USER MANUAL

Treetech

LAP

Lite Temperature Monitor

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1.1 Legal information

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1.1.1 Disclaimer

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1.2 Presentation

This manual presents all the recommendations and instructions for installation, operation and maintenance of the Lite Temperature Monitor - LAP.

1.3 Typographical conventions

Throughout this text, the following typographical conventions were adopted:

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

Italics: Terms in foreign language, alternative or with their use outside the formal situation are written in italics.

Underlined: References to external documents.

1.4 General and safety information

This section presents relevant aspects of safety, installation and maintenance of LAP.

1.4.1 Safety symbols

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

Warning:
This symbol is used to alert the user of potentially dangerous operating or maintenance procedures in which higher caution must be taken. Minor or moderate injuries may occur, as well as damage to the equipment.

Caution:
This symbol is used to alert the user of a potentially dangerous operating or maintenance procedure, which demands extreme caution in its conduction. There may occur serious injuries or even death. Possible damages to the equipment may be irreparable.

Risk of electric shock:
This symbol is used to alert the user of an operating or maintenance procedure that may result in electric shock if not strictly overseen. There may be minor, moderate, serious injuries or death.

1.4.2 General symbols

This manual uses the following general symbols:

Important
This symbol is used to highlight important information.

Tip
This symbol represents instructions that facilitate the use or access to functions in the LAP.

1.4.3 Minimum profile recommended for LAP operator and maintainer

Installation, maintenance, and operation of equipment in electric power substations require special cares and, therefore, all recommendations of this manual, applicable standards, safety procedures, safe work practices and good judgment must be used during all handling stages of the Lite Temperature Monitor - LAP.

Only authorized and trained staff – operators and maintainers – should handle this equipment.

To handle LAP, the operator should:

1. Be trained and authorized to operate, ground, turn on and turn off the LAP, following maintenance procedures according to the safety practices established, these being under the sole responsibility of the LAP operator;
2. Be trained in the use of PPEs, CPEs and first-aid;
3. Be trained in the working principles of the LAP, as well as its configuration;
4. Follow regulatory recommendations regarding interventions in any type of equipment included in an electric power system.

1.4.4 Environmental and voltage conditions required to installation and operation

The table below lists important information on the environmental and voltage requirements.

Table 1 – Operation Conditions

Condition	Range/description
Application	Equipment for sheltered use in substations, industrial and similar environments.
Indoor/outdoor use	Indoor use
Protection level (IEC 60529)	IP20
Altitude* (IEC EN 61010-1)	Up to 2000 m
Temperature (IEC EN 61010-1)	
Operation	-10...+70 °C
Storage	-10...+70 °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 level (IEC EN 61010-1)	Level 2
Atmospheric pressure** (IEC EN 61010-1)	80...110 kPa

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

1.4.5 Test and installation instructions

This manual must be available to those responsible for installation, maintenance and users of the Lite Temperature Monitor - LAP.

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

1. Read this manual carefully before installing, operating and performing maintenance on the LAP. Errors in the installation, maintenance or adjustments of the LAP can cause undue alarms, fail to emit relevant alarms and thus cause a misunderstanding of the real state of health and operation of the transformer or application, since the LAP is designed to support substation environments electrical systems, also contemplating industrial and commercial environments.

2. The installation, adjustments and operation of the LAP must be carried out by people trained and familiar with power transformers, control devices and command circuits of substation equipment or by being familiar and trained to implement the IED in its application, be it a motor, reactor, panel or installation that you want to apply the LAP.

3. Special attention must be given to the installation of the LAP, including the type and gauge of cables, installation location and commissioning, including the correct parameterization of the equipment.

The LAP must be installed in a sheltered environment (a panel without doors in a control room or an enclosed panel in cases of outdoor installation) that does not exceed the temperature and humidity specified for the equipment.

Do not install the LAP near heat sources such as heating resistors, incandescent lamps and high power devices or with heat sinks. It is also not recommended to install it near ventilation holes or where it may be hit by forced airflow, such as the outlet or inlet of cooling fans or forced ventilation ducts.

In case the panel where the LAP was installed has a window, use a G20 film or higher to prevent direct sunlight (ultraviolet rays) from entering the equipment. If the glass in this window is dark, then such a procedure is not necessary.

1.4.6 Cleaning and decontamination instructions

Be careful when cleaning the LAP. 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, polishes, 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 on the LAP, the following observations must be followed:

Do not open the equipment. There are no parts which can be repaired by the user inside it. This procedure must be done only by Treetech technical support, or professionals certified by Treetech. This equipment is completely maintenance free, and visual and operational inspections, periodic or not, can be done by the user. These inspections are not mandatory.

All parts of this equipment must be supplied by Treetech, or by one of its accredited suppliers, according to its specifications. If the users wish to acquire them in another way, they must strictly follow Treetech's specifications for this purpose. Thus, 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.

Opening the LAP at any time will lead to product warranty loss. In case of inappropriate opening, Treetech can not ensure the product correct functioning, regardless of whether the warranty period has expired or not.

1.5 Technical support

Do you already know our online customer service platform?

SAC

On the CS page is available the fast and direct communication channel with our support team. Ask questions, solve problems and have up to date the application of your Treetech product.

Treetech's knowledge base is also available, including catalogs, manuals, application notes, frequent questions and others.

It may be necessary to send the equipment to Treetech's technical support in some cases. In the customer service (SAC) we present all the necessary procedure and contacts.

1.6 Warranty terms and conditions

The Lite Temperature Monitor - LAP will be guaranteed by Treetech for a period of two (2) years from the acquisition date, exclusively against any manufacturing defects or quality defects that make it inappropriate for regular use.

The warranty will not cover product damage suffered as result of accidents, mistreatment, incorrect handling, incorrect installation and application, inadequate testing or in case of breach of the warranty seal.

Any need for technical assistance must be communicated to Treetech or its authorized representative, with the presentation of the equipment along with the respective purchase invoice.

No express or implied warranties other than those mentioned above are provided by Treetech. Treetech does not provide any guarantee of suitability of the LAP for a particular application.

The seller shall not be liable for any damage to property or for any loss and damage arising out of, connected with, or resulting from the purchase of the equipment, its performance or any services possibly provided along with the LAP.

In no event shall the seller be liable for damages incurred, including, but not limited to: loss of profits or income, impossibility of using the LAP or any associated equipment, capital costs, costs of purchased energy, costs of equipment, facilities or substitute services, downtime costs, buyers', customers' or employees' claims, regardless of whether such damages, claims or damages are based on contract, warranty, negligence, tort or otherwise. Under no circumstances will the seller be liable for any personal injury of any kind.

2 Introduction

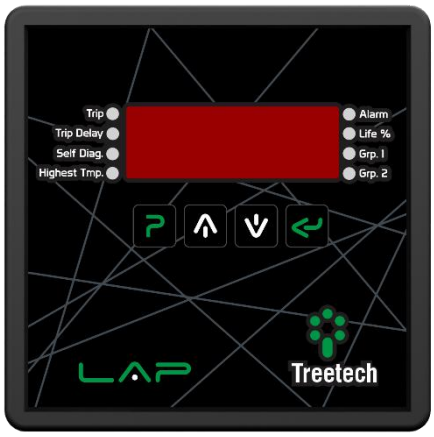


Figure 1 - Lite Temperature Monitor

Thermal monitoring of electrical equipment, such as dry transformers, motors, generators and others, is essential for their safe operation, allowing to obtain the maximum use of the investment from these assets without jeopardizing their useful life.

The Lite Temperature Monitor - LAP adds low cost and high reliability, performing the monitoring and thermal protection of these equipment, providing its safe operation while obtaining the maximum use of the assets and minimizing the risks to the safety of users, installations and the useful life of the monitored equipment.

The Lite Temperature Monitor - LAP has six temperature measurement inputs, allowing the monitoring of multiple temperatures. Some of the typical applications for the LAP are, among others:

- Temperature monitoring of the three windings of two dry transformers;
- Monitoring of oil temperatures in small transformers, where it is not necessary to measure the winding temperature (for winding temperature, see TM1/TM2 catalog); stator temperatures, bearings, lubricating oil, etc. in engines and generators;
- Temperature monitoring of five locations of a given dry transformer plus the ambient temperature where it is installed.

For each monitored temperature, alarm and equipment shutdown values are set individually.

2.1 Characteristics and functions

IED (Intelligent Electronic Device)

IED (Intelligent Electronic Device) specifically designed for application in dry transformers in substations and industrial or commercial installations.

Local indication of temperatures

Local indication of temperatures on display, with programmable indication mode: indication of the highest temperature, automatic scrolling of screens or indication of a fixed measurement.

Extended temperature measurement range from -55 to 250 °C.

Engineering algorithm

Engineering algorithm for online calculation of winding insulation aging.

Daily cooling activation

The daily cooling activation function prevents fans from remaining idle for long periods on machines operating at low load or during periods of low ambient temperature.

Alphanumeric display

Alphanumeric display with high brightness character richness, ease of understanding.

Selectable communication protocol

User selectable communication protocol between Modbus® RTU and DNP3, with support for timestamp accuracy of 1ms.

Input for sensors

Inputs for up to six RTD temperature sensors type Pt100 Ω at 0 °C, with self-calibration, ensuring high accuracy and stability over the entire ambient temperature range.

Relays

Output relays for alarm indications, shutdown, self-diagnosis and forced cooling command.

Self-diagnosis

Self-diagnosis for detecting internal faults. Total absence of mechanical parts for parameterization and calibration.

Serial communication

RS-485 serial communication port for integration into supervisory or remote monitoring systems. Modbus® RTU or DNP3 open communication protocols.

Current loop output

Programmable mA output that can be used analogically for remote temperature indication, or digitally, to activate external relays or signals. Programmable output range: 0...1, 0...5, 0...10, 0...20 or 4...20 mA.

2.1.1 Inputs

- ✓ Inputs for up to 6 Pt100 Ω type RTD temperature sensors with self-calibration, high stability over a wide range of ambient temperatures. Measuring range from -55 °C to 250 °C, with a maximum error of 0.5 °C between -55 °C and 150 °C and a maximum error of 1.0 between 150 °C and 250 °C.

2.1.2 Outputs

- ✓ Outputs for 4 configurable relays for self-diagnosis, shutdown, temperature alarm and cooling group;
- ✓ An output that makes it possible to perform two functions. Acting as an analog output in current loop (mA), which can be programmed by the user to remotely indicate the value of the measured temperatures, or as a digital output which, when active, is used to generate signals for external relays and signaling lights. If one is activated, the other function will be disabled.

2.1.3 Communication

- ✓ 1 RS-485 serial communication port;
- ✓ Modbus® RTU or DNP3 communication protocol, with timestamp support, capable of signaling events such as alarms, shutdowns, refrigeration activation, etc., with a precision of 1 ms.

2.2 Optional function

Upon request, the LAP can be supplied with an optional function listed below.:

2.2.1 Online calculation of winding insulation aging (optional)

The Aging Calculation Function carries out online monitoring of the loss of life of the winding insulation, providing important information for the diagnosis and prognosis of the state of the equipment:

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

The standards used to carry out this calculation are chosen by the operator, according to the transformer manufacture. The options are:

- ✓ **IEEE C57.96-1999:** IEEE Guide for Loading Dry-Type Distribution and Power Transformers.
- ✓ **IEC 60076-12:2008:** IEC Loading Guide for Dry-Type Power Transformers.

2.3 Basic functioning philosophy

The temperature measurement is carried out using resistive sensors of the Pt100 Ω type at 0 °C, which are installed where the temperature will be monitored. The sensors are connected directly to the LAP, so no external transducers are required. Six temperature measurement inputs are available. For each sensor, you can program independent alarm and shutdown levels.

The Lite Temperature Monitor has 4 relays, 2 with reversible contacts and 2 normally closed. It is possible to program their operating modes, as well as the events that will activate the 4 relays.

The equipment also provides an analog output in current loop (mA) that can be programmed in three ways:

- STND (Standard): Remotely indicates the measured temperature value through one of the RTDs;
- VRLS (Virtual Relay Signaling): It is possible to select the current that the LAP will output when the relay is activated (1 to 20, with the default being 10 mA);
- VRLE (Virtual Relay Eletromechanical): The current operates binary, 0 or 20 mA when the relay is activated.

The LAP has 2 forced cooling groups, responsible for activating the cooling fans or pumps. This occurs when the reading of one of the RTDs is greater than the one configured for activation, with the aim of cooling the transformer that is being monitored, their activation temperatures and the hysteresis for shutdown being programmable.

The RS-485 serial allows communication with the supervisory system or with other equipment, in addition to allowing access to programming and consultation of parameters, measurements and the LAP memory. The communication protocol to be used is selectable between the Modbus® RTU and DNP3 options.

2.3.1 Daily cooling activation

The Daily Cooling Activation function prevents fans and/or pumps from remaining inactive for long periods in transformers operating at low load or during periods of low ambient temperature. In this way, blocking of the shaft due to accumulation of dirt or dryness of grease is avoided. The cooling equipment will be activated daily, according to the internal clock of the equipment and depending on the selections made by the user:

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

The Cooling Exercise function can also be used for the purpose of pre-cooling in transformers subject to cyclic loads, programming the start of cooling for a time before the daily peak load, with the desired advance.

2.3.2 Conditions for the occurrence of forced cooling

There are 4 conditions that can activate the cooling groups and any one of them that is satisfied already implies the operation of 1 or more cooling groups.

- **Daily cooling activation**

If the daily activation is in progress, the other conditions are ignored as both groups will already be automatically turned on by the daily activation during its execution time. When it ends, the other conditions are evaluated again.

- **Ongoing self-diagnosis**

As self-diagnosis imply inaccuracy of temperature measurements or configured parameters for automatic activation, when a self-diagnosis is active, the 2 cooling groups are turned on as prevention.

All self-diagnoses directly influence some of the parameters for evaluating group activation.

- **Manual activation**

Since manual activation is a direct command, the activated group cannot alternate. If the group is already turned on non-alternately, there is no reason to account for the alternation once a group is turned on manually.

- **Automatic activation**

The automatic activation consists of triggering a certain temperature to be reached, according to the **subchapter 5.6**. Automatic activation is the only one that works with alternation (**ALTR** parameter).

2.3.3 How the online aging calculation works

2.3.1.1 Important concepts

This application consists of calculating the wear caused by temperature in the windings and, based on this, estimating the remaining useful life of the insulation. There are 3 quantities whose meanings are important for understanding this application:

- **Winding temperature:** The temperature to which the winding is subjected directly influences its wear. That is, the higher the temperature, the greater the wear. Wear is accounted for as a percentage in this algorithm, and at each time interval used in the calculation, it is accumulated;

- **Percentage of useful life:** The percentage of life is the actual amount of life the winding has left. It is calculated using the initial life parameter (user parameter) minus the accumulated wear;

- **Remaining lifetime:** It is the time it would take for the ongoing percentage to reach 0, taking into account the ongoing percentage life and degradation caused by temperature. This time is an estimate and varies according to the other 2 magnitudes.

Existem alguns parâmetros inseridos pelo usuário que são contabilizados nos cálculos e na estimativa final. Consult the **INAG Menu -** for more information.

2.3.1.2 Explaining the calculations

To use this option, it is necessary to understand the values that are inserted in the parameters that contribute to the online calculation of aging, and understand the indications offered by the display.

Calculations must be repeated for each active winding.

Accumulated loss of life

The accumulated loss of life determines the degradation of the winding in a given time interval, due to the temperature to which it was subjected. It is the accounting of the total aging of the winding so far.

Loss of life calculation is done every minute.

Accumulated loss of life is saved to non-volatile memory periodically. At application startup, the saved value must be loaded.

Percentage of useful life (LIF)

The percentage of life of the winding is calculated from the value of the initial percentage of life given by the **INL'x'** parameter and the accumulated loss of life.

The percentage of useful life is available to the user through the equipment query screens, see subchapter Erro! Fonte de referência não encontrada., and via protocols (in percentage, to 1 decimal place).

It is possible to parameterize a minimum tolerated value for the percentage of useful life **(LOLF)**. If the calculated value of **LIF** is smaller than the one parameterized in **LOLF**, the LAP will issue an alarm. For more details on how the parameters related to the option work, check the subchapter **5.8**.

LIF must be initialized with 100%

Estimated useful life (LFT)

Estimated service life is the time, in years, for the winding life to reach zero due to degradation, calculated from the percentage of useful life and loss of life.

First, the value in hours is filtered using the **FILT** parameter**.**

The **LFT** value, in years, is made available to the user through the equipment query screens and through the protocols (with 1 decimal place). Its comparison with the **LOLT** parameter must generate an alarm if it is smaller than the tolerance value.

The **Estimated Useful Life** must be initialized with a value greater than 50 years. If a variable is used to store the **LFT** value in hours, it must be initialized with a value greater than 438000 (hours in 50 years). These values must be used so that the filter action does not cause alarms until it stabilizes.

2.3.1.3 Influence of self-diagnosis on aging calculations

Any self-diagnosis occurring inhibits the Aging calculations. This is to avoid inaccurate calculations due to sensor errors or corrupted parameters in non-volatile memory.

2.4 Intended Use

The LAP should be used for monitoring up to six temperature sensors in dry power transformers.

3 Design and installation

3.1 System topology

Basically, the temperature monitoring system is composed of:

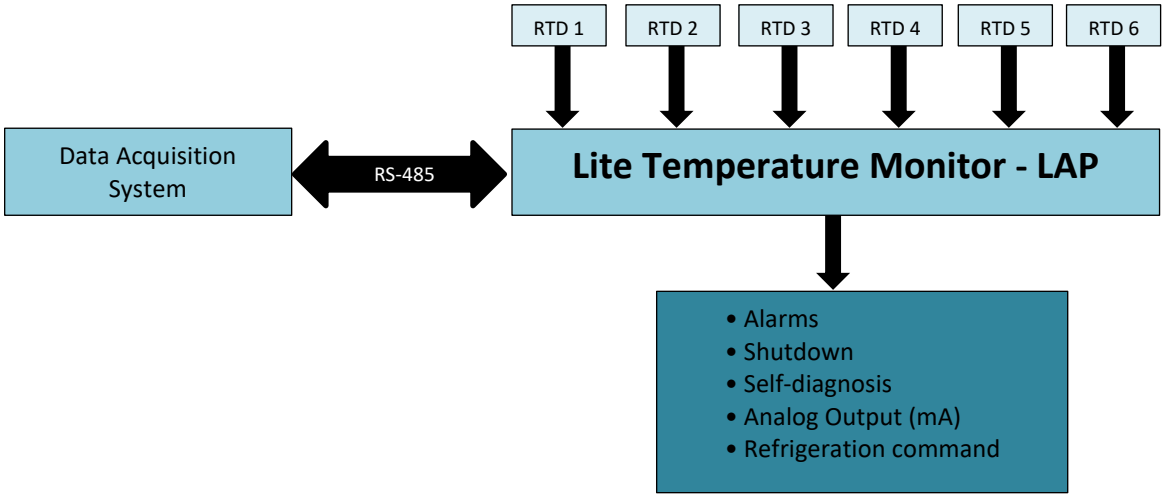


Figure 2 - Composition of the Temperature Monitoring system

The items needed for the system are:

- Lite Temperature Monitor - LAP;
- Pt100 Ω RTD sensors at 0 °C. (Quantity according to desired configuration);
- Three-way shielded cable for connecting RTD-type sensors;
- Two-way shielded twisted-pair cable for serial communication (optional);
- Box for outdoor installation (optional).

3.2 Electrical installation

The LAP is a versatile device that can serve many different types of applications.

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

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

This equipment works at dangerous supply voltage levels, which can cause death or serious injury to the operator or maintainer.

Some special care must be followed for the design and installation of the LAP, as described below.

A circuit breaker must be used immediately before the power supply (Universal power supply 85 to 265 Vdc/Vac, <5 W, 50/60 Hz), which corresponds to terminals 2 and 3 of the LAP.

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

Additionally, it must have indelible identification showing that it is the LAP electrical disconnect device.

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

- AC/DC power supply, Phase-Neutral: Monopolar circuit breaker, 1 A ≤ In ≤ 2 A, curve B or C, standards NBR/IEC 60947-2, NBR/IEC 60898 or IEEE 3004.5;

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

The minimum insulation for circuits connected to the LAP is 300 Vrms for auxiliary equipment and transducers, such as Pt100 and for equipment with its own power supply up to 50 Vrms.

The minimum insulation is 1.7 kVrms for equipment powered up to 300 Vrms, according to IEC EN 61010-1.

These values are relative to the intrinsic insulation of the devices connected to the LAP. Cases in which this value does not apply to equipment or devices connected to the LAP will be explicitly informed in this manual.

The schematic diagram of the LAP connections shows all the possibilities of connections they provide, identifying them as shown in the following figure.

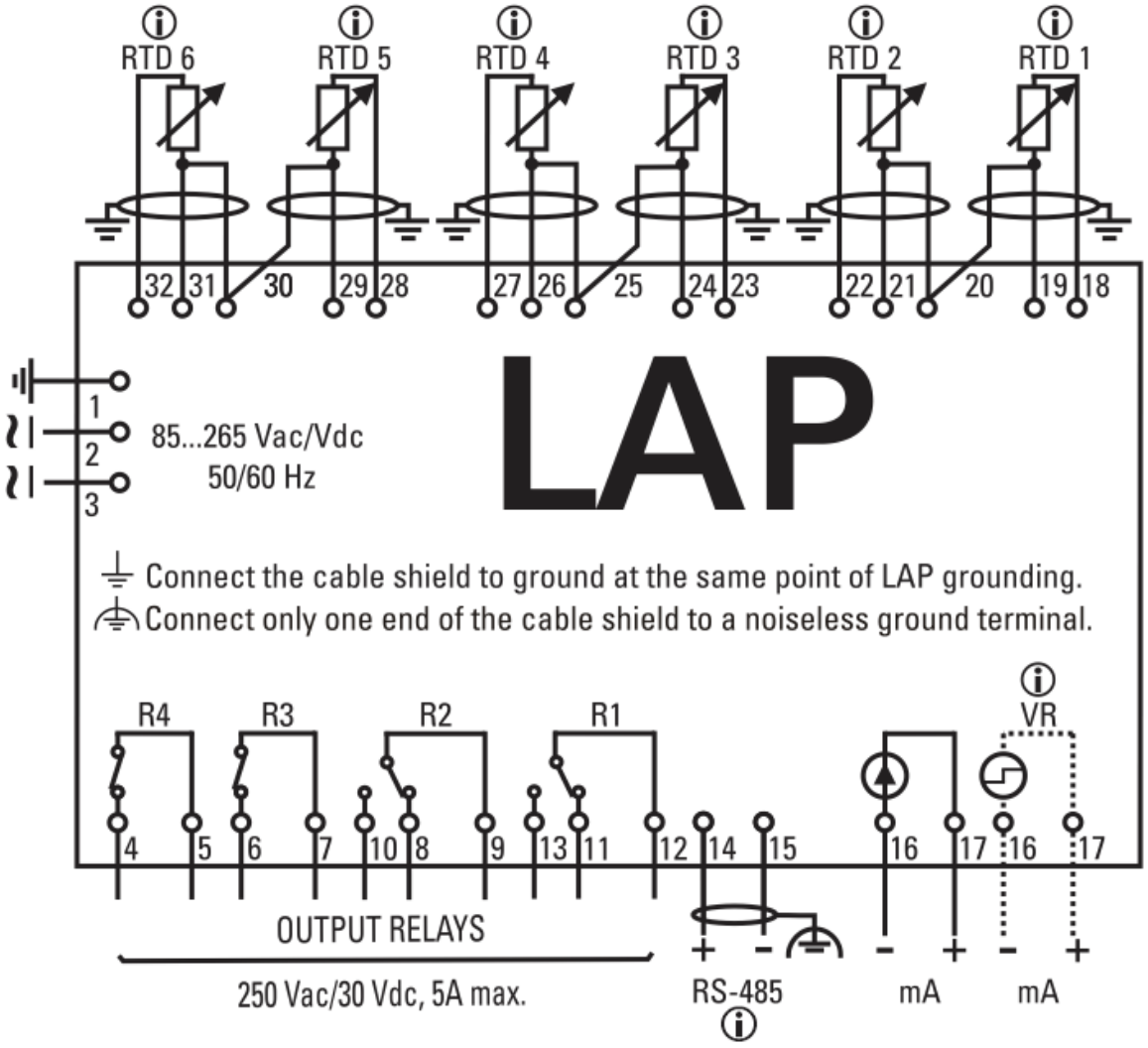


Figure 3 - LAP connection diagram

3.2.1 Input and output terminals

The inputs and outputs described below are available on the LAP. The contents of the table will be more detailed in other subchapters.

Table 2 - LAP Input terminals

Inputs	Terminals
Power and Ground: Universal power input 85 to 265 Vdc/Vac, 50/60 Hz, <5 W	01 - ground 02 - dc/ac 03 - dc/ac
RS-485 Port - Serial Communication Network with Monitoring or Supervisory System: Connection to a monitoring or supervisory system, using the Modbus® RTU or DNP3 protocol, via shielded twisted pair cable.	14 - (+) 15 - (-)
Temperature sensor - RTD 01: Input for direct connection of a Pt100 Ω sensor at 0 °C, in a three-wire measurement configuration. Color standardization for Pt100 terminals follows the IEC-60751 standard.	18 - (White) 19 - (Red) 20 - (Red)
Temperature sensor - RTD 02: Input for direct connection of a Pt100 Ω sensor at 0 °C, in a three-wire measurement configuration. Color standardization for Pt100 terminals follows the IEC-60751 standard.	22 - (White) 21 - (Red) 20 - (Red)
Temperature sensor - RTD 03: Input for direct connection of a Pt100 Ω sensor at 0 °C, in a three-wire measurement configuration. Color standardization for Pt100 terminals follows the IEC-60751 standard.	23 - (White) 24 - (Red) 25 - (Red)
Temperature sensor - RTD 04: Input for direct connection of a Pt100 Ω sensor at 0 °C, in a three-wire measurement configuration. Color standardization for Pt100 terminals follows the IEC-60751 standard.	27 - (White) 26 - (Red) 25 - (Red)
Temperature sensor - RTD 05: Input for direct connection of a Pt100 Ω sensor at 0 °C, in a three-wire measurement configuration. Color standardization for Pt100 terminals follows the IEC-60751 standard.	28 - (White) 29 - (Red) 30 - (Red)
Temperature sensor - RTD 06: Input for direct connection of a Pt100 Ω sensor at 0 °C, in a three-wire measurement configuration. Color standardization for Pt100 terminals follows the IEC-60751 standard.	32 - (White) 31 - (Red) 30 - (Red)

Table 3 - LAP output terminals

Outputs	Terminals
Relay 01 A reversing, potential-free relay with user-selectable NO or NC initial logic. This relay is parameterizable and configurable respectively with self-diagnosis, shutdown, temperature alarm, cooling group 1 and 2.	13 - NO 11 - NC 12 - Common
Relay 02 A reversing, potential-free relay with user-selectable NO or NC initial logic. This relay is parameterizable and configurable respectively with self-diagnosis, shutdown, temperature alarm, cooling group 1 and 2.	10 - NO 08 - NC 09 - Common
Relay 03 One NC relay, potential free. This relay is parameterizable and configurable respectively with self-diagnosis, shutdown, temperature alarm, cooling group 1 and 2.	07 - Common 06 - NC
Relay 04 One NC relay, potential free. This relay is parameterizable and configurable respectively with self-diagnosis, shutdown, temperature alarm, cooling group 1 and 2.	04 - NC 05 - Common
Current loop output An analog output in current loop (mA), which can be programmed by the user (see subchapter 5.7) to remotely indicate the value of the measured temperatures. **Digital output** The current loop output can be used in digital mode to activate an external circuit, either purely electronic (LED beacon) or electromechanical (external relay) in nature.	16 - (-) 17 - (+)

3.2.2 Power and Ground

The LAP has a universal power input (85 to 265 Vdc/Vac, 50/60 Hz).

Powering the LAP through the substation auxiliary services is advisable, especially when it is integrated into a serial communication network for data collection purposes for supervisory or monitoring systems.

3.2.3 RS-485 serial communication

The LAP can be connected to a data acquisition system (supervisory or monitoring system) through the RS-485 serial communication port.

Up to 31 devices can be interconnected in the same communication network. Available communication protocols are Modbus® RTU and DNP3.

The interconnection between the LAP and the data acquisition system must be carried out by means of a shielded twisted pair cable, keeping the mesh without interruption throughout the route. If there is a need for intermediate terminals to interconnect the serial communication, also pass the cable shielding through the terminal, avoiding its interruption.

The unshielded cable section due to the splice should be as short as possible, and it is advisable that the cable shield be grounded at only one end. The maximum distance of 1200 meters between the ends of the communication network must be obeyed, in accordance with the TIA-485-A-1998 standard.

In case of communication problems, especially where there are long networks (distance greater than 1000 m) and high transmission rates (greater than 9600 bps), the use of a terminating resistor of 120 Ω at each end of the serial communication network can solve these transmission errors by attenuating the reflection of the signal in the cable.

Another measure that can be tried is the installation of pull-up and pull-down resistors in just one point of the network, as shown in Figure 4. The direct voltage of 5 V to supply the pull-up and pull-down resistors may 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.

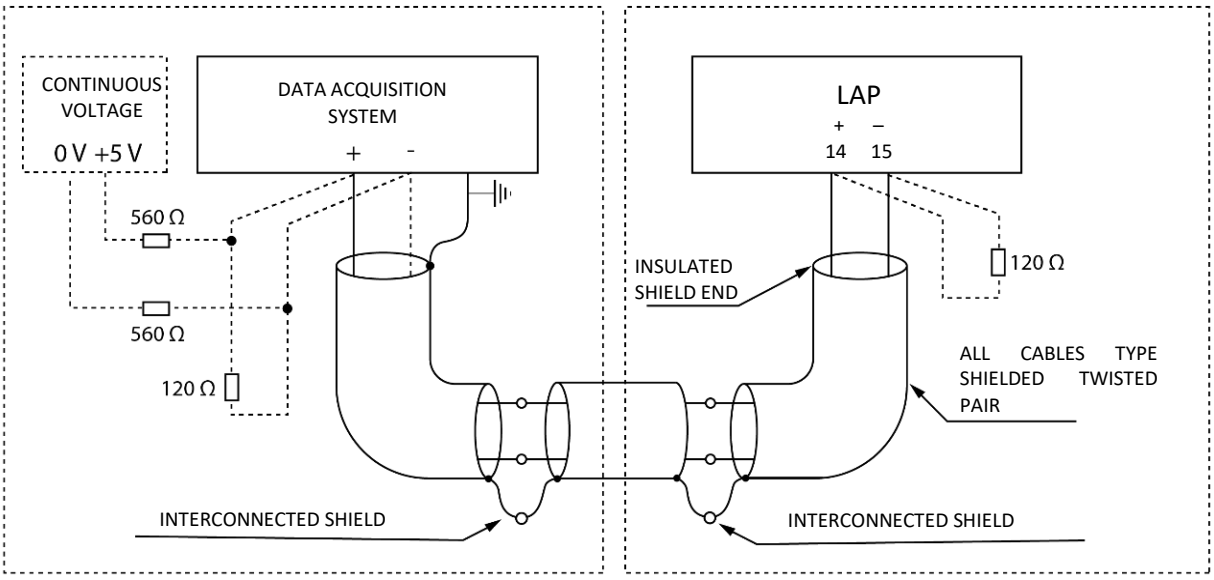


Figure 4 - RS-485 serial communication shield connection and grounding

3.2.4 Temperature sensors - RTD 01 to 06

Up to six RTD temperature sensors must be connected to the LAP through shielded cables, without interrupting the mesh, which must be grounded only at the end connected to the LAP, as close as possible to it. If there is a need for intermediate terminals to interconnect the RTD sensors, also pass the cable mesh through the terminal, avoiding its interruption. The section of unshielded cable due to the splice must be as short as possible, as shown in Figure 5.

The maximum resistance for each one of the ways used in the cable interconnecting the LAP with the Pt100 sensors is 3 Ω. That is, 6 Ω for the round trip from the Pt100 sensor to the LAP.

Considering the maximum resistance allowed in the connection between the Pt100 and the LAP, for a copper cable with a gauge of 1.5 mm^2, the Pt100 can be installed at a maximum distance of 265 m from the LAP. Other values will be possible with the correct cable sizing. If you need support for cable sizing, contact Treetech's CS.

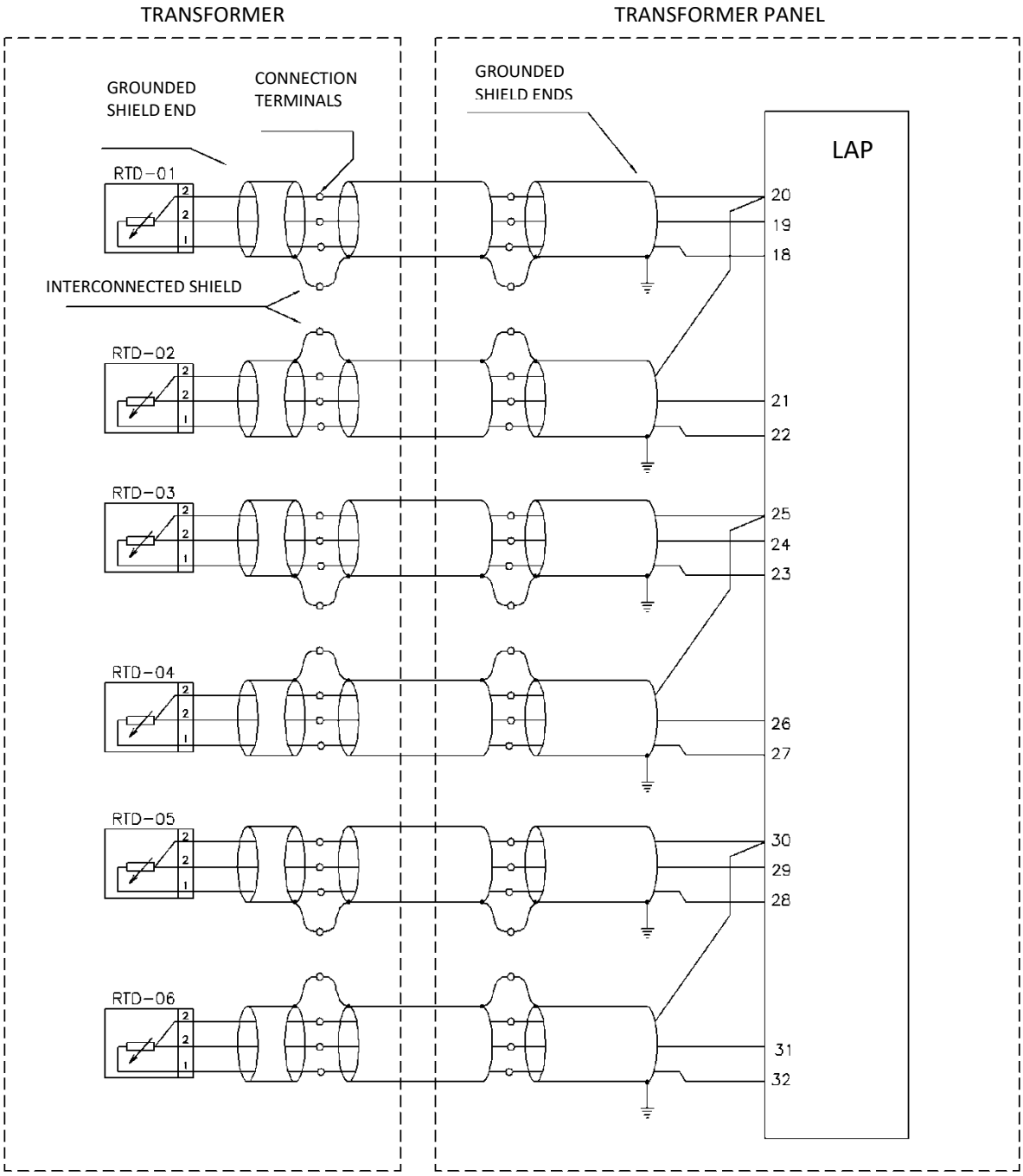


Figure 5 - Connection of the shield of the interconnection between RTD sensors and the LAP, in the standard configuration

3.2.5 Relays

All relays can be parameterized, any relay can act for self-diagnosis, shutdown, alarm or forced cooling system 1 and 2. All relays can switch loads up to 30 Vdc/250 Vac, with a maximum conduction capacity of 5 A.

The LAP presents a unique flexibility in the use of its signaling relays. The functions for each contact presented in this manual are just the default values, and can be freely changed by the operator, according to the subchapter **5.3**.

In case of de-energization of LAP, the relays will return to their initial state.

3.2.6 Current loop output - Analog output

The LAP has an analog current loop output (mA), which can be programmed by the user to remotely indicate the value of the measured temperatures. The output current range is also user selectable from 0 to 1, 0 to 5, 0 to 10, 0 to 20 and 4 to 20 options. which results in the maximum loads in ohms shown below:

Table 4 - Current loop output maximum load

Output Option	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

Both the start and end of scale are programmable, in the range of -55 to +250 °C in the 5.7.1 CONF.

The output variable can be selected from any of the measured temperatures or always the highest one.

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

3.2.6.1 Digital output

The LAP has a digital output mode, which uses the mA output to activate an external circuit. This circuit can be purely electronic (LED traffic light) or electromechanical (external relay) in nature. This mA output has 3 selectable operating modes, according to the subchapter 5.7.1.

3.3 Mechanical installation

The Lite Temperature Monitor - LAP must be installed protected from the weather, inside panels or sheltered in buildings. In either case, there must be an anti-condensation system.

The LAP is suitable for recessed installation, and can be attached, for example, to doors or front panels. Fixing clips are supplied with the equipment. The figure below shows the main dimensions of the equipment, as well as the dimensions of the cutout on the plate to insert it.

Special attention must be given to the thickness of the paint layers on the plate where the cutout is made, because in some cases, when high-thickness paint is used, the reduction of the cutout area can even prevent the insertion of the equipment.

The connection terminals are installed on the back of the LAP, in two fixed connectors. Cables from 0.5 to 2.5 mm^2 can be used, bare or with “pin” (or “needle”) type terminals.

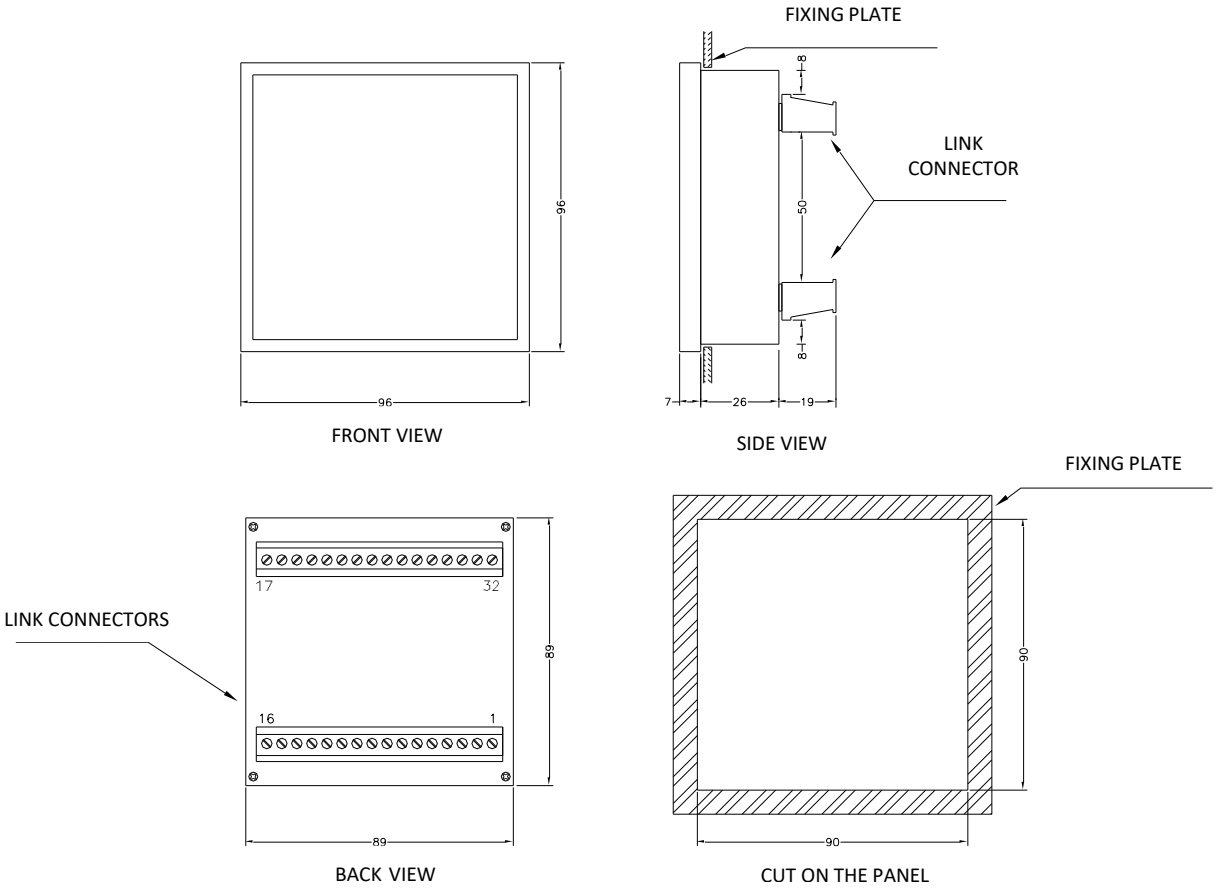


Figure 6 - Equipment dimensions - LAP

4 Operation

All operations on the Lite Temperature Monitor - LAP are performed through the keyboard on its front panel, shown in Figure 7, with no need for external keys or buttons.

The temperatures will be indicated on the display, and the conditions of alarms, shutdowns and forced ventilation commands will be indicated by the signaling LEDs.

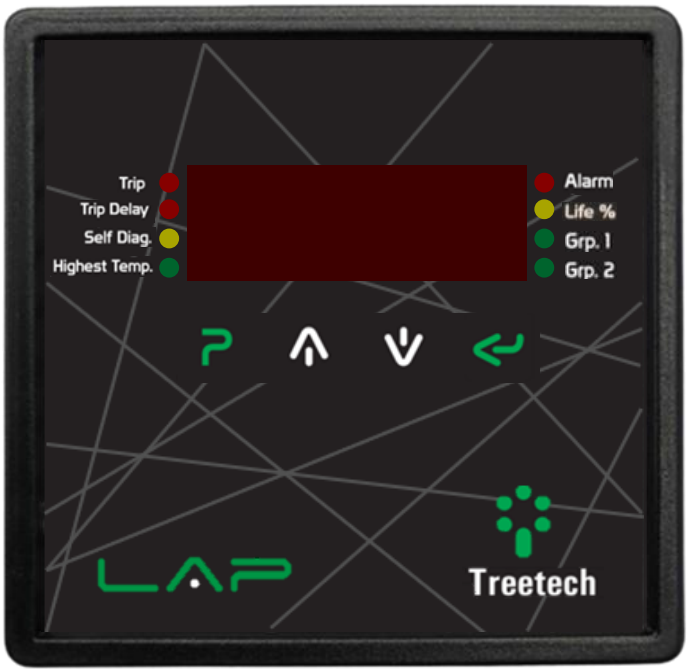


Figure 7 - LAP front display

4.1 Key function

The table shows the function of the keys on the front of the LAP.

Table 5 - Function of the Programming Keys

Key	Function
	**Programming key:** On the measurement screens, it allows selecting the forced ventilation working mode (manual, automatic or deactivated) and access to the password to enter the programming menu. In programming menus, exits the current menu returning to the previous level menu. If activated while changing a parameter, it returns to the previous level menu without saving the change made.
	**Up arrow key:** It allows navigation between query screens and between programming menus. When editing parameters, it increments the value or changes between selectable options.

	**Down arrow key:** It allows navigation between query screens and between programming menus. When editing parameters, it decrements the value or changes between selectable options.
	**Enter key:** It selects menus and parameters, saves programmed values and resets recorded maximum temperatures.

4.1.1 Accessing a submenu

When the submenu is shown on the device screen, press the key to proceed with programming. At any time, press the key to return to the main menu.

Optional menus will only be shown if enabled.

After accessing the desired submenu:

- Use the and keys to navigate between submenu parameters;
- Press to enter parameter editing;
- Press and to adjust the desired value for the parameter;
- Press to save the change made to the parameter;
- Press to return to the previous menu (if this key is pressed before Enter when editing a parameter, it will not be saved).

All parameters of features that are disabled will be hidden.

Example: Only RTDs 1, 2 and 3 were enabled. This implies that all alarms and temperatures for activation of cooling groups of RTDs 4, 5 and 6 will be blocked for editing.

This rule applies to association with relays, parameterization of groups, selection of variable for mA output and options.

4.2 Equipment information

By simultaneously pressing the keys and , it is possible to query equipment information, the equipment display will show: name, firmware version (FW), release, bootloader (BL), bootloader release, serial number 1 and 2, board revision (board revision year) and its active option, accessed by the key .

Equipment name:

Figure 8 – Command to access equipment information

Firmware version:

Figure 9 - Display indicating firmware version

Firmware release:

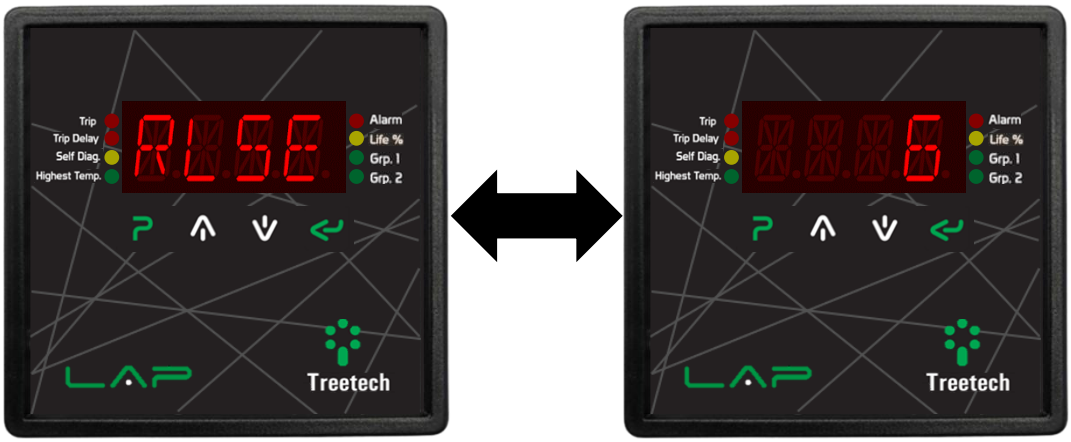


Figure 10 - Display indicating firmware release version

Bootloader version:

Figure 11 - Display indicating bootloader version

Bootloader release:

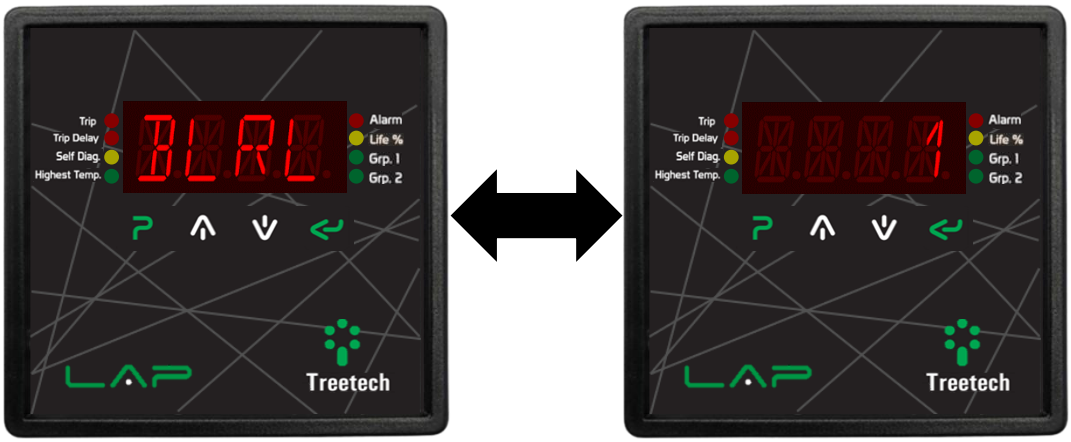


Figure 12 - Display indicating bootloader release version

Serial number:

The Serial Number is divided into part 1 and part 2, reading the complete serial number is done as follows:

Example:
If the serial number is 123456, **SNR1** will be 123 and **SNR2** will be 456.

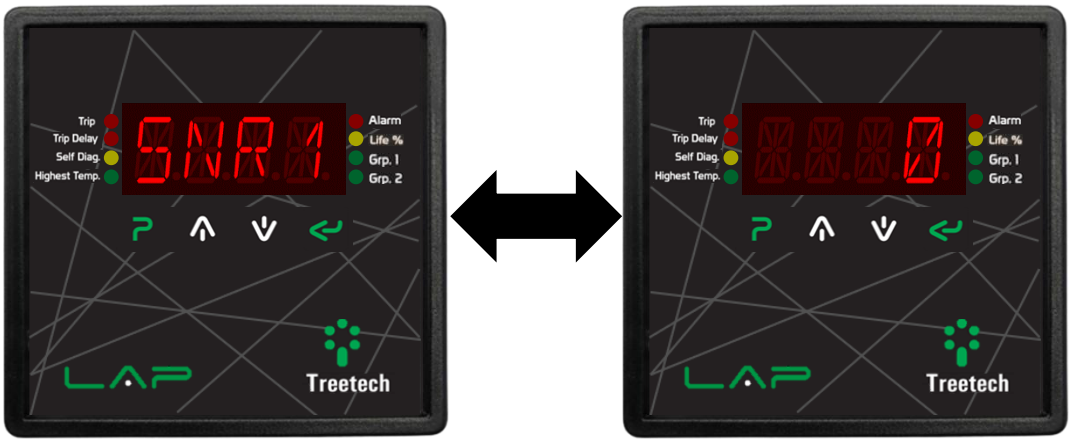


Figure 13 - Display indicating part 1 of the serial number

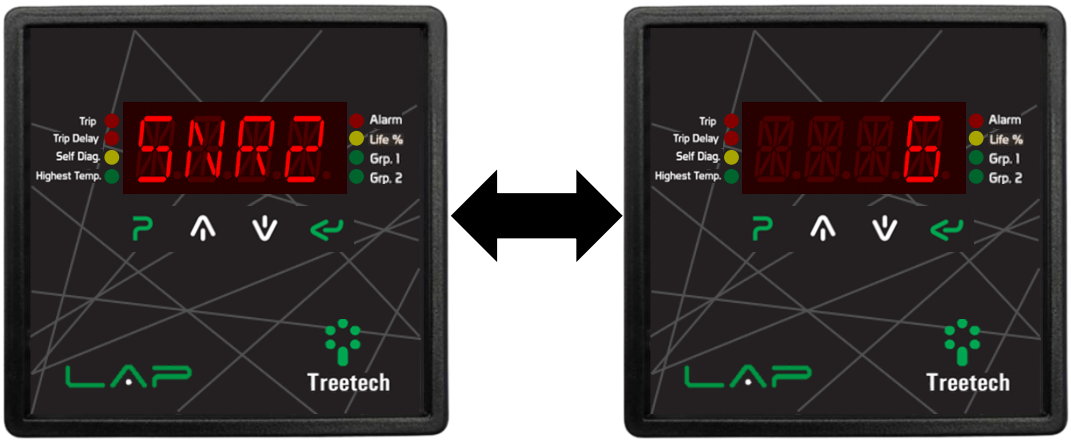


Figure 14 - Display indicating part 2 of the serial number

Board review - Week:

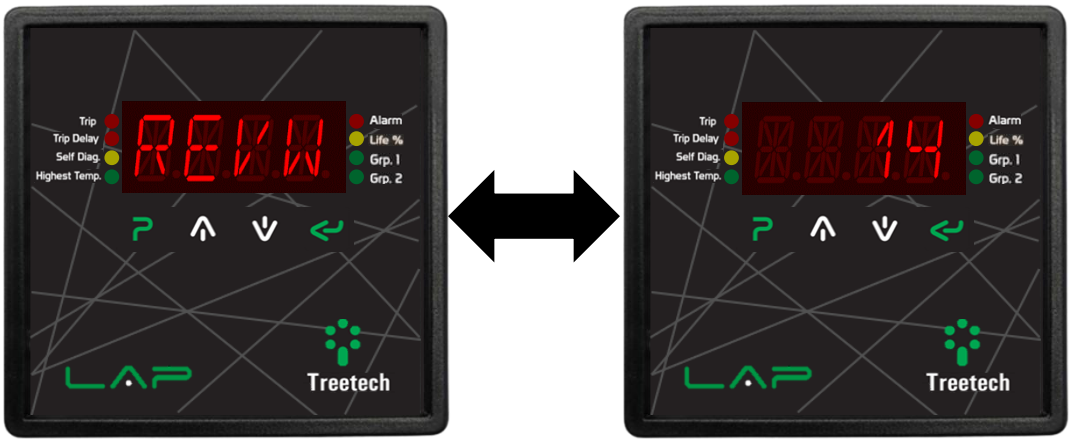


Figure 15 - Display indicating board revision week

Board review - Year:

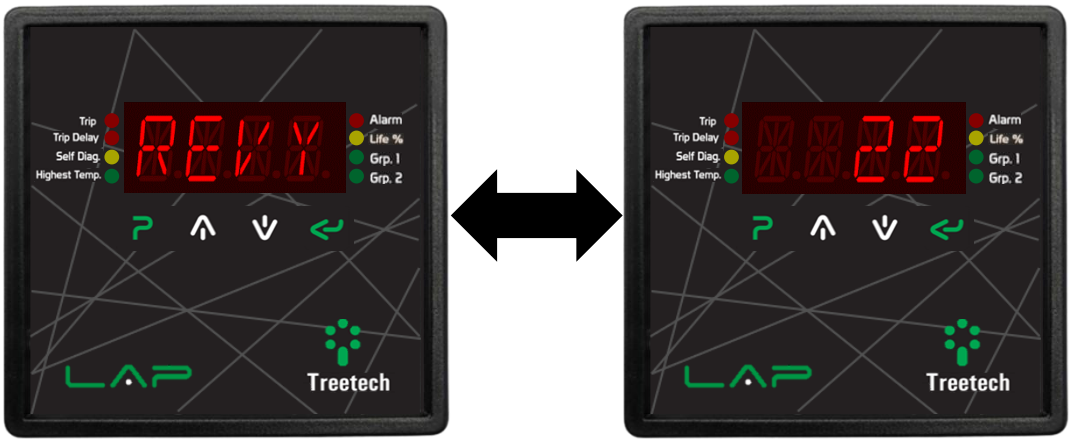


Figure 16 - Display indicating board revision year

List of options - To check the active options, press ↵ on this screen:

Figure 17 - Display indicating the access screen to the active options menu

By pressing  if you have an active option, the name of the option will appear flashing on the display.

Figure 18 - Display indicating the active **INAG** option

If there is no active option, this screen will be displayed:

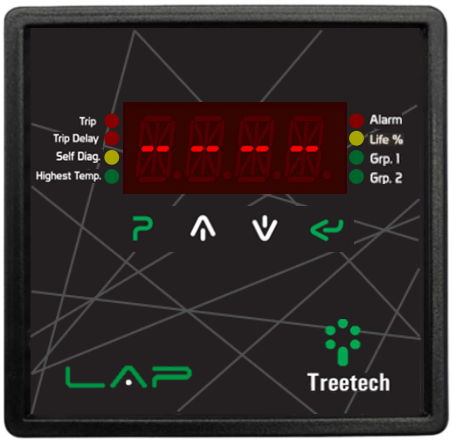


Figure 19 - Display indicating no active option

4.3 Signaling LEDs

The LAP has 8 signaling LEDs, which will light up according to their respective event, being:

- 3 alarm LEDs, signaled by red color: alarms (Alarm), shutdown delay (Trip Delay) and shutdown (Trip);
- 2 alert LEDs, signaled by yellow color: self-diagnosis (Self Diag.) and Low Life (Life %). Not as critical as alarms, but demand user attention;
- 3 warning LEDs, indicated by green color: Highest Temperature (Highest Temp.) and Cooling Groups (Grp. 1 and Grp. 2).

Figure 20 - LAP signaling LEDs

If the RTD that caused the event is on screen, the respective LED will flash.

The LEDs that indicate if the cooling group is active (Grp.1 and Grp.2) will keep flashing if the respective group has been activated manually. To learn how to manually trigger the cooling groups, check the subchapter Erro! Fonte de referência não encontrada..

4.4 Query screens

The LAP provides various information that can be consulted through its front panel, in addition to the forced cooling command.

4.4.1 Temperature measurements

During normal working mode, the Lite Temperature Monitor - LAP will indicate on its display the measured temperature as selected by the user in the **CONF Menu -** :

- Always display the highest temperature;
- Always display the temperature referring to only one of the sensors, in a fixed way;
- Always display the temperatures of all sensors sequentially, indicating the measurement of each sensor.

However, at any time, you can manually check the temperatures for each sensor using the keys and .

To differentiate the measurements of each of the six temperature sensors, its name is presented alternately with its measured temperature value, as shown in Figure 21**.** Sensors 1 to 6 are identified on the display with the abbreviations RTD1, RTD2, RTD3 and so on up to RTD6.

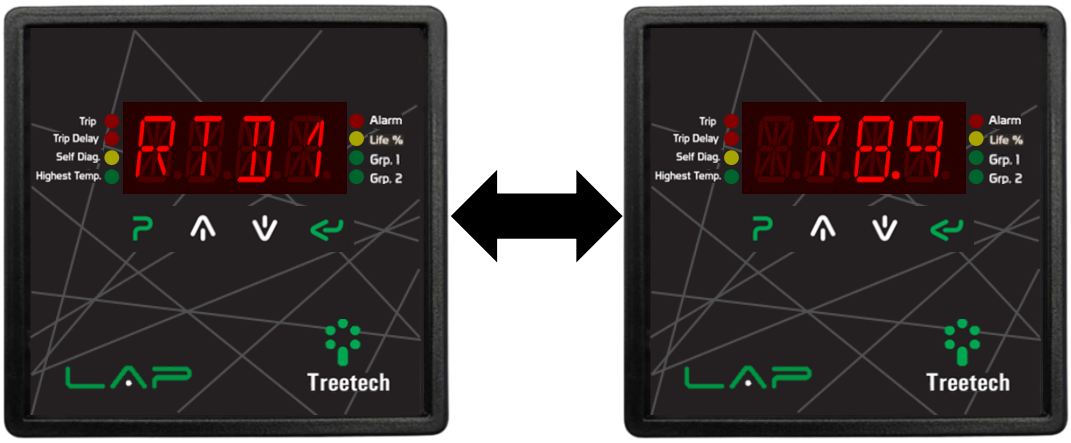


Figure 21 - Temperature indications on the display

4.4.1.1 Query of the maximum temperatures reached

The maximum temperature reached at each of the measurement inputs is stored in the LAP's non-volatile memory.

To check the records of maximum temperatures reached, press the key. The maximum values are indicated for each of the six temperature sensors alternately with their identification, through the abbreviations HIG1, HIG2... HIG6. Press the keys and to check the maximum temperatures of the sensors.

To reset (reset) the maximum temperature memorized for a given sensor, press and hold the key for 2 seconds: the maximum temperature record will be updated with the current temperature measured on this sensor.

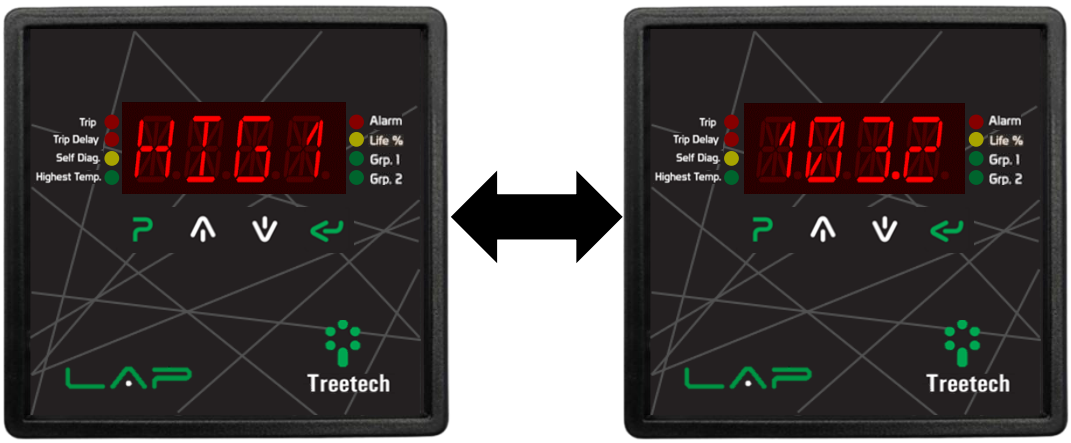


Figure 22 - Maximum temperature query

At any time press the P key to return to the temperature display. If there is no user intervention within a period of 20 seconds, the LAP automatically returns to displaying the current temperatures.

4.4.1.2 Alarm and shutdown indications

When the temperature value programmed for an event is reached (alarm or shutdown) the corresponding LED will light up, also activating the output contact of this event.

In the event of an alarm, the corresponding LED lights up and remains with a fixed indication, signaling that one of the measured temperatures has reached the programmed value.

Figure 23 - Alarm signaling LED indication

In the event of a shutdown, the LED corresponding to the indication of the delay for shutdown (Trip Delay) lights up and remains with a fixed indication, signaling that one of the measured temperatures has reached the programmed value.

Figure 24 – Signaling LED for shutdown delay indication

When the shutdown event starts, the display indicates which RTD was responsible (Example: If the measurement was made by RTD1, TRP1 will appear. This is replicated for all others).

The display will alternate between the time (minutes) and the trigger (TRP1, TRP2, TRP3....TRP6).

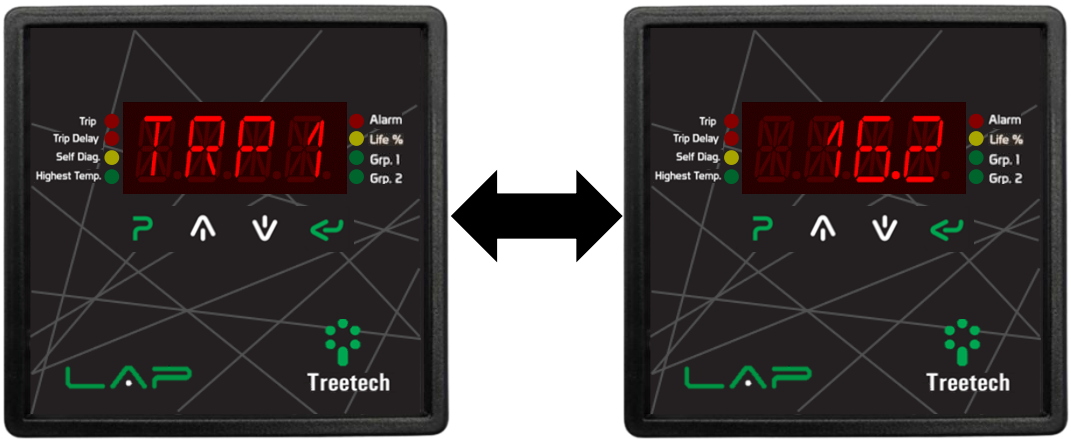


Figure 25 - Countdown to shutdown indication

When the RTD shutdown countdown reaches 0.0, the **TRIP** LED will light up indicating that the shutdown has been completed.

The shutdown will only be performed if the relay has been programmed for this purpose. To program the relay, refer to the **0** subchapter.

Figure 26 – Shutdown signaling LED

To find out which RTD has reached the programmed value for an event (alarm or shutdown), when the RTD is being shown on the display, the LEDs will start flashing, indicating that the temperature has exceeded its programmed value.

If the display mode is in **SCRL** (alternating display of all measurements cyclically) the LAP automatically displays the RTD timing that reached the shutdown value. The equipment shows the shutdown timing together with the other rotating warnings, and this process does not block navigation or the display of warnings. If more than one RTD has reached the shutdown value, the behavior is the same, the temperature and shutdown time of the first sensor that reached this programmed value is displayed and then the next one will be displayed.

If the display mode is in **STAY** (fixed display of the last sensor displayed on the front) the LAP automatically displays the RTD timing that reached the programmed value. The equipment shows the shutdown delay alternating with the last sensor displayed on the front panel. If more than one RTD has reached the shutdown value, the behavior is the same for all, the shutdown and shutdown delay screen of the first sensor that reached this programmed value is displayed and then the next one will be displayed.

4.4.2 Winding aging (optional)

When the **Aging calculation** option is available, it is also possible to check on the display the percentages and remaining useful life for each measured winding.

4.4.2.1 Indications of the remaining lifetimes

The remaining lifetimes, in years, for windings 1 to 6 are identified on the display with the abbreviations **LFT1**, **LFT2**, **LFT3** and so on up to **LFT6**. When the lifetime extrapolation exceeds 50 years, the display will show the abbreviation **HI** instead of a numeric value. If the value is less than 1 year, it is displayed with the text “<1.0”.

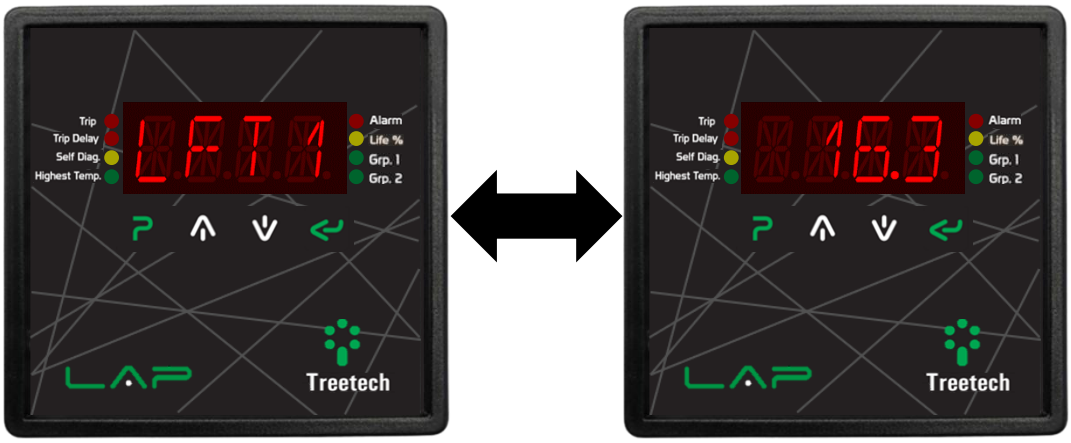


Figure 27 - Indication of lifetime, in years

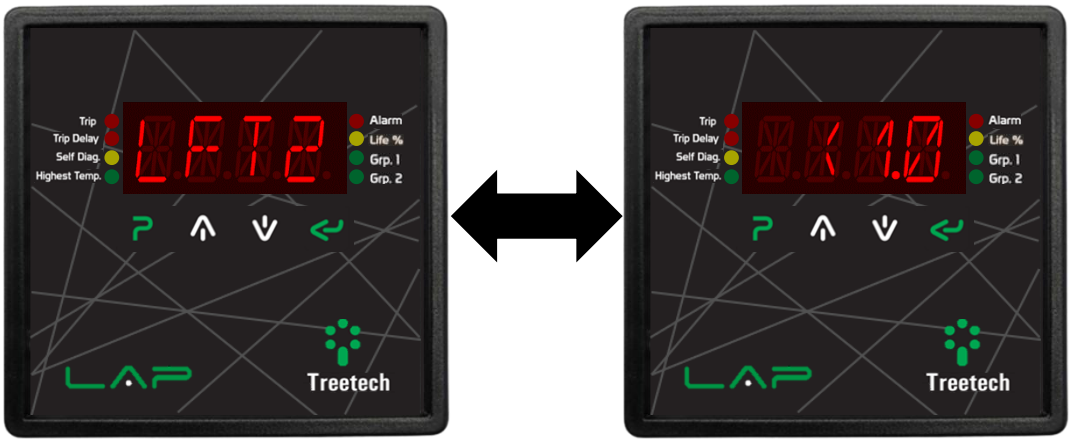


Figure 28 - Indication of lifetime less than 1 year

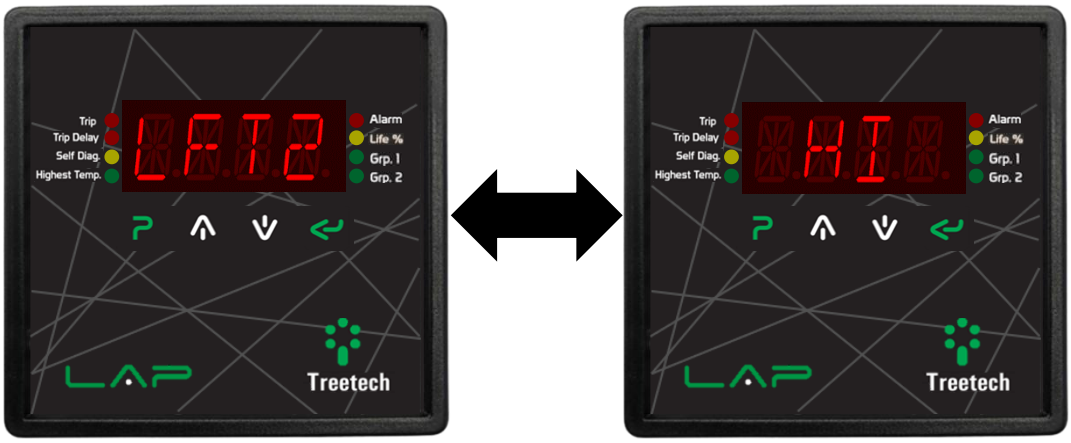


Figure 29 - Indication of lifetime greater than 50 years

4.4.2.2 Indications of the percentages of useful life

The percentages of remaining useful life for windings 1 to 6 are identified on the display with the abbreviations **LIF1**, **LIF2**, **LIF3** and so on up to **LIF6**.

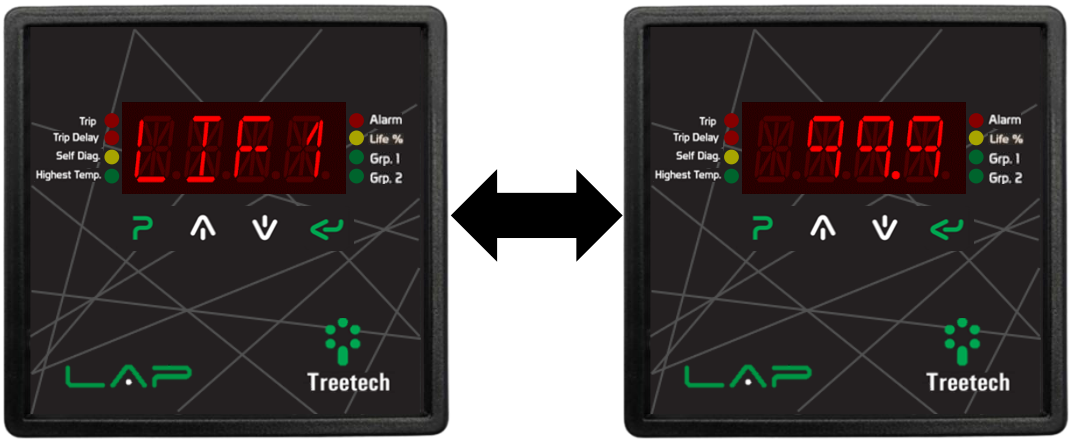


Figure 30 - Indications of remaining percent of winding life

4.4.2.3 Low life warning on aging query screens

In case the option **Online Calculation of Winding Insulation Aging** is enabled, a specific screen will be displayed when this algorithm detects an alarm situation.

When the remaining lifetime is below the minimum (parameterized value), the signaling LED **Life %** will turn on and an alert screen will appear, as shown in Figure 31.

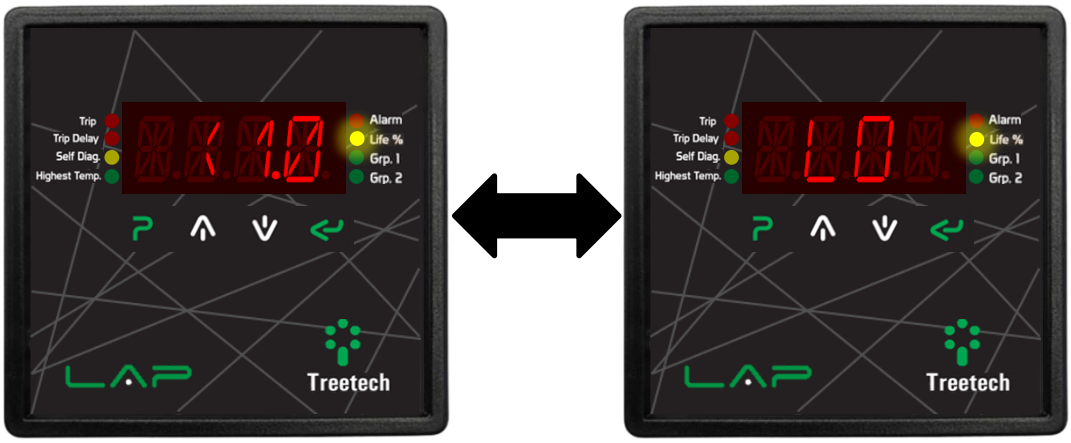


Figure 31 - Low remaining life alarm screen

When the percentage of life remaining is below the minimum (parameterized value), the signaling LED **Life %** will turn on and an alert screen will appear, as shown in Figure 32.

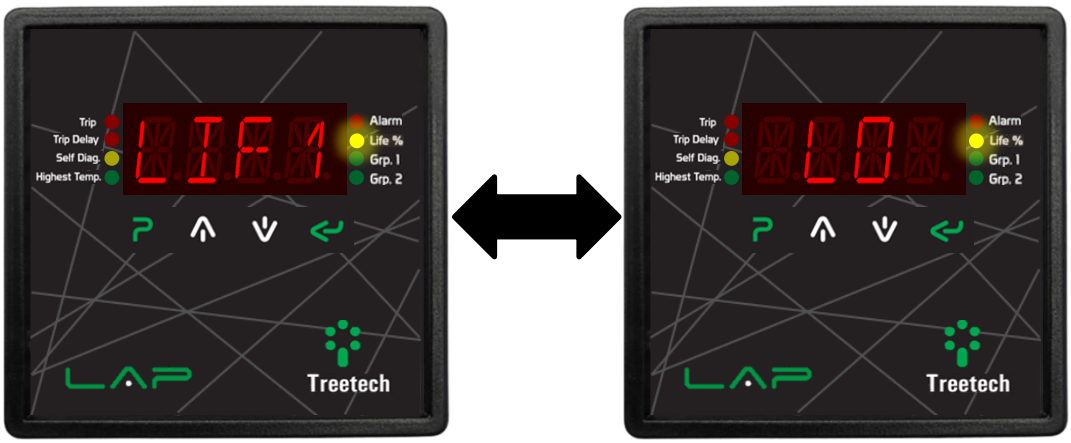


Figure 32 - Low percentage of remaining life alarm screen

Both alert screens appear intermittently, alternating at 5-second intervals with the default display chosen for the LAP.

4.4.3 CLCK submenu information

Tabela 6 – CLCK submenu information

CLCK submenu information	
CLCK submenu Use the arrows to continue browsing through other information or press ↵ on this screen to access the submenu and consult data about date and time. Once inside, navigate using the arrows ∧ and ∨. To return to the previous level press P.	
Month indication (MNTH) Indication of the month of the device's internal calendar.	
Day indication (DAY) Indication of the day of the device's internal calendar.	
Year indication (YEAR) Indication of the year of the device's internal calendar.	
Weekday indication (WDAY) Indicates the day of the week from the device's internal calendar.	
Hour indication (HOUR) Indication of the hour of the device's internal clock.	
Minute indication (MIN) Indication of minutes on the device's internal clock.	
Second indication (SEC) Indication of seconds on the device's internal clock.	
Indication of the time zone setting in hours (TZ H) Indicates the device's time zone setting in hours.	
Indication of the time zone setting in minutes (TZ M) Indicates the device's time zone setting in minutes.	

4.4.4 Forced cooling status

When the programmed temperature value for activating the forced cooling in any of the stages is reached (first or second stage), the corresponding signaling LED will turn on, also activating the output contact for this event.

When forced cooling is triggered by the user in Manual mode, the corresponding LED will indicate this condition on the front of the LAP, as shown in Figure 33.

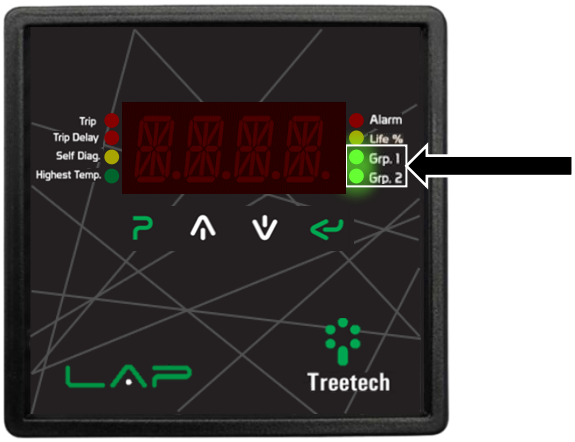


Figure 33 - Forced cooling signaling LEDs

4.4.3.1 Command of cooling groups

The LAP has the command function for up to 2 forced cooling groups. The refrigeration groups can be activated automatically when the temperatures programmed by the user are reached (**FAN** submenu), they can be activated manually or they can be deactivated, through the front keys of the LAP, dispensing with the use of external command keys.

To manually trigger the forced ventilation groups, follow the steps below:

Press the P key. The LAP will show CGO1 (cooling group 1) alternately with the current state of group 1: AUTO (automatic), ON (manually turned on) or OFF (group disabled).

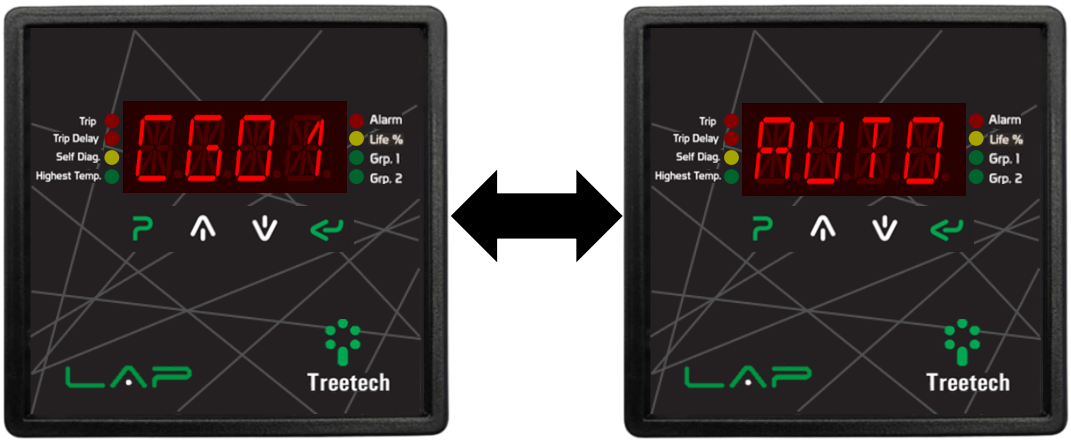


Figure 34 - Cooling group 1 alternately with current state AUTO

Use the keys ∧ and ∨ to toggle between cooling groups 1 and 2 (CGO1 and CGO2).

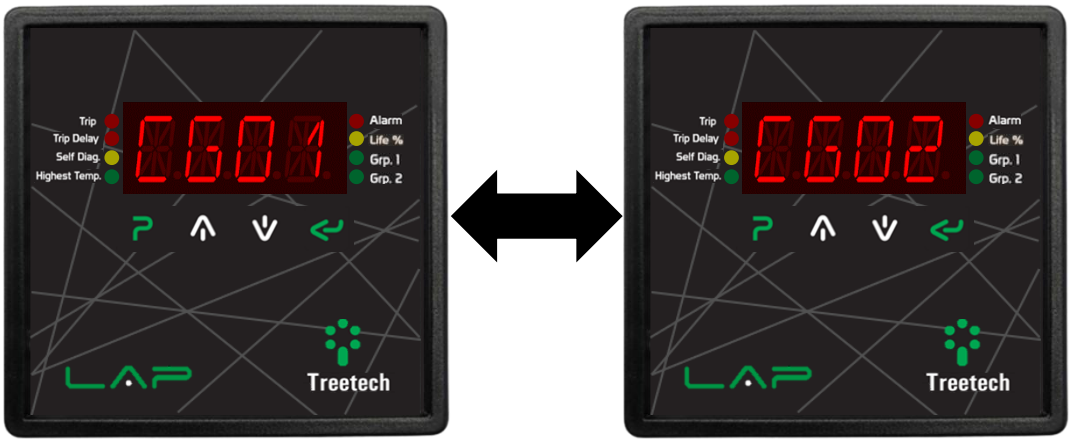


Figure 35 - Navigation between cooling groups

Press the key to access editing the status of the desired cooling group (CGO1 or CGO2). Press the key to switch on the cooling in manual mode (ON) or to return to automatic mode (AUTO), descend once more to deactivate the group (OFF). Press to confirm the selection made or to abandon editing without saving the changes made.

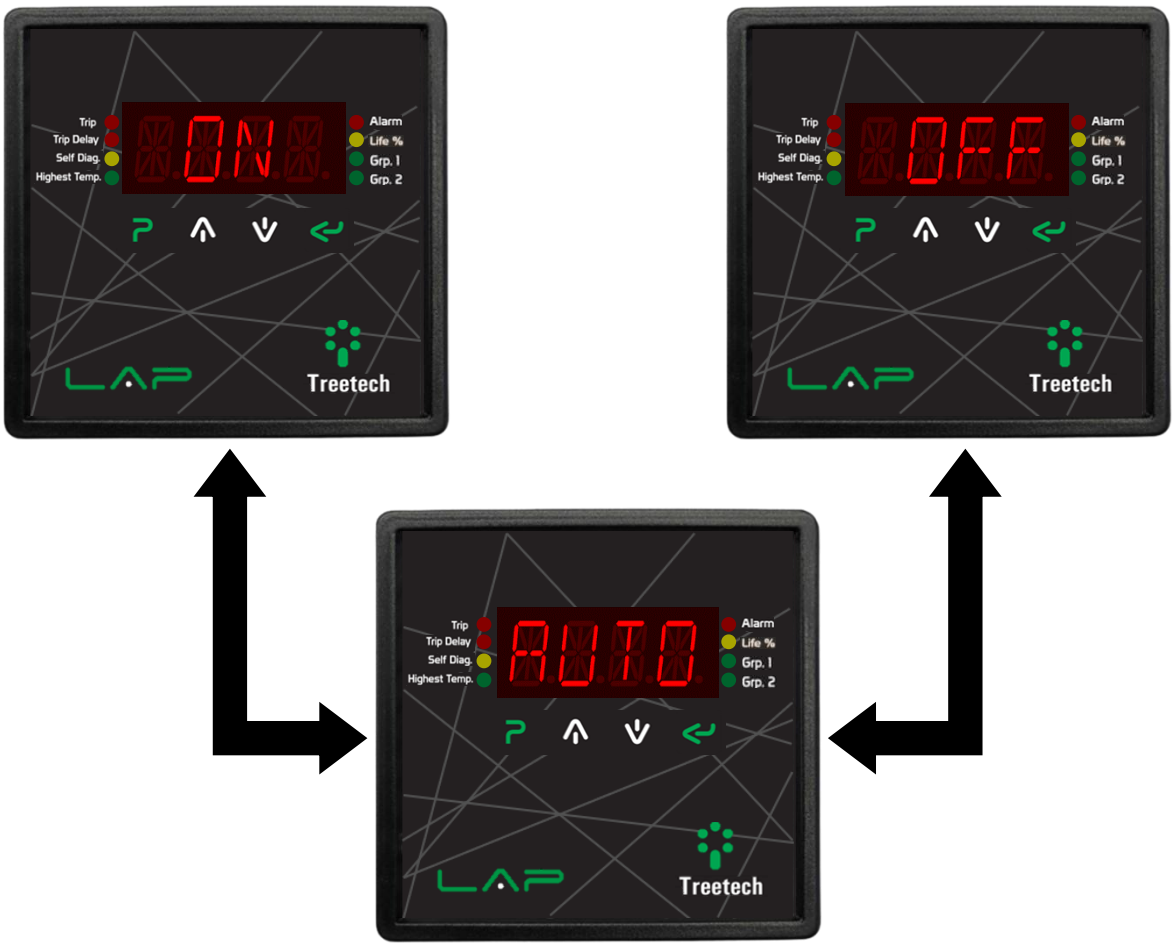


Figure 36 - Cooling group status edit

Press the key to return to temperature indications.

4.4.3.2 Activation timing

Activating a cooling group is an action that can cause power consumption spikes. To prevent 2 groups from being activated simultaneously, causing an even greater peak, a delay is performed that blocks the activation of the next group whenever one is already active.

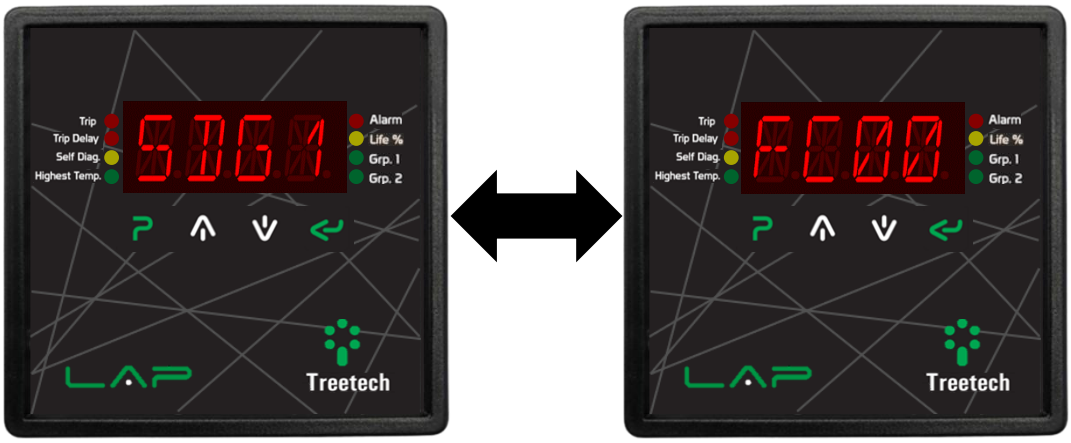
This delay is 10 seconds, and it happens regardless of the group, operating mode and alternation.

4.4.5 Warnings

On query screens, equipment warnings appear cyclically for 3 seconds between displays. The warnings are:

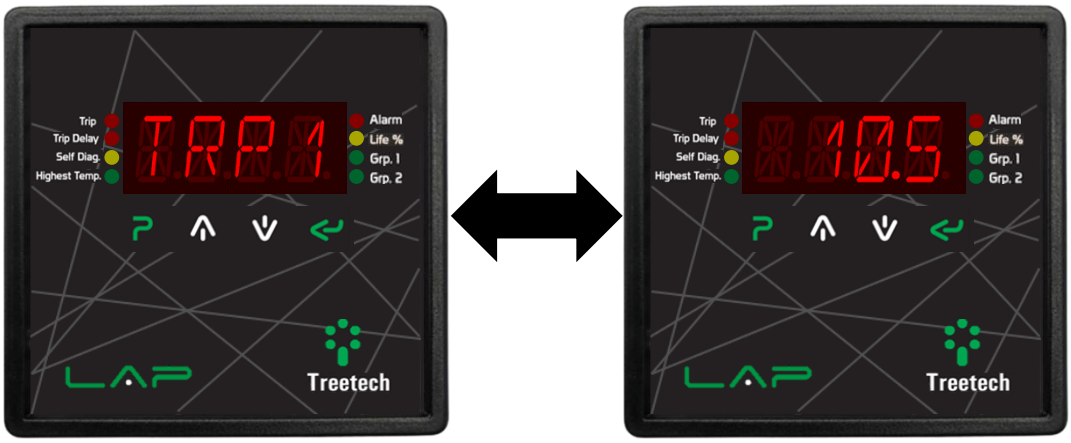
- Violation;

- Occurrence and code of self-diagnoses;



- Occurrence and code of alarms;

- Shutdown delay time (for each RTD occurring);



5 Parameterization

To guarantee its correct operation, several parameters must be adjusted in the LAP that will provide the equipment with the necessary information for its operation. Adjustments can be made through its front keyboard, or through the RS-485 communication, available to the user on the device's rear connector.

The programmable parameters are organized in several submenus, inserted in a main menu with password protected access. Within each submenu, the user will have access to a set of parameters that must be adjusted according to the needs of each application and the characteristics of the equipment in which the LAP is applied.

There are 10 standard menus and one optional menu, which is only displayed if the function is available:

5.1 Access to programming menus

1) On the general display screen, keep the P key pressed for 5 seconds.

2) Using the keys ∧ and ∨, adjust the password.

3) After setting the password, press the ↵ key to enter the first programming menu.

4) The first Menu (ALR) is displayed. Use the keys ∧ and ∨ to select a submenu and press ↵ to access its parameters.

The default value for the entry password for the menus is 0 (zero), and it can be reprogrammed by the user (see CNF submenu).

The initial number that is shown when reaching the 2nd figure can be used to recover the password, in case of forgetting. Inform the number to our CS.

5.1.1 Parameter map

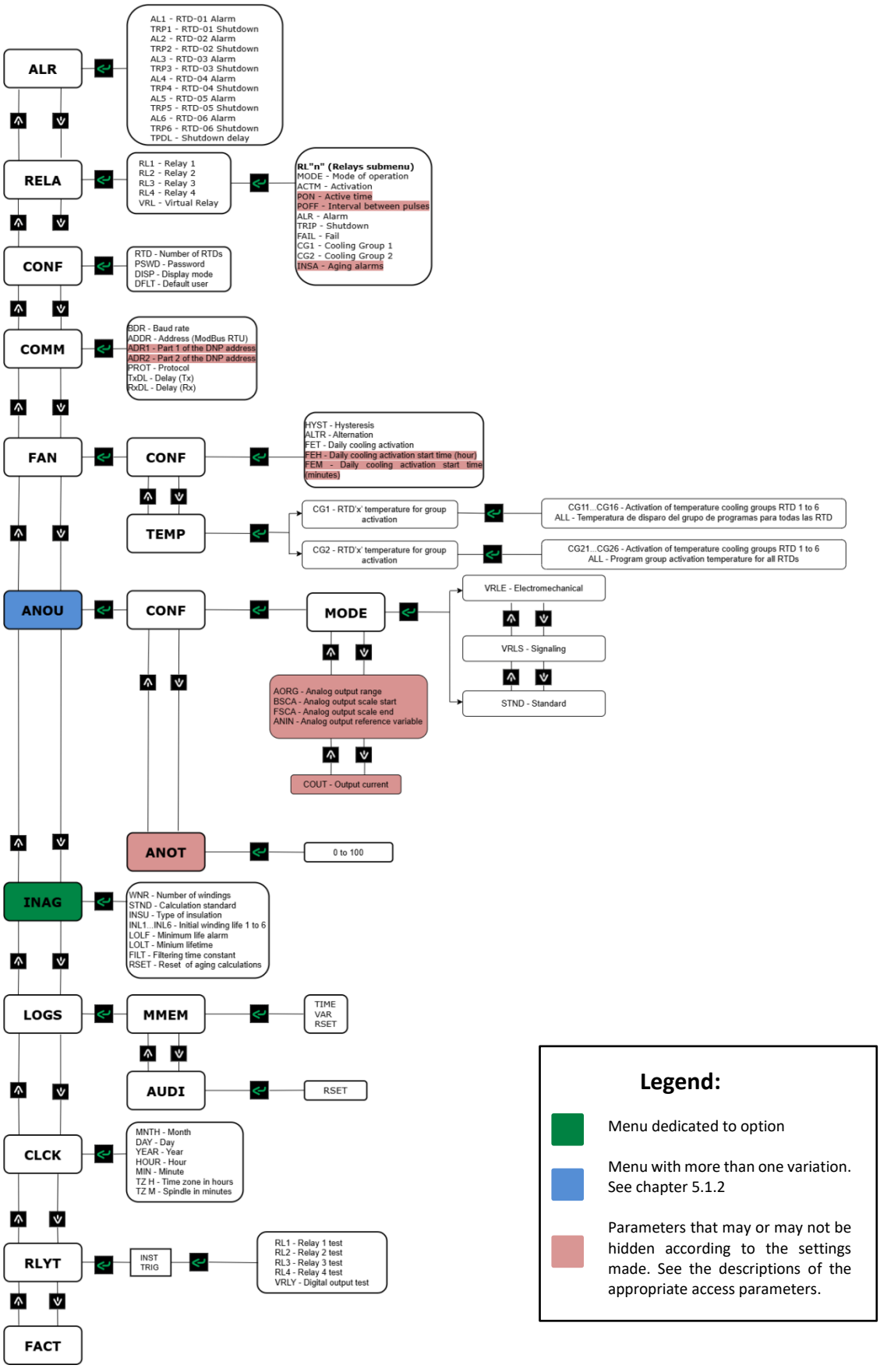


Figure 37 - Structure of access to submenus.

5.1.2 Map variations menu

Depending on the option selected in a parameter, this option can change submenus, generate new parameters or hide other functions.

As output 16 and 17 have more than one function, the ANOU menu can change according to the mode selected in the MODE parameter.

If the **STND** option is selected:

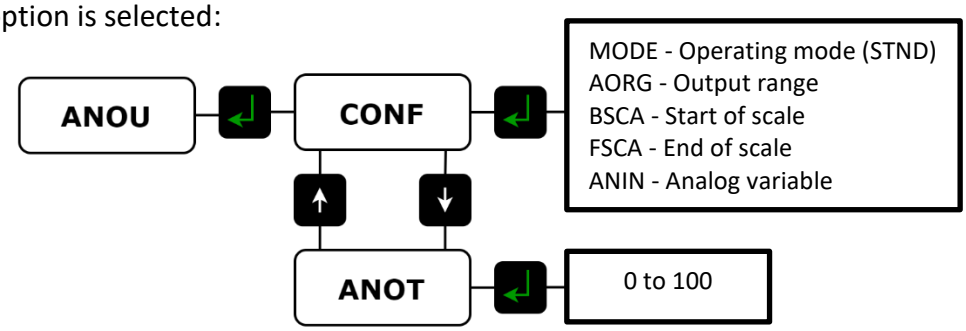


Figure 38 - Menu variation if STND is selected

If the **VRLS** option is selected:

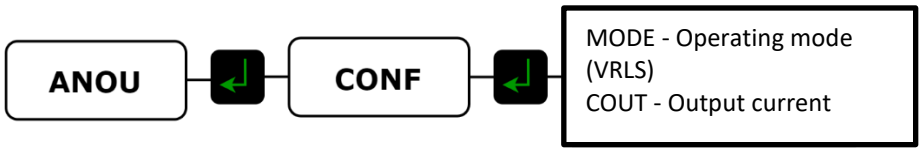


Figure 39 - Menu variation if VRLS is selected

If the **VRLE** option is selected:

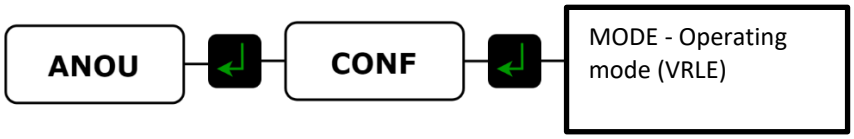


Figure 40 - Menu variation if VRLE is selected

5.2 ALR Menu - Alarms

This menu allows access to all parameters related to alarms and temperature shutdowns.

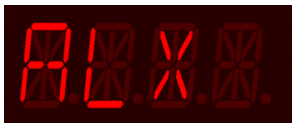
5.2.1 AL'x', TRP'x' and TPDL submenu

This menu contains settings for RTDs 1 through 6.

The 'x' indicates the RTD number.

Example: AL1, AL2, AL3... AL6 / TRP1, TRP2, TRP3... TRP6.

AL'x'- Alarm



It determines the temperature alarm value for each transformer RTD. The alarm is only deactivated if the temperature drops 1 °C or more below the trigger value.

Adjustment range: -55 to 250°C, in 1°C steps.
Standard value: 100 °C.

TRP'x' – Shutdown due to RTD-0'x' temperature

It determines the value for shutdown due to transformer temperature.

Adjustment range: -55 to 250°C, in 1°C steps.
Standard value: 110 °C.

TPDL - Shutdown delay

This parameter allows you to insert a delay between the moment when a shutdown temperature is reached and the instant when the shutdown relay is actually activated.

Adjustment range: 0.0 to 20.0 minutes, in 0.1-minute steps**.**
Standard value: 5 minutes.

5.3 RELA Menu - Relays

This menu allows access to all parameters related to the operation of the LAP output relays.

5.3.1 RL'x' submenu

This menu contains the settings for relays 1 to 4 and the digital output (**VRL**). These settings are repeated for the different relays.

The 'x' indicates the relay number.

Example: RL1, RL2, RL3 and RL4.

RL'x' - Relay

This submenu allows access to all parameters related to the relay.

VRL – Digital output

This submenu allows access to all digital output parameters.

Note: To activate the digital output, see subchapter 5.7.1 in the MODE parameter - Changes the operating mode of the analog output.

MODE - Operating mode

Contacts can be configured to work in normal mode (**NORM**) or reverse mode (**INVE**). In this way, it is possible to obtain several advantages, without compromising the safety or speed of contact actuation for the critical application.

Adjustment range:

NORM = Contacts change state when relay is activated.

INVE = When energizing the LAP, the contact will change state. When the relay is triggered, the contacts will return to the rest state.

Standard value: NORM.

ACTM – Activation mode

This parameter allows selecting between Latch or Pulse activation modes.

Adjustment range:

LATC = Latch Mode: it is the common way. In this mode, the relay remains activated as long as the event that caused the activation has not ceased..

PULS = Pulse Mode: nesIn this mode the relay will emit pulses. It is possible to configure the time in which the relay is active (**PON**) and the interval between one pulse and another (**POFF**). The relay will continue to emit pulses until the event that caused the activation has ceased.

Standard value: LATC.

PON - Active time

This parameter allows configuring the time in which the relay is active during the pulse. (Only appears if the parameter **ACTM** is in the **PULS** mode).

Adjustment range: 000.1 to 999.9 seconds.
Standard value: 000.1 second.

POFF - Interval between pulses

This parameter allows configuring the interval between active times, that is, the interval between pulses. (Only appears if the parameter **ACTM** is in the **PULS** mode).

Adjustment range: 000.1 to 999.9 seconds.
Standard value: 000.1 second.

ALR - Relay association to any alarm event

If this parameter is set to YES, the relay contact **RL'x'** will change state in the event of any alarm.

The relay can also be used to act from other events.

Adjustment range: YES, NO.
Standard value: YES for relay 3, NO for others.

TRIP - Associating the relay to any shutdown event

If this parameter is set to YES, the relay contact **RL'x'** will change state in the event of any shutdown.

The relay can also be used to act from other events.

Adjustment range: YES, NO.
Standard value: YES for relay 2, NO for others.

FAIL - Associating the relay to any self-diagnosis event

If this parameter is set to YES, the relay contact **RL'x'** will change state on occurrence of any self-diagnosis.

The relay can also be used to act from other events.

Adjustment range: YES, NO.
Standard value: YES for relay 1, NO for others.

CG1 - Associating the relay to the activation of the first stage of forced cooling

If this parameter is set to YES, the relay contact **RL'x'** will change state according to the actuation of the first stage of forced cooling. For parameterization details, check the subchapter **5.6.**

The relay can also be used to act from other events.

Adjustment range: YES, NO.
Standard value: YES for relay 4, NO for others.

CG2 - Associating the relay to the activation of the second stage of forced cooling

If this parameter is set to YES, the relay contact **RL'x'** will change state according to the actuation of the first stage of forced cooling. For parameterization details, check the subchapter **5.6**.

Adjustment range: YES, NO.
Standard value: NO.

INSA - Associating the relay to alarms due to insulation aging (optional)

If this parameter is set to YES, the relay contact **RL'x'** will change state in the occurrence of any alarm related to the **INAG Menu**.

This parameter will only be available if the optional **Insulation Aging** is enabled.

Adjustment range: YES, NO.
Standard value: NO.

5.4 CONF Menu - Configuration

It allows access to parameters related to the LAP's operating settings.

RTD - Number of Sensors

Number of Temperature Sensors (RTD) being used.

Adjustment range: 1 to 6.
Standard value: 6.

PSD - Password

Change the access password to the LAP configuration menu.

Adjustment range: 0 to 8191.
Standard value: 0.

DISP - Display

Temperature display mode on the LAP Display in normal operation.

Adjustment range:

HIGH = Display of the highest measured temperature among all sensors;
SCRL = Alternating display, the LAP displays each of the measured temperatures for 10 seconds, cyclically;
STAY = The display remains fixed on the last sensor viewed on the front;

Standard value: SCRL.

DFLT - Reset user parameters

Resetting user parameters resets the values of all parameters that are part of menus outside the **FACT menu**.

Adjustment range: YES, NO.
Standard value: NO.

5.5 COMM Menu - Communication

It allows access to parameters related to serial communication.

BDR - Transmission speed

Select the baud rate of serial communication.

Adjustment range: 4.8 / 9.6 / 19.2 / 38.4 / 57.6 / 115.2 kbps.
Standard value: 9.6 kbps.

ADDR - Address (Modbus® RTU)

Select the address of the LAP on the serial communication network.

It will only be available if the Modbus® RTU protocol is selected in the **PROT** parameter**.**

Adjustment range: 0 to 247.
Standard value: 247.

Presentation DNP3 Address on Display

The DNP3 address will be represented as follows:

ADR1 - Part 1 of the DNP address

Select the first part of the LAP address on the serial communication network, with the most significant digits. As in this protocol it is possible to have 65519 addresses, that is, 5 digits, it is necessary to use 2 parameters to represent them.

It will only be available if the DNP3 protocol is selected in the **PROT** parameter.

Adjustment range: from 0 to 65.
Standard value: 0.

ADR2 - Part 2 of the DNP address

Select the second part of the LAP address on the serial communication network, with the least significant digits.

It will only be available if the DNP3 protocol is selected in the **PROT** parameter.

Adjustment range: 0 to 999 if ADR1 < 65; 0 to 519 if ADR1 = 65, in steps of 1.
Standard value: 247.

PROT - Serial communication protocol

Select the communication protocol to be used: Modbus® RTU (MODB) or DNP3 (DNP3).

Adjustment range: MODB, DNP3.
Standard value: MODB.

TXDL - Tx Delay

Parameter responsible for defining the interframe waiting time for data transmission, that is, it is the waiting time between one transmission and another.

Adjustment range: from 5ms to 500ms.
Standard value: 25ms.

RXDL - Rx Delay

Parameter responsible for defining the interframe waiting time for receiving data, that is, it is the waiting time for receiving a data packet.

Adjustment range: from 5ms to 500ms.
Standard value: 5ms.

5.6 FAN Menu – Forced cooling

It allows access to parameters related to forced cooling groups commanded by the LAP.

Note: For this screen to be displayed, CGO1 or CGO2 must be enabled as automatic (AUTO).

5.6.1 CONF Submenu

Submenu for hysteresis, alternation and daily cooling activation settings of cooling groups.

HYST - Hysteresis

It is the difference between the starting and stopping temperature of fans and pumps. Determines a temperature reduction value, below the cooling start temperature, to turn off the fans and pumps, in order to prevent them from being turned on and off in succession with small temperature variations.

Adjustment range: from 0 to 9 °C, in steps of 1 °C.
Standard value: 5 °C.

ALTR - Alternation of cooling groups

The **ALTR** (Alernation) parameter enables or disables automatic alternation when activating the two cooling groups.

Example: When a cooling group is turned on, its usage time is counted. In this way, when sending the ventilation activation command, in which both groups are off, the time of use is taken into account to determine which one will be activated.

Observation: It is desirable that there is an alternation in activating the groups as the measured temperature rises. On the contrary, if the activation order of the groups is fixed, the group activated with the lowest temperature may have significantly more wear.

Adjustment range: ON, OFF.
Standard value: OFF.

FET – Time of daily activation

The cooling groups have automatic periodic activation to exercise fans, preventing them from being stopped for long periods.

This parameter is used to adjust the total daily time that the forced cooling groups must remain active. Exercise occurs every 24 hours and starts according to parameters **FEH**, **FEM** (these parameters will only be available if the value configured in the **FET** parameter was greater than 0 (zero).

In case it is necessary to deactivate the **Daily cooling activation**, just program this parameter with the value 0 (zero).

Adjustment range: 0 minutes to 999 minutes.
Standard value: 0 minutes.

FEH – Daily cooling activation start time (hours)

Adjustment of the time at which the forced cooling groups must be activated for the daily exercise of the fans.

Adjustment range: 0 to 23 hours, in 1 hour steps.
Standard value: 12 hours.

FEM - Daily cooling activation start time (minutes)

This parameter is used to configure the execution time of the exercise referring to the minutes.

Adjustment range: 0 to 59 minutes, in 1 minute steps.
Standard value: 0 minutes.

5.6.2 TEMP Submenu

Submenu for setting temperatures for activating groups.

5.6.1.1 Submenu - CG1/CG2

This menu contains the settings for triggering the cooling groups by temperature of RTDs 1 to 6.

The ‘x’ indicates the RTD number.

Example: CG11, CG12, CG13... CG16 / CG21, CG22, CG23... CG26.

Submenu for configuring forced cooling group 1 triggering.

CG1’x‘/CG2’x’ - RTD’x’ temperature for group activation

Select the forced cooling Group 1 trigger temperature in relation to the temperature measured by the RTD sensor.

Adjustment range: -55 °C to 250 °C.
Standard value: 80 / 90 °C.

ALL - Program group activation temperature for all RTDs

The **ALL** parameter serves to parameterize all RTDs simultaneously, when selecting a value in this parameter all RTDs will have the same selected value.

Example: If the parameters **CG11**, **CG12**, **CG13**, **CG14**, **CG15** and **CG16** are parameterized, respectively, with the values 80, 85, 90, 95, 100 and 105 and the value “95” is confirmed in parameter **ALL**, the values of these parameters will change to 95. It is possible, however, to change the values individually of each parameter later.

Adjustment range: -55 °C to 250 °C.
Standard value: 80 / 90 °C.

5.7 ANOU Menu - Analog output

It allows access to all parameters related to analog output.

5.7.1 CONF Submenu

It allows access to all configuration parameters related to analog output.

MODE - Changes the operating mode of the analog output

The current loop output can be used in both analog and digital modes. In analog mode the current will vary within a range of values, in digital mode it will change between 0 and the maximum programmed value.

Adjustment range:

VRLE (Electromechanical) = digital operating mode to control external relays on the board. In this case, the current operates in binary with 0 or 20 mA.

VRLS (Signaling) = digital operating mode to control signaling lights, where the current operates in binary form (0 or **COUT**). The value **COUT** (output current) can be selected in the **COUT** parameter.

STND (Standard): standard operating mode, generating a current from 0 to the end of the scale controlled by the temperature of one of the RTDs. The end of scale can be programmed in the **AORG** parameter.

Standard value: STND.

If one of the digital output modes is selected, the analog output parameters will not be available.

COUT - Output current

Selects the current output value, in mA, used to actuate external elements when the **VRLS** mode is selected.

It is possible to select the **VRLS** mode in the **MODO** parameter in the **0** subchapter**.**

Adjustment range: 0 to 20 mA.
Standard value: 10 mA.

AORG - Analog output range

Selects current loop output range, in mA, for remote indication.

Adjustment range: 4 to 20, 0 to 20, 0 to 10, 0 to 5, 0 to 1 mA.
Standard value: 4 to 20 mA.

BSCA - Analog output scale start

It configures the variable value for the start of scale of the analog output.

Adjustment range: -55 °C to 250 °C.
Standard value: 0 °C.

FSCA - Analog output scale end

It configures the value of the variable for the full scale of the analog output.

Adjustment range: -55 °C to 250 °C.
Standard value: 250 °C.

ANIN - Selects the analog output reference variable

Selection of the variable associated with the current loop output.

Adjustment range:

TPR'x' = It will indicate the temperature of the selected RTD'x' sensor;
HIGT = The highest measured temperature of all RTD sensors will be displayed;

Standard value: HIGT.

5.7.2 ANOT - Analog output test

Parameter for testing the analog output, where the selected value is the full scale percentage.

Example: If the parameter was selected 50%, the analog output will output half of the selected full scale value.

Adjustment range: 0 to 100 %.
Standard value: 50 %.

5.8 INAG Menu - Aging (optional)

It allows access to all parameters related to Insulation Aging.

This parameter will only be available if the optional **Insulation Aging** is enabled.

WNR - Number of windings

This parameter allows selecting the number of windings to be monitored (limited by the number of enabled RTDs).

Adjustment range: 1 to 6.
Standard value: 6.

STND - Calculation rule

It determines the calculation rule used: **IEC 60076-12:2008** or **IEEE C57.96-1999**. Its value changes the options of the next parameter, the **Insulation Class** (or “Thermal Class”).

Adjustment range: IEC or IEEE.
Standard value: IEC.

INSU - Insulation class

The insulation class is data provided on the transformer nameplate, this value will influence the aging calculations. In case the **IEC 60076-12:2008** standard option is selected in the **STND** parameter:

Adjustment range: 105A, 120E, 130B, 155F, 180H, 200 or 220.
Standard value: 180H.

If the **IEEE C57.96-1999** standard option is selected in the **STND** parameter:

Adjustment range: 150, 180 or 220.
Standard value: 180.

INL’x’ - Percentage of initial life of the winding

This parameter is used to enter the initial life percentage of the winding.

Observation: The “x” indicates the winding number from 1 to 6.

Adjustment range: 0 to 100 %.
Standard value: 100 %.

LOLF - Percentage of tolerated useful life

Tolerance value compared to calculated value of percentage of life remaining in order to generate an alarm.

It is possible to parameterize a minimum tolerated value for the percentage of useful life. If the calculated value of **LIF** (percentage of useful life) is less than the chosen value of this parameter, the LAP will issue an alarm.

Adjustment range: 0 to 100 %.
Standard value: 25 %.

LOLT - Shortest tolerated useful lifetime

Tolerance value compared with the estimated useful life value, in years, in order to generate an alarm.

It is possible to parameterize a minimum tolerated value for the service life. If the calculated value of **LFT** (useful lifetime) is less than the chosen value of this parameter, the LAP will issue an alarm.

Adjustment range: 0 to 20 years.
Standard value: 1 year.

FILT - Filtering time constant

This parameter serves to select the value of the filtering time constant.

Adjustment range: 1 to 720 hours.
Standard value: 24 hours.

RSET - Reset of calculations

Command to reset the calculated values and restart the process.

Adjustment range: YES, NO.
Standard value: NO.

5.9 LOGS Menu

It allows access to all parameters related to the logs.

The log is a history of activities that the equipment stores in its memory so that it can be consulted at any time.

5.9.1 MMEM Submenu

It allows access to all parameters related to the mass memory log. The Mass Memory Log records temperature changes, alarm triggers, shutdowns and other information with date and event.

TIME - Forced recording period

It determines the time interval for a new recording in the mass memory to be carried out, in minutes.

Adjustment range: 60 minutes to 9999 minutes.
Standard value: 60 minutes.

VAR - Temperature variation

It determines a value of variation in the measured temperatures, in degrees Celsius, which, if exceeded, causes the LAP to record a new recording in the mass memory, allowing to extend the time for the oldest data in the memory to be overwritten, preventing recordings if the measurements do not vary significantly.

Example: If the ongoing temperature is 70 °C and the VAR parameter is 5 °C, when reaching a temperature higher than 75 °C or lower than 65 °C, a recording will be performed.

Adjustment range: 1 °C to 20 °C.
Standard value: 5 °C.

RSET - Reset

Mass memory log reset command.

Adjustment range: YES, NO.
Standard value: NO.

5.9.2 AUDI Submenu

It allows access to all parameters related to the audit log.

It contains saved information so that the user can consult them and check the operations carried out on the equipment.

RSET - Reset

Audit log reset command.

Adjustment range: YES, NO.
Standard value: NO.

5.10 CLCK Menu - Clock

It allows you to adjust the equipment calendar.

If the equipment is restarted, the LAP date and time will return to their default values.

MNTH - Month

Setting the ongoing month in the equipment calendar.

Adjustment range:

JAN = January;	**APR** = April;	**JUL** = July;	**OCT** = October;
FEB = February;	**MAY** = May;	**AUG** = August;	**NOV** = November;
MAR = March;	**JUN** = June;	**SEP** = September;	**DEC** = December;

Standard value: JAN.

DAY - Day

Setting the ongoing day in the equipment calendar.

Adjustment range: 1 to 31.
Standard value: 1.

YEAR - Year

Setting the ongoing year in the equipment calendar.

Adjustment range: 1 to 99.
Standard value: 0.

HOUR - Hour

Setting the ongoing hour on the device's clock.

Adjustment range: 0 a 23 hours.
Standard value: 10h.

MIN - Minute

Setting the ongoing minute on the device's clock.

Adjustment range: 0 a 59 minutes.
Standard value: 0 minute.

TZ H - Time zone in hours

Setting the time zone, in hours, on the device's clock.

Adjustment range: -12 to 14 hours.

Standard value: -3 hours.

TZ M - Time zone in minutes

Setting the time zone, in minutes, on the device's clock.

Adjustment range: 0 to 59 minutes.
Standard value: 0.

5.11 RLYT Menu – Relay tests

It allows testing the operation of each LAP output relay, forcing its activation. When this menu is accessed, all LAP relays revert to the off state.

This menu contains the settings for relays 1 to 4 and the digital output (**VRLY**). These configurations are repeated for the different relays.

The 'x' indicates the relay number.

Example: RL1, RL2, RL3 and RL4.

RLY'x' - Activates or deactivates output relay 'x'

It allows you to momentarily change the state of the selected relay.

Adjustment range: ON, OFF.
Standard value: OFF.

VRLY – Virtual relay activation test

This is a virtual relay, driven by logic, as it has no physical activation.

This parameter will only be visible if the mode selected in the MODE parameter in subchapter 5.7.1 is VRLS or VRLE.

Adjustment range: ON, OFF.
Standard value: OFF.

5.12 FACT Menu

It allows access to factory parameters. It is for the exclusive use of Treetech's technical service and is protected by a password, not being accessible to the equipment operator.

6 Commissioning for entry into service

Once the installation of the equipment has been carried out in accordance with this manual, the commissioning must follow the basic steps below:

- ✓ Check the electrical installation according to the recommendations in this manual. Check correctness of electrical connections (e.g. through continuity tests);
- ✓ Make sure that no contact operation will interact with other systems during this phase. If necessary, isolate all command, alarm and shutdown contacts;
- ✓ Reconnect the ground cables to terminal 1 of the LAP, if they have been disconnected for applied voltage tests. Power up the LAP with any voltage in the range 85 to 265 Vdc/Vac, 50/60 Hz;
- ✓ Carry out all the parameterization of the LAP, according to the instructions in this manual;
- ✓ With a continuity meter, test the actuation of the alarm, shutdown and forced cooling contacts. The actuation of the contacts can be forced through the RLYT submenu;
- ✓ Connect temperature calibrator, resistive decade or check the temperature of the Pt100 connected to each LAP measurement input, checking if the measurements are correct;
- ✓ With a DC milliammeter, check if the current loop outputs show values consistent with the corresponding temperature values;
- ✓ Reconnect contacts that may have been isolated.

7 Troubleshooting

7.1 Equipment displays self-diagnosis messages on the display

The LAP has 2 self-diagnosis indexes, “SDG1” and “SDG2”, which appear alternating along with the code on the display in the event of an anomaly.

The LAP displays the self-diagnosis code by flashing slowly (about 1 second).

Figure 41 - Self-diagnosis indication on the LAP

7.1.1 Viewing the self-diagnosis memory

The LAP firmware constantly checks the integrity of its functions and the temperature sensors connected to it through its self-diagnosis circuits and algorithms. Any anomaly detected is signaled through the fault contact and through the self-diagnosis messages indicated on the equipment display, helping in the fault diagnosis and solution process.

The Self-Diagnosis Memory function allows you to know all the diagnostic events that occurred in the LAP, such as bad contacts in the wiring of the temperature sensors or internal faults. This memory is non-volatile and cumulative, that is, it allows you to know all the events that occurred, but not when they occurred.

The Self-Diagnosis Memory is accessed by sequentially pressing the keys P and ↓. There are two self-diagnosis memory screens, identified by the abbreviations DGM1 and DGM2, which can be consulted by pressing the keys ↑ and ↓. On each of the screens, the initials DGM1 or DGM2 are indicated alternately with a numerical code that identifies the events that have occurred.

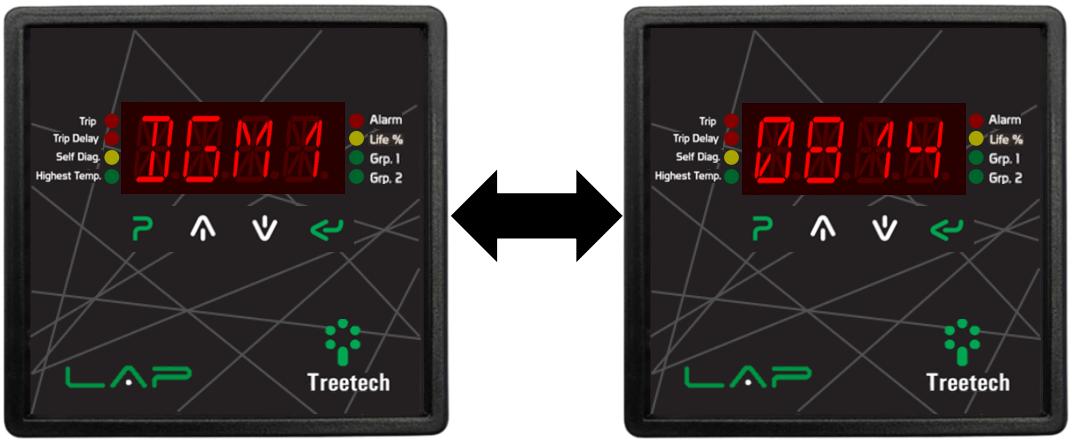


Figure 42 – Checking the self-diagnosis memory

To clear (reset) the self-diagnostic memory, press the ↵ for 5 seconds. If there is any active diagnosis, the memory will be restarted already indicating its occurrence. Press the P key to return to the indication screen.

To check the procedure in case of self-diagnosis and possible errors generated by the LAP, follow the instructions by clicking on the link below or scanning the QR code to be redirected to the Treetech CS.

Self-diagnosis

7.2 Viewing the alarm memory

The Alarm Memory function allows you to know all the events that occurred in the LAP, such as forced cooling activation, alarms and shutdowns. This memory is non-volatile and cumulative, that is, it allows you to know all the events that occurred, but not when they occurred. If you have two different events, the result displayed in the position relative to this event is a sum of them.

The Alarm Memory is accessed by sequentially pressing the keys P and ↑. There are two alarm memory screens, identified by the letters ALM1 and ALM2, which can be consulted by

pressing the keys and . On each of the screens, the acronym ALM1 or ALM2 is displayed alternately with a numerical code that identifies the events that have occurred.

Figure 43 - Alarm memory query screens

To clear (reset) the Alarm Memory, press the key. for 5 seconds. If there is an active alarm, the memory will be reset already indicating its occurrence. Press the key to return to the indication screen.

To interpret the codes provided by the alarm memory, consult the code table by clicking on the link below or scanning the QR code to be redirected to the Treetech CS.

Alarm Memory

8 Technical Data

Table 7 - Technical data table

Information	Description
Supply voltage:	85...265 Vac/Vdc, 50/60 Hz
Maximum consumption:	< 5 W
Operating temperature:	-10...+70 °C
Degree of protection:	Front panel IP50 Back IP20
Electrical connections:	0,5...2,5 mm^2, 22...12 AWG
Fixation:	Built-in panel mounting
Current loop output: Maximum error: Options (selectable) and maximum load:	One programmable analogue or digital output 0.5% of full scale 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
Relay outputs: Type and functions (default): Maximum switching capacity:	Potential free contacts 2 programmable reversible relays 2 programmable NC relays 250 Vac, 5 A / 30 Vdc, 5 A
Direct temperature measurements (e.g. windings, oil, environment, stators, etc.): Sensor: Measuring range: Maximum error at 20°C: Deviation due to temperature variation: Connection type:	Six inputs for RTD sensors with continuous self-calibration Pt100 Ω at 0 °C -55...250 °C 0.5% of full scale 20 ppm / °C 3-wire
Remaining lifespan forecast: Applied mathematical models:	Calculated. **IEEE C57.96-1999**: IEEE Guide for Loading Dry-Type Distribution and Power Transformers **IEC 60076-12:2008:** IEC Loading Guide for Dry-Type Power Transformers
Communication protocols:	Modbus® RTU or DNP3 (parameterizable)
Serial communication ports:	1 RS-485 for supervisory system

9 Specifications for ordering

The LAP is a multifunction equipment, having its characteristics selected in its programming menus. These adjustments can be made directly on its front panel or via RS-485 serial communication.

The power input is universal (85 to 265 Vdc/Vac 50/60 Hz).

For the purchase order of the device, it is only necessary to specify:

1. Product name

LAP – Lite Temperature Monitor.

2. Quantity

The number of units to be purchased.

3. Optional

Inform if you want the option of **OnLine Calculation of Winding Insulation Aging** enabled.

4. Accessories

Treetech supplies items that are necessary for the LAP to work. If you want to add the purchase of an accessory, just inform it during the LAP order.

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