1:
Classify this alarm into one of the categories listed in the setting range or disable the alarm classification.
SETTING RANGE: Red, Yellow, Blue and Disabled.
DEFAULT VALUE: Red.

ALARM DUE TO TEMPERATURE OF WINDING 2:
Classify this alarm into one of the categories listed in the setting range or disable the alarm classification.
SETTING RANGE: Red, Yellow, Blue and Disabled.
DEFAULT VALUE: Red.

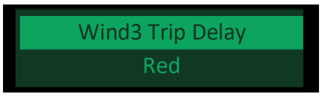
SHUTDOWN DUE TO TEMPERATURE OF WINDING 2:
Classify this alarm into one of the categories listed in the setting range or disable the alarm classification.
SETTING RANGE: Red, Yellow, Blue and Disabled.
DEFAULT VALUE: Red.



DELAY OF SHUTDOWN DUE TO TEMPERATURE OF WINDING 2:
Classify this alarm into one of the categories listed in the setting range or disable the alarm classification.
SETTING RANGE: Red, Yellow, Blue and Disabled.
DEFAULT VALUE: Red.

ALARM DUE TO TEMPERATURE OF WINDING 3:
Classify this alarm into one of the categories listed in the setting range or disable the alarm classification.
SETTING RANGE: Red, Yellow, Blue and Disabled.
DEFAULT VALUE: Red.

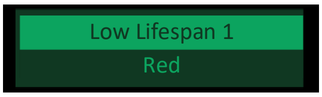
SHUTDOWN DUE TO TEMPERATURE OF WINDING 3:
Classify this alarm into one of the categories listed in the setting range or disable the alarm classification.
SETTING RANGE: Red, Yellow, Blue and Disabled.
DEFAULT VALUE: Red.



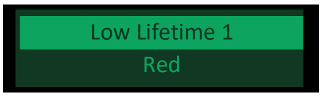
DELAY OF SHUTDOWN DUE TO TEMPERATURE OF WINDING 3:
Classify this alarm into one of the categories listed in the setting range or disable the alarm classification.
SETTING RANGE: Red, Yellow, Blue and Disabled.
DEFAULT VALUE: Red.

MAXIMUM INSTANTANEOUS DIFFERENTIAL:
Classify this alarm into one of the categories listed in the setting range or disable the alarm classification.
SETTING RANGE: Red, Yellow, Blue and Disabled.
DEFAULT VALUE: Red.

MAXIMUM FILTERED DIFFERENTIAL:
Classify this alarm into one of the categories listed in the setting range or disable the alarm classification.
SETTING RANGE: Red, Yellow, Blue and Disabled.
DEFAULT VALUE: Red.

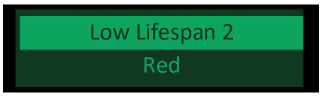


LOW LIFESPAN IN WINDING 1:
Classify this alarm into one of the categories listed in the setting range or disable the alarm classification.
SETTING RANGE: Red, Yellow, Blue and Disabled.
DEFAULT VALUE: Red.



LOW REMAINING LIFETIME IN WINDING 1:
Classify this alarm into one of the categories listed in the setting range or disable the alarm classification.
SETTING RANGE: Red, Yellow, Blue and Disabled.
DEFAULT VALUE: Red.

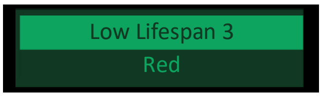
HIGH LOSS OF LIFESPAN IN WINDING 1:
Classify this alarm into one of the categories listed in the setting range or disable the alarm classification.
SETTING RANGE: Red, Yellow, Blue and Disabled.
DEFAULT VALUE: Red.



LOW LIFESPAN IN WINDING 2:
Classify this alarm into one of the categories listed in the setting range or disable the alarm classification.
SETTING RANGE: Red, Yellow, Blue and Disabled.
DEFAULT VALUE: Red.

LOW REMAINING LIFETIME IN WINDING 2:
Classify this alarm into one of the categories listed in the setting range or disable the alarm classification.
SETTING RANGE: Red, Yellow, Blue and Disabled.
DEFAULT VALUE: Red.

HIGH LOSS OF LIFESPAN IN WINDING 2:
Classify this alarm into one of the categories listed in the setting range or disable the alarm classification.
SETTING RANGE: Red, Yellow, Blue and Disabled.
DEFAULT VALUE: Red.



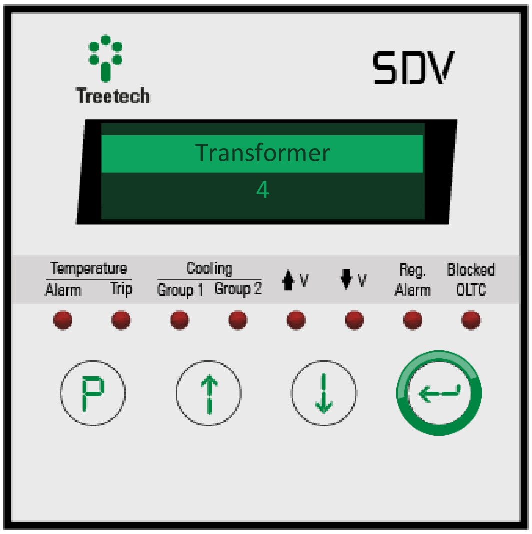
LOW LIFESPAN IN WINDING 3:
Classify this alarm into one of the categories listed in the setting range or disable the alarm classification.
SETTING RANGE: Red, Yellow, Blue and Disabled.
DEFAULT VALUE: Red.

LOW REMAINING LIFETIME IN WINDING 3:
Classify this alarm into one of the categories listed in the setting range or disable the alarm classification.
SETTING RANGE: Red, Yellow, Blue and Disabled.
DEFAULT VALUE: Red.

HIGH LOSS OF LIFESPAN IN WINDING 3:
Classify this alarm into one of the categories listed in the setting range or disable the alarm classification.
SETTING RANGE: Red, Yellow, Blue and Disabled.
DEFAULT VALUE: Red.

5.4.3 Transformer

The transformer parameterization submenu is subdivided into two other submenus. The first is where some general characteristics of the transformer are parameterized. In the second submenu, for each active cooling stage, the parameters related to the calculation of the temperature of the windings and the hotspot are configured.



5.4.3.1 Configuration

NUMBER OF WINDINGS:
In this screen the user adjusts the value according to the number of windings of the transformer.
SETTING RANGE: 1 to 3.
DEFAULT VALUE: 3.

TYPE OF HOT-SPOT FACTOR:
Choose the standard whose methodology will be adopted to calculate the temperature of the windings, especially with regard to the hot-spot:

- ANSI IEEE C57.91:2011; ABNT NBR 5416:1997;
- IEC 60076-7:2018; ABNT NBR 5356-7:2017.

SETTING RANGE: ANSI, IEC.
DEFAULT VALUE: ANSI.

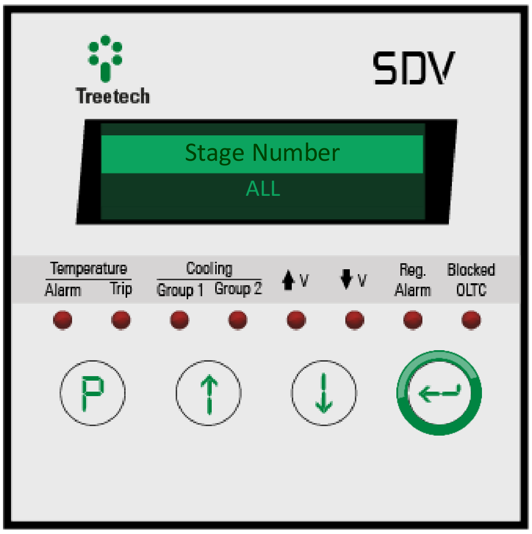
TIME CONSTANT OF THERMAL INERTIA OF WINDING 1:
Time constant in seconds, related to the thermal inertia of the transformer/reactor winding. This parameter is usually obtained by the transformer/reactor manufacturer in heating tests or by calculation. In case it is not possible to obtain it by one of these two ways, the typical value of 300 s can be adopted.
SETTING RANGE: 72 to 999 s.
DEFAULT VALUE: 300 s.

TIME CONSTANT OF THERMAL INERTIA OF WINDING 2:
Time constant in seconds, related to the thermal inertia of the transformer/reactor winding. This parameter is usually obtained by the transformer/reactor manufacturer in heating tests or by calculation. In case it is not possible to obtain it by one of these two ways, the typical value of 300 s can be adopted.
SETTING RANGE: 72 to 999 s.
DEFAULT VALUE: 300 s.

TIME CONSTANT OF THERMAL INERTIA OF WINDING 3:
Time constant in seconds, related to the thermal inertia of the transformer/reactor winding. This parameter is usually obtained by the transformer/reactor manufacturer in heating tests or by calculation. In case it is not possible to obtain it by one of these two ways, the typical value of 300 s can be adopted.
SETTING RANGE: 72 to 999 s.
DEFAULT VALUE: 300 s.

5.4.3.2 Cooling stages

STAGE NUMBER:
Choose one of the following:



- **0** - Configures parameters for calculating temperature rises when no forced cooling stage is activated;
- **1** - Configures parameters for calculating temperature rises when the first stage of forced cooling is in operation;
- **2** - Configures parameters for calculating temperature rises when the second stage of forced cooling is in operation;
- **ALL** - Simultaneously configures, with the same values, the calculation parameters for all previous situations. It must be used when there are no differences in temperature rises due to the operation of the cooling groups.

Then configure each of the calculation parameters listed below:

HOT-SPOT FACTOR IN WINDING 1:

Hot-spot factor according to the model adopted by ANSI IEEE C57.91:2011 and ABNT NBR 5416:1997 (HS+) standards or by IEC 60076-7:2018 and ABNT NBR 5356-7:2017 (HS*) standards. In the first case, it is the difference between the temperature of the hottest spot (hot-spot) and the average temperature of the winding. According to the IEC standard, it is the ratio between the rise in temperature of the hottest spot over the top oil temperature and the rise in the average temperature of the winding over the average temperature of the oil.

SETTING RANGE: 0.00 to 20.00.

DEFAULT VALUE: 1.00.

TEMPERATURE RISE EXPONENT OF WINDING 1:

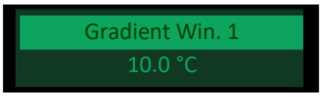
Exponent used in the calculation of winding temperature rise as a function of copper losses, defined by the type of transformer oil circulation. Value selection is flexible, with some notable numbers however:

	Winding exponent - Standards IEC 60076-7:2018 and ABNT NBR 5356-7:2017	
	NUMBER	DESCRIPTION
Distribution transformers	1.6	Transformers cooled by natural or forced oil circulation (ONAN, ONAF, OFAF, OFWF)
Large and medium power transformers	1.3	Transformers cooled by natural or forced oil circulation (ONAN, ONAF, OFAF, OFWF)
	2.0	Transformers cooled by oil directed circulation (ODAF, ODWF)

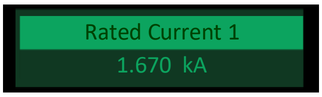
Winding exponent - Standards ABNT NBR 5416:1997 and IEEE C57.91:2011	
Número	Descrição
1.6	Transformers cooled by natural or forced oil circulation (ONAN, ONAF, OFAF, OFWF)
2.0	Transformers cooled by oil directed circulation (ODAF, ODWF)

SETTING RANGE: 0.0 to 4.0.

DEFAULT VALUE: 1.6.



TEMPERATURE GRADIENT OF WINDING 1 - OIL:
Winding-oil temperature gradient, defined by IEC 60076-7:2018/NBR 5356-7:2017 as the difference between the average winding temperature and the average oil temperature, after the thermodynamic stabilization of the transformer at rated load, and by NBR 5416:1997/IEEE C57.91:2011 as the raise in the average temperature of the winding in relation to the temperature of the top of the oil, after thermodynamic stabilization of the transformer at rated load. This parameter is usually obtained by the transformer/reactor manufacturer in heating tests or by calculation.
SETTING RANGE: **0.0 to 50.0 °C.**
DEFAULT VALUE: **10.0 °C.**



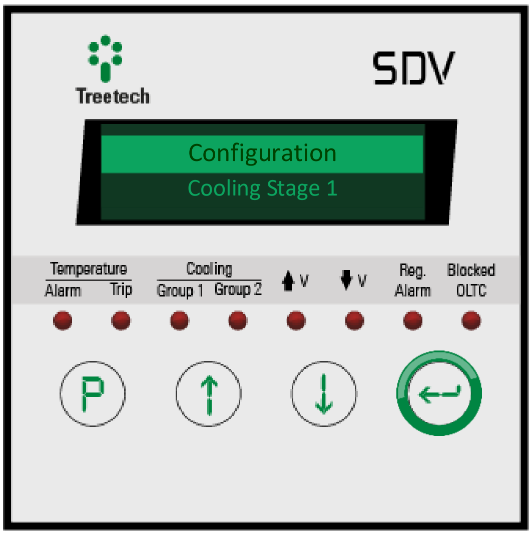
RATED CURRENT OF WINDING 1:
Current in transformer/reactor winding during measurement of temperature rise parameters (GEO, HS+ and HS*). It generally corresponds to the rated current of the transformer/reactor.
SETTING RANGE: **0.000 to 9.999 kA; 10.00 to 99.99 kA.**
DEFAULT VALUE: **1.670 kA.**

RATIO OF THERMAL IMAGE CT OF WINDING 1:
Parameterize the transformation ratio of the thermal image CT of winding 1.
CT Ratio = CT primary current / CT secondary current.
SETTING RANGE: **1 to 9999.**
DEFAULT VALUE: **500.**

As long as the functionality for monitoring the temperature of 3 windings is active and the corresponding number of windings is parameterized in the item “N. Windings”, all configuration items in this section will be repeated for windings 2 and 3 of the transformer.

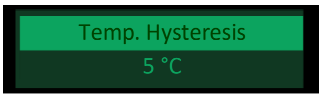
5.4.4 Forced cooling

The submenu in which the forced cooling operation is parameterized is subdivided into three other submenus. The first is where some general characteristics of transformer cooling are parameterized.
In the second submenu, specific characteristics of the first stage of forced cooling are configured.
In the third submenu, specific characteristics of the second stage of forced cooling are configured.

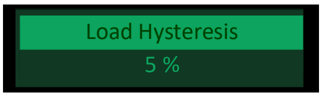


5.4.4.1 Configuration

TOTAL NUMBER OF FORCED COOLING GROUPS:
For example, in transformers with 1 cooling group, 1 should be programmed, and in transformers with two cooling groups, 2 should be programmed.
SETTING RANGE: 1 or 2.
DEFAULT VALUE: 2.



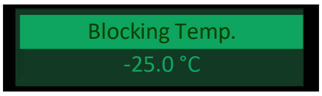
TEMPERATURE HYSTERESIS FOR COOLING SHUTDOWN:
Temperature reduction value, below the starting temperature of the cooling stage, to turn off the fans/pumps, to prevent them from being turned on and off successively with small temperature variations.
SETTING RANGE: 0 to 9 °C.
DEFAULT VALUE: 5 °C.



LOAD HYSTERESIS FOR COOLING SHUTDOWN:
Load percentage reduction value, below the cooling stage start percentage, to turn off the fans/pumps, to prevent them from being turned on and off successively with small load variations.
SETTING RANGE: 0 to 9 %.
DEFAULT VALUE: 5 %.

COMPOSITION OF COOLING GROUP 1:
Informs whether cooling group 1 has oil pumps or just fans. The operation of group 1 will be blocked if it has pumps, and the oil temperature is below the limit selected in the "Blocking Temp." parameter.
SETTING RANGE: Fan, Pump.
DEFAULT VALUE: Fan.

COMPOSITION OF COOLING GROUP 2:
Informs whether cooling group 2 has oil pumps or just fans. The operation of group 1 will be blocked if it has pumps, and the oil temperature is below the limit selected in the "Blocking Temp." parameter.
SETTING RANGE: Fan, Pump.
DEFAULT VALUE: Fan.



PUMP BLOCKING TEMPERATURE:
Temperature below which the operation of oil pumps must be blocked in order to avoid the risk of static electrification of very cold oil. This parameter will only be displayed if one of the cooling groups has pumps.
SETTING RANGE: -55 to 200 °C.
DEFAULT VALUE: -25 °C.

HOUR OF DAILY COOLING ACTIVATION:

Adjustment of the time when the forced cooling groups will be activated for the daily activation of fans and/or pumps. This parameter will only be displayed if the **FEXC** option is enabled.

SETTING RANGE: 0 to 23 h.

DEFAULT VALUE: 22 h.

MINUTE OF DAILY COOLING ACTIVATION:

Adjustment of the minute (in addition to the time selected in the previous parameter) in which the forced cooling groups will be on for the daily activation of the fans and/or pumps. This parameter will only be displayed if the **FEXC** option is enabled.

SETTING RANGE: 0 to 59 min.

DEFAULT VALUE: 30 min.

DURATION OF DAILY COOLING ACTIVATION:

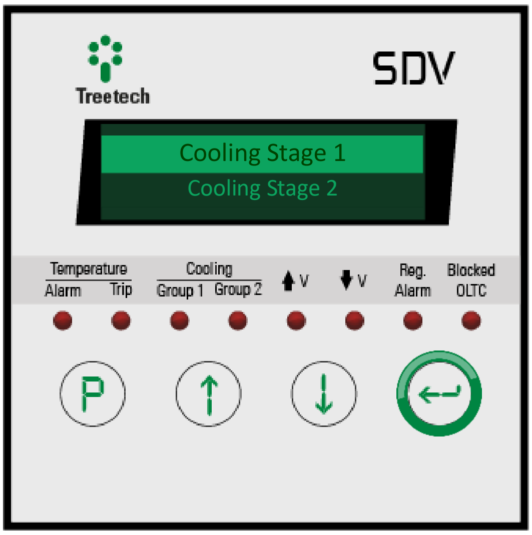
Adjustment of the total daily time that the forced cooling groups must remain activated for the exercise of fans or pumps. If it is necessary to disable the Daily Cooling Activation function, just program this parameter with the value zero. This parameter will only be displayed if the **FEXC** option is enabled.

SETTING RANGE: 0 to 999 min.

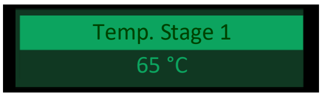
DEFAULT VALUE: 45 min.

5.4.4.2 Cooling stages 1 and 2

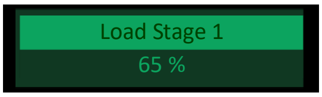
Cooling stages describe how they should behave and which cooling groups should be active in a given transformer load or temperature situation. In these submenus, distribute and configure the operation of the cooling groups into two distinct cooling stages.
Since the parameters to be configured for cooling stage 1 and 2 are the same, when selecting any of them, the submenu displayed will be as described below, with "N" in place of 1 or 2, depending on the selected submenu:



REFERENCE TEMPERATURE FOR CONTROL:
Informs whether, in automatic mode, the cooling stage should be controlled by the temperature of the top of the oil or by the temperatures of the windings.
SETTING RANGE: **Winding, Oil.**
DEFAULT VALUE: **Winding**



TEMPERATURE TO ACTIVATE STAGE "N":
Temperature for activating the stage “N” of forced cooling (oil temperature or winding temperature, as chosen in the previous parameter).
When the cooling stage is activated, one of the cooling groups selected as “YES” in the parameters “Cooling Group 1” and “Cooling Group 2” will be on, prioritizing the activation of the group with the shortest operating time.
SETTING RANGE: **-55 to 200 °C.**
DEFAULT VALUE: **65 °C.**



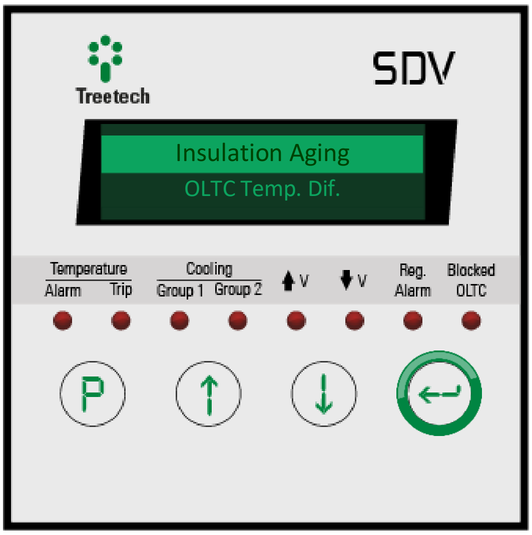
LOADING TO ACTIVATE STAGE "N":
Percent loading to trigger the forced cooling stage “N”.
When the cooling stage is activated, one of the cooling groups selected as “YES” in the parameters “Cooling Group 1” and “Cooling Group 2” will be on, prioritizing the activation of the group with the shortest operating time.
This parameter will only be shown if the **PCOL** option is available.
SETTING RANGE: 50 to 200 %.
DEFAULT VALUE: 65 %.

REGISTRATION OF COOLING GROUP 1 IN FORCED COOLING STAGE "N":
Selects whether or not cooling group 1 is enrolled in stage “N” of forced cooling, that is, whether it can be used by the cooling stage when its temperature or activation load percentage is reached.
SETTING RANGE: YES, NO.
DEFAULT VALUE: YES.

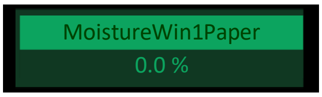
REGISTRATION OF COOLING GROUP 2 IN FORCED COOLING STAGE "N":
Selects whether or not cooling group 1 is enrolled in stage “N” of forced cooling, that is, whether it can be used by the cooling stage when its temperature or activation load percentage is reached.
SETTING RANGE: YES, NO.
DEFAULT VALUE: YES.

5.4.5 Insulation aging

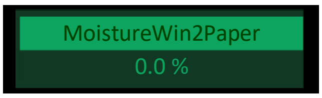
Configure aspects of transformer insulation aging calculation from this submenu.



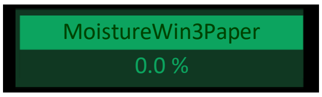
ENABLE INSULATION AGING FUNCTION:
Enables the insulation aging monitoring function. This parameter will only be available if the **INAG** option is enabled.
SETTING RANGE: **YES, NO.**
DEFAULT VALUE: **YES.**



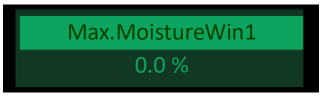
MOISTURE ON PAPER IN WINDING 1:
Water content in the winding 1 insulating paper in % of dry mass. It is possible to define the moisture in the paper based on oil samples according to NBR 5356:2017.
SETTING RANGE: **0.0 to 10.0 %.**
DEFAULT VALUE: **0.0 %.**



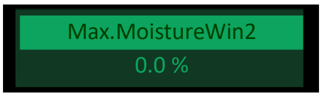
MOISTURE ON PAPER IN WINDING 2:
Water content in the winding 2 insulating paper in % of dry mass. It is possible to define the moisture in the paper based on oil samples according to NBR 5356:2017.
SETTING RANGE: **0.0 to 10.0 %.**
DEFAULT VALUE: **0.0 %.**



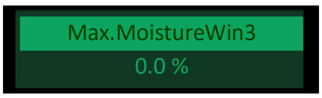
MOISTURE ON PAPER IN WINDING 3:
Water content in the winding 3 insulating paper in % of dry mass. It is possible to define the moisture in the paper based on oil samples according to NBR 5356:2017.
SETTING RANGE: 0.0 to 10.0 %.
DEFAULT VALUE: 0.0 %.



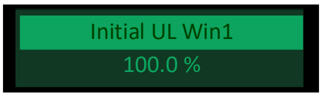
MAXIMUM MOISTURE ON PAPER IN WINDING 1:
Maximum moisture in winding 1 insulating paper for normal thermal aging (not accelerated). The standard NBR 5356:2017 can be used as a reference, which establishes the limits of 2.0% for transformers below 230 kV and 1.5% for transformers of 230 kV and above.
SETTING RANGE: 0.0 to 3.0 %.
DEFAULT VALUE: 1.5 %.



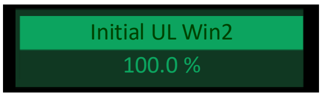
MAXIMUM MOISTURE ON PAPER IN WINDING 2:
Maximum moisture in winding 2 insulating paper for normal thermal aging (not accelerated). The standard NBR 5356:2017 can be used as a reference, which establishes the limits of 2.0% for transformers below 230 kV and 1.5% for transformers of 230 kV and above.
SETTING RANGE: 0.0 to 3.0 %.
DEFAULT VALUE: 1.5 %.



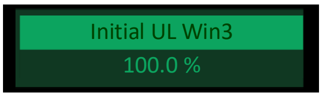
MAXIMUM MOISTURE ON PAPER IN WINDING 3:
Maximum moisture in winding 3 insulating paper for normal thermal aging (not accelerated). The standard NBR 5356:2017 can be used as a reference, which establishes the limits of 2.0% for transformers below 230 kV and 1.5% for transformers of 230 kV and above.
SETTING RANGE: 0.0 to 3.0 %.
DEFAULT VALUE: 1.5 %.



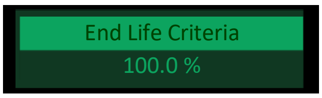
INITIAL LIFESPAN OF WINDING 1:
Initial value of the lifespan of winding 1 insulation. Must be parameterized as 100% on new transformers.
SETTING RANGE: 0.0 to 100.0 %.
DEFAULT VALUE: 100.0 %.



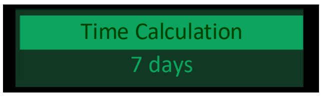
INITIAL LIFESPAN OF WINDING 2:
Initial value of the lifespan of winding 2 insulation. Must be parameterized as 100% on new transformers.
SETTING RANGE: 0.0 to 100.0 %.
DEFAULT VALUE: 100.0 %.



INITIAL LIFESPAN OF WINDING 3:
Initial value of the lifespan of winding 3 insulation. Must be parameterized as 100% on new transformers.
SETTING RANGE: 0.0 to 100.0 %.
DEFAULT VALUE: 100.0 %.



END OF LIFESPAN CRITERIA:
Choose the criterion for the end of insulation lifespan. The IEEE/IEC standard provides the last four criteria for end-of-life assessment, and the first comes from the NBR.
SETTING RANGE: NBR 5416-1997, 50% Ultimate Tensile Strength, 25% Ultimate Tensile Strength, Degree of Polymerization 200, Functional Life Test.
DEFAULT VALUE: NBR 5416-1997.



TIME CONSTANT FOR CALCULATION:

Time constant for calculating the life loss rate and extrapolating the remaining lifetime.

SETTING RANGE: 1 to 30 days.

DEFAULT VALUE: 7 days.

LOSS OF LIFESPAN RESET:

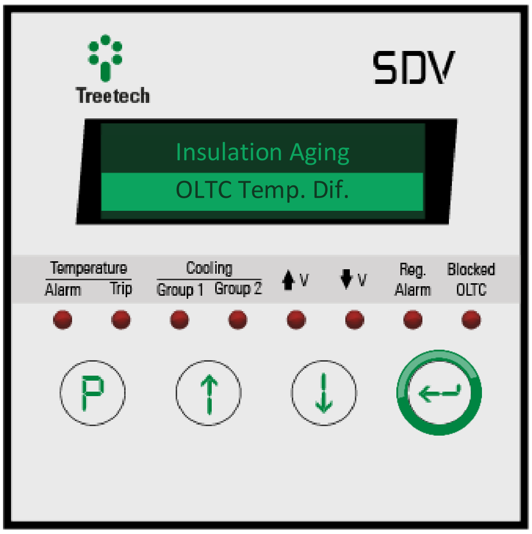
Reset of loss of lifespan stored in non-volatile memory. Especially useful when the device has just been put into operation on a transformer.

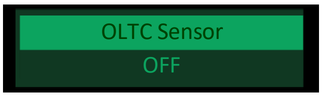
SETTING RANGE: YES, NO.

DEFAULT VALUE: NO.

5.4.6 Temperature differential

Configure the characteristics of monitoring the temperature differential between the transformer and tap changer oils in this submenu.

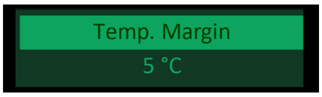




OLTC SENSOR:
Indicate which sensor is mounted to measure the tap changer temperature. Only those who have not yet been assigned to other roles will appear as an option.
SETTING RANGE: OFF, PT1, PT2.
DEFAULT VALUE: OFF.

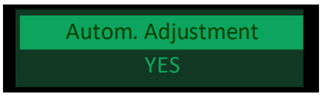
FILTERING TIME CONSTANT:
Time constant for filtering the tap changer temperature differential for forming the filtered differential.
SETTING RANGE: 0 to 720 min.
DEFAULT VALUE: 180 min.

TIMING FOR ALARMS:
Timing for issuing alarms by temperature differential of tap changers.
SETTING RANGE: 1 to 240 min.
DEFAULT VALUE: 20 min.



MARGINS FOR AUTOMATIC ALARM ADJUSTMENT:
Safety margin added to the largest differential registered between tap changer and transformer temperatures during the automatic learning period. Used to set the alarm threshold.
SETTING RANGE: 1 to 10 °C.
DEFAULT VALUE: 5 °C.

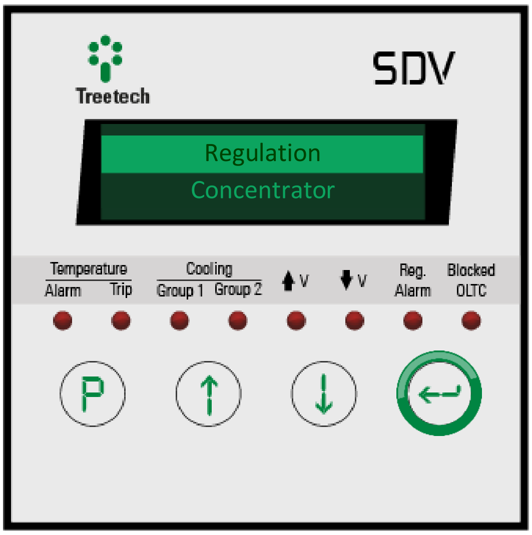
SAMPLING TIME FOR ALARMS:
Total sampling time for automatic adjustment of alarms by instantaneous and filtered temperature differentials.
SETTING RANGE: 1 to 720 hrs.
DEFAULT VALUE: 336 hrs.



AUTOMATIC ALARM ADJUSTMENT:
It allows starting (YES) or interrupting (NO) the automatic adjustment process of the instantaneous and filtered temperature differential alarms. When selecting YES, the time countdown for automatic adjustment will start, as programmed in the parameter above.
SETTING RANGE: YES, NO.
DEFAULT VALUE: YES.

5.5 Regulation

To access the voltage regulation parameterization menu, navigate with the arrows until the "Regulation" line is highlighted, then press ↵. In the regulation setting menu there are four submenus.
The first, "Config. Regulation", allows basic aspects of regulation to be configured.
The second submenu, "Transformer", is for the parameterization of the data of the transformer to be regulated.
The third, "Alarms", must be used to configure the regulation's basic alarms.
The fourth and final submenu, "Advanced", allows the user to make advanced configurations of various aspects of voltage regulation.



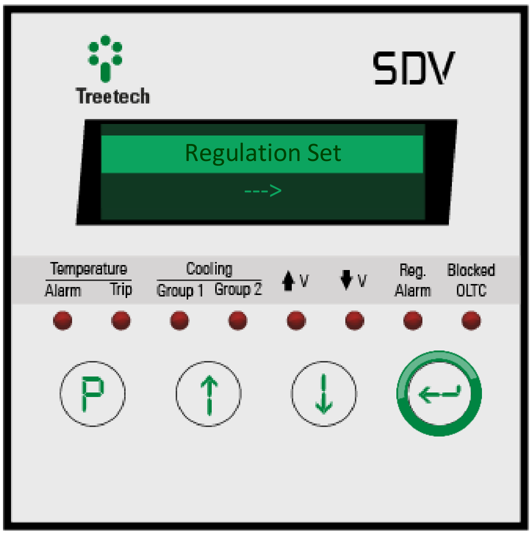
5.5.1 Regulation configuration

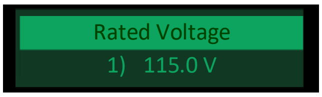
ENABLE REGULATION:
This parameter allows enabling or disabling the regulation function, due to maintenance, temporary non-use or any other applicable reasons, when the SDV is purchased in the model with regulation. When disabled, the equipment does not perform any function related to voltage regulation, remaining only as a temperature monitor.
SETTING RANGE: YES, NO.
DEFAULT VALUE: YES.

COMMAND PULSE TIME:
This parameter defines the time that the command relays for increasing and decreasing voltage, relays 4 and 5 respectively, will be closed.
SETTING RANGE: 0.5 to 2.0 s.
DEFAULT VALUE: 1.0 s.

5.5.1.1 Regulation set

This submenu allows you to define the parameters of each of the ten regulation sets. Press and use the and keys to select one of the available regulation sets, then press again to access the parameters.
Parameterization of set 1 is mandatory, used as a standard when there is no other active regulation set, while the parameterization of the other sets is optional.





RATED VOLTAGE:
It is the theoretical voltage value that you want to maintain in the load, referred to the secondary of the measurement PT, that is:

$$\text{Rated voltage} = \frac{\text{Desired voltage on load}}{\text{PT transformation ratio}}$$

Example:

$$\text{Desired voltage on load} = 13200\ \text{V}$$

$$\text{PT transformation ratio} = \frac{13800\ \text{V}}{115\ \text{V}} = 120$$

$$\text{Rated voltage} = \frac{13200\ \text{V}}{120} = 110\ \text{V}$$

SETTING RANGE: 10.0 to 240.0 V.
DEFAULT VALUE: 115.0 V.

TYPE OF TIMING:
The timing feature is used to avoid unnecessary operations of the on-load tap changer during momentary line voltage fluctuations, such as when starting a large motor.
In this parameter we can select between two types of timing:

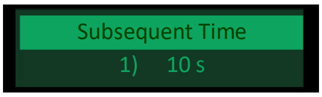
- **LINEAR**: where the time to start an on-load tap changer operation (after detection of a voltage deviation greater than insensitivity) is always equal to the values set in the “Timing Step” parameter, obeying the selected deviation ranges;
- **INVERSE**: where the time to start an on-load tap changer operation varies inversely proportional to the deviation of the measured voltage from the rated voltage (the greater the difference between the measured voltage and the rated voltage, the shorter the time for operation of the on-load tap changer). It is used for faster voltage regulation in case of large voltage deviations.

The timing effectively applied by the SDV after detecting a voltage deviation greater than the insensitivity will be given by:

$$\text{Effective time} = \text{Adjusted time} \cdot \left(\frac{\text{Adjusted deviation}}{\text{Measured deviation}}\right)$$

Where,
Adjusted time: it will be the value programmed in the parameter “Time to Increase” if the measured deviation is negative, or it will be the adjustment in “Time to Decrease” if the measured deviation is positive, both in “Timing Step”.” >> 1;
Adjusted deviation: it is the value programmed in the “Deviation” parameter in “Timing Step” >> 1.

SETTING RANGE: Linear, Inverse.
DEFAULT VALUE: Linear.



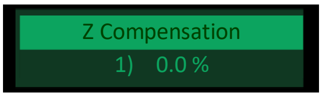
SUBSEQUENT TIME:
The time for the first operation of the on-load tap changer will be set in the parameter "Timing Step". If a single tap changer operation is not enough for the voltage to return to the set limits, the SDV will use the subsequent time setting as an interval for the other commands to the on-load tap changer.

SETTING RANGE: 0 to 180 s.
DEFAULT VALUE: 10 s.

DROP COMPENSATION TYPE:
Line drop compensation is a feature of the SDV that allows the voltage across the load (not the voltage at the transformer output) to be kept within set limits, considering the voltage drop across the line between the transformer and the load due to its resistance and reactance. The SDV calculates the load voltage using measurements of transformer output voltage and load current, in addition to programmed line parameters. Two user-programmed line drop compensation methods are available in the SDV:

- **RX**: normally used in systems where the voltage drop in the line is more significant, therefore requiring better compensation accuracy. It is necessary to know the two parameters of the line: its Resistance (R) and Reactance (X). When the RX method is selected, the parameters "Voltage Drop Ur" and "Voltage Drop Ux" must be programmed (see below);
- **Z**: this is a simplified method, in which a percentage of global voltage drop in the line is programmed instead of the individual parameters R and X. It does not have the same precision as the RX method because it does not take into account possible variations in the load's power factor, variations that cause a change in the percentage of voltage drop. However, in applications where the load power factor does not undergo significant changes, or if the voltage drop is small, this method can present satisfactory results, with the advantage of simplicity of adjustments. When the Z method is selected, the "Z Compensation" parameter must be programmed (see below).

SETTING RANGE: Z, RX.
DEFAULT VALUE: Z.

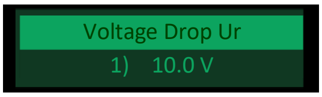


Z COMPENSATION:

This item will only be displayed if the parameter “Drop Compensation Type” is set to “Z”. It is the line voltage drop as a percentage of the transformer output voltage, adjusted to the rated current of the SDV (5 A). The Z Compensation adjustment can be obtained experimentally, if the transformer output voltage, the load voltage and the load current are measured simultaneously, then applying the formula below:

$$\text{Z Comp.} = 100 \cdot \left(\frac{\text{Transformer Output Voltage} - \text{Load voltage}}{\text{Transformer Output Voltage}}\right) \cdot \left(\frac{5 \cdot \text{CT Ratio}}{\text{Load Current}}\right)$$

SETTING RANGE: 0.0 to 15.0 %.
DEFAULT VALUE: 0.0 %.

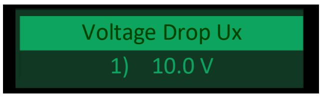


VOLTAGE DROP IN UR:

This item will only be displayed if the parameter “Drop Compensation Type” is set to “RX”. It is the resistive component of the line voltage drop, in volts, referred to the PT secondary and adjusted to the SDV rated current (5 A).

$$U_r = 5 \cdot R \cdot \left(\frac{\text{CT Ratio}}{\text{PT Ratio}}\right)$$

Where R is the line resistance from the transformer to the load in ohms.
SETTING RANGE: -25.0 to 25.0 V.
DEFAULT VALUE: 10.0 V.

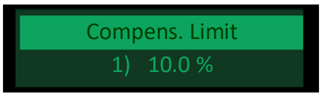


VOLTAGE DROP IN UX:

This item will only be displayed if the parameter “Drop Compensation Type” is set to “RX”. It is the reactive component of the line voltage drop, in volts, referred to the VT secondary and adjusted to the SDV rated current (5 A).

$$U_x = 5 \cdot X \cdot \left(\frac{\text{CT Ratio}}{\text{PT Ratio}}\right)$$

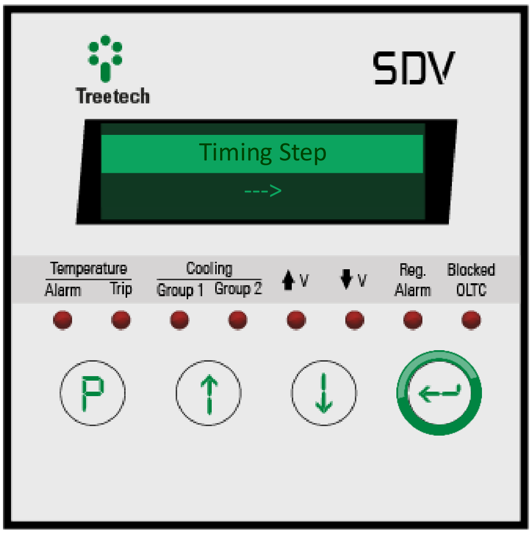
Where X is the reactance of the line between the transformer and the load in ohms.
SETTING RANGE: -25.0 to 25.0 V.
DEFAULT VALUE: 10.0 V.



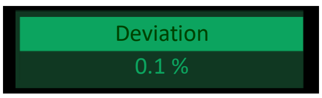
COMPENSATION LIMIT:
During line drop compensation operation, the SDV will cause the transformer output voltage to rise in order to keep the load voltage within limits. This voltage rise will be proportional to the load current, so very high load currents could cause a large voltage rise at the transformer output. To avoid this occurrence, this parameter is programmed to establish a higher voltage rise threshold expressed as a percentage of the rated voltage.
SETTING RANGE: 0.0 to 25.0 %.
DEFAULT VALUE: 10.0 %.

5.5.1.1.1 Timing step

In this submenu, we adjust the insensitivity (or dead band) allowed for voltage regulation, that is, the load voltage deviation limit, expressed as a percentage of the rated voltage, which, if exceeded, will start the time count for the first tap changer operation (time to raise and time to lower voltage).
The SDV allows up to three different deviation steps to be programmed, each with its own voltage increasing time and voltage decreasing time settings. To enter the section, press .



SELECT STEP:
When accessing the submenu “Timing Step”, the item “Select Step” will appear on the screen, where the user will select the step to be programmed among options 1, 2 and 3. Parameter programming must start with step 1. The parameters listed below will be programmed for each of the steps.



DEVIATION:

Percentage of deviation between the voltage measured at the load and the rated voltage (programmed) that, if exceeded, starts the counting of the times to raise or lower voltage, programmed as described below.

SETTING RANGE: 0.1 to 10.0 %.

DEFAULT VALUE: 0.1 %.

TIMING TO INCREASE:

Timing for the first raise voltage command for the on-load tap changer (according to the “Type of Timing” parameter).

SETTING RANGE: 0 to 180 s.

DEFAULT VALUE: 15 s.

TIMING TO DECREASE:

Timing for the first lower voltage command to the on-load tap changer (see also “Type of Timing parameter).

SETTING RANGE: 0 to 180 s.

DEFAULT VALUE: 15 s.

The voltage deviation setting in timing step 1 must not be less than half the voltage step (voltage difference between two consecutive taps) of the on-load tap changer in order to avoid tap changer instability:

$$\text{Deviation 1} > 50\ \% \cdot \frac{\text{Voltage step}}{\text{Rated voltage} \cdot \text{PT Ratio}}$$

Example:

$$\text{OLTC Voltage step} = 172.5\ \text{V}$$

$$\text{PT Ratio} = \frac{13800\ \text{V}}{115\ \text{V}} = 120$$

$$\text{Rated voltage} = \frac{13200\ \text{V}}{120} = 110\text{V}$$

$$\text{Deviation 1} > 50 \cdot \frac{172.5\ \text{V}}{110\ \text{V} \cdot 120}\%$$

$$\text{Deviation 1} > 0.65\ \%$$

The deviation settings for timing steps 1, 2, and 3 interact with each other as follows:

When setting the deviation for step 1, the start of the deviation adjustment range for step 2 is determined there, which in turn will determine the start of the deviation adjustment range for step 3. For example:

Initially, the deviation of step 1 is adjusted, which has an adjustment range from 0 to 10%. Let's say the adjustment was fixed at 3%.

Next, the deviation of step 2 will be adjusted, which will have its adjustment range starting at 3%, going up to 10%. Let's say the adjustment was fixed at 5%.

Finally, the deviation of step 3 is adjusted, which will have its adjustment range starting at 5%, going up to 10%. Let's say the adjustment was fixed at 8%.

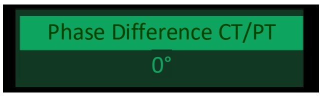
Once the 3 steps have been adjusted as exemplified above, let's say that we return to step 2 to change the deviation value, initially set at 5%.

As the deviations of steps 1 and 3 are set at 3% and 8% respectively, this time the adjustment range of the step 2 deviation is limited to the range between 3% and 8%.

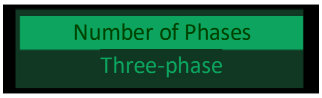
Let's say you need to adjust a value less than 3 %, for example 2 %. In this case, it is first necessary to change the step 1 deviation adjustment, decreasing it to a value less than 2 %.

In this way, we create different timing bands for the on-load tap changer actuation as a function of the voltage deviation amplitude. Note that the three timing steps will only be effective if the Type of Timing parameter is selected for linear timing. Otherwise, when inverse timing is selected, only timing step 1 settings will be effectively used for SDV operation.

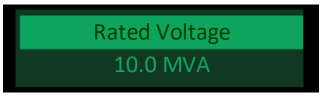
5.5.2 Transformer



PHASE DIFFERENCE BETWEEN CT AND PT:
There are several possible combinations for connecting the PT and CT to the SDV, and each combination produces an angular phase difference between the voltage and current signals. In this parameter, the phase difference angle between the voltage measured by the PT and the current measured by the CT is adjusted. This value will be used for the correct calculation of the power factor.
See the section **Error! Reference source not found.** for information and examples on possible connection combinations.
SETTING RANGE: 0°, 30°, 60°, 90°, 120°, 150°, 180°, 210°, 240°, 270°, 300° and 330°.
DEFAULT VALUE: 0°.



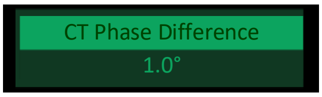
NUMBER OF PHASES:
Select the type of monitored transformer between three-phase and single-phase.
SETTING RANGE: Three-phase, Single-phase.
DEFAULT VALUE: Three-phase.



RATED VOLTAGE:
To calculate the transformer loading percentage, it is necessary to inform the SDV of the rated voltage of the transformer (or transformer bank).
SETTING RANGE: 0.0 to 999.9 MVA.
DEFAULT VALUE: 10.0 MVA.

RATED CURRENT:
To calculate the transformer loading percentage, it is necessary to inform the SDV of the rated current of the transformer (or transformer bank).
SETTING RANGE: 0.01 to 655.35 MVA.
DEFAULT VALUE: 5.00 kA.

CT USED FOR REGULATION:
Select which CT will be used for regulation calculations (CT shared with temperature gradient calculations).
SETTING RANGE: 1, 2 and 3.
DEFAULT VALUE 1.



CT PHASE DIFFERENCE:
Parameterize the phase difference introduced in the measurement by the CT selected for regulation (1, 2 or 3). If an association of CTs or a similar CT is used, different from the regulation CT, there may be an angle difference between the measured current and the current at the input of the IED. This parameter aims to compensate for these cases.
SETTING RANGE: 0.0° to 10.0°.
DEFAULT VALUE: 1.0°.

DIRECTION OF THE TC USED FOR REGULATION:
Parameterize the connection polarity of the CT selected for regulation (1, 2 or 3).
SETTING RANGE: Normal, Inverted.
DEFAULT VALUE: Normal.

MEASUREMENT PT RATIO:
Adjustment of the transformation ratio of the measuring PT being obtained by dividing the voltage in the primary winding of the PT by the voltage in the secondary winding.
Example:
Considering the voltage of the primary winding of the PT being equal to 138 kV and the voltage of the secondary winding being equal to 115 V, we get the value of the PT voltage ratio:

$$\text{PT Ratio} = \frac{138000\ \text{V}}{115\ \text{V}} = 1200$$

SETTING RANGE: 1 to 9999.
DEFAULT VALUE: 100.

MEASUREMENT CT RATIO:
Adjustment of the measurement CT transformation ratio, obtained by dividing the CT primary winding current by the secondary current.
Example:
Considering the CT primary winding current equal to 250 A and the secondary current equal to 5 A, we arrive at the value of the CT current ratio:

$$\text{CT Ratio} = \frac{250\ \text{A}}{5\ \text{A}} = 50$$

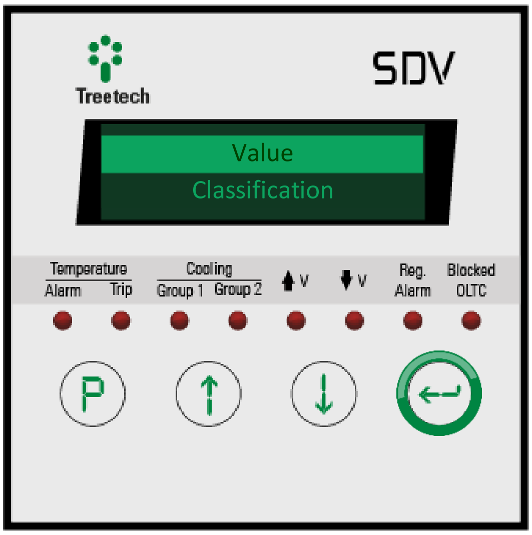
SETTING RANGE: 1 to 9999.
DEFAULT VALUE: 100.

AUXILIARY PT RATIO:
Parameterize the auxiliary PT ratio, used for voltage measurement by the SDV.
SETTING RANGE: 1 to 9999.
DEFAULT VALUE: 180.

ENABLE OLTC CHECK:
This parameter allows the user to activate the **OLCK** option and it will only be displayed if the equipment has this option enabled.
SETTING RANGE: YES, NO.
DEFAULT VALUE: YES.

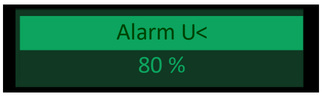
OLTC LIMIT CHECK:
Select the number of times the SDV should check the OLTC before generating an alarm. This parameter will only be displayed if the **OLCK** option is enabled.
SETTING RANGE: 1 to 99.
DEFAULT VALUE: 5.

5.5.3 Alarms



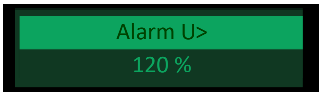
The alarm configuration submenu is divided into two other submenus. The first is where the threshold values and properties for alarms related to voltage regulation are defined.
The second submenu is where the alarm priority level is classified according to the color code explained in the section **Error! Reference source not found.**. Choose the highlighted section and press the key  to see the options.

5.5.3.1 Value



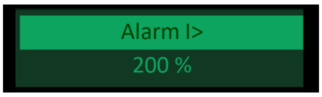
ALARM DUE TO UNDERVOLTAGE:
The undervoltage alarm signals an excessive drop in the voltage measured at the PT. This drop can be caused, for example, by a short circuit.
This alarm is issued when the voltage measured at the PT secondary has a value lower than or equal to the value set in the Alarm U< parameter, expressed as a percentage of the adjusted rated voltage.
To avoid false alarms during transformer de-energization, this alarm will not be issued if the measured voltage is below 10% of the rated voltage.
To prevent the SDV from triggering the on-load tap changer to try to raise the voltage during a short circuit, the user can select the alarm of U< as a condition for tap changer blocking in the OLTC Blocking parameter.
SETTING RANGE: 10 to 99 %.
DEFAULT VALUE: 80 %.

TIMING OF ALARM DUE TO UNDERVOLTAGE:
It allows setting a timing for the undervoltage alarm, which will only be activated if the voltage remains below the value established in the Alarm U< parameter for a time longer than the set time. This avoids unnecessary triggering of the alarm due to short-term events such as transients in the power system, for example.
Timing is not applied to undervoltage on-load tap changer blocking, if selected, which occurs instantaneously.
SETTING RANGE: 0 to 200 s.
DEFAULT VALUE: 10 s.



ALARM DUE TO OVERVOLTAGE:
This alarm is issued when the voltage measured at the PT secondary has a value greater than or equal to the value set in the Alarm U> parameter, expressed as a percentage of the adjusted rated voltage. This condition can be harmful to loads connected to the transformer.
When overvoltage occurs, the SDV can immediately operate the on-load tap changer in order to lower the voltage, disregarding timing adjustments.
If this quick operation is to be avoided, the user can select the U> alarm as a condition for tap changer blocking in the OLTC Blocking parameter.
SETTING RANGE: 101 to 199 %.
DEFAULT VALUE: 120 %.

TIMING OF ALARM DUE TO OVERVOLTAGE:
It allows setting a timing for the overvoltage alarm, which will only be activated if the voltage remains above the value established in the Alarm U> parameter for a time longer than the set time.
This avoids unnecessary triggering of the alarm due to short-term events such as transients in the power system, for example. Timing is not applied to overvoltage on-load tap changer blocking, if selected, nor to rapid voltage reduction operation, which occurs instantaneously.
SETTING RANGE: 0 to 200 s.
DEFAULT VALUE: 10 s.



ALARM DUE TO OVERCURRENT:

The overcurrent alarm is issued when, due to a short circuit or overload, the current measured in the CT secondary has a value greater than or equal to that set in the Alarm I> parameter, expressed as a percentage of the rated current of the SDV (5 A).

Operating the on-load tap changer with high currents can be harmful to its contacts. To prevent the SDV from triggering the on-load tap changer to try to raise the voltage during a short circuit, the user can select the alarm of I> as a condition for tap changer blocking in the OLTC Blocking parameter.

SETTING RANGE: 10 to 200 %.

DEFAULT VALUE: 200 %.

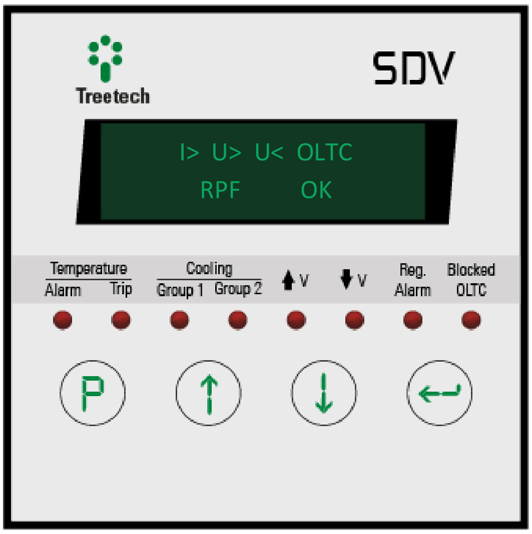
TIMING OF ALARM DUE TO OVERCURRENT:

It allows setting a timing for the overcurrent alarm, which will only be activated if the measured current remains above the value established in the Alarm I> parameter for a time longer than the set time.

This avoids unnecessary triggering of the alarm due to short-term events. Timing is not applied to overcurrent on-load tap changer blocking, if selected, which occurs instantaneously.

SETTING RANGE: 0 to 200 s.

DEFAULT VALUE: 10 s.



OLTC BLOCKING

It allows selection of the conditions that will block the on-load tap changer, if they occur. To activate or deactivate a blocking condition, use the and keys respectively and press to move to the next condition. The available options are:

- **I> :** Blocking by overcurrent;
- **U>** : Blocking by overvoltage;
- **U<** : Blocking by undervoltage;
- **OLTC**: Blocking by triggered OLTC, situation in which the OLTC keeps changing the tap without having been commanded by a known source, which could mean, among other things, a problem in the mechanism;
- **RPF**: Blocking by reverse power flow.

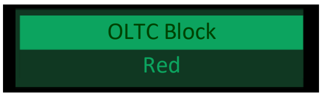
When one or more conditions programmed in these parameters occur, the SDV will not issue any command to the OLTC, blocking the action of increasing or decreasing the voltage. The OLTC blocking function can be associated with an output contact, which can be used to interrupt the tap changer control supply or motor, even aborting operations already started in the drive mechanism before the operation of the main contacts.

5.5.3.2 Classification

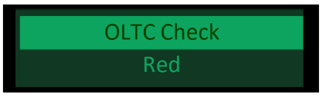
CLASSIFICATION OF ALARM DUE TO UNDERVOLTAGE:
Allows the user to classify the undervoltage alarm priority level according to the color code described in section 7.2.
SETTING RANGE: Red, Yellow, Blue e Disabled.
DEFAULT VALUE: Yellow.

CLASSIFICATION OF ALARM DUE TO OVERVOLTAGE:
Allows the user to sort the overvoltage alarm priority level according to the color code described in section 7.2.
SETTING RANGE: Red, Yellow, Blue e Disabled.
DEFAULT VALUE: Yellow.

CLASSIFICATION OF ALARM DUE TO OVERCURRENT:
Allows the user to classify the overcurrent alarm priority level according to the color code described in section 7.2.
SETTING RANGE: Red, Yellow, Blue e Disabled.
DEFAULT VALUE: Yellow.



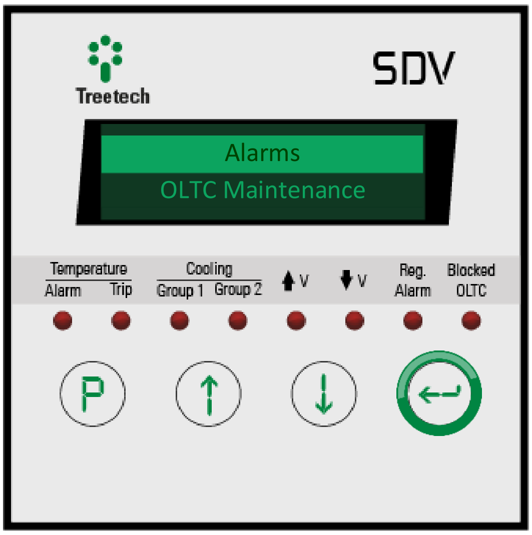
CLASSIFICATION OF OLTC BLOCKING EVENTS:
Allows the user to sort the alarm priority level of OLTC blocking events according to the color code described in section 7.2.
SETTING RANGE: Red, Yellow, Blue e Disabled.
DEFAULT VALUE: Red.



CLASSIFICATION OF OLTC CHECK EVENTS:
Allows the user to sort the alarm priority level of OLTC check events according to the color code described in section 7.2.
This parameter will only be available if the **OLCK** option is enabled.
SETTING RANGE: Red, Yellow, Blue e Disabled.
DEFAULT VALUE: Red.

5.5.4 Advanced

The advanced settings submenu is divided into two submenus. The first is for configuring SDV special alarms and can be accessed by pressing ⏎ when highlighted. The second submenu is for parameterization of the on-load tap changer maintenance items. To enter, press ⏎.



5.5.4.1 Alarms - Classification

The alarm configuration submenu presents the “Classification” menu, which allows the user to classify the alarm priority level according to the color code explained in section 7.2.

CLASSIFICATION OF ALARM DUE TO THE MAXIMUM NUMBER OF OLTC OPERATIONS:
Allows the user to sort the priority level of the alarm for maximum number of operations according to the color code described in section 7.2.
SETTING RANGE: Red, Yellow, Blue e Disabled.
DEFAULT VALUE: Blue.

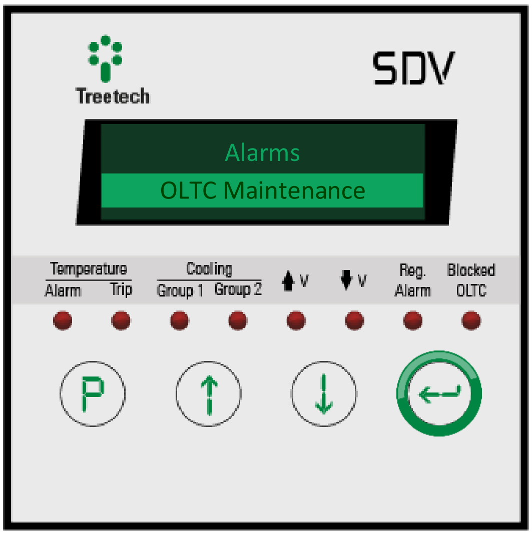
CLASSIFICATION OF ALARM DUE TO SWITCHED CURRENT INTEGRAL:
Allows the user to classify the priority level of the switched current integral alarm, according to the color code described in section 7.2.
SETTING RANGE: Red, Yellow, Blue e Disabled.
DEFAULT VALUE: Blue.

CLASSIFICATION OF WARNING OF THE MAXIMUM NUMBER OF OLTC OPERATIONS:
Allows the user to sort the priority level of the warning for maximum number of operations according to the color code described in section 7.2.
SETTING RANGE: Red, Yellow, Blue e Disabled.
DEFAULT VALUE: Blue.

CLASSIFICATION OF WARNING OF SWITCHED CURRENT INTEGRAL:
Allows the user to sort the priority level of the warning for the square of the high switched current integral according to the color code described in section 7.2.
SETTING RANGE: Red, Yellow, Blue e Disabled.
DEFAULT VALUE: Blue.

5.5.4.2 On-load tap changer maintenance

This item will present the on-load tap changer maintenance parameterization items described below.



ENABLE TAP CHANGER MAINTENANCE FUNCTION:
Enables the tap changer maintenance function. This parameter will only be available if the **OLMT** option is enabled.
SETTING RANGE: YES, NO.
DEFAULT VALUE: YES.

INITIAL NUMBER OF OPERATIONS:

Defines the total number of operations of the tap changer since the start of its operation. It allows the present number of tap changer operations to be adjusted so that the SDV count matches the mechanical counter on most OLTCs.

The OLTC operation counter is incremented each time the measured tap position changes.

This number is adjustable in two steps. First press to enter the variable. Change the three most significant figures using and , then confirm the value by pressing again. This will also move the cursor to the three least significant figures, which can now be changed in the same way.

To cancel any changes to these values that are being made by mistake, press , and as usual this will exit the variable without saving the changes being made.

SETTING RANGE: **0 to 999999.**

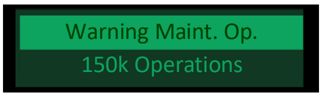
DEFAULT VALUE: **000000.**

NUMBER OF OPERATIONS SINCE THE LAST MAINTENANCE:

Defines the partial number of tap changer operations since the last maintenance or inspection performed on it. It allows you to adjust the number of operations since maintenance on tap changers that were already in operation when the SDV was installed. The counter is incremented each time the measured tap position changes.

SETTING RANGE: **0 to 999999.**

DEFAULT VALUE: **000000.**



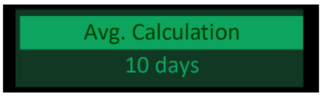
WARNING OF MAINTENANCE FOR NUMBER OF OPERATIONS:
Defines the number of operations for OLTC maintenance, as indicated by its manufacturer. When the counter of No. Op. Last Maint. reaches the configured value, the SDV issues a warning indicating that maintenance on the tap changer must be carried out. The warning can be signaled on a programmable output relay.
The maintenance warning indication remains active in the SDV and programmed warning contacts will remain on until the user manually acknowledges the warnings. This procedure informs the SDV that the maintenance has already been performed. Once this recognition is made, the No. Op. Last Maint. recorder is reset and maintenance warnings are disabled.
SETTING RANGE: 0 to 999 k.
DEFAULT VALUE: 150 k.

INTEGRAL OF THE TOTAL SWITCHED CURRENT SQUARED:
Defines the sum of the current switched by the OLTC squared (Ipu^2) since the beginning of its operation and allows adjusting the present value of this sum in tap changers that were already in operation when the SDV was installed.
The sum is incremented by the measured load current value, converted to p.u. (per unit) and squared, the instant there is a change in the OLTC tap position.
SETTING RANGE: 0.00 to 99.99*10^3; 100.0 to 999.9*10^3; 1000 to 2000*10^3.
DEFAULT VALUE: 0.00*10^3.

INTEGRAL OF THE PRESENT SWITCHED CURRENT SQUARED:
Defines the sum of the current switched by the OLTC squared (Ipu^2) since the last maintenance performed on the tap changer. It allows adjusting the present value of this sum in tap changers that were already in operation when the SDV was installed.
The sum is incremented by the measured load current value, converted to p.u. (per unit) and squared, the instant there is a change in the OLTC tap position.
SETTING RANGE: 0.00 to 99.99*10^3; 100.0 to 999.9*10^3; 1000 to 2000*10^3.
DEFAULT VALUE: 0.00*10^3.

WARNING OF MAINTENANCE FOR THE SWITCHED CURRENT INTEGRAL:
Defines the value of the sum of the current switched by the OLTC squared (Ipu^2) for the OLTC maintenance, as indicated by its manufacturer. When the I^2 after Maint. recorder reaches the configured value, the SDV issues a warning indicating that maintenance on the tap changer must be carried out.
The maintenance warning indication remains active in the SDV and programmed warning contacts will remain on until the user manually acknowledges the warnings. This procedure informs the SDV that the maintenance has already been performed. Once this recognition has been carried out, the "I^2 after Maint." is reset and maintenance warnings are disabled.
SETTING RANGE: 0.00 to 99.99*10^3; 100.0 to 999.9*10^3; 1000 to 2000*10^3.
DEFAULT VALUE: 2000*10^3.

OLTC RATED CURRENT:
Defines the rated current of the on-load tap changer referred to the secondary of the measuring CT. The setting is used as a basis for converting the load current measured during switching from amps to p.u. (per unit).
SETTING RANGE: 0.10 to 10.00 A.
DEFAULT VALUE: 5.00 A.



DAYS FOR CALCULATION OF AVERAGES:
Defines the number of days that will be used both for calculating the average of daily commutations and for the daily average of the switched current squared Ipu^2.
SETTING RANGE: 10 to 365 days.
DEFAULT VALUE: 10 days.

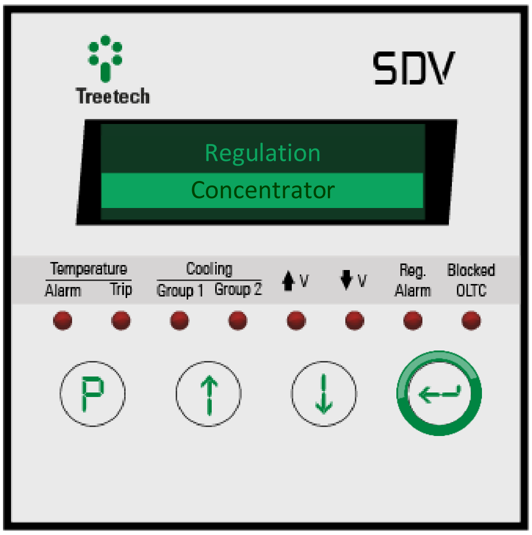
WARNING OF MAINTENANCE:
Defines the number of days in advance that the tap changer maintenance warning will be issued.
SETTING RANGE: 0 to 365 days.
DEFAULT VALUE: 30 days.

AVERAGE RESET:
Resets the average number of tap changer operations and switched current.
SETTING RANGE: **YES, NO.**
DEFAULT VALUE: **NO.**

5.6 Concentrator

To access the Concentrator parameterization menu, navigate with the arrows until the "Concentrator" line is highlighted, then press .

This submenu will only be available if the **CONC** option is enabled.

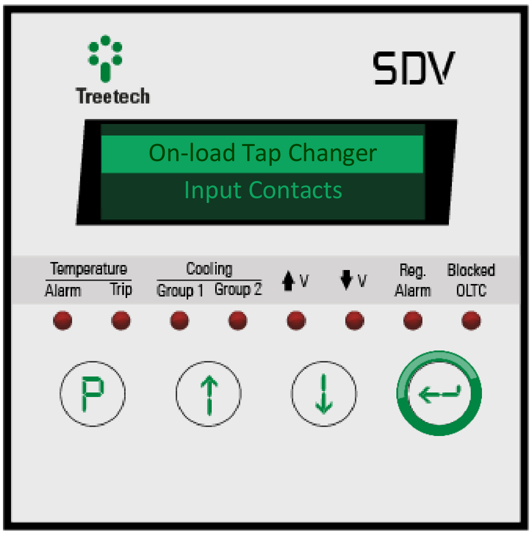


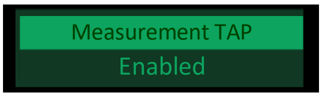
CONCENTRATOR:
Parameter to enable or disable the parallelism concentrator function in SDV (COMM-04 mode). Enables or disables communication with the SPS. This parameter will only be available if the **CONC** option is enabled.
SETTING RANGE: YES, NO.
DEFAULT VALUE: YES.

CONCENTRATOR IDENTIFICATION:
Number that identifies the SDV in the SCADA system. Used to identify which SDV is enabled as a parallelism concentrator. This parameter will only be available if the **CONC** option is enabled.
SETTING RANGE: 1 to 65535.
DEFAULT VALUE: 1.

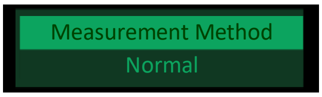
5.7 On-load tap changer

To access the on-load tap changer parameterization menu, navigate with the arrows until the line “On-load Tap Changer” line is highlighted, then press .

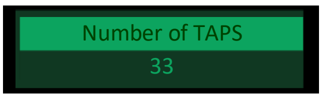




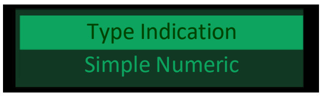
MEASUREMENT OF TAP POSITION:
Choose whether or not to enable the tap position measurement function.
SETTING RANGE: **Enabled, Disabled.**
DEFAULT VALUE: **Disabled.**



METHOD OF TAP POSITION MEASUREMENT:
Choose the tap position measurement method from normal, simple calibration or advanced calibration. If the selected measurement method is simple or advanced calibration, the transmitter calibration parameters will be enabled in the “Advanced” menu.
SETTING RANGE: **Normal, Simple Cal., Advanced Cal.**
DEFAULT VALUE: **Normal.**



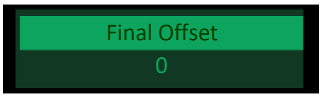
OLTC NUMBER OF TAPS:
Select the number of OLTC taps that the SDV should monitor.
SETTING RANGE: **1 to 49.**
DEFAULT VALUE: **33.**



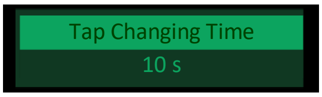
TYPE OF POSITION INDICATION:
There are several methods to measure the tap position. Depending on the monitored tap changer model, choose one of the methods listed below.
SETTING RANGE: Simple Numeric, Inverse Alphanumeric, Alphanumeric, Reverse Bilateral, Bilateral.
DEFAULT VALUE: Simple Numeric.

RESISTANCE OF THE TRANSMITTER STEP:
Enter here the resistance value of the step of the potentiometric transmitter used to measure the tap position.
SETTING RANGE: 4.7 to 20.0 Ω.
DEFAULT VALUE: 10.0 Ω.

INITIAL OFFSET:
Choose the value of the initial step of the transmitter resistance, proportional to the parameter “Resistance”, that is, Initial Resistance = Initial Offset * Resistance.
SETTING RANGE: 0 to 5.
DEFAULT VALUE: 0.



FINAL OFFSET:
Choose the value of the final step of the transmitter resistance, proportional to the parameter “Resistance”, that is, Final Resistance = Final Offset * Resistance.
SETTING RANGE: 0 to 5.
DEFAULT VALUE: 0.



TAP CHANGING TIME:
Set the time required for the tap changer to change a tap position.
SETTING RANGE: 1 to 100 s.
DEFAULT VALUE: 10 s.

CENTRAL TAP:
Inform here which is the central tap of the tap changer.
SETTING RANGE: 2 to 48.
DEFAULT VALUE: 17.

CORRELATION BETWEEN TAP raise AND VOLTAGE CHANGE:
On some tap changers, increasing the tap can be an operation that increases or decreases the voltage. In this parameter, the type of tap changer used must be indicated.
SETTING RANGE: Raise Voltage, Lower Voltage.
DEFAULT VALUE: Raise Voltage.

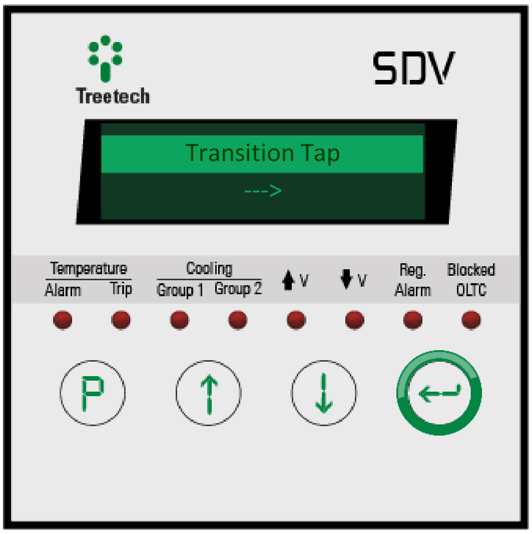
MINIMUM TAP ALLOWED:
Enter the minimum tap number to be allowed.
SETTING RANGE: 1 to 49.
DEFAULT VALUE: 1.

MAXIMUM TAP ALLOWED:
Enter the maximum tap number to be allowed.
SETTING RANGE: 1 to 49.
DEFAULT VALUE: 33.

CURSOR RESISTANCE FOR ALARM:
If the SDV identifies that the resistance of the cursor is greater than the value defined in this parameter, the equipment will issue an alarm of high resistance of the cursor.
SETTING RANGE: 5 to 20 Ω.
DEFAULT VALUE: 20 Ω.

OLTC TRANSITION TAP

Defines the intermediate positions of the tap changer, if any. The user can create up to 3 rules, as follows:



NUMBER OF INTERMEDIATE TAPS:
Choose the number of the intermediate tap to be parameterized.
SETTING RANGE: 1 to 3.
DEFAULT VALUE: 1.

ENABLE INTERMEDIATE TAP:
Enable or disable the parameterization for the previously selected intermediate tap.
SETTING RANGE: ON, OFF.
DEFAULT VALUE: OFF.

```
No.1 ON 01→ 02
Op:2 R:OFF I²:1x
```

LOCATION OF INTERMEDIATE TAP(S):
Enter the initial tap position of the change that has an intermediate transition, **n**. The **n+1** will be updated automatically, and the start position must be between 1 and 48 (when the OLTC tap number is 49).
SETTING RANGE: 1 to 48.
DEFAULT VALUE: 1.

```
No.1 ON 01→ 02
Op:2 R:OFF I²:1x
```

NUMBER OF OPERATIONS BY INTERMEDIATE TAP VARIATION:
Enter the number of operations that occur until the transition between the start and end tap is complete.
SETTING RANGE: 2 to 5.
DEFAULT VALUE: 2.

```
No.1 ON 01→ 02
Op:2 R:OFF I²:1x
```

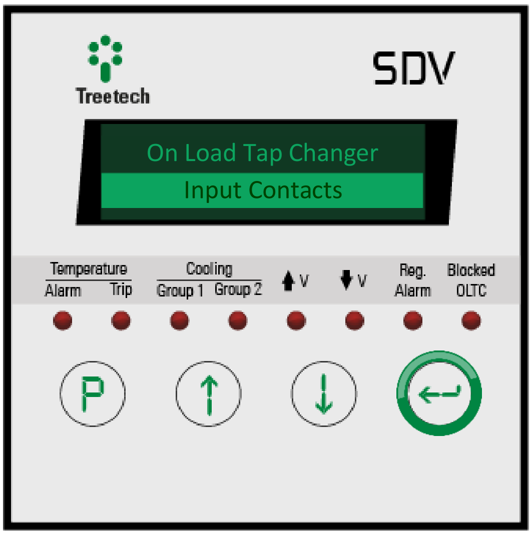
PRESENCE OF RESISTANCE BETWEEN THE INTERMEDIATE TAPS:
Indicates whether the intermediate taps have step resistance or not.
SETTING RANGE: ON, OFF.
DEFAULT VALUE: OFF.

```
No.1 ON 01→ 02
Op:2 R:OFF I²:1x
```

SWITCHED CURRENT MULTIPLICATION FACTOR:
Definition of the multiplier factor of the integral of the squared switched current (I^2). This parameter can only be filled in if the **OLTC** option is enabled.
SETTING RANGE: 1 to 5.
DEFAULT VALUE: 1.

5.8 Input contacts

To access the Input Contacts parameterization menu, navigate with the arrows until the line “Input Contacts” is highlighted, then press  .



INPUT CONTACTS 1 AND 2:

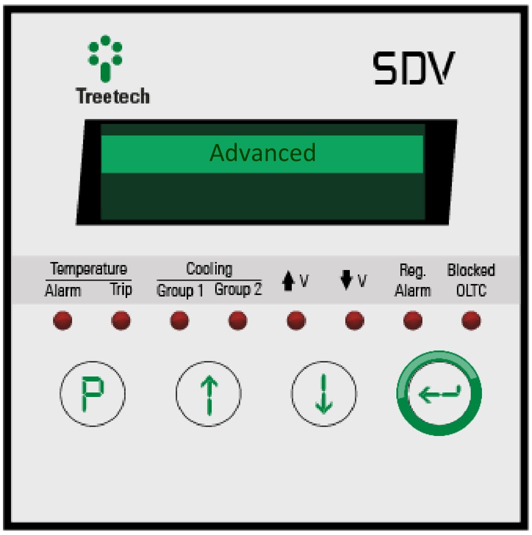
The SDV can receive different types of commands from external sources, such as control panels and buttons installed in remote locations from the device. For this, SDV input contacts 1 and 2 can be configured to receive different types of commands if the **DIGI** option is enabled. When entering this option, select the contact you want to configure and assign its role:

- **Local/Remote**: Allows you to remotely define whether the device should receive commands locally or from a remote source (level 0 = local/level 1 = remote).
- **Autom./Manual**: Configures the selected input contact to receive a signal indicating whether the device should provide automatic or manual voltage regulation (level 0 = automatic/level 1 = manual).
- **Raise TAP**: Configures the selected input contact to receive a remote command pulse to raise tap. This option will only be displayed if the **TAPP** option is enabled.
- **Lower TAP**: Configures the selected input contact to receive a remote command pulse to lower tap. This option will only be displayed if the **TAPP** option is enabled.
- **Enab. Conc.**: Configures the selected input contact to remotely enable or disable the parallelism concentrator function (level 0 = disabled/level 1 = enabled). This option will only be displayed if the **CONC** option is enabled.

SETTING RANGE: --, Local/Remote, Autom./Manual, Raise TAP, Lower TAP, Enab. Conc.
DEFAULT VALUE: --.

5.9 Advanced

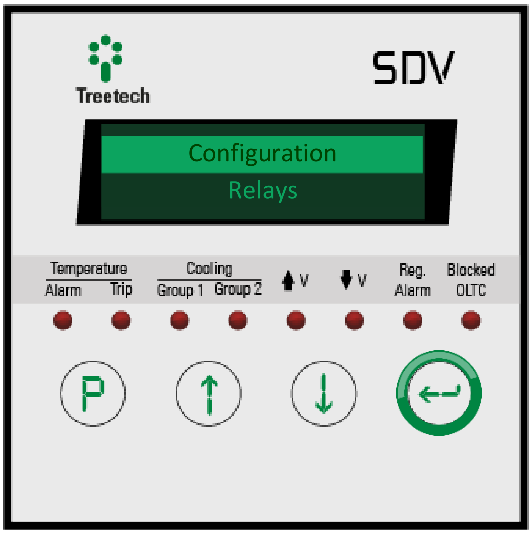
To access the advanced parameterization menu, navigate with the arrows until the "Advanced" line is highlighted.
In the advanced parameterization menu there are three submenus. The first is for general purpose advanced settings, and can be accessed by pressing when highlighted.
The second submenu is for setting the output relays. To enter, press .
There is also the "Factory" menu, for exclusive use by Treetech.



When trying to access the factory menu with the wrong password, the SDV will show the message VOID on its display for a few seconds. The indication time of this message increases as retries are made with an incorrect password. After 5 attempts with the incorrect password, the SDV will completely block access to this menu and the message "VOID" will become permanent. Although the operation of the equipment is not affected, this fact constitutes a loss of warranty.

5.9.1 Configuration

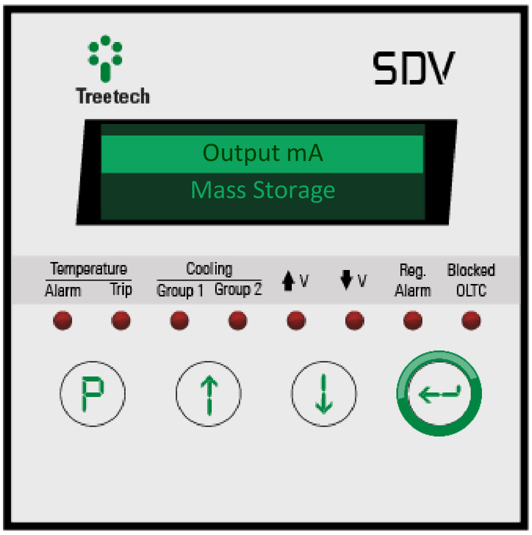
The configuration submenu is subdivided into five other submenus. In the first one, the analog outputs are configured in a mA current loop.
The second submenu is where the mass storage is configured, available through the **MMEM** option.
In the third submenu, the CT ratios are parameterized.
The submenu "Transmitter Calibration" is only enabled if "Simple Cal." or "Advanced Cal." is selected in the parameter "Measurement Method" in the menu "On-Load Tap Changer".
The last submenu is used to restore the equipment's default settings.



5.9.1.1 Analog outputs

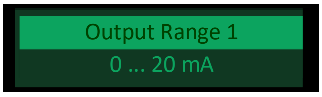
In principle, there are four analog outputs available on the SDV, but when there are outputs with ranges that include negative current values, the number of ports may decrease. Configure the analog outputs to transmit the desired information in the desired format.

Outputs with negative currents are always symmetrical. Therefore, when programming them, it is enough to parameterize the first output of a pair to a negative value so that the second is automatically parameterized to a positive value. In these cases, the screen where these outputs would be parameterized is not displayed.



As the parameter types to be adjusted are the same for all analog outputs, in this section the mA1 output items will be presented. The items for the other outputs are identical and can be found in the same submenu, in sequence, using the arrows.

Naturally, outputs that are unavailable for the reasons described above will not be found.

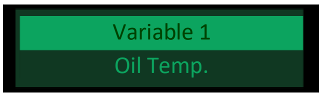


STANDARD OF CURRENT LOOP ANALOG OUTPUT mA1:

Set the current loop output range for remote indication.

SETTING RANGE: -20 ... 20 mA, -10 ... 10 mA, -5 ... 5 mA, -1 ... 1 mA, 4 ... 20 mA, 0 ... 20 mA, 0 ... 10 mA, 0 ... 5 mA, 0 ... 1 mA.

DEFAULT VALUE: 0 ... 20 mA.



VARIABLE OF CURRENT LOOP ANALOG OUTPUT mA1

Select which information you wish to transmit via the selected analog output

SETTING RANGE: -, Oil Temp, Win. 1 Temp., Win. 2 Temp., Win. 3 Temp., Hottest Win., PT 1, PT 2, PT Voltage, CT 1 Current, CT 2 Current, CT 3 Current, Phase Difference, Active Power, Reactive Power, Apparent Power, TAP Position.

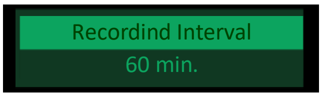
DEFAULT VALUE: Oil Temp.

VALUE MEASURED AT THE START OF THE OUTPUT SCALE mA1:
Set the correspondence between the initial mA scale current and the first scale value of the measured quantity.
SETTING RANGE: -99.9 to 999.9.
DEFAULT VALUE: 0.0.

VALUE MEASURED AT THE END OF THE OUTPUT SCALE mA1:
Set the correspondence between the final mA scale current and the last scale value of the measured quantity.
SETTING RANGE: -99.9 a 999.9.
DEFAULT VALUE: 150.0.

5.9.1.2 Mass storage

To download the mass storage data, see the Mass Storage and Oscillography Download Guide (ID and SD line)[1].



RECORDING INTERVAL:
Selects the time between times when recordings will be made. The SDV has 23,000 positions for recording variables. Depending on the interval chosen between recordings, the mass storage may take more or less time to fill up. To know how long the memory will take to be completely occupied, just do:

$$\text{Total time} = \text{Positions}[\text{rec.}].\text{interval}\left[\frac{\text{min}}{\text{rec.}}\right] = 32767.\text{interval}\ [\text{min}]$$

The default value for this parameterization is 60 min, this would give:

$$\text{Total time} = 32767.60 = 1966020\ \text{minutes} \cong 1365\ \text{days}$$

When the maximum number of records is reached, the oldest records are replaced by the new ones.
SETTING RANGE: 1 to 9999 min.
DEFAULT VALUE: 60 min.

[1] https://treetech.atlassian.net/wiki/x/D4C1Fw

TEMPERATURE VARIATION FOR EXTRAORDINARY RECORDING:
Regardless of the recording interval, if the transformer oil temperature varies above the programmed in this item, a new record will be made in the log of all variables.
SETTING RANGE: 1 to 20 °C.
DEFAULT VALUE: 5 °C.

RECORDING RESET:
"YES" must be selected if the intention is to erase the memory contents so far. Otherwise, keep "NO" selected.
SETTING RANGE: YES, NO.
DEFAULT VALUE: NO.

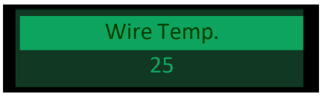
5.9.1.3 CT Ratio

CT "N" (1, 2 OR 3) RATIO:
Set the CT "n" (1, 2 or 3) transformation ratio, clip-on or regulation.
SETTING RANGE: 1 to 10000.
DEFAULT VALUE: 3030.

5.9.1.4 Transmitter calibration

PRESENT TAP POSITION:
Indicate the present tap position for the calibration. This parameter will only be displayed if the parameter "Measurement Method" in the menu "On-Load Tap Changer" is set to "Simple Cal." or "Advanced Cal.".
SETTING RANGE: 1 to 49.
DEFAULT VALUE: 1.

TRANSMITTER TEMPERATURE:
Potentiometric transmitter temperature at the time of calibration. This parameter will only be displayed if the parameter “Measurement Method” in the menu menu “On-Load Tap Changer” is set to “Advanced Cal.”.
SETTING RANGE: -55 to 200 °C.
DEFAULT VALUE: 25 °C.



TEMPERATURE OF CONDUCTORS:
Temperature of the conductors connecting the potentiometric transmitter to the SDV at the time of calibration. This parameter will only be displayed if the parameter “Measurement Method” in the menu “On-Load Tap Changer” is set to “Advanced Cal.”.
SETTING RANGE: -55 to 200 °C.
DEFAULT VALUE: 25 °C.

CALIBRATE TRANSMITTER SHORT-CIRCUITED BETWEEN CURSOR-START:
After applying a short circuit between the cursor measurement inputs and the beginning of the potentiometric transmitter (terminals 62 and 51 of the SDV), select the “Calibrate” option so that the SDV performs the calibration. This parameter will only be displayed if the parameter “Measurement Method” in the menu “On-Load Tap Changer” is set to “Simple Cal.” or “Advanced Cal.”.
SETTING RANGE: -, Calibrate.
DEFAULT VALUE: -.

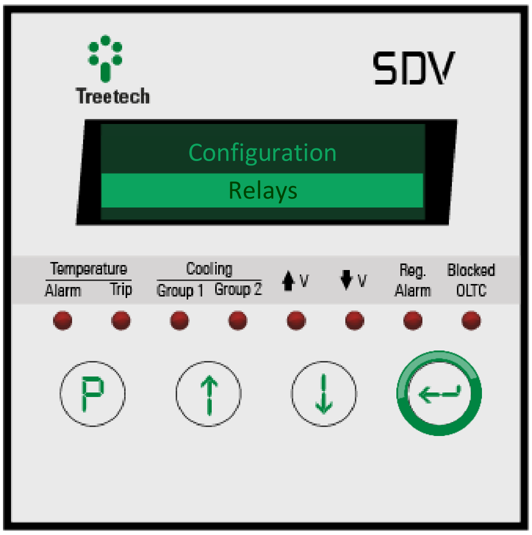
CALIBRATE TRANSMITTER SHORT-CIRCUITED BETWEEN CURSOR-END:
After applying a short circuit between the cursor measurement inputs and the end of the potentiometric transmitter (terminals 62 and 53 of the SDV), select the “Calibrate” option so that the SDV performs the calibration. This parameter will only be displayed if the parameter “Measurement Method” in the menu “On-Load Tap Changer” is set to “Simple Cal.” or “Advanced Cal.”.
SETTING RANGE: -, Calibrate.
DEFAULT VALUE: -.

5.9.1.5 Default setting

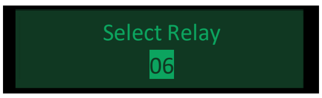
RESTORE FACTORY SETTINGS:
"YES" should be selected only if the intention is to restore the factory default parameterization, that is, **all the equipment parameterizations will be lost**. Otherwise, keep "NO" selected.
SETTING RANGE: **YES, NO.**
DEFAULT VALUE: **NO.**

5.9.2 Relays

The relay configuration submenu is divided into three categories. In the first, configure the relays for general functions.
In the second, configure the relays for functions related to temperature monitoring.
In the third, configure the relays for regulation-related functions.



5.9.2.1 General



SELECT RELAY:
The first step in this submenu is to select the relay you want to configure. The General submenu allows the selection of five relays.
SETTING RANGE: **06 to 10.**
DEFAULT VALUE: **06.**

Mode
Normal

MODE:
Relays 06 to 10 are always NO, by hardware definition. However, the SDV allows the electrical assembly logic to be inverted by firmware such that all relays can operate in NO and NC modes.
SETTING RANGE: Normal, Inverse.
DEFAULT VALUE: Normal.

Class. Green Color
NO

ACTIVATION IN THE GREEN STATUS:
Activates the relay when the general state of alarms is green, that is, when there is no abnormality detected.
SETTING RANGE: NO, YES.
DEFAULT VALUE: NO.

Class. Yellow Color
NO

ACTIVATION IN THE YELLOW STATUS:
Activates the relay when any of the alarms classified as yellow is active.
SETTING RANGE: NO, YES.
DEFAULT VALUE: NO.

Class. Blue Color
NO

ACTIVATION IN THE BLUE STATUS:
Activates the relay when any of the alarms classified as blue is active.
SETTING RANGE: NO, YES.
DEFAULT VALUE: NO.

Class. Red Color
NO

ACTIVATION IN THE RED STATUS:
Activates the relay when any of the alarms classified as red is active.
SETTING RANGE: NO, YES.
DEFAULT VALUE: NO.

It is not necessary to “occupy” four relays to know about the general alarm status on a remote control panel. By programming only two relays according to the suggestion below, with a simple logic it is possible to know all the status.

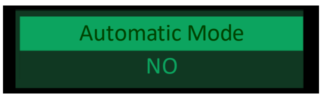
Relay A: Set “YES” to “Class. Yellow Color” and to **“**Class. Red Color”**.** Program “NO” for the remainder.
Relay B: Set “YES” to “Class. Blue Color” and to **“**Class. Red Color”**.** Program “NO” for the remainder.

Table 11 - Relay parameterization suggestion

Relay A	Relay B	Interpretation
0	0	0, Green
0	1	1, Blue
1	0	2, Yellow
1	1	3, Red

In fact, there are many more alarms than relays to signal them, but a relay can be triggered for more than one reason, and this allows you to know the status of alarms by category.
To read all alarms individually at a distance, an interesting option is to acquire a monitoring system such as Treetech's SIGMA ECM®, which also integrates other substation equipment and allows more advanced engineering calculations.

TAP READING ERROR:
Activates the relay when there is an active tap reading error. This parameter will only be displayed if the **TAPP** option is enabled.
SETTING RANGE: NO, YES.



AUTOMATIC MODE SIGNALING:
Activates the relay when the SDV operating mode is in automatic.
SETTING RANGE: NO, YES.
DEFAULT VALUE: NO.

MANUAL MODE SIGNALING:
Activates the relay when the SDV operating mode is in manual.
SETTING RANGE: NO, YES.
DEFAULT VALUE: NO.

LOCAL MODE SIGNALING:
Activates the relay when the SDV command mode is in local.
SETTING RANGE: NO, YES.
DEFAULT VALUE: NO.

REMOTE MODE SIGNALING:
Activates the relay when the SDV command mode is in remote.
SETTING RANGE: NO, YES.
DEFAULT VALUE: NO.

5.9.2.2 Temperature

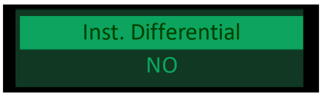
SELECT RELAY:
The first step in this submenu is to select the relay you want to configure. The Temperature submenu allows the selection of five relays.
SETTING RANGE: 06 to 10.
DEFAULT VALUE: 06.

ALARM DUE TO OIL TEMPERATURE
Activates the relay when there is an oil temperature alarm.
SETTING RANGE: NO, YES.
DEFAULT VALUE: NO.

DELAY OF SHUTDOWN DUE TO OIL TEMPERATURE:
Activates the relay when there is an oil temperature shutdown timing in progress.
SETTING RANGE: NO, YES.
DEFAULT VALUE: NO.

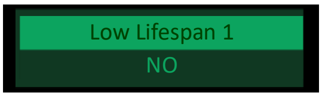
ALARM DUE TO TEMPERATURE OF WINDING “N” (1, 2 OR 3):
Activates relay by an alarm due to temperature of winding “n” (1, 2 or 3).
SETTING RANGE: NO, YES.
DEFAULT VALUE: NO.

DELAY OF SHUTDOWN DUE TO TEMPERATURE OF WINDING “N” (1, 2 OR 3):
Activates the relay when there is a shutdown timing in progress due to temperature of winding "n".
SETTING RANGE: NO, YES.
DEFAULT VALUE: NO.



INSTANTANEOUS DIFFERENTIAL:
Activates relays when there is an alarm due to temperature instantaneous differential between transformer and tap changer.
SETTING RANGE: NO, YES.
DEFAULT VALUE: NO.

FILTERED DIFFERENTIAL:
Activates relays when there is an alarm due to temperature filtered differential between transformer and tap changer.
SETTING RANGE: **NO, YES.**
DEFAULT VALUE: **NO.**



LOW LIFESPAN OF INSULATION IN WINDING “N”:
Activates the relay when there is an alarm due to low lifespan of insulation in winding “n” (1, 2 or 3).
SETTING RANGE: **NO, YES.**
DEFAULT VALUE: **NO.**

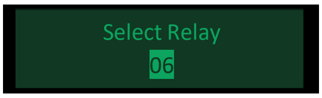
LOW REMAINING LIFETIME OF INSULATION IN WINDING “N”:
Activates the relay when there is an alarm due to low remaining lifetime of insulation in winding “n” (1, 2 or 3).
SETTING RANGE: **NO, YES.**
DEFAULT VALUE: **NO.**

HIGH LOSS OF LIFESPAN OF INSULATION IN WINDING “N”:
Activates the relay when there is an alarm due to high loss of life of insulation in winding “n”.
SETTING RANGE: **NO, YES.**
DEFAULT VALUE: **NO.**

5.9.2.3 Regulation

The regulation submenu is divided into two categories. In the first, configure the relays for general functions
In the second, configure the relays for advanced regulation functions.

5.9.2.3.1 Basic

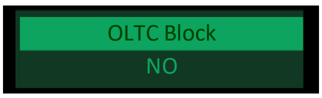


SELECT RELAY:
The first step in this submenu is to select the relay you want to configure. This submenu allows the selection of five relays.
SETTING RANGE: 06 to 10.
DEFAULT VALUE: 06.

ALARM DUE TO UNDERVOLTAGE:
Activates the relay when there is an undervoltage alarm.
SETTING RANGE: NO, YES.
DEFAULT VALUE: NO.

ALARM DUE TO OVERVOLTAGE:
Activates the relay when there is an overvoltage alarm.
SETTING RANGE: NO, YES.
DEFAULT VALUE: NO.

ALARM DUE TO OVERCURRENT:
Activates relay when there is an overcurrent alarm.
SETTING RANGE: NO, YES.
DEFAULT VALUE: NO.



OLTC BLOCKING:
Activates relay when there is an OLTC blocking condition.
SETTING RANGE: NO, YES.
DEFAULT VALUE: NO.

OLTC CHECK:

Activates the relay when the algorithm identifies a tap changer actuation failure. This parameter will only be displayed if the **OLCK** option is enabled.

SETTING RANGE: NO, YES.

DEFAULT VALUE: NO.

5.9.2.3.2 Advanced

SELECT RELAY:

The first step in this submenu is to select the relay you want to configure. This submenu allows the selection of five relays.

SETTING RANGE: 06 to 10.

DEFAULT VALUE: 06.

MAINTENANCE FOR NUMBER OF OLTC OPERATIONS:

Activates the relay when the number of operations for tap changer maintenance, defined in the “Warning Maint Op.” parameter, is reached.

SETTING RANGE: NO, YES.

DEFAULT VALUE: NO.

INTEGRAL OF THE TOTAL SWITCHED CURRENT SQUARED:

Activates the relay when the sum of the squares of the currents at the time of the OLTC operation has reached the value for maintenance for switched current, defined in the parameter “Warning Maint. Ipu^2”, indicating contact wear.

SETTING RANGE: NO, YES.

DEFAULT VALUE: NO.

ADVANCE WARNING OF MAINTENANCE FOR NUMBER OF OPERATIONS:
Defines the relay actuation in case of advance warning of maintenance for number of OLTC operations, considering the “No. Op. Last Maint.” counter, the daily average of tap changes and the number of days for warning with advance for maintenance.
SETTING RANGE: NO, YES.
DEFAULT VALUE: NO.

ADVANCE WARNING OF MAINTENANCE FOR SUM VALUE OF SWITCHED CURRENT:
Defines the relay actuation in the event of a warning by the sum of the current switched by the OLTC squared (Ipu^2), considering the counter “I^2 after Maint.” the daily average of switched current squared and the number of days for warning with advance for maintenance.
SETTING RANGE: NO, YES.
DEFAULT VALUE: NO.

6 Web interface

FRIENDLY WEB INTERFACE

Using the latest HTML5 and Bootstrap technologies, all communication management and visualization of SDV information are done directly on the equipment's web interface, without the need for a license or installation of proprietary software.

ACCESS TO THE WEB INTERFACE

To access the SDV website, just type the equipment's IP address in a web browser with HTML5 support. The configured IP addresses can be consulted through the front of the equipment. To do this, navigate to the “General” menu using the key and press the key. Then press the key. With the equipment screen showing “Network Settings”, press. The IP will be shown, as in the image on the right.

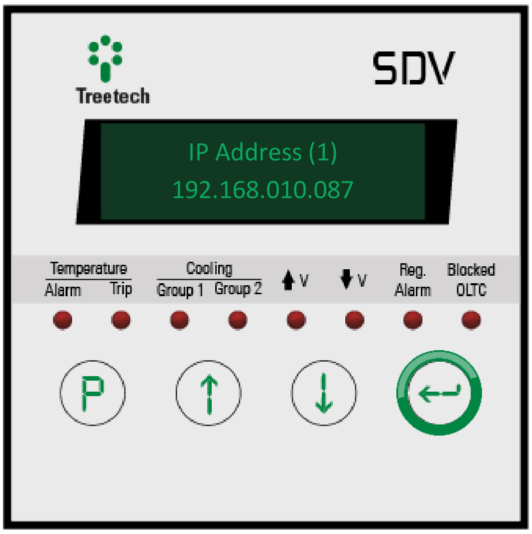


Figure 30 - Illustration of the SDV front displaying the IP for website access

6.1 General navigation

In order to facilitate navigation, the SDV website has a general symbology, which is repeated on several pages.
Depending on user profile permissions, some fields will not be available.
For details, refer to section 6.7.

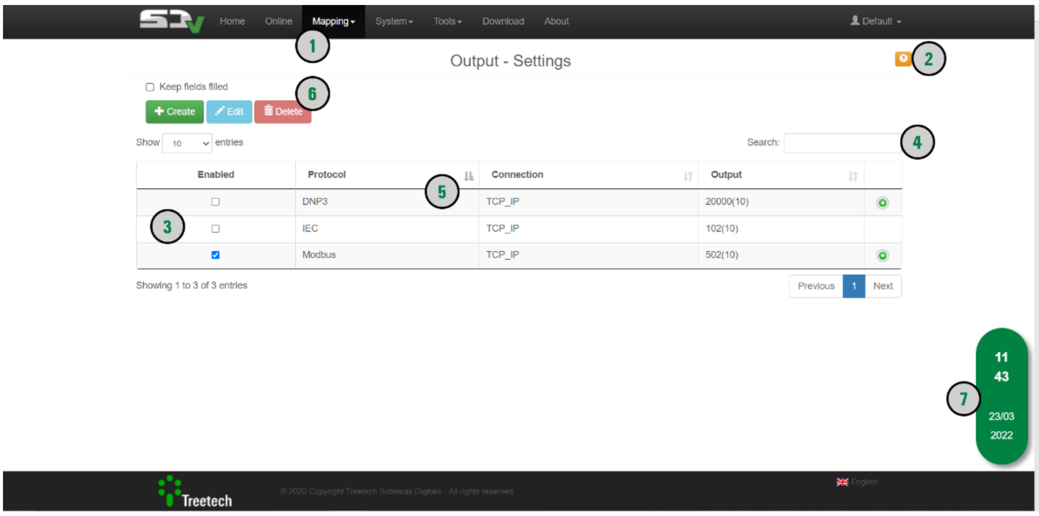


Figure 31 - General navigation through the website

1. Tabbed browsing

At the top of the screen, next to the IED logo, the user can navigate through tabs. Remember that before logging in, only the “Home”, “Download” and “About” tabs will be available.

2. Help buttons

A small orange button with a question mark is located at strategic points and is easy to see on the screen. By clicking on the button, the user will have access to explanatory information about the fields and elements contained in the corresponding screen.

3. Enabled

This check-box called “Enabled” appears constantly on some forms. It serves to enable or disable items related to it.
These also appear within the table and can be used as quick access to enable or disable items.

Some “Asset” check-boxes have an interlock system that prevents them from being activated.

4. Search box

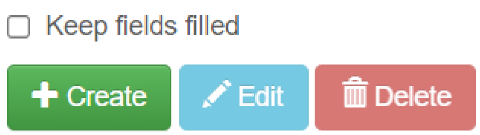
To filter the content shown in the table, use the search box, usually located above a table.

5. Item list

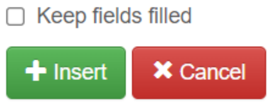
Below the search box, a table shows the list of items found. They can be arranged according to filters in the first rows of the table.

6. Action buttons

Three buttons, one green, one light blue and one red, located above the table, serve to perform actions. In addition, a check-box to keep the fields filled in will be available right above the buttons, so that, when the action is finished, the fields are preserved in the form or not.

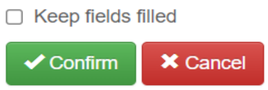


Clicking on the “Create” button will open an empty form with the necessary fields to create a dataset.



Below the form, two buttons will appear: “Add”, to confirm the inclusion of data; and “Cancel”, if the user wants to return to the previous step and cancel the creation action.

Both the “Edit” button and the “Delete” button will only be available by selecting one of the rows in the table.
Clicking on the “Edit” button, the form will open with the fields already filled in according to the selected line.



Below the form, two buttons will appear: “Confirm”, to confirm the changes made; and “Cancel”, if the user wants to return to the previous step and cancel the editing action.

When clicking on the “Delete” button a dialog box will ask you to confirm the deletion of the selected row in the table.

7. Time

The highlighted panel shows the time in local format and the date. This panel is responsive so the user can access local time and UTC information by hovering the cursor over the panel.

6.2 Homepage

From this screen, you can have an overview of the SDV communication status.

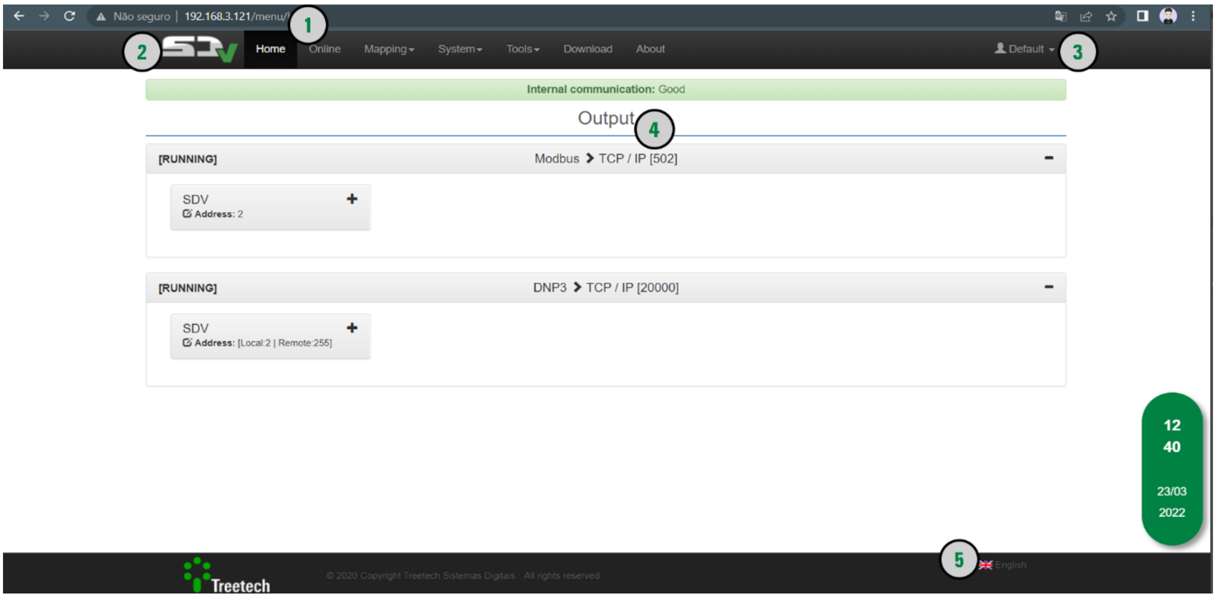


Figure 32 - SDV website home screen

1. IP address

The IP address displayed on the front of the product must be entered into a web browser that supports HTML5.

2. Product identification

In the upper left corner of the screen, the SDV logo identifies the IED.

3. Login

A green button located in the upper right corner of the screen allows the user to log in to the system and access other screens.

4. Output groups

In the central part of the screen, the user can consult and interact with the expandable blocks that represent the SDV output connections and their information as well as the status and history of the communication.

5. Language

In the lower right corner of the homepage, the user can select the language. To do this, simply click on the flag of the country of origin of the desired language.

6.3 About

This is the system information query screen. Here the user finds data such as: equipment serial number, system firmware version and installed application version. In addition, when interacting with the buttons below the screen, the user has access to some “Parameters” and “Changelog” information.

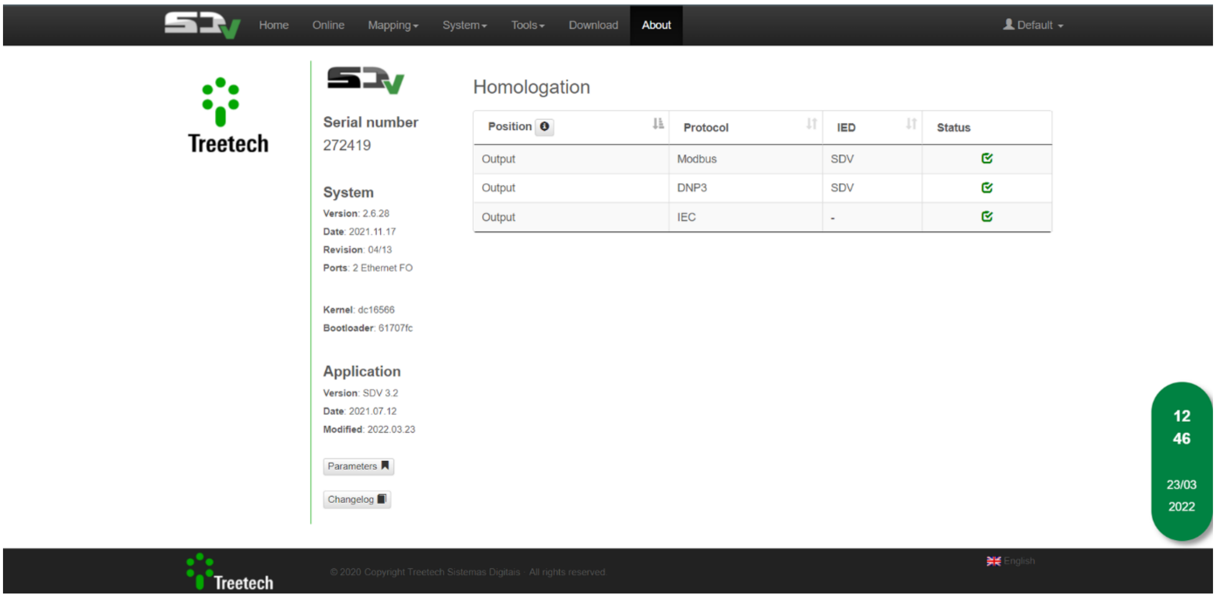


Figure 33 - System information screen

6.4 Login

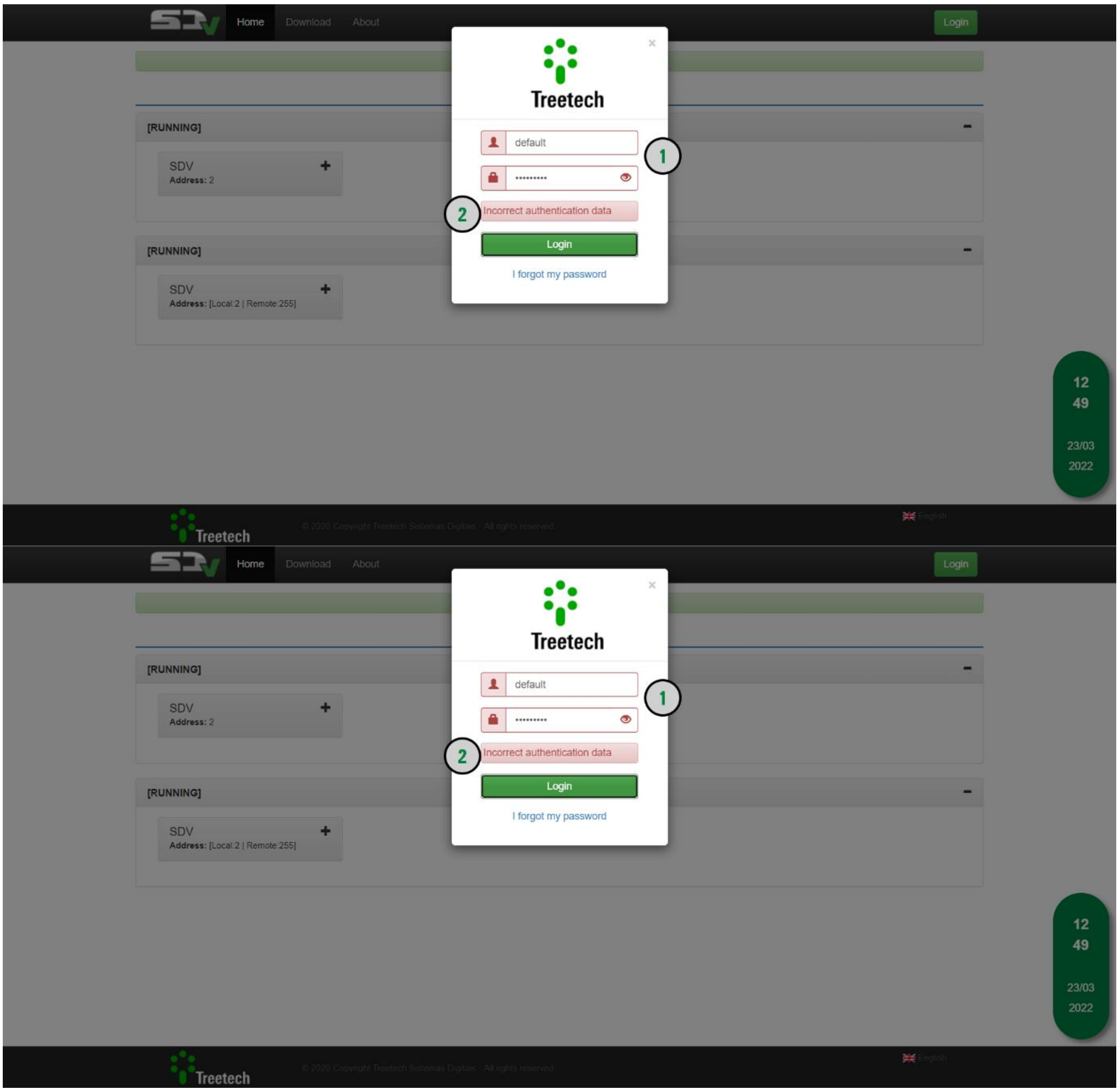


Figure 34 - Entering username and password

1. Login and password

To access more details of the IED and to acquire data online via the website, it is necessary to have a valid username and password. To do this, simply click on the green “Login” button, located in the upper right corner of the screen.
A window will appear, with space for username and password. After filling in the spaces, just click on the green “Login” button to access the system.

2. Wrong username and/or password

If the username and/or password are not correct, a message will be displayed inside a red text box, alerting you to the error.

3. Timeout

If the user logs in, but does not remain active browsing the system, after ten minutes, the session expires. In the final thirty seconds, a countdown window alerts the user to the end of the session.

6.5 Editing the profile

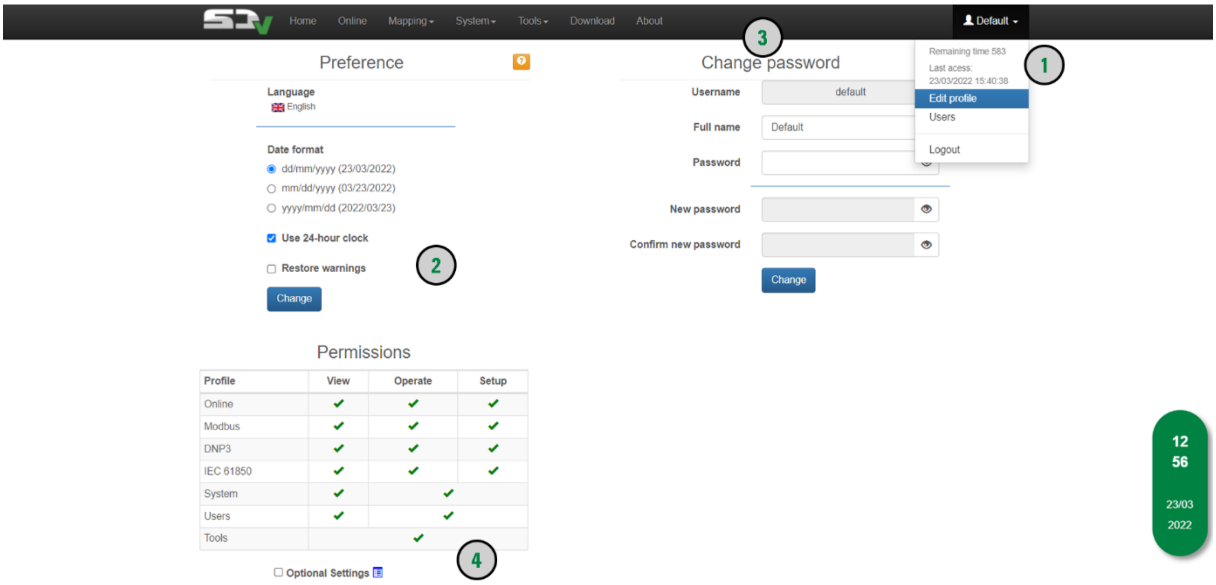


Figure 35 - Editing the profile on the SDV website

1. Access

If the user wants to make changes to their profile, changing their password or their login, just click on the username, available in the upper right corner of the screen. In the collapsible menu, the user must click on the “Edit Profile” button to access the page shown above.

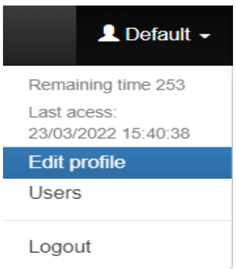


Figure 36 - Access to the profile editing page

2. Language, date format, clock and website warnings

On the left side of the screen, just below the “Preferences” heading, the user can configure the preferences for the visualization. In this space, it is allowed to select the language and the date format (dd/mm/yyyy, mm/dd/yyyy or yyyy/mm/dd). In addition, the clock display format (12 or 24h) can be changed, as well as whether or not to open dialog boxes with warnings. Click the blue “Change” button to confirm the changes.

3. Password

On the right side of this screen, the user can change their password. For this it is necessary user identification first, typing login and current password. From there, the new password can be changed and confirmed. Click the blue “Change” button to confirm the changes.

4. Permissions and optional settings

In the lower left part of the screen, a table is displayed that indicates the permissions of the current user in each of the functionalities. Just below the table is a checkbox that enables or disables a set of optional advanced settings for some screens.

6.6 System

Through this menu, the user will be able to access the network settings, the system clock and date settings, the process manager, the system restart and restore commands, the update screen and the functions of exporting and importing settings.

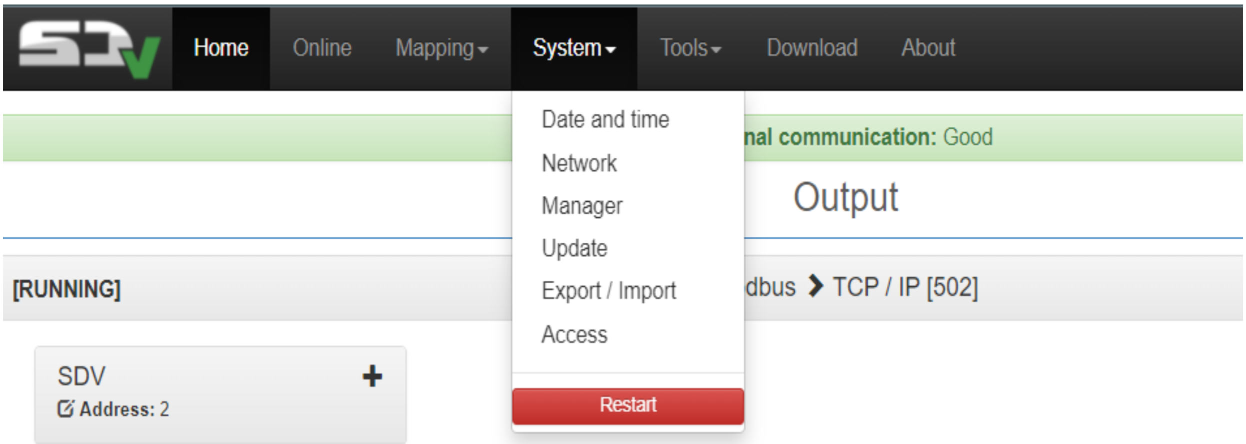


Figure 37 - “System” tab of the SDV website

6.6.1 Date and time

In this screen the user can modify the date and time of the SDV.

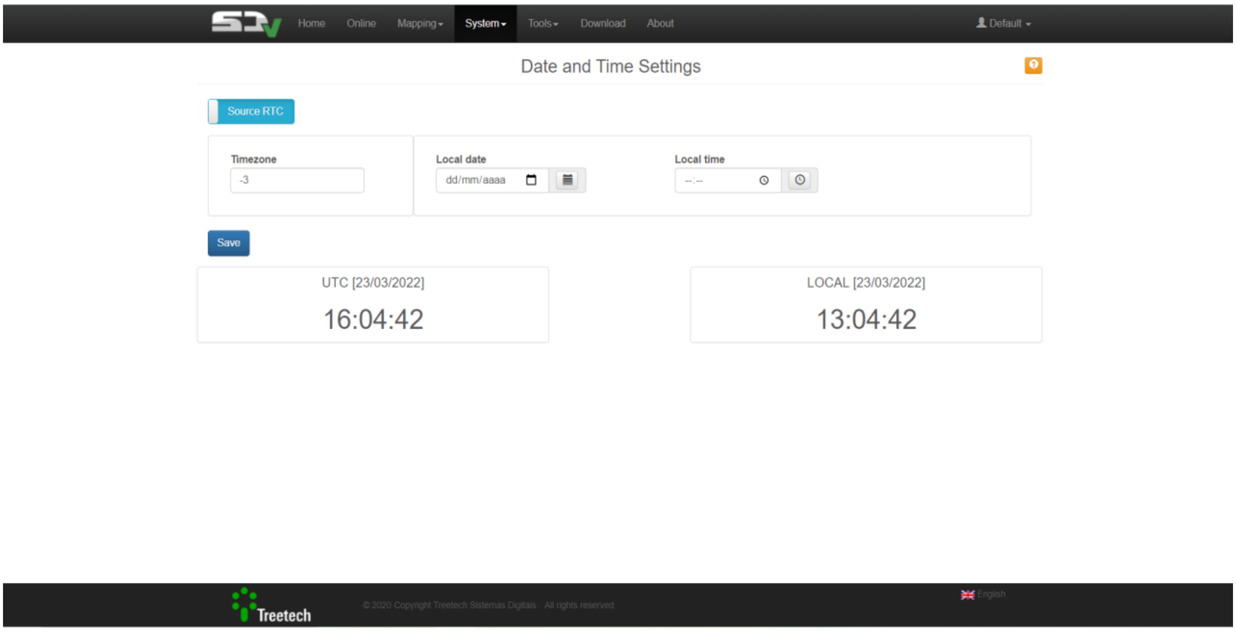


Figure 38 - System tab > Date and time of the SDV website

1. NTP/RTC source

On the source button, two options are available: NTP, which uses Ethernet settings to update the clock; and RTC, which allows manual time adjustment.
If the option chosen is NTP, the user must also choose the time zone, IP and interval for the update. It may be necessary to configure an IP address in the "Gateway" field of the IP configuration in order for the SDV to have access to the NTP IP.
If the source is RTC, the user, in addition to selecting a time zone, must manually adjust the equipment's date and time. To make it easier, it is possible to copy the date and time from the local computer by clicking on the icons attached to the adjustment fields.

2. Settings form

By toggling the source button, mentioned earlier, the form will be re-adapted to the necessary settings for the chosen source.

6.6.2 Network

The Ethernet settings are available on this screen.

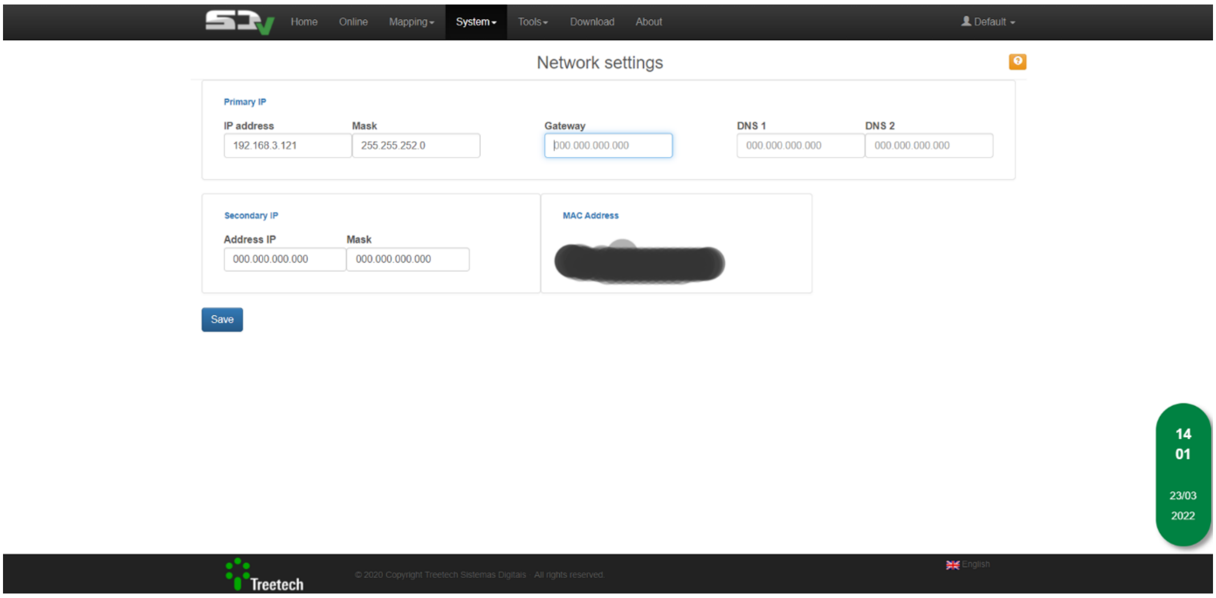


Figure 39 - Ethernet settings screen

The user can manually modify IP address and netmask of both primary and secondary IP. Also, it is possible to change the gateway address, DNS 1 and DNS 2.

6.6.3 Process manager

This screen contains the SDV process manager.

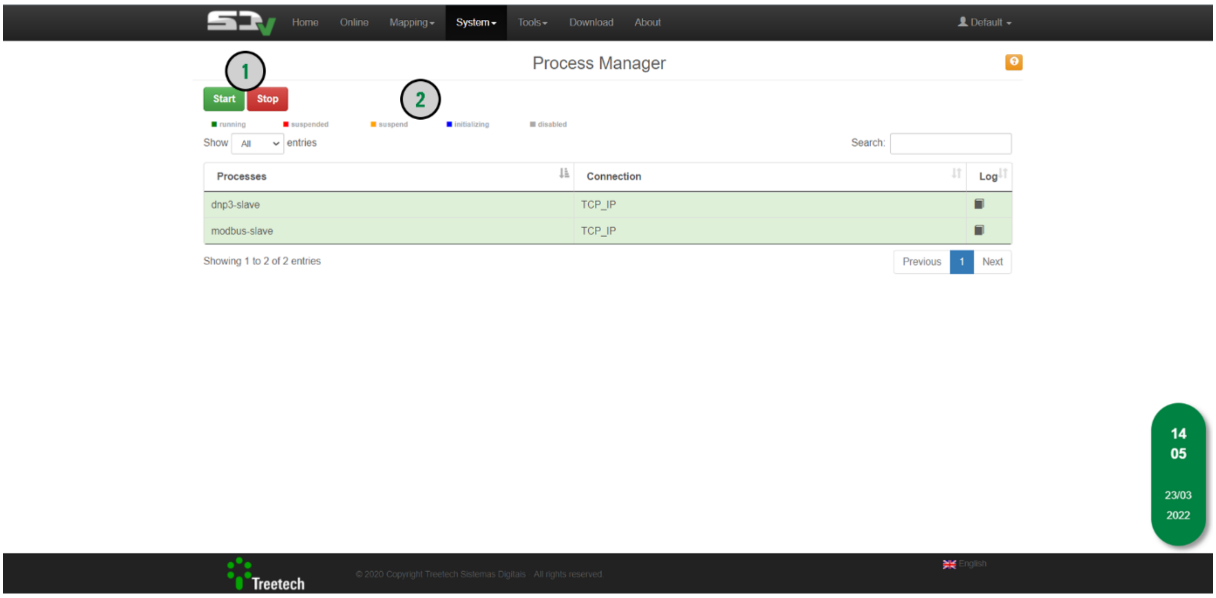


Figure 40 - Process management screen

1. Action buttons

The buttons “Start”, in a green box, and “Stop”, in a red box, allow the user to start or stop the SDV processes.

2. Captions

Below the buttons, small colored labels show the possible status of each process: running, suspended, suspend, initializing and inactive.

3. Process list

Below the search box, a list of found processes is shown. They can be organized according to the name of the columns presented in the table header: processes or connection.

6.6.4 Update

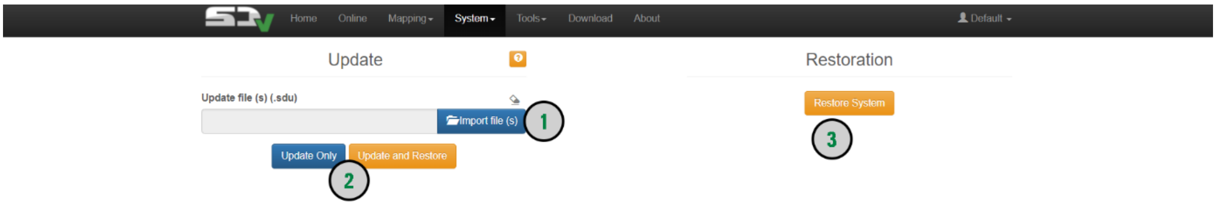


Figure 41 - Screen for restoring defaults and updating the equipment

1. Import file

When pressing the blue button "Import file(s)", a window will be displayed, allowing the user to select the file in ".sdu" format for the equipment update.

2. "Update Only" / "Update and Restore"

After importing the update file, simply click on one of the options below to update the equipment. The "Update Only" button will perform the update without restoring factory defaults. The "Update and Restore" button will perform the update and restore the factory defaults; this is necessary in cases where the update includes changes in the application version. When updating restoring factory defaults, the user login password will be requested, and it will be possible to check the option "Keep IP address". If this option is not checked, the device will return to the default IP (192.168.10.87).

3. System restore

As well as allowing the user to restart the IED, the SDV website guarantees the possibility to restore all the product's factory settings. To do this, click on the orange "System Restore" button. User login password will be prompted. Only users with permission will be able to perform such an operation. It will also be possible to check the option "Keep IP address" so that the user maintains access to the same address that is already configured. If this option is not checked, the device will return to the default IP (192.168.10.87).

6.6.5 Export and import

On this screen, it is possible, through the "Export (.back)" button, to transfer the user, mapping, and IEC 61850 settings to a file in ".back" format. Furthermore, the reverse process can be done through the "Import (.back)" button.

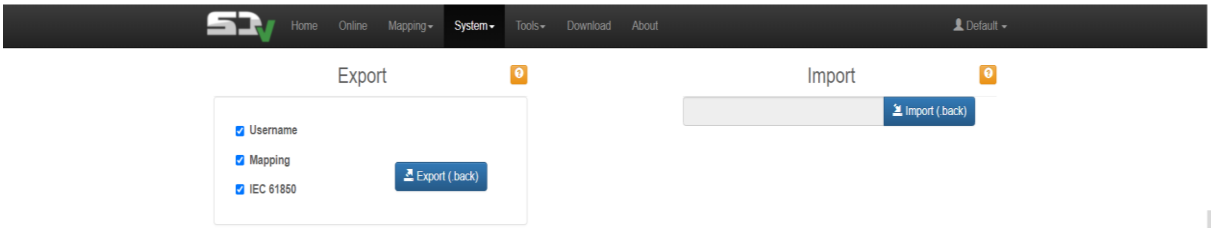


Figure 42 - User, mapping and IEC 61850 settings import and export screen

6.6.6 Access

On this screen, it is possible to configure secure access to the website using the HTTPS protocol.

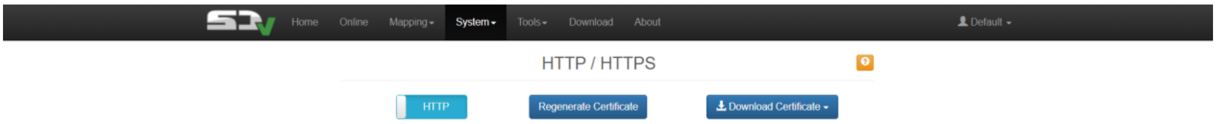


Figure 43 - Access configuration screen

6.6.7 Restart

The SDV website allows the user to remotely restart the equipment. To do this, simply click on “Restart” on the “System” tab.

6.7 User registration

On this page, you can check which users are registered to use the system, as well as make changes to them and register new ones. Different access profiles can be allocated to each user.
To access this menu, just click on your username, available in the upper right corner of the screen and then click on the “Users” button.

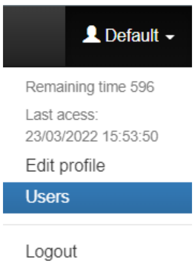


Figure 44 - Access to the user management page

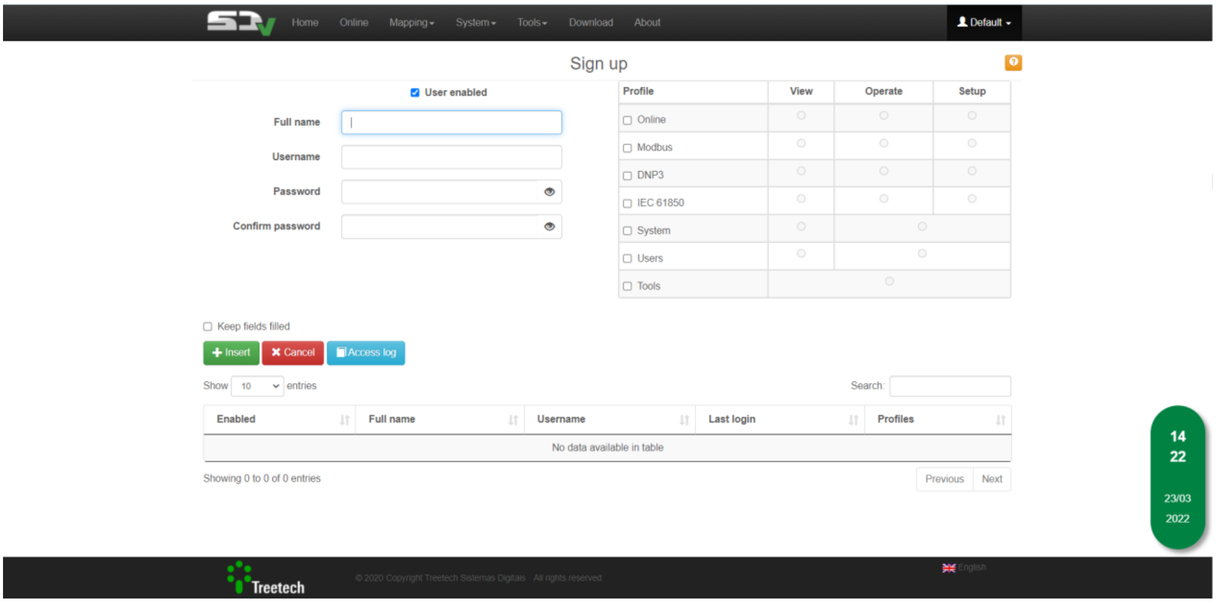


Figure 45 – "Users" tab of the SDV website

6.7.1 Adding a new user

To allow other users to access the website, the administrator user must access the "Users" tab, located on the top bar of the screen.

Four fields must be filled in to include the new user: "Full name", "User", "Password" and "Confirm password".

In the right corner of the screen, the permissions for the new user are selected in a table with four columns. The "Profile" column displays the tabs that the new user can access: "Online", "Modbus", "DNP3", "IEC 61850", "System", "Users" and "Tools".

In the other columns, the level of access to each tab is detailed between the options "View", "Operate" and "Configure".

- **View -** the user will be able to see the settings, but will not be able to modify, delete or create anything;
- **Operate -** the user will be able to activate and deactivate the existing settings, and also change the protocol address of any IED;
- **Configure -** the user has full control to modify, delete and create configurations in the system.

6.8 Download

The "System Log" page, accessed through the "Download" tab, allows the user to download, in a text file, the communication log of all ports and protocols used. It is also possible to download the application log, system log and current configurations to send to Treetech in case of help request.

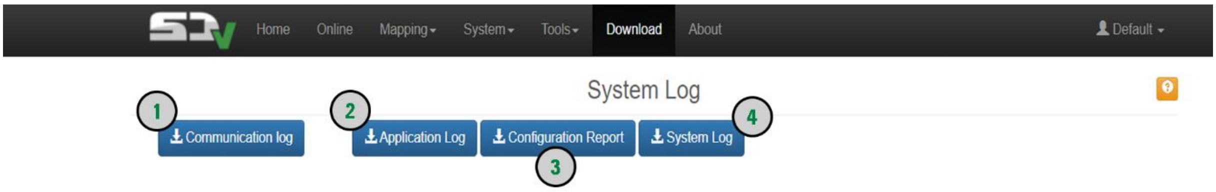


Figure 46 - "Download" menu, "System Log" page of the SDV website

1. Download communication log

To download the communication log, the user must click on the first blue button on the left of the screen. The downloaded text file represents the history of inbound and outbound communication.

2. Download application log

The application log is also registered, and a report can be downloaded by the user. Just click on the second blue button. Although the user can download it, **access to this log is restricted to Treetech technical support**.

3. Download system log

Another log available for download is the system log. To download it, just click on the third blue button. Although the user can download it, **access to this log is restricted to Treetech technical support**.

4. Download configuration report

The last type of log available for download is the configuration log. Located in the upper right corner of the screen, a blue button allows you to download this report. Although the user can download it, **access to this log is restricted to Treetech technical support**.

6.9 Online

Through this page, the user has access to all read variables and their respective values. It is also possible to make changes (written) to write or simulated variables.

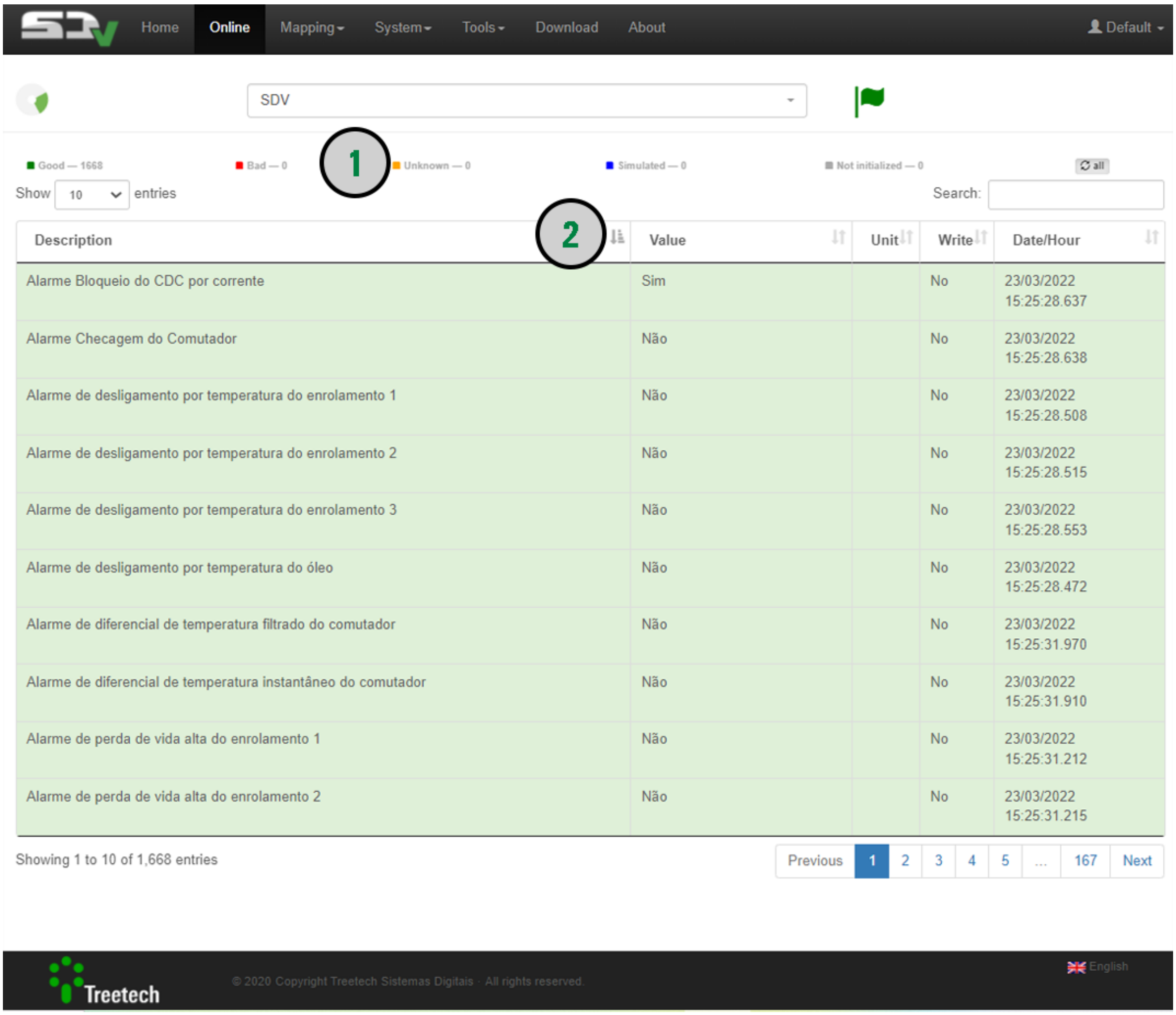


Figure 47 - "Online" menu of the SDV website

1. Status

Captions explain the colors of each abstract in the table: green lines represent good communication; red lines, bad communication; yellow lines, unstable communication, called here as indeterminate; blue lines are used when that abstract is set to simulated; gray lines indicate that abstract has never been read.

2. Table filters and navigation

The table header allows the user to sort abstracts by "Name", "Value", "Unit", "Written", "Description" and "Date/Time".

6.10 Mapping

6.10.1 Definitions

In this section, output connections are created and configured. For more details on this menu, see the IED Configuration Guide[1].

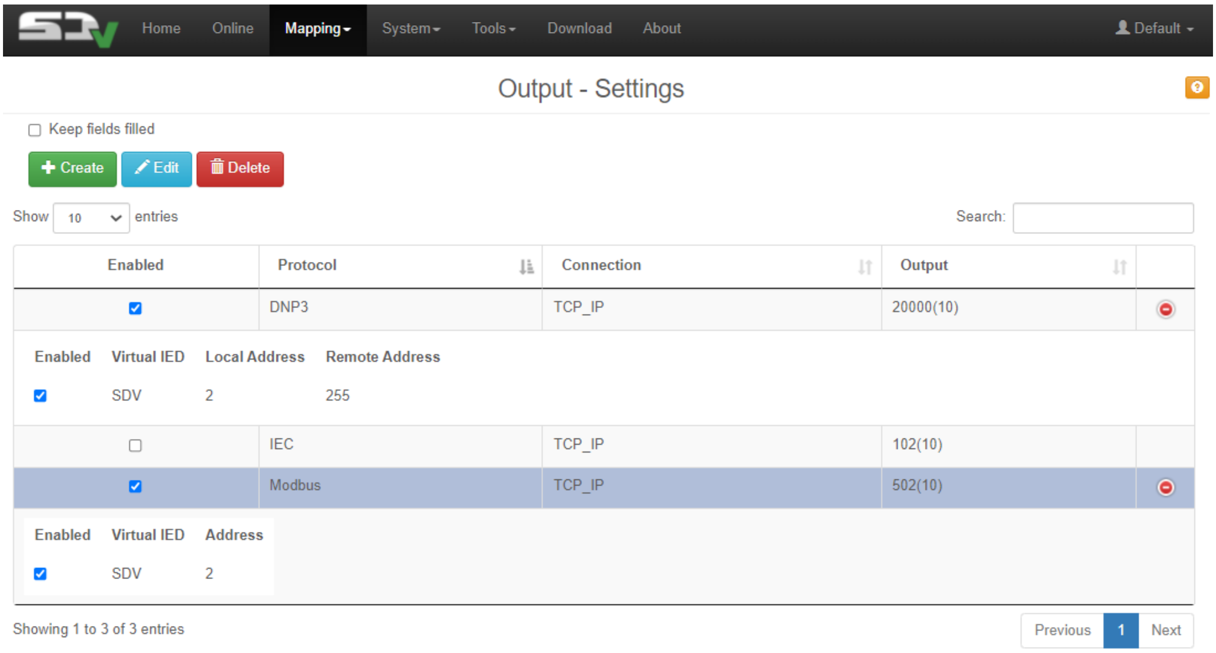


Figure 48 – ”Mapping” Menu > SDV website ”Definitions” page

6.10.2 Modbus / DNP3 / IEC 61850

In this section it is possible to configure the points to be distributed in the SDV output connections, available in the Modbus®, DNP3 and IEC 61850 protocols.

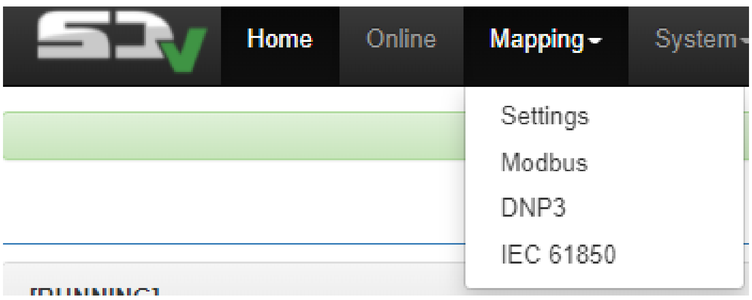


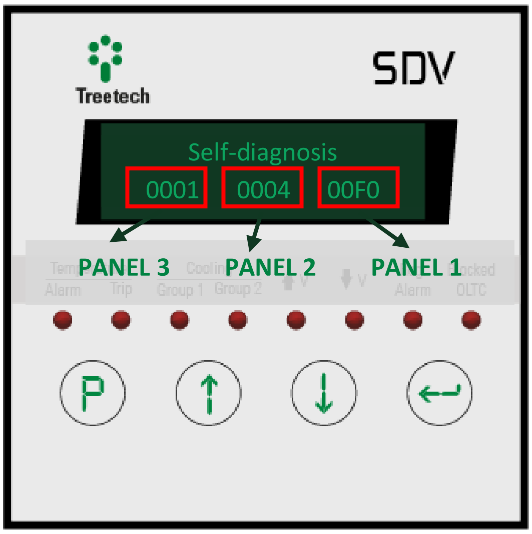
Figure 49 - Access to the screens of each communication protocol on the SDV website

[1] https://sac.treetech.com.br/en/support/solutions/articles/69000801869-ied-configuration-guide

7 Troubleshooting

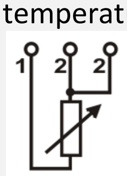
7.1 Self-diagnosis

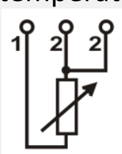
The SDV features three self-diagnostic panels, each with four hexadecimal digits and the possibility to represent up to four different alarms. Each failure is represented by one of the following values: 1, 2, 4, and 8. The value shown in the digit will be the sum of the value of all active alarms in that digit. If, for example, a certain digit is showing the number 3, this means that alarms 1 and 2 are active (1 + 2 = 3). In case a digit shows the letter B for example, alarms 1, 2 and 8 are currently active, as in hexadecimal numbers B=1+2+8.

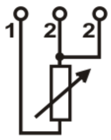


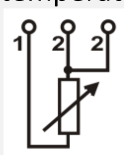
The tables below present all the SDV self-diagnostic codes and the recommended procedures for each case.

Table 12 – Self-diagnosis

Self-diagnosis panel 1			
Code	**Description**	**Probable cause**	**Recommended procedure**
0001	Self-diagnosis in the parameterization saved in the flash	Internal failure of the SDV or unidentified external cause.	Contact Treetech technical support.
0002	Internal self-diagnosis when reading RTDs.	Internal failure of the SDV or unidentified external cause.	Contact Treetech technical support.
0004	Self-diagnosis of maximum difference between sensors.	Bad contact or disconnection in one of the cables connected to terminals 1 or 2 of the temperature sensors.  Use of unshielded cable to connect the Pt100 sensor to the SDV.	Check for bad contacts or disconnections along the entire route of the cables connected to terminals 1 or 2 of the temperature sensors, including the connection to the SDV, the passage terminals and the connection to the sensors. Check if shielded cable is being used to connect the

		Redundant top oil temperature measurement is programmed in the “Sensor Oil 2” parameter, but only one sensor is being used for the top oil. Parameter “Max. Temp. Dif.” programmed too low. Shields of the cables connecting the SDV to the Pt100 sensor not grounded or grounded in more than one place. Internal failure of the temperature sensor.	temperature sensors to the SDV. Correct the programming of the “Sensor Oil 2” parameter according to the configuration actually used for the temperature sensors. Correct the programming of the parameter “Max. Temp. Dif.”, so that it does not fall below the normal temperature difference between the redundant top oil sensors selected in the “Sensor Oil 1” and “Sensor Oil 2” parameters. Check that the shield of the cable connecting the SDV to the temperature sensor is grounded only on one side of the connection and the other end insulated. Replace defective temperature sensor.
0008	Internal self-diagnosis (offset internal voltage).	Internal failure	Contact Treetech technical support.
0010	Self-diagnosis reading on Pt100 (RTD1)	Bad contact or disconnection in one of the cables connected to terminal 1 of the temperature sensor.  Use of unshielded cable to connect the Pt100 sensor to the SDV.	Check for bad contacts or disconnections along the entire length of the cable connected to terminal 1 of the temperature sensor, including the connection to the SDV, the passage terminals and the connection to the sensor. Check if shielded cable is being used to connect the temperature sensor to the SDV.

0020	Self-diagnosis reading on Pt100 (RTD2).	Shields of the cables connecting the SDV to the Pt100 sensor not grounded or grounded in more than one place. The sensor is not in use, but its measurement is enabled in the "Sensor Pt1" and "Sensor Pt2" parameters. Internal failure of the temperature sensor.	Check that the shield of the cable connecting the SDV to the temperature sensor is grounded only on one side of the connection and the other end insulated. Disable the measurement of unused sensors by changing the parameter "Sensor Pt1" and "Sensor Pt2". Replace defective temperature sensor.
0040	Calibration self-diagnosis on Pt100 (RTD1).	Bad contact or disconnection in one of the cables connected to terminal 2 of the temperature sensor.  Use of unshielded cable to connect the Pt100 sensor to the SDV.	Check for bad contacts or disconnections along the entire route of the cables connected to terminals 2 of the temperature sensor, including the connection to the SDV, the passage terminals and the connection to the sensor. Check if shielded cable is being used to connect the temperature sensor to the SDV.
0080	Calibration self-diagnosis on Pt100 (RTD2).	Shields of the cables connecting the SDV to the Pt100 sensor not grounded or grounded in more than one place. The sensor is not in use, but its measurement is enabled in the "Sensor Pt1" and "Sensor Pt2" parameters. Internal failure of the temperature sensor.	Check that the shield of the cable connecting the SDV to the temperature sensor is grounded only on one side of the connection and the other end insulated. Disable the measurement of unused sensors by changing the parameter "Sensor Pt1" and "Sensor Pt2". Replace defective temperature sensor.

0100	Self-diagnosis in reading the AC channel (V_L).	Internal failure of the SDV or unidentified external cause.	Contact Treetech technical support.
0200	Self-diagnosis in reading the AC channel (Iwin1).		
0400	Self-diagnosis in reading the AC channel (Iwin2).		
0800	Self-diagnosis in reading the AC channel (Iwin3).		
1000	RTD1 overflow self-diagnosis.	Internal failure of the SDV or unidentified external cause.	Contact Treetech technical support.
2000	RTD2 overflow self-diagnosis.		
4000	RTD1 temperature jump self-diagnosis.	Bad contact or disconnection in one of the cables connected to terminals 1 or 2 of the temperature sensor.  Use of unshielded cable to connect the Pt100 sensor to the SDV. Shields of the cables connecting the SDV to the Pt100 sensor not grounded or grounded in more than one place. Internal failure of the temperature sensor.	Check for bad contacts or disconnections along the entire route of the cables connected to terminals 1 or 2 of the temperature sensor, including the connection to the SDV, the passage terminals and the connection to the sensor. Check if shielded cable is being used to connect the temperature sensor to the SDV. Check that the shield of the cable connecting the SDV to the temperature sensor is grounded only on one side of the connection and the other end insulated. Replace defective temperature sensor.
8000	RTD2 temperature jump self-diagnosis.		

Self-diagnosis panel 2			
Code	**Description**	**Probable cause**	**Recommended procedure**
0001	Oil overflow self-diagnosis.	Internal failure of the SDV or unidentified external cause.	Contact Treetech technical support.
0002	Iwin1 overflow self-diagnosis.		
0004	Iwin2 overflow self-diagnosis.		
0008	Iwin3 overflow self-diagnosis.		
0010	CT1 overflow self-diagnosis.		
0020	CT2 overflow self-diagnosis.		
0040	CT3 overflow self-diagnosis.		
0080	PT overflow self-diagnosis.		
0100	Communication self-diagnosis with the HU-IO.		
0200	Communication self-diagnosis with the HU-C.		
1000	Flash read/write self-diagnosis.	Internal failure: self-diagnosis of general flash writing.	Reparameter the equipment, entering each of the parameters and confirming with the “enter” key. If the defect persists, replace the defective SDV and contact Treetech technical assistance.
2000	Flash read/write self-diagnosis.		
4000	Flash read/write self-diagnosis.		

Self-diagnosis panel 3			
Code	**Description**	**Probable cause**	**Recommended procedure**
0001	Transmitter reading self-diagnosis.	Cables connecting the potentiometric transmitter to the SDV are not shielded. Shielding of the cables connecting the potentiometric transmitter to the SDV is grounded at more than one point, not	Replace the cables connecting the potentiometric transmitter to the SDV with shielded cables, as instructed in chapter 3. Ground the shield of the cables connecting the

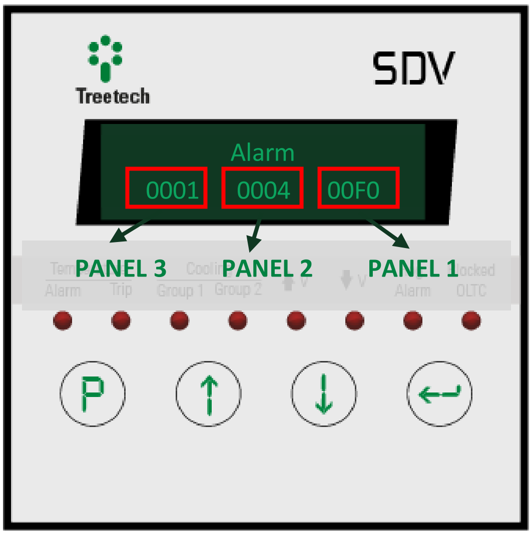
		grounded or without shield continuity along the way. Bad contact in the cursor of the potentiometric position transmitter or in the cables connecting it to the SDV. Cables connecting the potentiometric transmitter to the SDV with resistance greater than 8 ohms per wire - very low gauge depending on the distance traveled. Cables connecting the potentiometric transmitter to the SDV with different gauges or lengths on each ways. Self-diagnosis in parameter settings Number of Taps and/or Resistance, Initial Offset, Final Offset and Transition tap of the SDV. The resistors per step of the potentiometric transmitter have a tolerance greater than 1 % of their rated value.	potentiometric transmitter to the SDV at only one point and maintain the continuity of the shield, according to the instructions in chapter 3. Eliminate the bad contact in the cables or in the cursor of the potentiometric transmitter. Replace the cables connecting the potentiometric transmitter to the SDV with cables with a suitable gauge, according to the instructions in the chapter 3. Replace the cables connecting the potentiometric transmitter to the SDV with shielded cables with identical gauge in the 3 ways, according to the instructions in the chapter 3. Correct the settings for the Number of Taps, SDV Resistance, Initial Offset, Final Offset and OLTC Transition Tap parameters, according to the instructions in chapter 3. Replace the potentiometric transmitter step resistors with others with an accuracy better than or equal to 1%.
0002	Transmitter A/D self-diagnosis.	Internal failure.	Restart the equipment by disconnecting the SDV from the power supply and reconnecting immediately. If this action does not have

			any effect or the same self-diagnosis is presented after a certain period of time, contact Treetech technical assistance.
0010	Concentrator communication self-diagnosis.	Internal failure to the SDV or failure in the communication network with the SPS.	Check the entire communication network between the SDV and the SPS. If it is not possible to solve the problem, contact Treetech technical assistance.
0020	Synchronism self-diagnosis between banks or phases in the system.	Failure of the SPS or tap changer control circuit.	Check the control circuit of the tap changers and the relays for increasing / decreasing tap of the SPS. If it is not possible to solve the problem, contact Treetech technical assistance.
0040	Programming self-diagnosis (EPG).	SPS programming failure.	Check the SPS programming on the network. If it is not possible to solve the problem, contact Treetech technical assistance.
0080	Error reading tap on the system.	Cables connecting the potentiometric transmitters to the SPS are not shielded. Shielding of the cables connecting the potentiometric transmitters to the SPS grounded at more than one point, not grounded or without shield continuity along the way. Bad contact in the cursor of the potentiometric position transmitters or in the cables connecting them to the SPS. Cables connecting the potentiometric transmitter to the SPS with resistance greater than 8 ohms per wire - very low gauge	Replace the cables connecting the potentiometric transmitter to the SPS with shielded cables. Ground the shield of the cables connecting the potentiometric transmitters to the SPS at only one point and maintain the continuity of the shield. Eliminate bad contact in cables or cursor of potentiometric transmitters. Replace the cables connecting the potentiometric transmitters

		depending on the distance traveled.	to the SPS with cables with a suitable gauge.
		Cables connecting the potentiometric transmitters to the SPS with different gauges or lengths on each way.	Replace the cables connecting the potentiometric transmitter to the SDV with shielded cables with identical gauge in the 3 ways.
		Self-diagnosis in the settings of the tap and/or RES parameters of the SPS.	Correct the SPS tap and RES parameter settings.
		There are resistors on the potentiometric transmitters in the intermediate tap positions.	Remove resistors from the tap changer's intermediate positions, replacing them with jumpers.
		The resistors per step of the potentiometric transmitter have a tolerance greater than 1 % of their rated value.	Replace the potentiometric transmitter step resistors with others with an accuracy better than or equal to 1%

7.2 Alarms

For alarms, the SDV also has three panels, each with four hexadecimal digits and can represent up to four different alarms. Each alarm is represented by one of the following values: 1, 2, 4 and 8. The value shown in the digit will be the sum of the value of all active alarms in that digit. If, for example, a certain digit is showing the number 3, this means that alarms 1 and 2 are active (1 + 2 = 3). In case a digit shows the letter B for example, alarms 1, 2 and 8 are currently active, as in hexadecimal numbers B=1+2+8.



In addition, alarms are color-coded in ascending order of urgency.

Table 13 - Alarm color table

Color	Code
Blue	Maintenance warning
Yellow	Minor alarm. Check occurrence.
Red	Severe alarm. Immediate attention required.

The table below describes all alarms available in the SDV:

Table 14 - SDV alarm table

Alarm panel 1	
Code	**Alarm description**
0001	Alarm due to high oil temperature.
0002	Alarm due to high temperature of winding 1.
0004	Alarm due to high temperature of winding 2.
0008	Alarm due to high temperature of winding 3.
0010	Alarm due to shutdown for oil temperature.
0020	Alarm due to shutdown for temperature of winding 1.
0040	Alarm due to shutdown for temperature of winding 2.
0080	Alarm due to shutdown for temperature of winding 3.
0100	Alarm due to delay of shutdown for oil temperature.
0200	Alarm due to delay of shutdown for temperature of winding 1.
0400	Alarm due to delay of shutdown for temperature of winding 2.
0800	Alarm due to delay of shutdown for temperature of winding 3.

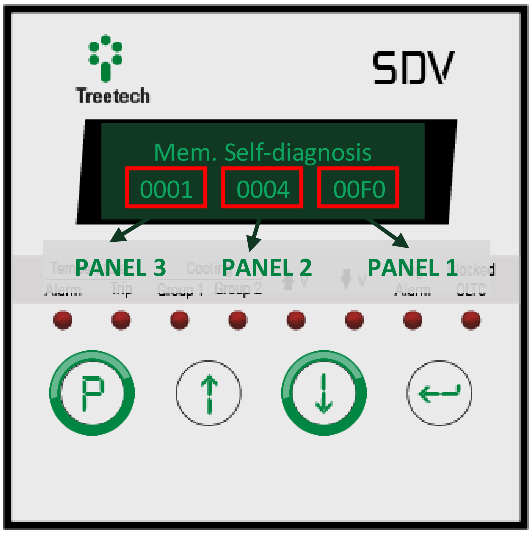
Alarm panel 2	
Code	**Alarm description**
0001	Alarm due to instantaneous temperature differential.
0002	Alarm due to filtered temperature differential.
0004	Alarm due to low lifespan in winding 1.
0008	Alarm due to low lifespan in winding 2.
0010	Alarm due to low lifespan in winding 3.
0020	Alarm due to low remaining lifetime in winding 1.
0040	Alarm due to low remaining lifetime in winding 2.
0080	Alarm due to low remaining lifetime in winding 3.
0100	Alarm due to high loss of lifespan in winding 1.
0200	Alarm due to high loss of lifespan in winding 2.
0400	Alarm due to high loss of lifespan in winding 3.

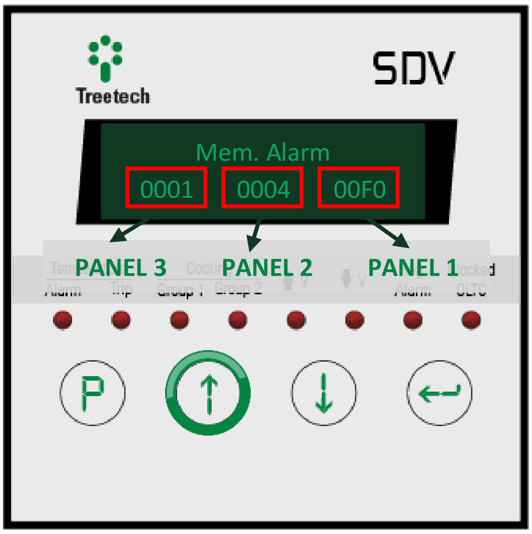
Alarm panel 3	
Code	**Alarm description**
0001	Alarm due to overvoltage.
0002	Alarm due to overcurrent.
0004	Alarm due to undervoltage.
0008	Alarm due to OLTC blocking.
0010	Alarm due to OLTC check.

0020	Alarm due to OLTC maintenance for number of operations.
0040	Alarm due to OLTC maintenance for switched current squared.
0080	Alarm due to advance warning of OLTC maintenance for number of operations or switched current squared.
4000	Alarm due to high transmitter cursor resistance.

7.3 Alarm and self-diagnosis memories

To check which alarms and self-diagnoses have occurred recently, simply consult their respective memories. To do this, press the and keys at the same time. To navigate between the screens, use the keys and . To clear alarm or self-diagnosis memories, access the desired screen, press and hold .





8 Commissioning for entry into service

After installing the equipment, commissioning must follow the basic steps below.

8.1 General commissioning guidelines

- ✓ Before energizing the transformer, check that the current transformer circuits (CTs) are correctly connected to the SDV input, ensuring that no CTs are open;
- ✓ Check the mechanical and electrical installations, according to the recommendations in the chapter 3 of this manual. Also check the correctness of electrical connections (for example, through continuity tests);
- ✓ Carry out all the parameterization of the SDV, according to the instructions in the chapter 3 of this manual;
- ✓ f dielectric strength tests are carried out on the wiring (applied voltage), disconnect the cables connected to the ground terminal of the SDV in order to avoid destroying the protections against overvoltages inside the device. These protections are internally connected between the input/output terminals and ground, clamping the voltage at about 300 V. The application of high voltages over a long period (eg 2 kV for 1 minute) would cause such protections to be destroyed;
- ✓ Reconnect the ground cables to the SDV terminals, if they have been disconnected for applied voltage tests;
- ✓ Power the SDV with any voltage in the range of 85 to 265 Vac/Vdc, 50/60 Hz;
- ✓ Check that the current loop output has the correct value in relation to the associated variable;
- ✓ With a continuity indicator, test the actuation of the alarm contacts. The closing and opening of the contacts can be forced by changing their operating mode from NO to NC and vice versa;
- ✓ With a suitable computer, communication converter and software, as applicable, check the functionality of the RS-485 port of the SDV.

8.2 Commissioning guidelines for regulation functionality

- ✓ Disable commands to the on-load tap changer or select the tap changer for local command before energizing the SDV;
- ✓ Check that the voltage, current and power factor measurements of the SDV are correct and test the actuation of the dry contact inputs;
- ✓ If possible, use variable AC voltage and current sources to vary these quantities at the SDV input. Check that the results match on the screen;
- ✓ Check the activation of the contacts to raise and lower voltage, the operation of the various alarms (U<, U>, I>) and the tap changer block;

- ✓ Normalize commands for OLTC.

8.3 Commissioning guidelines for temperature functionality

- ✓ Make sure that no contact operations will interact with other systems during this phase. If necessary, isolate all command, alarm and shutdown contacts;
- ✓ Connect temperature calibrator, decade resistance or check the temperature of the Pt100 connected to each SDV measurement input, checking if the measurements are correct;
- ✓ Inject AC current into the SDV current measurement inputs, verifying that the indications are correct on the equipment query screens;
- ✓ With a continuity meter, test the actuation of alarm, shutdown and forced cooling contacts. The actuation of the contacts can be forced, for example, by reducing the respective settings to values lower than the present measurements.
- ✓ Reconnect contacts that may have been isolated.

9 Technical data and type tests

9.1 Technical data

Hardware	Range/description
Voltage supply	85...265 Vac/Vdc, 50/60 Hz
Maximum consumption	≤ 13 W
Operating temperature	-40...+85 °C
Degree of protection	Front panel IP50, backside IP20
Connections	0.3...2.5 mm², 22...12 AWG
Fixing	Panel fixing

Measurement inputs	Range/description
Currents (for regulation only)	1 external CT, measuring range from 0 to 10 Ac rms on the CT primary
Currents (for thermal imaging)	2 external clip-on CTs, measuring range 0 to 10 Ac rms on CT primary
Rated frequency	50/60 ±2 Hz
Voltage	1 external PT, measuring range from 0 to 185 Vac rms on the PT primary
Temperatures	2 3-wire Pt100 Ω at 0 °C sensors, measuring range from -55 to +200 °C
Dry contacts	2 potential free
Tap positions	1 to 49 positions Resistance per step: 4.7...20 Ω Total resistance: 4.7...1400 Ω

Maximum errors	Range/description
Currents	0.5% of the measurement in the range of 0.5 to 10 Aca in the primary of the CTs
Voltages	1 % of the measurement in the range of 80 to 160 Vac on the regulation PT primary
Temperatures	0.5% of full scale + sensor error

Outputs	Range/description
Relay outputs	Up to 3 reversible + 11 NO
Maximum switching voltage	250 Vdc/Vac
Maximum switching power*	70 W/250 VA
Maximum driving current	5 A
Current loop analog outputs	Up to 4 unipolar or 2 bipolar, with common positive
Maximum error of analog outputs	0.5% of full scale
Selectable options and maximum load	0...1 mA, 10 kΩ

	0...5 mA, 2 kΩ 0...10 mA, 1 kΩ 0...20 mA, 500 Ω 4...20 mA, 500 Ω
Bipolar options and maximum load	-1...1 mA, 10 kΩ -5...5 mA, 2 kΩ -10...10 mA, 1 kΩ -20...20 mA, 500 Ω

Network interfaces	Description
Serial communication ports	1x TIA-485-A (RS-485) 1x TIA-485-A (RS-485)/TIA-232-F (RS-232) 1x TIA-485-A (RS-485), for parallelism
IEEE 802.3 communication ports (10/100 Mbps)	2x *Ethernet* RJ45 (10/100BASE-T) or 2x *Ethernet* F.O. (10/100BASE-FX; MM 1310 nm SC connector) or 1x *Ethernet* F.O. (10/100BASE-FX; MM 1310 nm SC connector) + 1x Serial F.O. (MM 850 nm SC connector)*
Protocols	Modbus® RTU Modbus® TCP Modbus® RTU/TCP DNP3 RTU DNP3 TCP IEC 61850[1] MMS *server* IEC 61850[2] GOOSE *publisher*

* Customer must choose only one of the 3 configurations.

[1] The .icd file can be created from any .icd generator software and later imported through the SDV web interface.
[2] The .icd file can be created from any .icd generator software and later imported through the SDV web interface.

9.2 Type tests

The SDV is an equipment built on the ***SmartSensor* 3** platform, on which the type tests presented were carried out:

Surge immunity (IEC 60255-22-5 and IEC 61000-4-5)	
Waveform, intensity, amount of surges	1.2/50 µs ±2 kV common mode ±1 kV differential mode 5 per polarity (+/-)
Immunity to electrical transients (IEC 60255-22-1, IEC 61000-4-12 and IEEE C37-90-1)	
Peak value 1st cycle, frequency	±2,5 kV common mode ±1 kV differential mode 1 MHz
Applied voltage (IEC 60255-5)	
Dielectric strength	2 kV at 60 Hz for 1 min
Voltage pulse (waveform, amplitude and number of pulses)	1.2/50 µs ±5 kV 3 per polarity (+/-)
Immunity to radiated electromagnetic fields (IEC 60255-22-3 and IEC 61000-4-3)	
Frequency range, modulation, field strength, power supply	80...2500 Mhz AM, 80 %, 1 kHz sinusoidal 10 V/m 127 Vac, 60 Hz
Immunity to conducted electromagnetic disturbances (IEC 60255-22-6 and IEC 61000-4-6)	
Field strength, frequency range, modulation, power supply	10 Vrms 0.15...80 MHz AM, 80 %, 1 kHz sinusoidal 127/220 Vac, 60 Hz
Immunity to industrial frequency magnetic fields (IEC 61000-4-8)	
Intensity	10 A/m
Electrostatic discharges (IEC 60255-22-2, IEC 61000-4-2 and IEEE C37.90.3)	
Intensity, power supply	±8 kV in air mode ±6 kV in contact mode 127/220 Vac, 60 Hz
Immunity to fast electrical transients (IEC 60255-22-4, IEC 61000-4-4, IEEE C37-90-1)	
Power supply, inputs and outputs	±4 kV
Power supply failure (IEC 61000-4-11)	
Voltage dips	0% U for 1/2 cycle 40% U for 5 cycles 70% U for 25 cycles 127/220 Vac, 60 Hz
Short interruptions	0% U for 300 cycles 127/220 Vac, 60 Hz
Cold withstand (IEC 60068-2-1)	

Temperature, test time	-40 °C 16 hours
Dry heat withstand (IEC 60068-2-2)	
Temperature, test time	85 °C 16 hours
Moist heat withstand (IEC 60068-2-78)	
Temperature and relative humidity, test time	40 °C, 85% UR 24 hours
Thermal cycle (IEC 60068-2-14)	
Temperature range, total test time	-40...+85 °C 120 hours
Vibration response (IEC 60255-21-1)	
Application method	Sinusoidal
Amplitude and frequency range	0.075 mm, 10...59 Hz 9.8 m/s^2 (1 gn), 59...150 Hz
Duration	8 min/axis
Vibration durability (IEC 60255-21-1)	
Application method	Sinusoidal
Amplitude and frequency range	19.6 m/s^2 (2 gn), 10...150 Hz
Duration	160 min/axis

10 Order specification

In the SDV purchase order, it is necessary to specify the following items:

3. Name of product

Smart Device for Voltage Regulation - SDV.

4. Quantity

Number of units.

5. Model

Choose one of the following options:

- **SDV FOFO -** 2x *Ethernet* F.O. (10/100BASE-FX; MM 1310 nm SC connector; MM 1310 nm SC connector).
- **SDV FOSR -** 1x *Ethernet* F.O. (10/100BASE-FX; MM 1310 nm SC connector) + 1x Serial F.O. (MM 850 nm SC connector).
- **SDV RJ45 -** 2x *Ethernet* RJ45 (10/100BASE-T).

6. Functionality

Choose one of the following options:

- **Voltage regulation** - The SDV preserves the quality of the voltage in the load, keeping it within a certain range of values, programmed by the user.
- **Voltage regulation + temperature measurement of a winding** - This functionality of the SDV allows the maintenance of the voltage quality in the load. Furthermore, from readings of the temperature of the insulating oil and a load current of the transformer, the SDV calculates (thermal image) the temperature of a winding.
- **Voltage regulation + temperature measurement of up to three windings** - This functionality of the SDV allows the maintenance of the voltage quality in the load. In addition, based on the readings of the insulating oil temperature and one or more transformer load currents, the SDV calculates (thermal image) the temperature of up to three windings.

7. Options

According to the model and functionality chosen, there are different combinations of options available, as shown in the table below.

	REG	REG + 1 WIN	REG + 3 WIN
MMEM	Available	Available	Available
PCOL	Not available	Available	Available
FEXC	Not available	Available	Available
INAG	Not available	Available	Available
OLTD	Not available	ⓘ	ⓘ
DIGI	Available	Available	Available
TAPP	Available	Available	Available
OLMT	Available	Available	Available
OLCK	Available	Available	Available
CONC	Available	Available	Available

Caption:

(green)	Available
ⓘ	Oil temperature redundancy is restricted, as it requires a Pt100 for OLTC temperature
(grey)	Not available

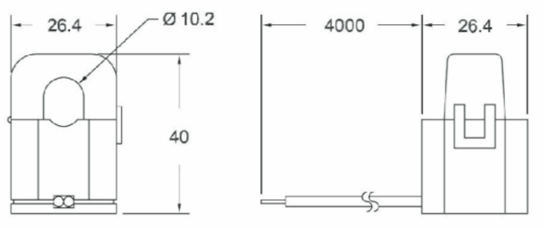
11 Accessories

There are additional accessories to the SDV, and depending on the functions chosen, some are required for its operation, while others are optional.

11.1 Required accessories

1. External split-core window type CTs (clip-on)

The use of external split-core window type CTs is required to read the transformer load currents. This item is supplied in the quantity required for the type of application desired, and the quantity must be requested in the purchase order.

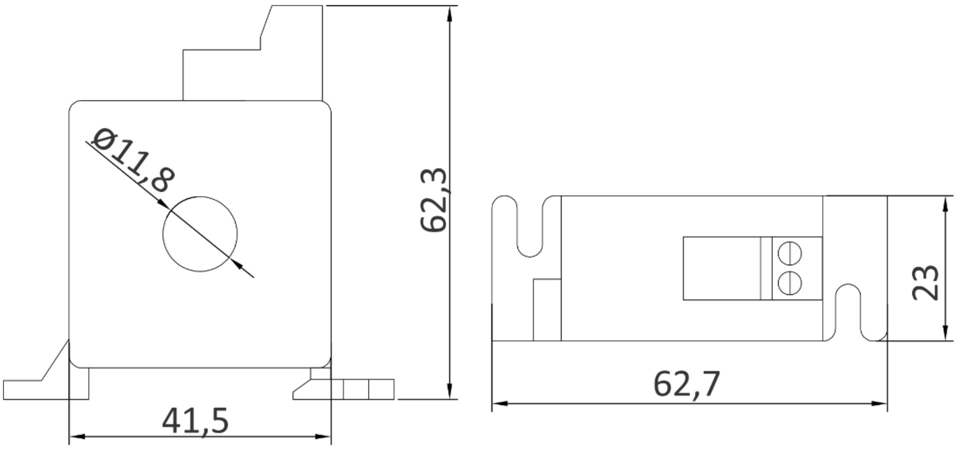


Dimensions in mm

Characteristics	Range/description
Measuring range	0...10 Aca
Maximum measurement current of the primary	75 Arms, 50/60 Hz
Ratio	3100
Maximum resistance of the secondary	1000 Ω
Maximum error (linearity)	1 % at 300 Ω load
Power	≤ 0.5 VA (measurement only)
Cabling	18 AWG, 600 V, 105 °C
Operating temperature	-40...+85 °C
Protection	Secondary with protection against load disconnection

2. Regulation CT

The use of an external auxiliary CT is required for the use of the SDV in voltage regulation of transformers. This item is supplied in the quantity required for the type of application desired, and the quantity must be requested in the purchase order.

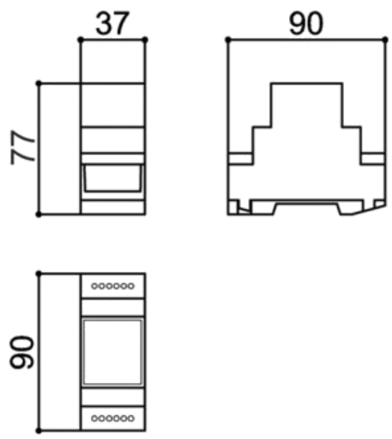


Dimensions in mm

Characteristics	Range/description
Measuring range	0...10 Aca
Maximum measurement current of the primary	10 Arms, 50/60 Hz
Ratio	3030
Maximum resistance of the secondary	200 Ω
Maximum error (linearity)	1 % at 300 Ω load
Maximum phase error	≤ 1° at 300 Ω load
Power	≤ 0.5 VA (measurement only)
Operating temperature	-40...+85 °C
Protection	Secondary with protection against load disconnection and external electrical transients

3. Regulation PT

The use of SDV in voltage regulation of transformers requires the installation of an auxiliary PT. This item is supplied in the quantity required for the type of application desired, and must be requested in the purchase order, with the characteristics listed in the table below.

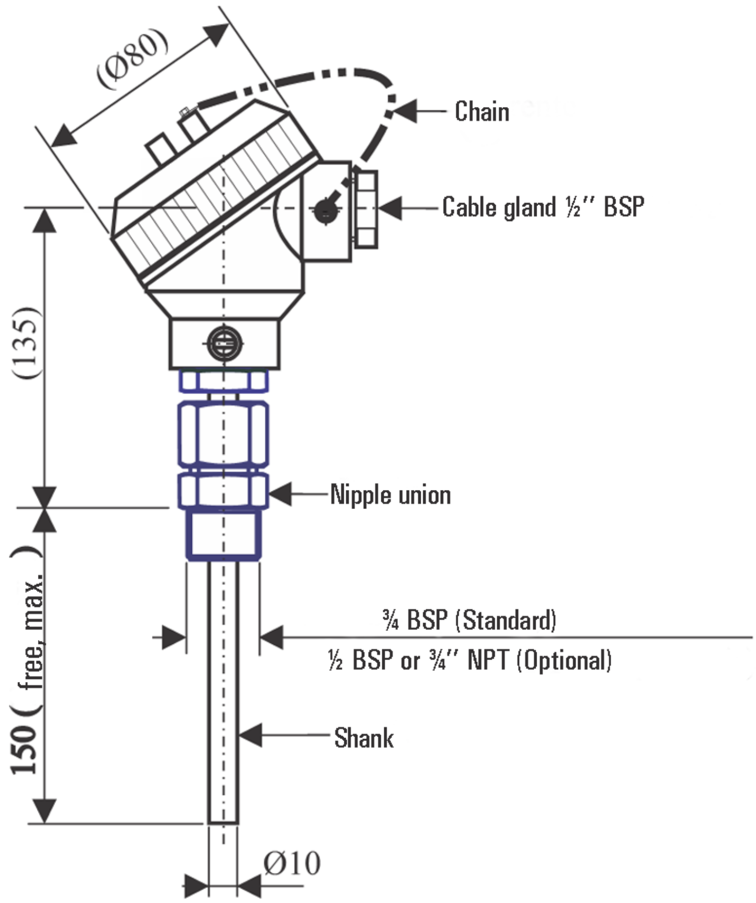


Dimensions em mm

Characteristics	Range/description
Mounting	Mounting box for 35 mm DIN rail
Maximum measurement voltage of the primary	185 Vrms, 50/60 Hz
Maximum measurement voltage on the secondary	1.03 Vrms (rated NP/NS = 180)
Power	≤ 1 VA (measurement only)
Maximum phase error	±1 % at 1 kΩ load
Dielectric strength	2500 Vrms, 60 Hz, 1 minute and 5 kV impulse (1.2/50 μs) between: -primary and secondary; -primary and shielding; -secondary and shielding.
Maximum capacitance between primary and secondary (with shield disconnected)	50 pF
Operating temperature	-40...+85 °C
Protection	Capacitive between primary and secondary and available on an external terminal for grounding (objective: capacitive decoupling to avoid interference with other measurements)

4. Pt100 temperature sensor

The top oil temperature measurement in power transformers is usually performed through a temperature sensor installed in a thermowell on the transformer cover. The sensors used must be of the Pt100 Ω at 0 °C type. If necessary, Treetech has a sensor suitable for installation in a thermowell, according to the drawing below (special dimensions on request), supplied as an accessory.



Dimensions in mm

Characteristics	Range/description
Standard	ASTM E1137, class B
Resistance coefficient	0.3850 Ω/°C
Measuring range	-100...+300 °C
Connection head	Cast aluminium, painted
Shank (stem)	Stainless steel
Cable gland	Nickel plated brass
Chain	Nickel plated brass
Screws	Nickel plated brass or stainless steel
Adapter	Stainless steel
Insulation	2.5 kV, 50/60 Hz, 1 min.

11.2 Recommended accessories

1. Quick Install Panel - PIR

The Smart Device for Voltage Regulation - SDV must always be installed sheltered from the weather, and for this it is usually installed inside a control panel or inside a building. In cases where this is not convenient, as for example, in retrofitting old transformers, the SDV can be supplied in an easy-to-install weatherproof cabinet.

Characteristics	Range/description
Models	PIR-1 for one monitor (SDV), PIR-2 or PIR-3 for other Treetech monitors
Fixing to the transformer	Bolted or with high load capacity magnets
Fixing the SDV	In removable rack
Wiring connection	Removable multi-pole plugs at the bottom of the cabinet
Degree of protection	IP55
Insulation test	2 kV, 50/60 Hz, 1 min

2. Weather shelter

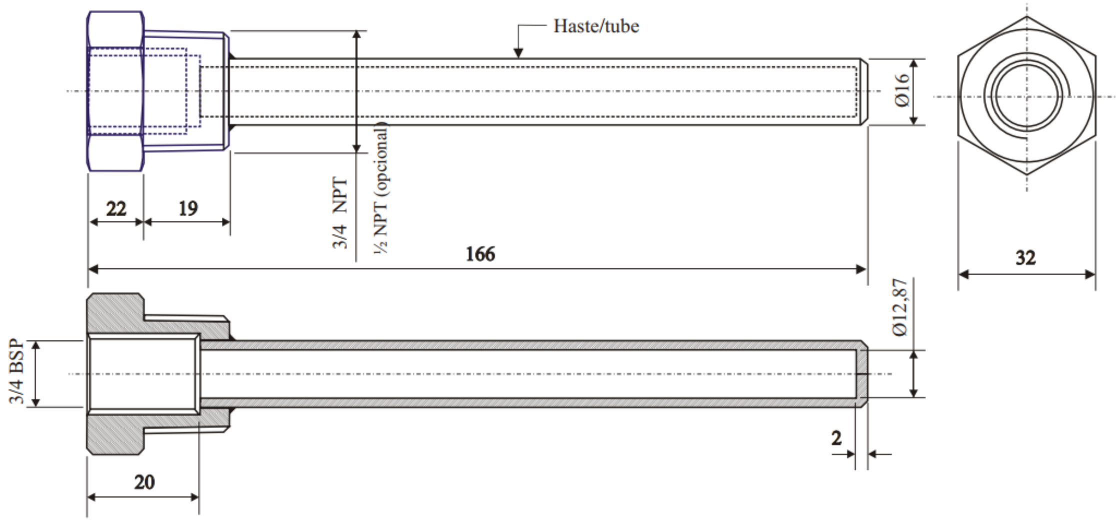
If it is desired to measure the ambient temperature in unsheltered places, a weather shelter must be used to protect the Pt100 sensor, minimizing errors caused by sun, rain, wind, etc. would cause on the measurement. Treetech has an adequate weather shelter.

3. Thermowell

Thermowells are used to give full protection to sensors in the places where they are installed. They are also intended to fully seal the process against pressure losses, leaks or possible contamination.

Mounting sensors with thermowells is necessary where safety and installation conditions are highly critical.

Added to this is the ease of removing the sensor for maintenance or replacement, without the inconvenience of a downtime in the process.



Dimensions em mm

The wells are made of 304 stainless steel, a very corrosion resistant material and widely used as protection at temperatures up to 900 °C.

Characteristics	Range/description
Internal thread (Pt100)	3/4" BSP
External thread (process)	3/4" NPT or 1/2" NPT

4. Sigma ECM® Monitoring Software

The variables related to the state and functioning of the assets are captured by Treetech's IEDs, such as the SDV, and sent to Sigma ECM®, which treats them through algorithms and mathematical models built in accordance with Brazilian (NBR) and international standards (IEC and IEEE). This treatment gives rise to the diagnosis of the current state of the equipment and the prognosis of its future state, for the detection of defects still in an incipient phase.

The computer with the software can be located in the substation control room or in a remote location, allowing access to all information to others connected to the intranet network.

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