English

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TECHNICAL MANUAL

LAD

Temperature Monitor
For Dry Transformers

Treetech

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Table of Contents

Figure List

Table List

1 Foreword

1.1 Legal Information

The information contained herein is subject to change without notice.

Treetech Sistemas Digitais Ltda. may possess patents or other types of records and intellectual property described in this document.

The possession of this document by any person or entity does not confer to that person or entity any right to those patents or records.

1.2 Introduction

This manual includes all recommendations and instructions to install, operate and maintain the Temperature Monitor for Dry Transformers - LAD.

1.3 Typographical conventions

The following conventions have been adopted for this text:

In Bold: Symbols, terms and words in bold type are more significant in the context. Therefore, special attention must be given to these symbols, words or terms.

In Italics: Words in a foreign language, alternative or used outside their formal situation are in italics.

1.4 General information and Safety

This section introduces relevant aspects concerning safety, installation and maintenance of the LAD.

1.4.1 Safety Symbols

This manual uses three types of risk classification, as follows:

Attention

The **Attention** symbol is used to inform the user to the fact that an operating or maintenance procedure is potentially dangerous, demanding more attention while being performed. People can get slightly or moderately injured, and damage to the equipment may occur.

Warning

The **Warning** symbol is used to warn the user against a potentially dangerous operating or maintenance procedure, where extreme care must be exercised. Serious injuries or death may happen. Possible irreversible damage to the equipment may occur.

Electric Shock Risk

The **Electric Shock Risk symbol** is to alert the user against an operating or maintenance procedure that, if not strictly followed, may cause electric shock. Slight, moderate, severe injuries may happen or death may occur.

1.4.2 General symbols

This manual uses the following symbols for general purposes:

Important
The **important** symbol is used to stress relevant information.

Tip
The symbol **Tip** represents instructions which make the use or access to functions of the Periscope easier.

1.4.3 Minimum recommended profile of the person operating and maintaining the LAD

Equipment installation, maintenance and operation in electric power substations require special care and, therefore, all recommendations in this manual, applicable standard, safety procedures, safe work practices and good judgment must be exercised and used during all handling phases of the Temperature Monitor for Dry Transformers (LAD).

For the purposes of using this manual, an authorized person who has gone through appropriate training is aware of the inherent risks, both electric and environmental, when handling the LAD.

Only authorized and trained people – operation and maintenance personnel – should handle this equipment.

a) The operator, or the maintenance person in charge of the equipment must be trained and authorized to operate, ground, and turn the LAD on and off following the maintenance procedures according to the established safety practices, that are under the total responsibility of the operator and the maintenance crew of the LAD;
b) Be trained in using PPEs and CPEs and first aids;
c) Trained on the LAD working principles, as well as its configuration.
d) Follow the regulatory recommendations about interventions in any kind of equipment in an Electric Power System.

1.4.4 Minimum recommended profile of the person operating and maintaining the LAD

The following program lists important information about the environmental and voltage requirements:

Condition	Interval / Description
Application	Equipment to be installed in sheltered locations in substations, industrial facilities and similar.
Indoor/ Outdoor Use	Indoor Use
Protection Grade (IEC 60529)	IP 20
Altitude* (IEC EN 61010-1)	Up to 200 m
Temperature (IEC EN 61010-1)	
Operation	-10 °C to +70 °C
Storage	-40 °C to +85 °C
Relative Humidity (IEC EN 61010-1)	
Operation	5% to 95% – Not Condensed
Storage	3% to 98% – Not Condensed
Fluctuation of the Power Supply Voltage (IEC EN 61010-1)	Up to ±10% Nominal Voltage
Overvoltage (IEC EN 61010-1)	Category II
Degree of Pollution (IEC EN 61010-1)	Degree 2
Atmospheric Pressure ** (IEC EN 61010-1)	80 kPa at 110 kPa

* At altitudes over 2000m there are already successful applications.
** At pressures under 80 kPa there are already successful applications.

1.4.5 Test and Installation Instructions

This manual must be made available to the ones that are responsible for the installation, maintenance and users of the Temperature Monitor for Dry Transformers – LAD.

In order to ensure safety for users, as well as equipment protection and correct operation, the following minimum recommendations must be followed while installing and maintaining the LAD:

1. Read this manual carefully before installing, operating or maintaining the LAD. Errors in the installation, maintenance or in the LAD setup may cause problems in the OLTC operation, insufficient voltage regulation, unnecessary alarms or yet lack of relevant alarms.
2. LAD installation, setup and operation must be done by trained personnel well acquainted with power transformers or voltage regulators, control devices and substation equipment command circuits.
3. Special attention should be paid to the installation of the LAD (Chapter 3 - Project and Installation), including cable type and gauge and terminals used, as well as to the startup procedures (Chapter 5 - Procedure to Start Operation), including the correct parameterization of the equipment (Chapter 4.4 - Parameterization Menus).

The LAD must be installed ina shelter of some kind, (a panel without doors in a control room or a closed panel if installed outdoors) that does not exceed the temperature and humidity specified for the equipment.

The LAD should not be installed next to heat sources such as heating resistors, incandescent bulbs or high voltage devices or devices with heat sinks. It is not recommended either that it be installed close to vents or where it may be hit by a forced air flow such as cooling fan outlet or inlet or ducts of a forced air cooling system.

1.4.6 Cleaning and Decontamination Instructions

Be careful when cleaning the LAD. Use ONLY a clean cloth with soap or detergent diluted in water to clean the cabinet, front panel or any other part of the equipment. Do not use abrasive cleaning materials, polishing products or aggressive chemical solvents (such as alcohol or acetone on any of its surfaces.

Turn off and disconnect the equipment before cleaning any part of it.

1.4.7 Inspection and Maintenance Instructions

When inspecting or maintaining the LAD, the following recommendations must be followed:

Do not open your equipment. The user cannot repair any of its parts. This must be done by Treetech's customer service team, or by its accredited technicians. This equipment is completely maintenance-free and the user can regularly perform visual and operational inspections of it, periodically or not. Those inspections are not mandatory.

If the LAD is opened at any time its product warranty shall be voided. In case the equipment has been unduly opened, Treetech will be unable to guarantee that it works appropriately, regardless of warranty and expiration date.

All parts of this equipment shall be supplied by Treetech, or by one of its accredited vendors according to its specifications. If the user wants to purchase the parts from other source, the user must strictly follow Treetech's specifications for this purpose. Therefore, user performance and safety will not be compromised. If these specifications are not followed, the user and the equipment may be exposed to unforeseen risks.

1.5 Technical Support

In order to obtain technical support for the LAD or any other Treetech product, contact us at the address below:

Treetech Digitals Systems Ltda. – Technical Support
Rua José Alvim, 100 – Salas 03 e 04 – Centro
Atibaia – São Paulo – Brasil
Zip Code 12.940-800
CNPJ (corporate taxpayer ID): 74.211.970/0002-53
IE: 190.159.742.110
Phone: 011 + 55 (11) 2410-1190 x201
FAX: 011 + 55 (11) 2410-1190 x702

1.6 Warranty

The Temperature Monitor for Dry Transformers - LAD shall be covered by Treetech's warranty for 2 (two) years, counting from the date of purchase, exclusively against eventual manufacturing defects or quality flaws that may prevent it from being used regularly.

The warranty does not cover damage undergone by the product as a consequence of accidents, mishandling, incorrect installation and application, inadequate tests or broken warranty seal.

The eventual need for technical support must be communicated to Treetech or to its authorized representative, and the equipment should be shipped back to them with the respective sales receipt.

No express or implied warranty, in addition to those mentioned above is provided by Treetech. Treetech does not guarantee that the LAD will be adequate to any particular application.

The seller will not be liable for any type of damage to property or any losses and damages that may appear, are connected, or result from purchasing this equipment, from its performance or any service that may be supplied together with the LAD.

Under no circumstances shall the seller be liable for any losses, including but not limited to: loss of profit or performance, impossibility of using the LAD or any associated equipment, capital costs, energy costs, cost of acquired power, equipment costs, installations or substitute services, stoppage costs, client complaints, claims filed by the client's employees, and it does not matter whether the aforementioned damages, claims or losses are based on the contract, warranty against negligence, a crime or anything else. Under no circumstance, the vendor shall be deemed liable for any personal damage, of any sort.

1.7 Revision History

Revision	Date	Description	Revised by
1.00	4/12/2014	*Initial Emission*	Eric Dias

2 Introduction

Technical thermal monitoring of electric equipment such as dry transformers, engines, generators and others is essential for their safe operation, allowing the user to obtain from these assets the highest investment for the best use of the equipment without risk to its service life.

The LAD Temperature Monitor adds low cost and high reliability, thus providing monitoring and thermal protection to these pieces of equipment, and making their operation safer while obtaining the best use of assets and minimizing the risks to the safety of the users, installations and service life of the monitored equipment.

The LAD Temperature Monitor has six temperature measurement inputs allowing multiple temperatures to be monitored. Here are some of the typical applications of the LAD, among others:

- Monitoring temperatures of the three windings of two dry transformers;
- Monitoring temperatures of the oil of small transformers where it is not necessary to measure the winding temperature (*for winding temperature, see TM1/TM2 catalog)*;
- Stator, bearing, lube oil temperatures etc. in engines, motors and generators.
- Monitoring temperatures of five places in a certain dry transformer plus the ambient temperature where the transformer is installed.

For each monitored temperature, certain values are individually adjusted for alarm and disconnecting the equipment. There are also optional settings to automatically turning on the forced cooling - for example, *fans or pumps* – in two stages.

2.1 Main Features

The LAD Temperature Monitor for Dry Transformers has a series of useful features, which are described below:

- IED (Intelligent Electronic Device) specifically planned to be applied in dry transformers in substations and industrial or commercial facilities;
- Local indication of temperatures on a display, with a programmable indication mode: indication of the highest temperature, automatic screen scrolling or indication of a fixed measurement;
- Extended temperature measurement range from -55 through 200 °C;
- Engineering algorithm for online calculation of the aging of the insulation ;
- Optional cooling exercise function, to prevent fan failure;
- High brightness LED display for easy viewing;
- RS-485 serial communication port for integration to supervision or monitoring remote system integration. Open communication protocols Modbus-RTU or DNP3 (Optional);
- Inputs for up to six temperature sensors of the RTD Pt-100 at 0 °C with self-calibration, guaranteeing high precision and stability throughout the ambient temperature range;

Figure 1: Temperature Monitor for Dry Transformers – LAD

2.2 Optional functions

According to the order, the LAD can be supplied with one or more of the following optional functions:

Optional 1 - DNP3 Protocol

User-selectable communication protocol; the user can choose between Modbus- RTU and DNP3 level 1, with timestamp support with 1ms accuracy.

Optional 2 – Analog Output

Programmable analog output for remote temperature indication, selectable by the user, for the indication of the highest temperature or a predetermined temperature.

Programmable output range: 0-10, 0-20 or 4-20 mA.

Option 3 - Fan Exercise

The Cooling or Fan Exercise function prevents lack of fan activity for long periods of time, in equipment operating with a low load or during low ambient temperature seasons. This is done so the axis is not blocked due to dirt or dry grease buildup. Cooling equipment must be activated daily, according to the internal clock of the equipment and depending of the previous selections made by the user.

Option 4 - Winding Insulation Aging Online Calculation:

The Aging Calculation Function performs the online monitoring of the loss of service life of the winding insulation, therefore making important information available for the diagnosis and prognosis of the equipment state:

- Current percentage of remaining service life, from 100% (new insulation) to 0% (end of insulation service life);
- Average loss of insulation life, in % a day, calculated for a period of time chosen by the user;
- Extrapolation of the remaining service life of the insulation, calculated as a function of the

aforementioned variables (remaining life percentage and average loss of life rate).

The standards used for this calculation are chosen by the operator, according to the transformer manufacturer's recommendations. 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 Operation Philosophy

Temperature is measured through Pt-100 Ω resistive sensors at 0 °C, which are installed at the place the temperature is to be monitored. The sensors are connected directly to the LAD, and no external transducers are necessary. Six temperature measurement inputs are available. Independent alarm and disconnection levels can be programmed for each sensor.

The working mode of the reversible contacts can be selected as normally open (NO) or normally closed (NC), through the equipment's programming menus.

In addition to that, for each output contact, regardless of the working mode, the contact with the opposite function is also available (reversible contact). Therefore, several data acquisition logics can be used without the need to duplicate or reverse the contacts.

The LAD has a self-diagnosis contact, which signals any condition in which a measurement failure occurs, auxiliary power supply failure or equipment internal failure. This is also a reversible and programmable contact.

The forced cooling activation is conditioned to the highest among the measured temperatures, and the activation value of the first and second stages is programmable, as well as the hysteresis for ventilation shutdown.

The RS-485 serial communication channel, through the Modbus protocol allows access to programming and checking LAD parameters, measurements and memory. The DNP3 protocol (optional) can be used for this same purpose.

3 Project and Installation

3.1 System Topology

Due to being a stand-alone equipment, the gas monitoring system of the GMP is made of just a few modules, which are easily installed:

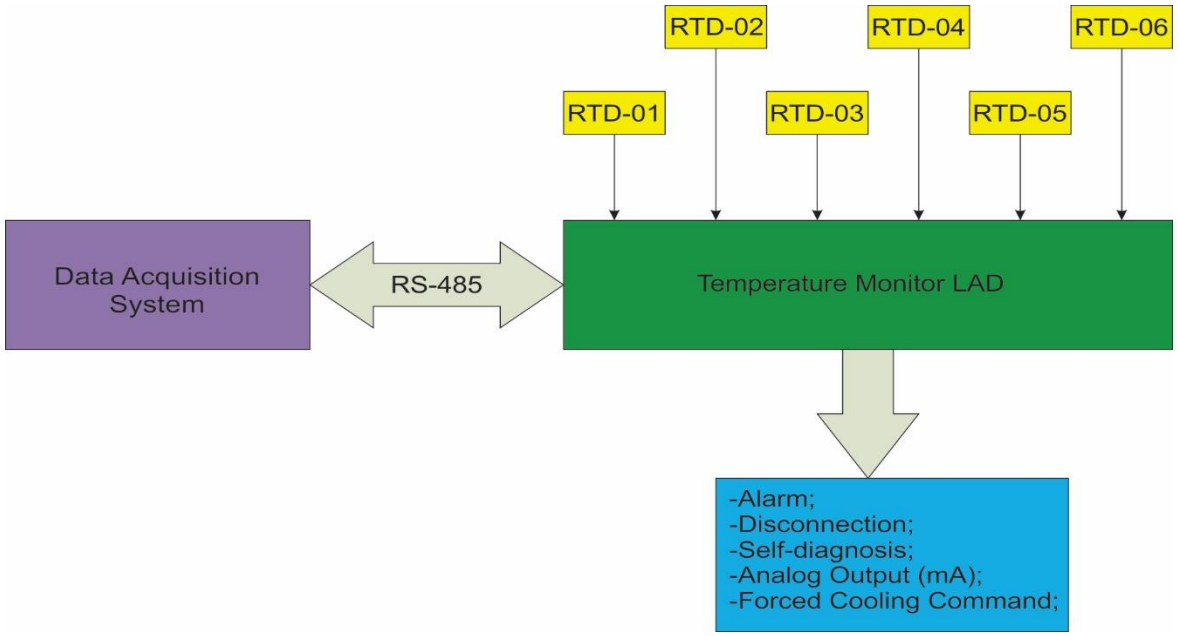


Figure 2: Composition of the Temperature Monitoring system

The items that are necessary to install the system are:

- LAD Temperature Monitor;
- RTD Pt-100 Ω Sensors at 0 °C. (Quantity according to the desired configuration);
- Three-way shielded cable to connect the RTD sensors;
- Shielded two-way twisted pair cable for serial communication (optional);
- Box for outdoor installation (optional)

3.2 General considerations

The RTDs - the temperature sensors - must be connected to the Temperature monitor through a shielded cable, without interrupting the grid, which should be grounded at the end connected to the LAD.

The RS-485 serial communications port must be connected through a shielded twisted pair, keeping the grid uninterrupted, until its ter minals, and grounding only one of the extremities. The maximum distance allowed for this type of serial communication is 1200m.

The alarm, disconnection and self-diagnosis contacts, in addition to being reversible, can be configured to work in a normally open (NO) mode or normally closed (NC) mode through the Relays menu. It is possible, then, to obtain several advantages from this flexibility. One of them is the duplication of contacts considering a reverse working logic in the final application, without harming the safety or operating speed of the contact for the critical application.

3.3 Mechanical installation

The LAD Temperature Monitor must be installed in a place that is protected from the weather inside panels or buildings. In any case, an anti-condensation system must exist. The LAD Temperature monitor is adequate to be installed in a closet, and can be fastened, for example, on panel doors or front plates. Fasteners and mounting hardware in general are provided with the LAD. See below the main dimensions of the equipment, as well as the dimensions of the cutout on the plate to insert it.

Special attention must be paid to the thickness of the painting layers of the plate where the

mounting hole is to be cut, because in some cases, when high thickness paint is used, the resulting reduction in the hole may even prevent the insertion of the equipment. Connection terminals are installed in the rear plate of the LAD, in two fixed connectors. Cables measuring 0.3 to 2.5mm can be used, either bare or with pin or needle terminals.

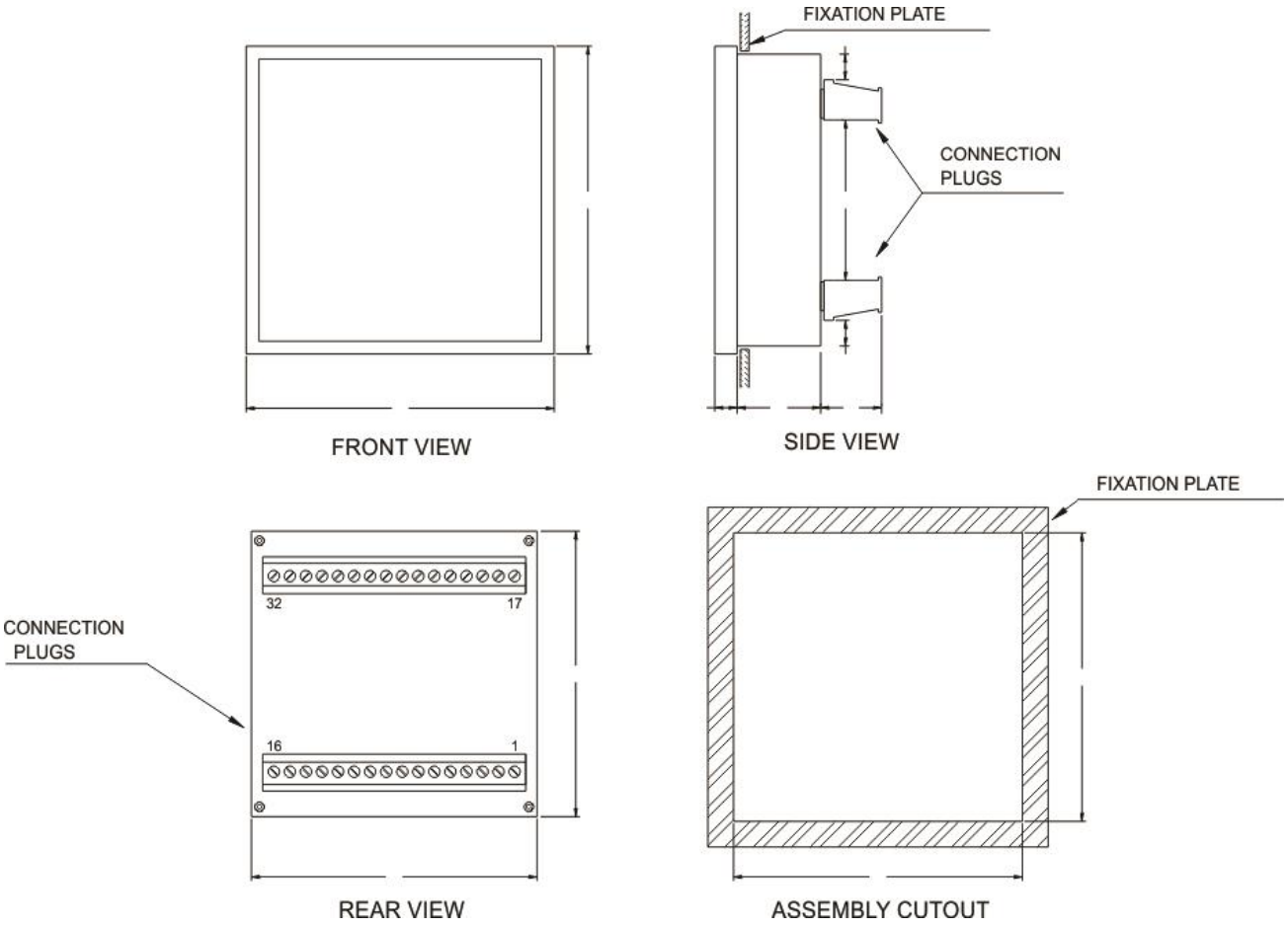


Figure 3: Equipment Dimensions - LAD

3.4 Electric Installation

The LAD is a versatile equipment, which can be used in several different types of applications. Due to that, its installation requires a level of study and care higher than equipment that is dedicated only to one application or task.

Study and understand the application in which you intend to use the LAD.
Know the operating, electric and configuring characteristics of the LAD.
Therefore, you will be able to obtain the best performance from the equipment as well as minimize the risks to its safety.

This equipment works at dangerous power voltage levels, and it may cause death or severe injury to its operator or to the maintenance crew.

The project and the installation of the LAD require some special care as described below:

A circuit breaker should be used immediately before the power supply input *(Universal power supply - 38 ~ 265 Vdc/Vac, <5 W, 50/60 Hz)*, corresponding to pins, 1 and 2 of the LAD. This circuit breaker should have a pole number corresponding to the number of phases in the power supply – and the poles should interrupt only the phases, never the neuter or the ground – and provide electric and thermal protection to the wires supplying power to the equipment.
The circuit breaker must be close to the equipment and be easily handled by the operator. Additionally, it must have an indelible identification showing that it is the LAD's electric disconnection device.

The following circuit breaker specification is recommended, when it is used exclusively for the LAD:
AC/DC power supply, Phase-Neuter: Monopolar circuit breaker, 1 A ≤ In ≤ 2 A, B or C bends, standards.
NBR/IEC 60947-2, NBR/IEC 60898 or IEEE 1015-2006;
AC/DC power supply, Phase-Phase: Bipolar circuit breaker, 1 A ≤ In ≤ 2 A, bend B or C, standards.
NBR/IEC 60947-2, NBR/IEC 60898 or IEEE 1015-2006.

The minimum insulation for the circuits connected to the LAD is 300 Vrms for auxiliary equipment and auxiliary transducers, such as Pt-100 and for equipment with its own power supply up to 50 Vrms.
The minimum insulation is 1.7 kVrms for equipment supplied up to 300 Vrms, as per IEC EN 61010-1.
These values are relative to intrinsic insulation of the devices connected to the LAD. If this value does not apply to equipment or devices connected to the LAD this will be explicitly informed in this manual.

The LAD connection schematics in the Standard version, which does not have a mA analog output, is shown in **Figure 4**.

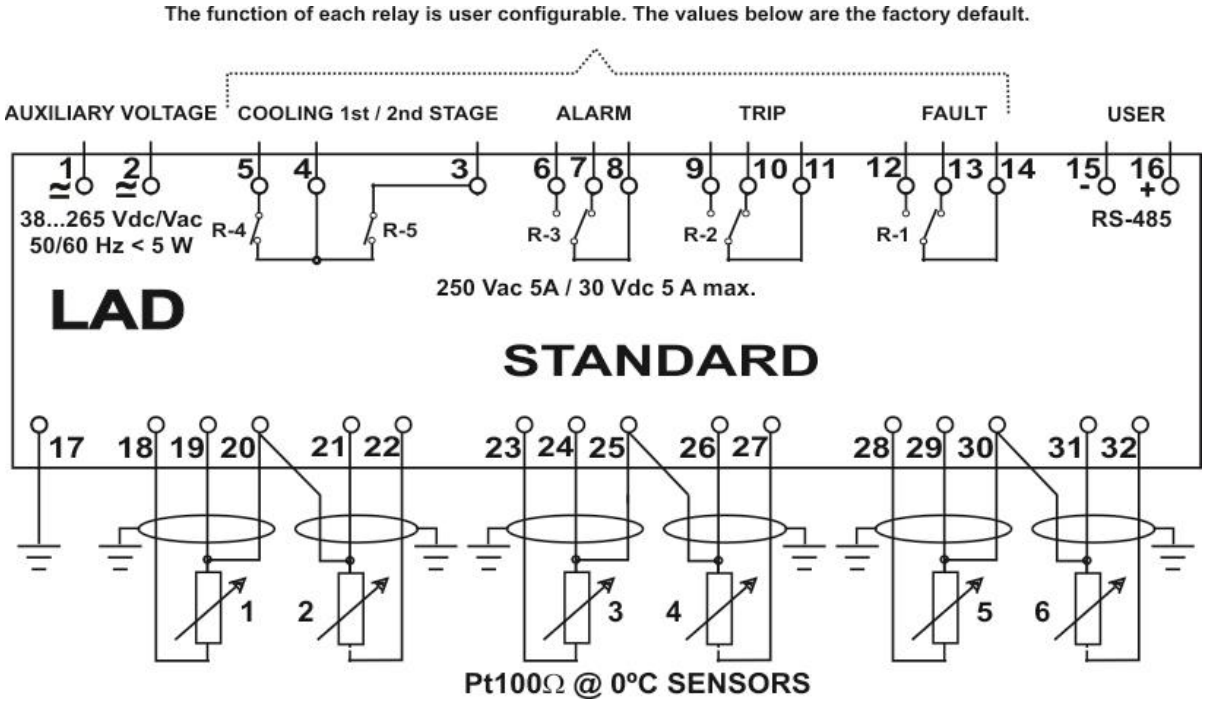


Figure 4: Input and Output Terminals of the LAD in its standard configuration.

The LAD's connection diagram in case the optional "Analog Output" "is used, is shown in **Figure 5**.

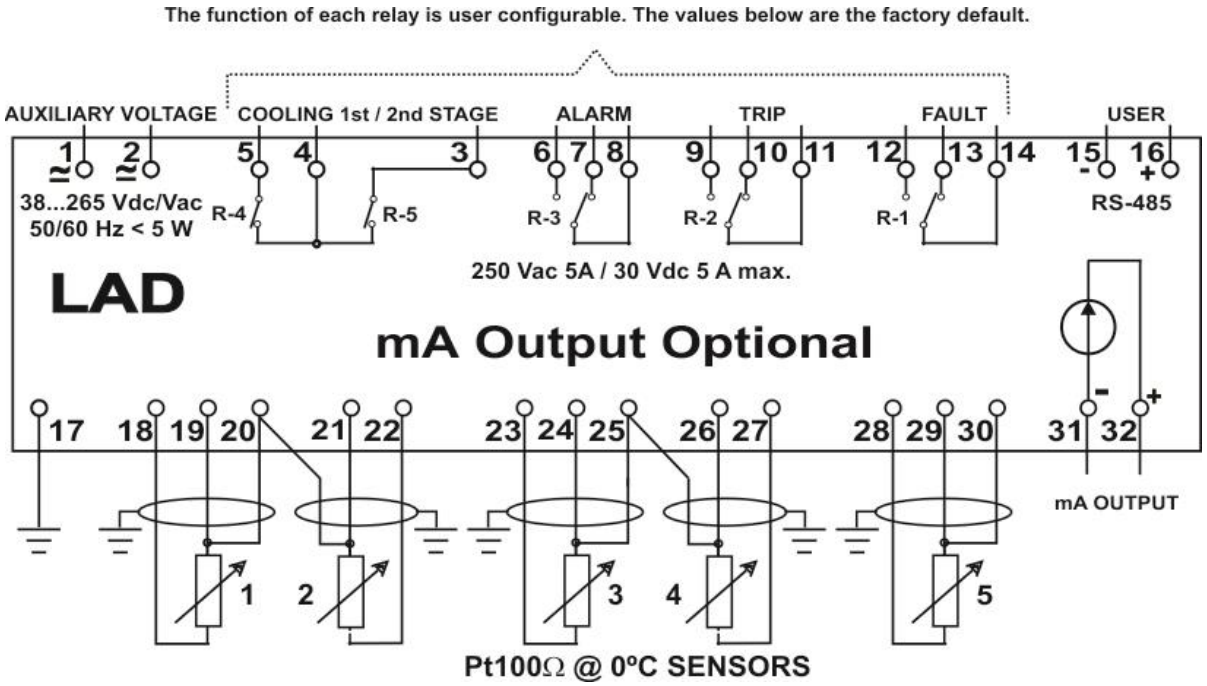


Figure 5: Input and Output Terminals of the LAD in its standard configuration.

When using the option “Analog Output”, the measurement input of the temperature sensor number 6 is not available.

Special attention must be paid to the correct connection of the LAD, in all the steps of the installation. Errors in equipment connection can cause risks to the operator and irreversible damage to the equipment. Damage for misuse is not covered by the warranty.

3.4.1 Input Terminals

The LAD can be divided, in order to simplify its understanding, in blocks of input and output terminals. These blocks shall be explained one by one. The Input block is shown in **Table 1**.

Table 1: LAD Input Terminals

INPUTS	TERMINALS
1) Power Supply and Grounding: Input for universal power supply 38 to 265 Vdc/Vac, 50/60 Hz, <5 W	*17 – ground* *01 – dc/ac* *02 – dc/ac*
2) RS-485 Port – Serial Communication Network with Monitoring or Supervisory System. Connection to a monitoring or supervisory system using the MODBUS- RTU protocol or DNP3 (optional), via shielded twisted pair cable.	*15 – (-)* *16 – (+)*
3) RTD 01 Temperature Sensor: Input for direct connection of a Pt-100 Ω sensor at 0 °C, in the three-wire measurement configuration. Color standardization das cores for the Pt-100 head follows IEC-60751 standards.	*18 – (White)* *19 – (Red)* *20 – (Red)*
4) RTD 02 Temperature Sensor: Input for direct connection of a Pt-100 Ω sensor at 0 °C, in the three-wire measurement configuration. Color standardization das cores for the Pt-100 head follows IEC-60751 standards.	*22 – (White)* *21 – (Red)* *20 – (Red)*
5) RTD 03 Temperature Sensor: Input for direct connection of a Pt-100 Ω sensor at 0 °C, in the three-wire measurement configuration. Color standardization das cores for the Pt-100 head follows IEC-60751 standards.	*23 – (White)* *24 – (Red)* *25 – (Red)*
6) RTD 04 Temperature Sensor: Input for direct connection of a Pt-100 Ω sensor at 0 °C, in the three-wire measurement configuration. Color standardization das cores for the Pt-100 head follows IEC-60751 standards.	*27 – (White)* *26 – (Red)* *25 – (Red)*
7) RTD 05 Temperature Sensor: Input for direct connection of a Pt-100 Ω sensor at 0 °C, in the three-wire measurement configuration. Color standardization das cores for the Pt-100 head follows IEC-60751 standards.	*28 – (White)* *29 – (Red)* *30 – (Red)*
8) RTD 06 Temperature Sensor: Input for direct connection of a Pt-100 Ω sensor at 0 °C, in the three-wire measurement configuration. Color standardization das cores for the Pt-100 head follows IEC-60751 standards.	*32 – (White)* *31 – (Red)* *30 – (Red)*

1) Power Supply and Grounding

The LAD has a universal power supply input (38 to 265 Vdc/Vac - 50/60 Hz).

It is recommendable to supply power to the LAD through the auxiliary substation services especially when this is integrated to a serial communication network for the purpose of collecting data for supervisory or monitoring systems.

2) RS-485 Port - Supervisory System

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

Up to 31 units can be connected in a same communication network. The standard/default communication protocol is the Modbus-RTU, and the DNP3 protocol is also available as optional. Consult the Communication **Protocols document LAD – 1.0-pt** for details of the protocols of communication.

The connection between the LAD and the data acquisition system must be through a shielded twisted pair cable, keeping the network uninterrupted throughout its path. If it is necessary to have intermediate end terminals for serial communication purposes, the cable shielding should be passed through a terminal so it is not interrupted. The unshielded cable stretch due to a patch must be the shortest possible and it is recommendable that the shielding of the cable is grounded in only one end. The maximum distance of 1200 m between the extremes of the communication network must be obeyed.

If there is a communication problem, especially where there are long networks (distance over 1000 m) and high transmission rates (over 9600 bps), the use of a termination resistor of 120 Ω in each end of the serial communication network may solve these transmission errors, through the attenuation of the reflection of the signal in the cable.
Another measure, which can be tried, is to install *pull-up* and *pull-down* resistors only in one point of the network, according to what has been indicated in Figure 6. The direct voltage of 5 V to supply e *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 inside, therefore do not need external resistors.

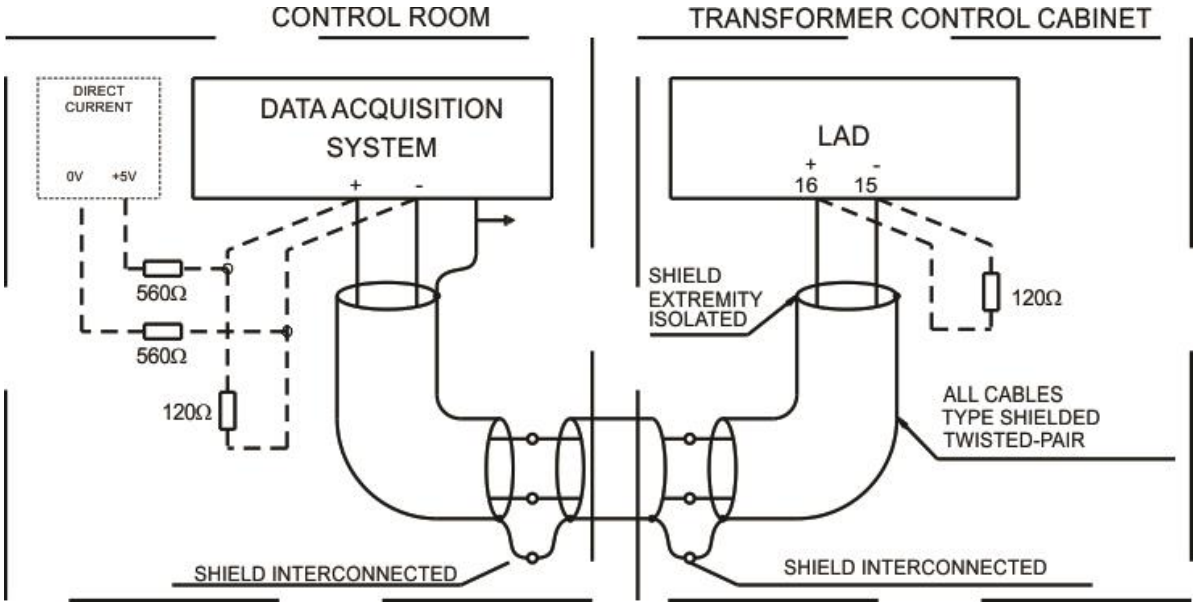


Figure 6: Connection and grounding of the RS-485 serial communication

3) Temperature Sensors RTD 01 to 06

Up to 06 RTD temperature sensors can be connected to the LAD through shielded cables, without interruption of the networks, which must be grounded only at the end that is connected to the LAD, as close as possible to it.

If there is any need for intermediate terminals to link RTD sensors, pass the cable shielding through the terminal too so it is not interrupted. The part of the cable that is unshielded due to a patch must be the shortest possible as shown in **Figure 7**.

Whenever the "Analog Version" LAD is used, only inputs 1 through 5 will be available.

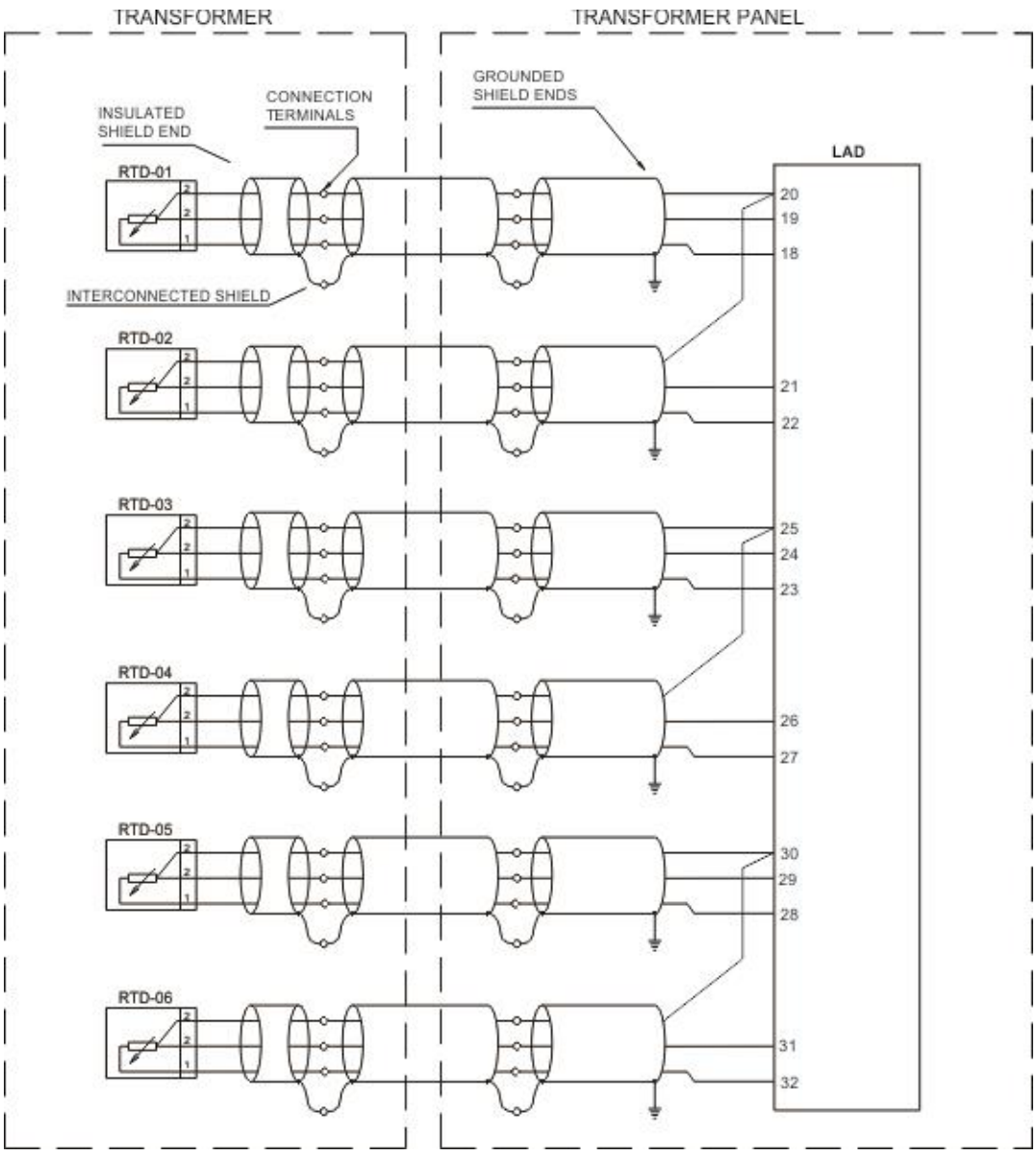


Figure 7: Connecting the shielding of the link between RTD and LAD sensors in the standard configuration

3.4.2 Output Terminals

The LAD can be divided, in order to simplify its understanding, in blocks of input and output terminals. These blocks shall be explained one by one. The output block is shown in **Table 2**.

Table 2: LAD Input Terminals

OUTPUTS	TERMINALS
1) Relay 1 – Self-diagnosis: A potential-free reversible relay, with NC or NO (NF or NA) initial logic selectable by the user, it signals power supply failure, internal failure or measurement sensor failure.	*12 – NO* *13 – NC* *14 – Common*
2) Relay 2 – Shutdown: A reversible relay, potential-free, with initial user-selectable NO or NC-logic used to protect the transformer.	*09 – NO* *10 – NC* *11 – Common*
3) Relay 3 – Alarm: A reversible relay, potential-free, with user-selectable NO or NC initial logic signals a high temperature alarm.	*06 – NO* *07 – NC* *08 – Common*
4) Relay 4 – Forced Cooling Command - First Stage: A NC (NF) potential-free relay to command the first stage of forced cooling.	*04 – Common* *05 – NC*
5) Relay 5 – Forced Cooling Command - Second Stage: A NC (NF) potential-free relay, to command the second stage of the forced cooling.	*04 – Common* *03 – NC*
6) Current Loop output – Analog Output (Optional)[1]: An output for the remote indication of the measured temperature, selected through the programming menu in the LAD itself. Output pattern selected by the user from the following options: 0-10 mA, 0-20 mA or 4-20 mA.	*32 – (+)* *31 – (-)*

1) Self-Diagnostic Relay

It is formed by a reversible, potential-free relay, with NO or NC initial logic, selectable by the user. It signals power supply failure, or any internal failures detected by the diagnosis system.

When the LAD is energized this contact changes its state, going back to the resting position when there is an internal flaw or lack of power supply. The self-diagnosis contact may commute loads in up to 250 Vac / 30 Vdc, with a conduction capacity of 5 A.

2) Disconnection Relay

The disconnection relay of the LAD may be directly connected to the transformer's protection circuit. This contact remains activated for the whole period during which the disconnection condition occurs. It is formed by a reversible, potential-free relay, with NO or NC initial logic, selectable by the user.

The disconnection contact may commute loads in up to 250 Vac / 30 Vdc, with a conduction capacity of 5 A.

3) Alarm Relay

The alarm contact of the LAD can be connected directly to the transformer protection circuit. This contact remains active during all the whole period in which the condition of alarm is occurring. It is formed by a reversible potential-free relay, with NO or NC (NA or NF) logic selectable by the user. The alarm contact may commute loads in up to 250 Vac / 30 Vdc, with a conduction capacity of 5 A.

4) Forced Cooling Command Relay - First Stage

NC potential-free contact to command the first stage of forced cooling. After it energizes the LAD this contact changes states, returning to the off position to turn on the cooling. If there is any failure, this contact returns to the resting position, consequently, in this situation the cooling is activated as a preventive measure.

The command contact of the first stage of the forced cooling can switch loads in up to 250 Vac / 30 Vdc, with a conduction capacity of 5 A.

5) Forced Cooling Command Relay - Second Stage

Potential-free contact (NC) for commanding the second stage of forced cooling. After it energizes the LAD this contact changes states, returning to the off position to turn on the cooling. If there is any failure, this contact returns to the resting position, consequently, in this situation the cooling is activated as a preventive measure.

The forced cooling second stage contact may commute loads in up to 250 Vac / 30 Vdc, with a conduction capacity of 5 A.

The LAD shows a unique flexibility in the use of its signaling relays.
The functions for each contact shown in this manual are only the default values and can be freely altered by the user to meet the specific needs of his application.

The LAD reversible relays can be used together with the default configuration to meet various needs of any kind of application.

6) Current Loop Output - Analog Output (Optional)

The LAD has a current loop analog output (mA) that may be programmed by the user to remotely indicate the value of the measured temperatures. The output current range can also be selected by the user between options 0-10, 0-20 or 4-20 mA. The maximum output current load is 10 V, which result in the maximum loads in ohms shown below:

Table 3: Maximum current loop output load

Output Option	Maximum Load
0-10 mA	1000 Ω
0-20 mA	500 Ω
4-20 mA	500 Ω

Both the beginning and the end of scale are programmable, in the -55 °C to +200 °C range. The output variable can be selected among any one of the measure temperatures or always the highest among them.

It is recommendable to use a shielded twisted pair cable, grounded in just one of the extremities, to minimize the interferences.

4 Operation and Exhibition of Measurements in the LAD

4.1 Local Interface

All operations in the Temperature Monitor are entered through the frontal panel, shown in **Figure 8** and no keys or external buttons are needed.

Temperatures are indicated in the display, and the forced cooling alarms, disconnection or command conditions will be indicated by the signaling LED's.

If any of the temperature sensors fails, the LAD signals it through a specific LED. The LAD also has a LED that is dedicated to indicating internal equipment failure.

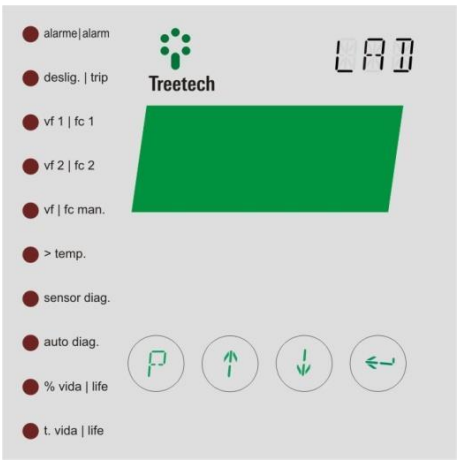


Figure 8: LAD Frontal Display

Table 4 shows the LAD frontal keyboard functions.

Table 4: Functions of the Programming Keys

	**Programming Key** In the measurement screens, it allows to select the working mode of the forced ventilation (manual or automatic) and also access to password to enter the programming menu. In the programming menus, it leaves the current menu and returns to the previous menu. . If it is activated during the alteration of a parameter, it goes back to the prior level in the menu without saving any changes
	**Up Arrow Key** It navigates between temperature measurements, between programming menus and increases programmed values.
	**Down Arrow Key** It navigates between temperature measurements, between programming menus and decreases programmed values.
	**Enter Key** Selects the menus and parameters, saves programmed values and resets the maximum temperatures that were recorded.

Table 5 shows the function of the signaling LEDs on the LAD's frontal panel.

Table 5: Signaling LEDs' functions

alarme|alarm	They signal the occurrence of an alarm event. This event takes place when the measured temperature reaches the disconnection limit, which was configured.
deslig. | trip	Signals the occurrence of a shutdown event. This event takes place when the measured temperature reaches the disconnection limit, which was configured.
vf 1 | fc 1	Signals the activation of the first forced cooling group.
vf 2 | fc 2	Signals the activation of the second forced cooling group.
vf | fc man.	Signals that the forced cooling has been activated manually.
> temp.	Signals the automatic display of the highest temperature.
sensor diag.	Signals an abnormality in one of the temperature sensors, detected by self-diagnosis.
auto diag.	Signals an abnormality inside the LAD, detected by self-diagnosis.
% vida | life	Signals that the percentage of remaining life time of one or more windings is below the minimum programmed limit (only if the Aging Calculation Optional Function is available)
t. vida | life	Signals that the remaining life time of one or more windings is below the minimum programmed limit (only if the Aging Calculation Optional Function is available)

In order to verify what is the firmware version of the LAD, press the following keys simultaneously: P and ← . The complete number of the firmware version will be displayed for some seconds.

4.2 Measurement and status Indications

4.2.1 Temperature Measurements

During normal working mode, the LAD Temperature Monitor will indicate on its display the temperature measured as selected by the user:

- Always show the highest temperature;
- Always show just the temperature for one the sensors;
- Always show the temperatures of all sensors as a sequence, indicating the measurement taken by each one of the sensors for 10 seconds.

Nevertheless, at any time, the user can manually check any temperatures taken by each sensor through keys ↑ and ↓.

In order to differentiate the measurements of each one of the six temperature sensors, their respective names name alternates on the display with the value of the measured temperature, as shown in Figure 9. Sensors 1 to 6 are identified in the display with the acronyms rtd 1, rtd2 ... rtd6.

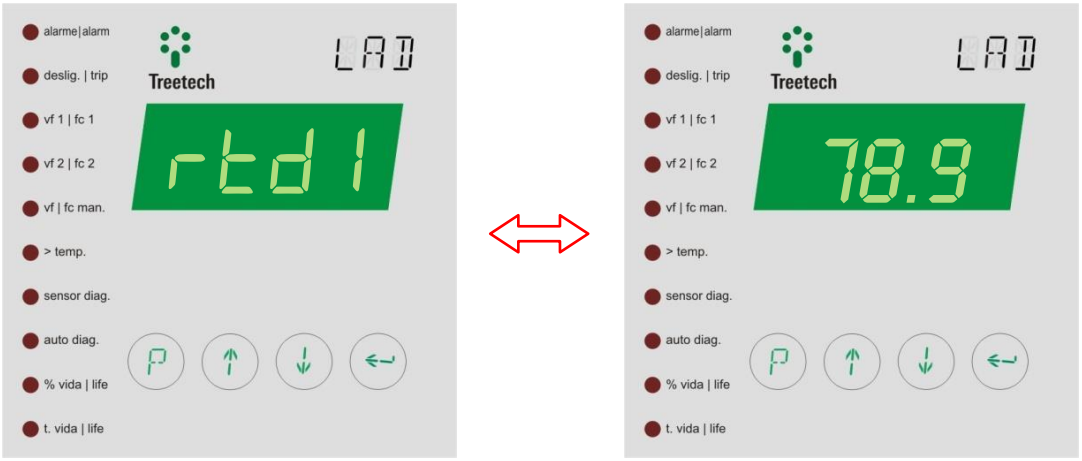


Figure 9: Temperature indications on the display

4.2.2 Winding Aging

Whenever the Aging Calculation Option is available, it is also possible to check on the display the remaining service life percentages for each measured winding as well as the estimated remaining service lifetime. In order to differentiate the indications regarding each one of the six windings, the identification texts are presented alternating with the values, as shown in **Figure 10**, **Figure 11** and **Figure 12**.

Remaining life periods for the windings in years are identified on the display as LFt 1, LFt2 ... LFt6 (**Figure 11**). Whenever the extrapolation of the lifetime goes beyond 50 years, the display will show the abbreviation HI instead of a numeric value (**Figure 11**).

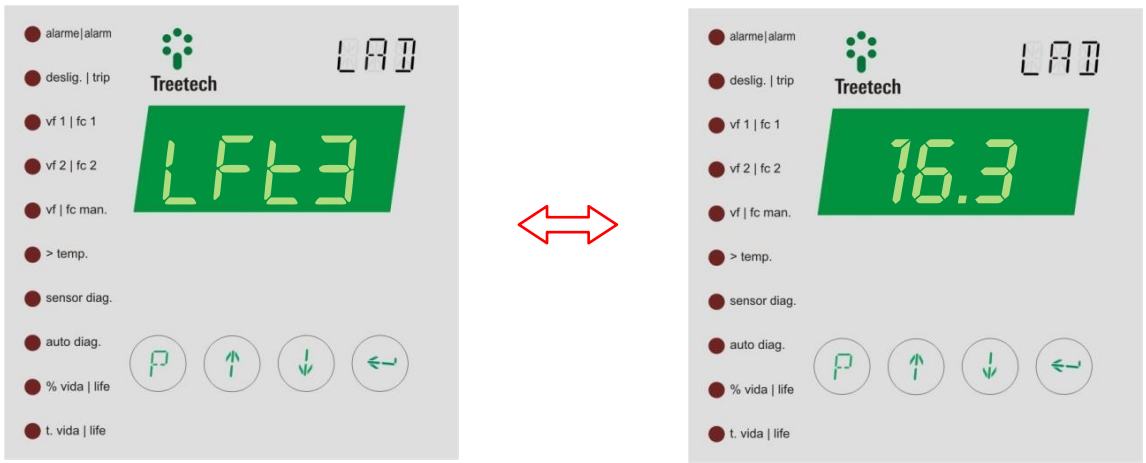


Figure 10: Life duration indications in years.

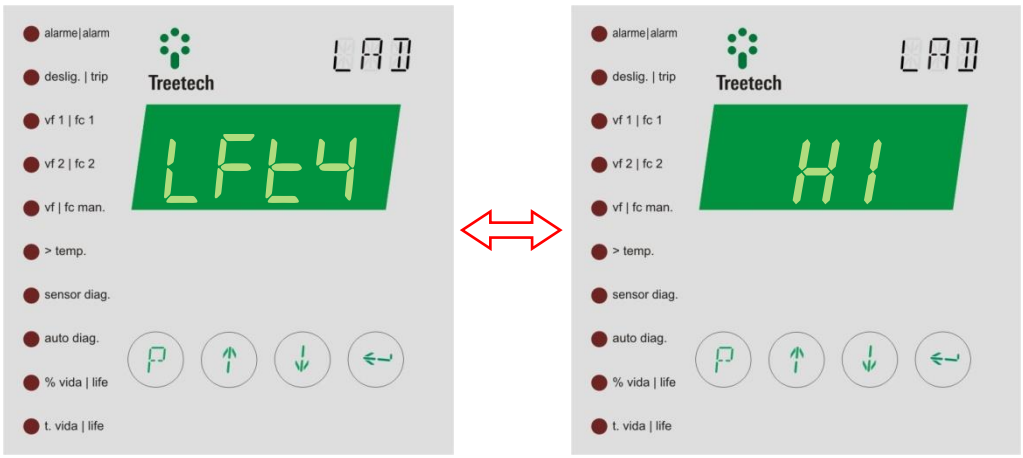


Figure 11: Life duration indications over 50 years.

The percentages of remaining service life for the 1 to 6 windings, though, are identified on the display with the following abbreviations: LIF1, LIF2 ... LIF6 (**Figure 12**).

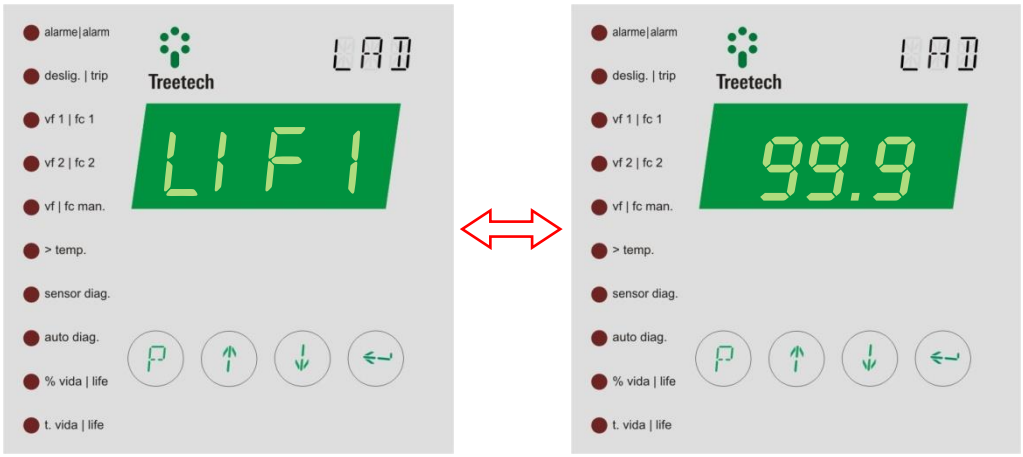


Figure 12 – Indications of the remaining life of the winding as a percentage.

4.2.3 Forced Cooling Status

Whenever the temperature value that is programmed for turning on the forced cooling in any of the stages is reached (first or second stage) the signaling LED corresponding to it will light up, also activating the output contact of this event.

Whenever the forced cooling is turned on by the user in Manual mode, the corresponding LED will indicate this condition on the frontal LAD display, as indicated by **Figure 13**.

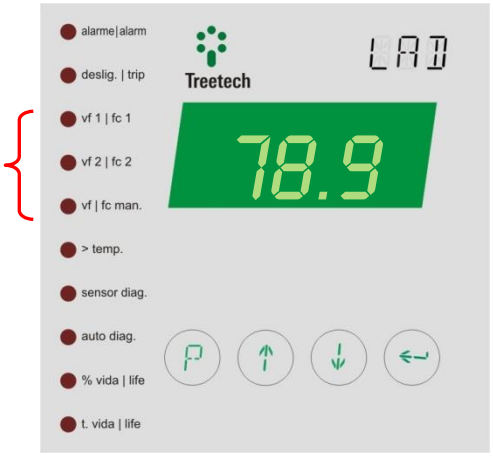


Figure 13 – Forced Cooling signaling LEDs

4.2.4 Indication of Alarms and Disconnections

Whenever the temperature value, which is programmed for an event is reached (alarm or disconnection), the corresponding signaling LED will turn on, and will also turn on the output contact of this event.

If an alarm goes off, the corresponding LED lights up and keeps on fixed, showing that some of the measured temperatures has reached the programmed value.

In order to distinguish which of the temperatures has activated the alarm, it suffices to navigate the display using the keys and .

The temperature that activated the alarm will alternate between the identification of the measurement and the temperature value faster than normal (around 1.5 s under an alarm condition and 2.5s under normal conditions). If more than one temperature has reached alarm values, the behavior is the same for all.

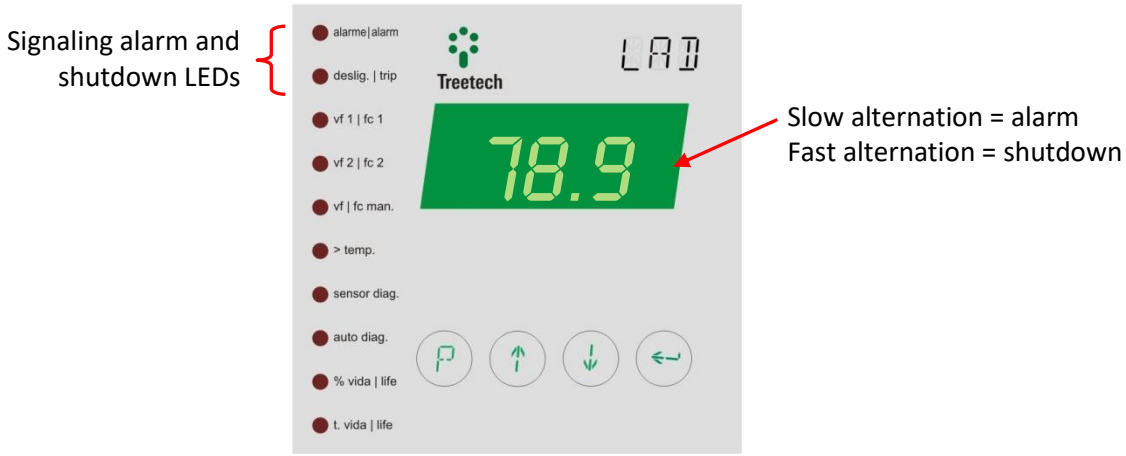


Figure 14: Alarm and/or Shutdown event indication

If there is a shutdown even the corresponding LED lights up and keeps on fixed, meaning that at least one of the measured temperatures has reached the programmed value.

The temperature that activated the disconnection will alternate between the identification of the measurement and the temperature value faster than normal (around 0.8 s in shutdown conditions,

and 2.5 s in a normal condition).

If a disconnection-timing event occurs, the LAD will automatically show the temperature at which the disconnection event took place. The LAD alternates between showing this temperature and the remaining time before shutdown (shutdown delay), as shown in **Figure 15**. The search screens are blocked, but it is possible to access only the LAD configuration.

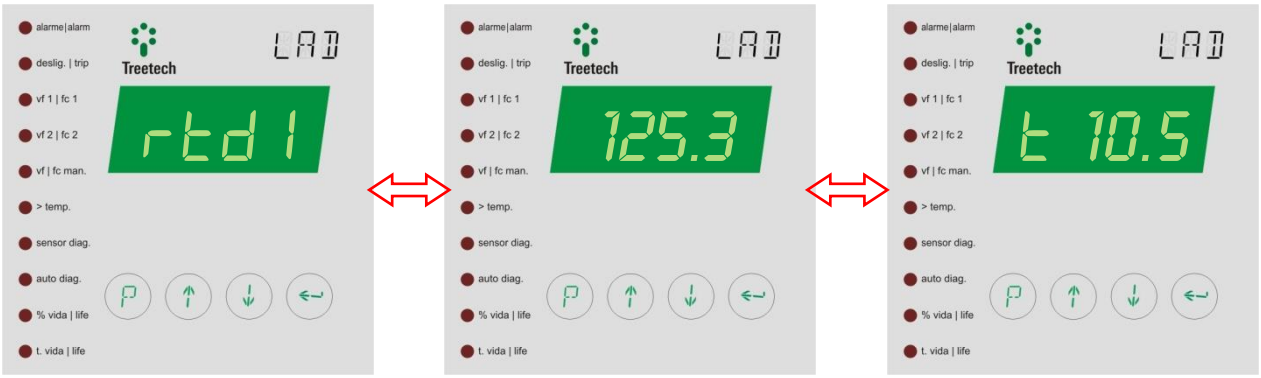


Figure 15: Temperature indication and countdown to shutdown (min.)

If more than one temperature reaches the shutdown value, the behavior is the same for all of them. The shutdown screen is shown for the first temperature that reached this value. When the countdown for this first temperature reaches zero, the next screen with a temperature reaching the shutdown level is shown.

4.2.5 Self-diagnosis Indications

If any anomaly takes place, the corresponding self-diagnosis code will be indicated on the display, as shown in **Figure 16**.

The LAD presents the self-diagnosis code blinking slowly (around 1 s). The meaning of this code can be found in **chapter 6.2 - Understanding the LAD Self-Diagnosis**.

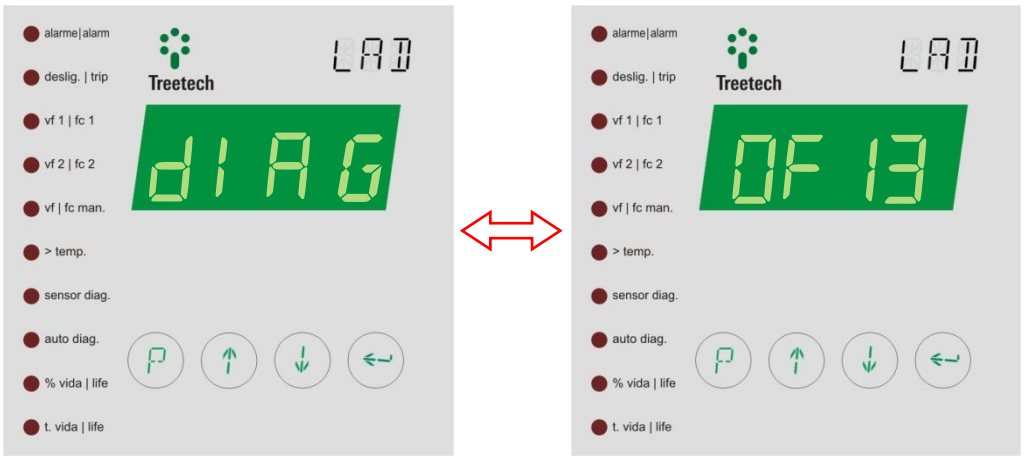


Figure 16: LAD Self-Diagnosis Indication

4.2.6 Aging Alert Screens

If the optional "Online Winding Insulation Aging Calculation" is enabled, a specific warning screen will appear when this algorithm detects an alarm situation.

When the remaining service life is below the minimum (parameterized value), an alert screen will appear, as shown in **Figure 17**. When the remaining life percentage is below the minimum (parameterized value), an alert screen will appear, as shown in **Figure 18**.

Both the alert screens appear intermittently, alternating every 5 seconds in the chosen LAD standard display mode.

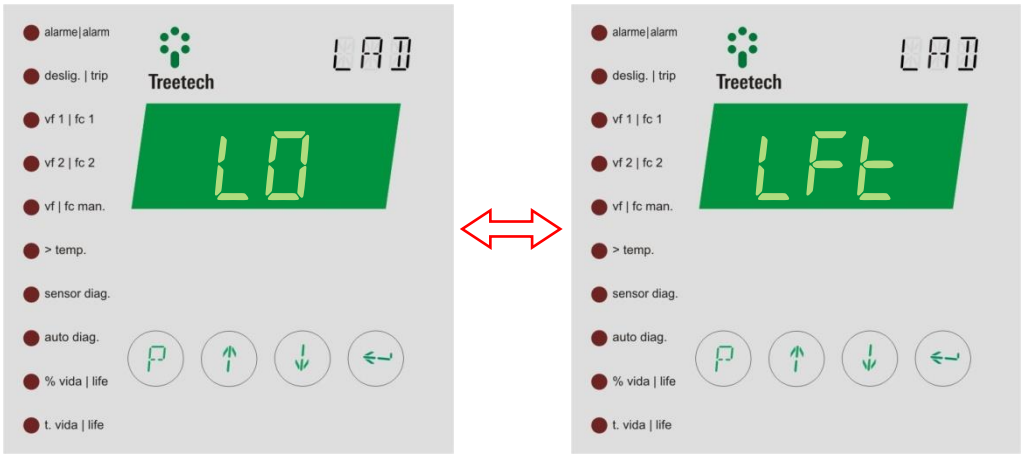


Figure 17: Low remaining service life alarm screen

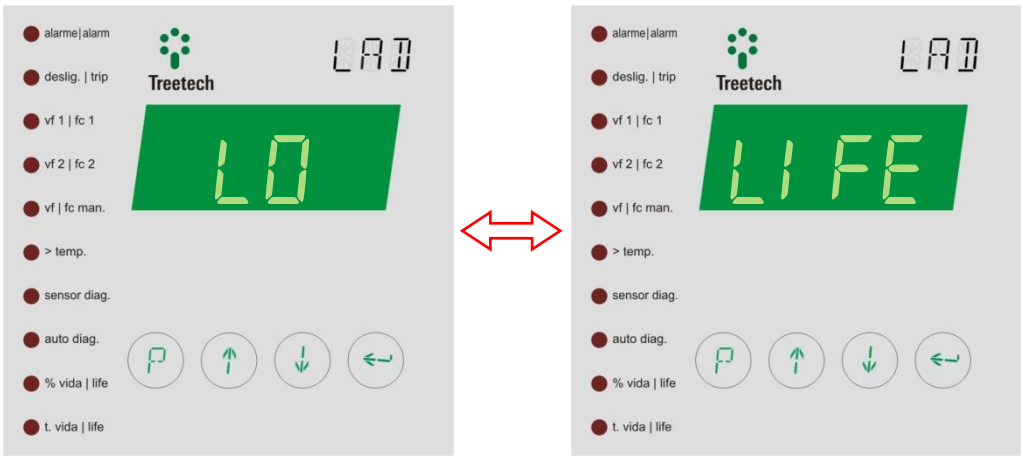


Figure 18: Low remaining life percentage alarm screen

4.3 Search and Commands Screens

The LAD makes several pieces of information available to be searched through its frontal panel in addition to the forced cooling command.

4.3.1 Maximum Temperature Reached Search

The LAD non-volatile memory stores the maximum temperature reached at each one of the measurements inputs.

In order to search the records of maximum temperatures reached, press the key .

The maximum values are indicated for each one of the six temperature sensors alternating with their identification, through the following abbreviations: *HIG1*, *HIG2* ... *HIG6*. Press keys and to check out the maximum temperatures of the several sensors.

In order to reset the maximum memorized temperature for a certain sensor, keep the key pressed for 2 seconds: the maximum temperature record will be updated with the current temperature measured by this sensor.

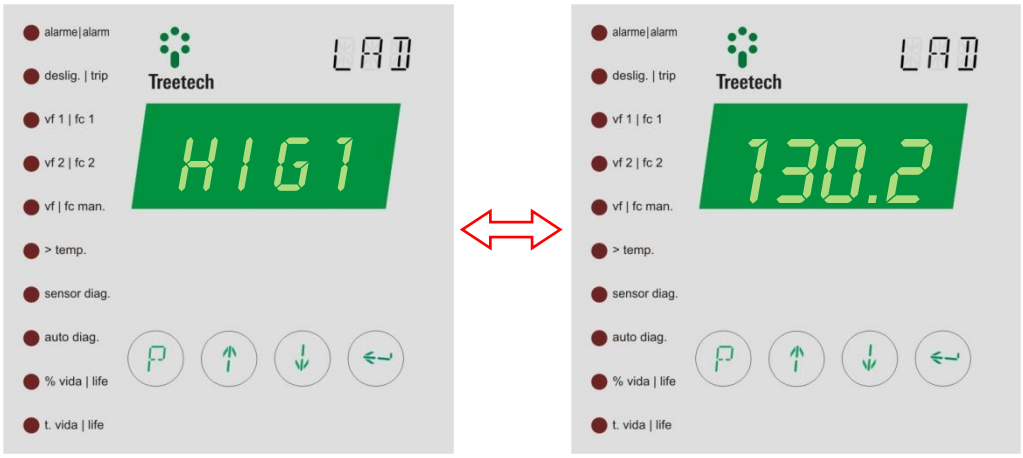


Figure 19: Checking maximum temperatures

4.3.2 Forced Cooling Manual Command

The LAD has a command function for up to 2 forced cooling groups. The cooling groups can be activated automatically when the user-programmed temperatures have been reached (submenu FAN) or be activated manually through the keys on the LAD's frontal panel, without using external command keys.

In order to manually activate the forced cooling groups, go through the following steps:

- Press the key . The LAD shows CGR1 (cooling group 1) alternating it with the current status of group 1: AUT (automatic) or ON (manually activated);
- Press keys and to alternate between the cooling groups and 1 and 2 (CGR1 and CGR2);
- Press key to access the desired cooling group status edit screen (CGR1 or CGR2). Press the key to turn on the cooling in the manual mode (ON) or to return to the automatic mode (AUT). Press the key to confirm the selection or to leave editing mode without saving the changes;
- Press the key , to return to temperature indications.

4.3.3 Viewing the alarm memory

The alarm memory function allows the user to know all the events that took place in the LAD, such as activation of forced cooling, alarms and shutdowns. This memory is non-volatile and cumulative, that is, it allows us to know all events that took place, but not when they took place. The

user can access the Alarm Memory by pressing the keys and sequentially. There are two alarm memory screens, identified by the abbreviations LAL 1 and LAL2, which can be viewed by pressing keys and . On each one of the screens, either the LAL 1 or LAL2 appears on the screen and keeps alternating with a numeric code that identifies the events that took place, according to **Table 6**, **Chapter 6.1 -Understanding the Alarm Memory.**

Figure 20: Alarm Memory Search Screens

In order to reset the Alarm Memory, press the key during 5 s. If there is any active alarm, the memory will be restarted, already indicating its occurrence. Press the key to go back to the indication screen.

4.3.4 Viewing the Self-Diagnosis Memory

The LAD firmware constantly checks the integrity of its functions and the functions of the temperature sensors connected to it through their circuits and self-diagnosis algorithms. Any detected anomaly is signaled through the failed contact and through self-diagnosis messages on the equipment display, helping in diagnosing and solving the problem.

The Self-Diagnosis Memory function allows knowing all the diagnostic events that took place in the LAD, such as bad contacts at the temperature sensor wiring or internal failures. This is a non-volatile, cumulative memory, that is, it allows the user to know all the events that took place, but not when they took place.

The Self-Diagnosis memory is accessed by pressing all  and  keys sequentially. The LDG abbreviation alternates with a numeric code that identifies the events that took place, according to **Table 8, chapter 6.2 - Understanding the LAD's Self-Diagnosis**.

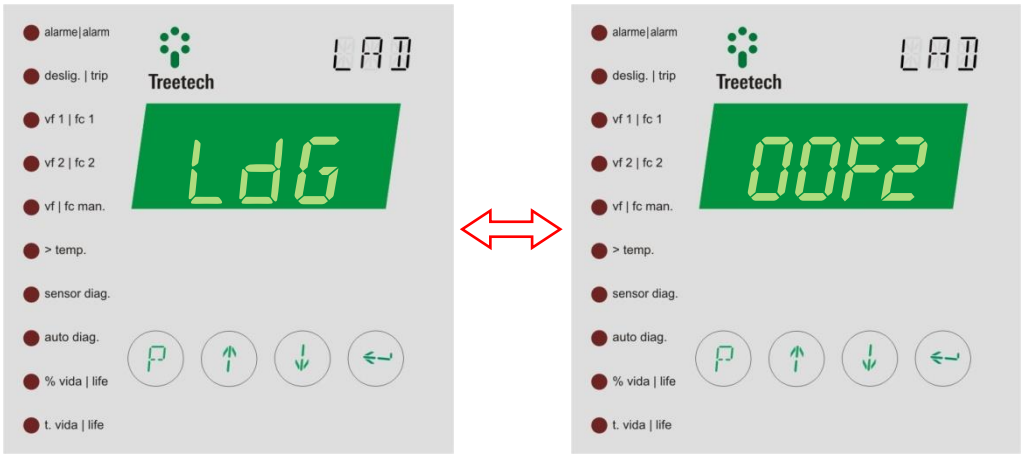


Figure 21: Checking the Self-Diagnosis Memory

To reset the self-diagnosis memory, press the key  for 5 s. If there is any active diagnosis, the memory will be restarted, already indicating its occurrence. Press the key  to return to the indication screen.

4.4 Parameterization Menus

In order to guarantee that it is correctly operated, several parameters must be adjusted in the LAD that will provide to the equipment the information needed for its operation.

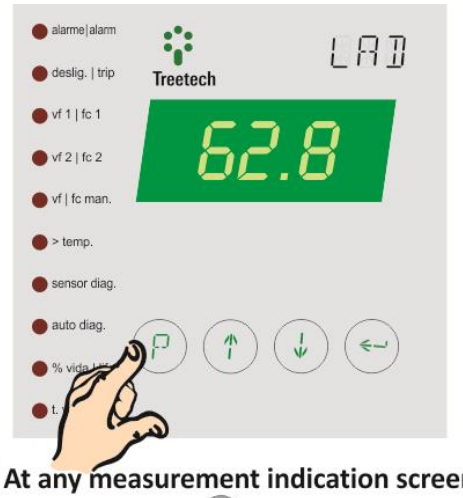
The settlements can be performed by means of his frontal keyboard, with the aid of the display, or of the RS-485 communication port, available for the user in the connector in the back of the device.

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

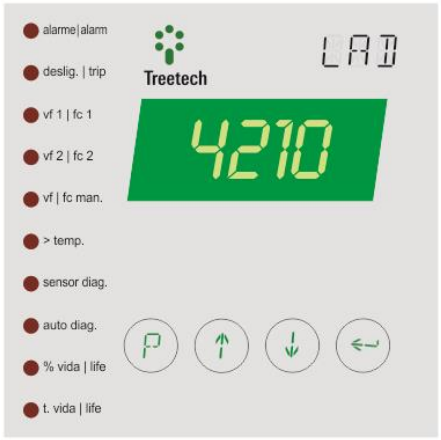
There are eight standard menus and two optional menus that are shown only if the function is available:

Menu Name	Abbreviation of the	Function
Alarms	ALR	Parameters concerning alarms and disconnections.
Relays	RELA	LAD Output relay configurations.
Configuration	CONF	General LAD configurations/setups.
Forced Cooling	FAN	Forced cooling configurations.
Analog Output	ANOU	Parameters concerning analog output (Optional)
Insulation Aging	AGNG	Parameters used in calculating aging of the insulation.
Relay Test	RLYT	It enables LAD relay testing.
Factory Only	FACT	Used only for technical support, and it is blocked with a factory password.

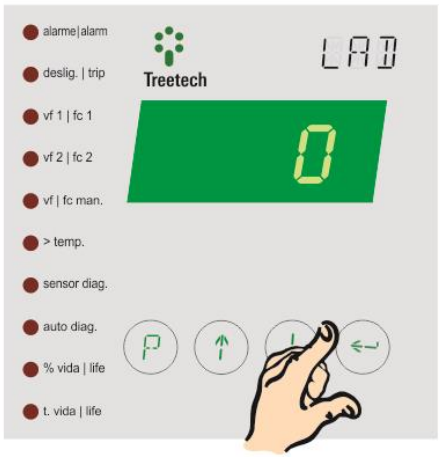
To access the LAD parameterization menu, do the following:



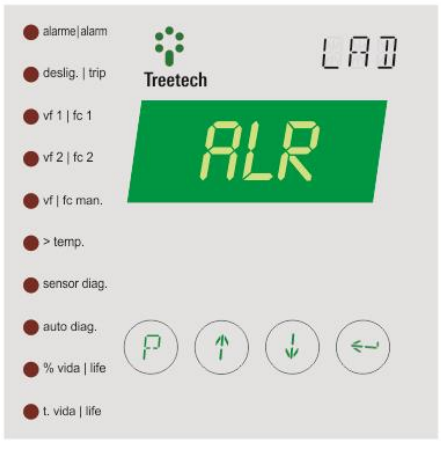
1) At any measurement indication screen, press and hold the (P) key for 5s.



2)The password screen will be displayed.



3) After setting the password, press the (↵) key to confirm and gain access to the parametrization menus.



4) The available menus are then displayed two at a time. Use (↓) and (↑) keys to browse them. The selected menu will be highlighted (the "Idioma/Language" menu is the one selected in the picture above). Press (↵) to gain access to the intended menu.

Figure 22 - Access to the LAD parameterization menu

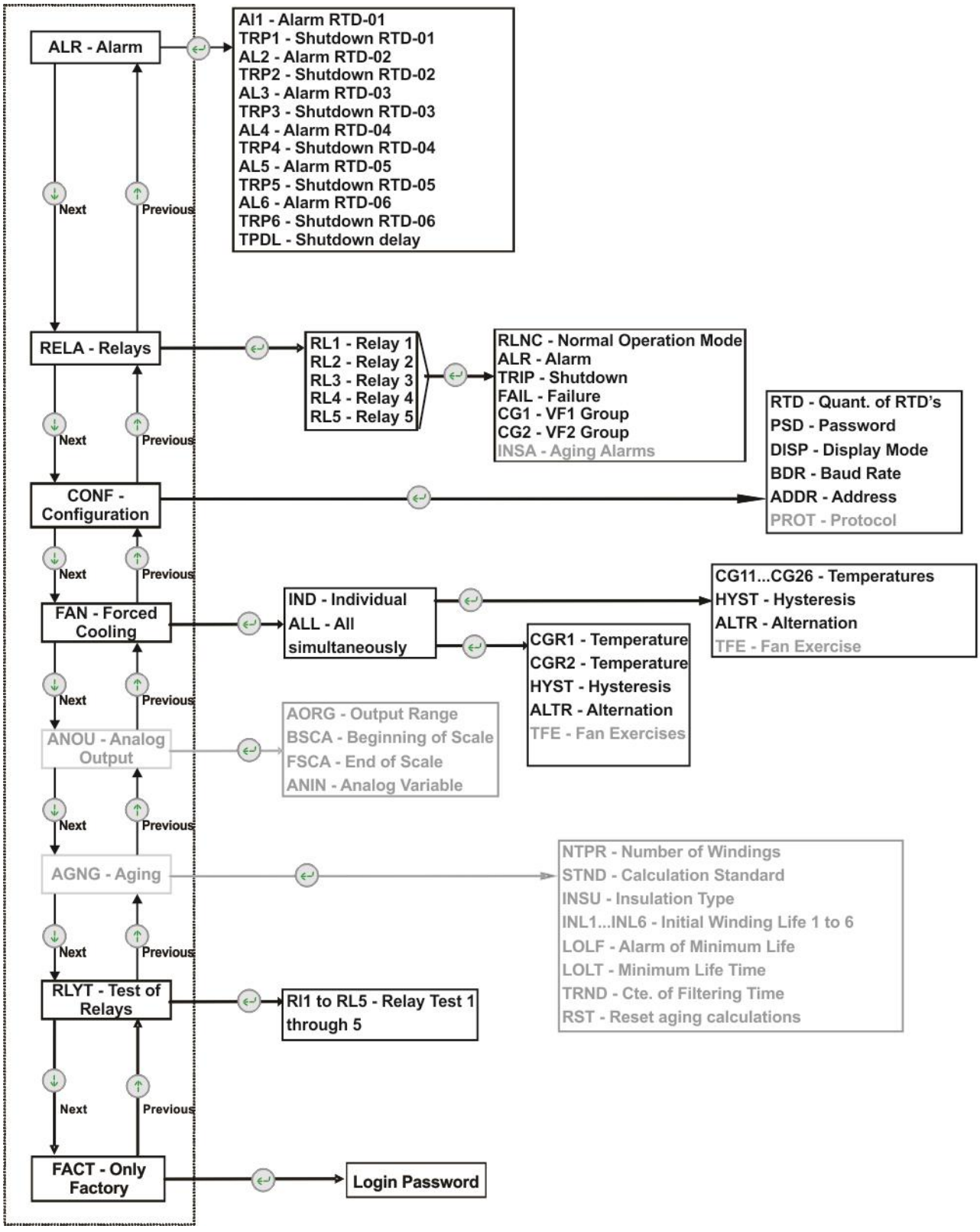


Figure 23 - Submenu access structure.

- **To Access a Submenu:**

To select a submenu, use the following keys: ↑ and ↓. Whenever the submenu is shown on the equipment's screen, press the key ← to start programming. At any moment, press the key P to go back to the main menu.

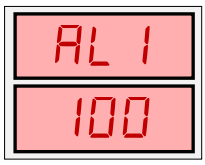
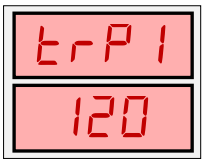
Optional menus will be shown only when enabled.

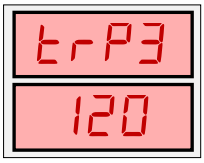
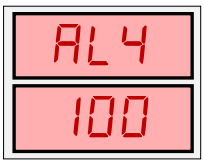
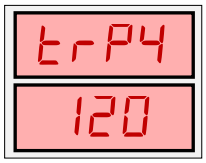
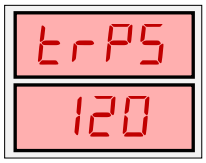
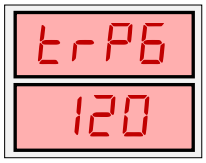
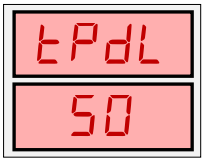
- **After Accessing the desired submenu:**

  - Use keys ↑ and ↓ to navigate between the submenu parameters;
  - Press ↵ to enter the parameter editing mode;
  - Press ↑ and ↓ to adjust the desired value for the parameter;
  - Press ↵ to save the alteration made in the parameter;
  - Press P to abandon the editing mode of the parameter without saving the changes and return to the previous menu.

4.4.1 ALR – Alarm Submenu

This submenu allows access to all parameters concerning temperature alarms and disconnections.

AL1 – RTD-01 Temperature Alarm **Adjustment range:** -55 °C to 200 °C, in 1 °C steps. **Standard Value:** 100 °C.	
TRP1 – RTD1 Temperature Disconnection **Adjustment range:** -55 °C to 200 °C, in 1 °C steps. **Standard Value:** 100 °C.	
AL2 – RTD-02 Temperature Alarm **Adjustment range:** -55 °C to 200 °C, in 1 °C steps. **Standard Value:** 100 °C.	
TRP2 – RTD-02 Temperature Disconnection **Adjustment range:** -55 °C to 200 °C, in 1 °C steps. **Standard Value:** 100 °C.	
AL3 – RTD-03 Temperature Alarm **Adjustment range:** -55 °C to 200 °C, in 1 °C steps. **Standard Value:** 100 °C.	

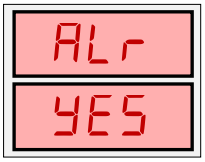
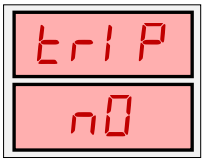
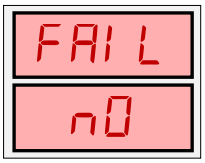
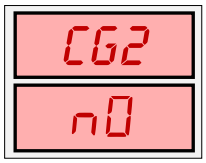
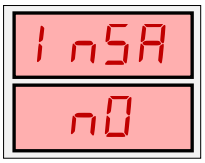
TRP3 – RTD-03 Temperature Disconnection **Adjustment range:** -55 °C to 200 °C, in 1 °C steps. **Standard Value:** 100 °C.	
AL4 – RTD-04 Temperature Disconnection **Adjustment range:** -55 °C to 200 °C, in 1 °C steps. **Standard Value:** 100 °C.	
TRP4 – RTD-04 Temperature Disconnection **Adjustment range:** -55 °C to 200 °C, in 1 °C steps. **Standard Value:** 100 °C.	
AL5 – RTD-05 Temperature Disconnection **Adjustment range:** -55 °C to 200 °C, in 1 °C steps. **Standard Value:** 100 °C.	
TRP5 – RTD05 - Temperature Disconnection **Adjustment range:** -55 °C to 200 °C, in 1 °C steps. **Standard Value:** 100 °C.	
AL6 – RTD-06 Temperature Disconnection **Adjustment range:** -55 °C to 200 °C, in 1 °C steps. **Standard Value:** 100 °C.	
TRP6 – RTD-06 Temperature Disconnection **Adjustment range:** -55 °C to 200 °C, in 1 °C steps. **Standard Value:** 100 °C.	
TPDL – Disconnection Delay This parameter allows the insertion of a delay between the moment in which a disconnection temperature is reached and the instant in which the disconnection relay is effectively activated. **Adjustment range:** 0 to 20 minutes, in 0,1 minute steps. **Standard Value:** 5 min.	

4.4.2 RELA – Relays Submenu

This submenu allows access to all the parameters concerning the operation of the LAD output relays.

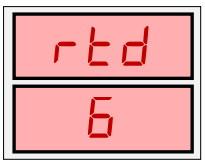
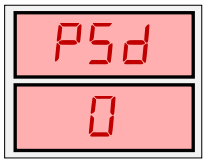
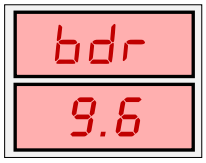
This submenu has the configurations for the Relays to 1 through 5. These configurations repeat for the different relays.

After selecting the relay that you desire to configure using keys ↑ and ↓, press ↵ to enter the options corresponding to that relay. To log out at any moment, press P.

RLNC – Alters the Relay Standard Status in a normal condition (without alarm/shutdown) **Adjustment range:** REST (rest, de-energized relay coil), ENER (energized relay coil. **Standard Value:** REST.	
ALR – Associates the previously chosen relay to any alarm event. **Adjustment range:** YES, NO. **Standard Value:** YES for relay #3, NO for the others.	
TRIP – Associates the previously chosen relay to any disconnection event. **Adjustment range:** YES, NO. **Standard Value:** YES for relay #2, NO for the others.	
FAIL – Associates the previously chosen relay to any self-diagnosis event. **Adjustment range:** YES, NO. **Standard Value:** YES for relay #1, NO for the others.	
CG1 – Associates the previously chosen relay to activation to the forced cooling first stage. **Adjustment range:** YES, NO. **Standard Value:** YES for relay #4, NO for the others.	
CG2 – Associates the previously chosen relay to activation of the forced cooling second stage. **Adjustment range:** YES, NO. **Standard Value:** YES for relay #5, NO for the others.	
INSA – Associates the previously chosen relay to the insulation aging alarms Shown only if Option 4 (Insulation Aging) is available. **Adjustment range:** YES, NO. **Standard Value:** NO.	

4.4.3 CONF – Configuration Submenu

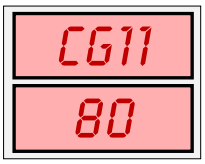
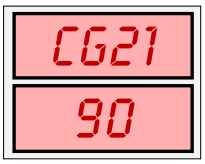
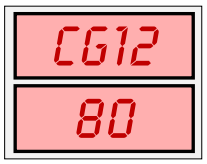
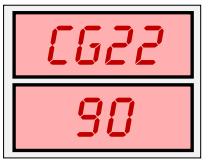
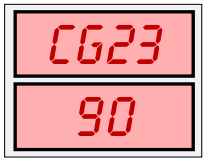
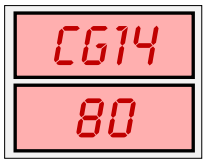
Allows access to the parameters concerning the LAD working configurations.

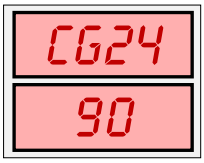
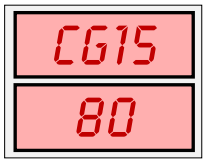
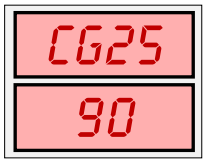
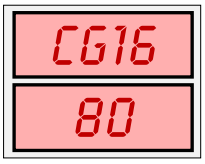
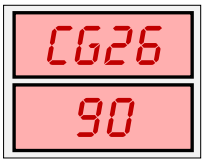
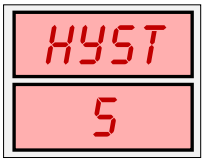
RTD – Number of Temperature Sensors (RTD), which are being used. **Adjustment range:** 1 to 6. **Standard Value:** 6.	
PSWD – Alters the password to access the LAD configuration menu. **Adjustment range:** 0 to 9999. **Standard Value:** 0. (*The default password is 0.)*	
DISP– Display mode for temperatures on the LAD screen during normal operation This parameter displays the following options: **STAY**: the screen stops and shows only the last sensor viewed on the front; **SCRL**: Alternation on the display the LAD loops the measured temperatures for 10 seconds each; **HIGH**: Displays the highest temperature measured by all sensors. **Adjustment range:** STAY, SCRL, HIGH. **Standard Value:** SCRL.	
BDR – Selects the transmission speed of the serial communication port **Adjustment range:** 4,8 / 9,6 / 19,2 / 38,4 / 57,6 / 115,2 kbps. **Standard Value:** 9,6 kbps.	
ADDR – LAD Address in the serial communication network **Adjustment range:** If the protocol Modbus-RTU is selected, from 1 to 31, in steps of 1; if the protocol DNP3 is selected, from 1 to 65535, in steps of 1. **Standard Value:** 1.	
PROT – Serial communication protocol used by the LAD in serial communication Existing Parameter only if the Optional function 1 (DNP3 protocol) is available. It allows the user to choose the communication protocol to be used, between Modbus and DNP3. If the Optional 1 is not available, the LAD uses the Modbus protocol as default. **Adjustment range:** RTU (Modbus-RTU), DNP (DNP3). **Standard Value:** RTU.	

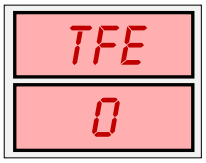
4.4.4 FAN – Forced Cooling Submenu

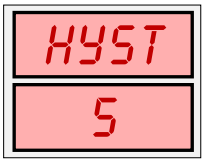
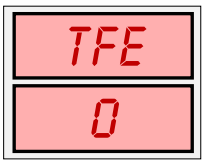
It allows the user to access the parameters for the control of the forced cooling groups commanded by theLAD. There are two main options in this menu: **IND** and **ALL**, which mean:

- **IND (*Individual)*:** Allows the individual configuration of the activation temperature of the forced cooling for each measurement inlet;
- **ALL:** Allows the configuration of the same activation temperature of the forced cooling for all measurement inlets, configuring only one general parameter set.

Configurations for the INDIVIDUAL option	
CG11 – Configures the activation temperature of the first stage of the forced cooling in relation to the RDT-01 temperature measurement. **Adjustment range:** -55 °C to 200 °C, in 1 °C steps. **Standard Value:** 80 °C.	
CG21 – Configures the activation temperature of the second stage of the forced cooling in relation to the RDT-01 temperature measurement. This parameter will not be shown if the Option 2 (Analog Output) is present, because in this case the second cooling group changes to the analog output. **Adjustment range:** -55 °C to 200 °C, in 1 °C steps. **Standard Value:** 90 °C.	
CG12 – Configures the activation temperature of the first stage of the forced cooling in relation to RDT-02 temperature measurement. **Adjustment range:** -55 °C to 200 °C, in 1 °C steps. **Standard Value:** 80 °C.	
CG22 – Configures the activation temperature of the second stage of the forced cooling in relation to the RDT-02 temperature measurement. This parameter will not be shown if the Option 2 (Analog Output) is present, because in this case the second cooling group changes to the analog output. **Adjustment range:** -55 °C to 200 °C, in 1 °C steps. **Standard Value:** 90 °C.	
CG13 – Configures the activation temperature of the first stage of the forced cooling in relation to the RDT-03 temperature measurement. **Adjustment range:** -55 °C to 200 °C, in 1 °C steps. **Standard Value:** 80 °C.	
CG23 – Configures the activation temperature of the second stage of the forced cooling in relation to the RDT-03 temperature measurement. This parameter will not be shown if the Option 2 (Analog Output) is present, because in this case the second cooling group changes to the analog output. **Adjustment range:** -55 °C to 200 °C, in 1 °C steps. **Standard Value:** 90 °C.	
CG14 – Configures the activation temperature of the first stage of the forced cooling in relation to the RDT-04 temperature measurement. **Adjustment range:** -55 °C to 200 °C, in 1 °C steps. **Standard Value:** 80 °C.	

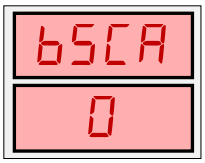
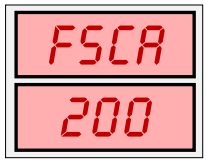
CG24 – Configures the activation temperature of the second stage of the forced cooling in relation to the RDT-04 temperature measurement This parameter will not be shown if the Option 2 (Analog Output) is present, because in this case the second cooling group changes to the analog output. **Adjustment range:** -55 °C to 200 °C, in 1 °C steps. **Standard Value:** 90 °C.	
CG15 – Configures the activation temperature of the first stage of the forced cooling in relation to the RDT-05 temperature measurement. **Adjustment range:** -55 °C to 200 °C, in 1 °C steps. **Standard Value:** 80 °C.	
CG25 – Configures the activation temperature of the second stage of the forced cooling in relation to the RDT-05 temperature measurement. This parameter will not be shown if the Option 2 (Analog Output) is present, because in this case the second cooling group changes to the analog output. **Adjustment range:** -55 °C to 200 °C, in 1 °C steps. **Standard Value:** 90 °C.	
CG16 – Configures the activation temperature of the first stage of the forced cooling in relation to the RTD-06 temperature measurement. **Adjustment range:** -55 °C to 200 °C, in 1 °C steps. **Standard Value:** 80 °C.	
CG26 – Configures the activation temperature of the second stage of the forced cooling in relation to the RDT-06 temperature measurement. This parameter will not be shown if the Option 2 (Analog Output) is present, because in this case the second cooling group changes to the analog output. **Adjustment range:** -55 °C to 200 °C, in 1 °C steps. **Standard Value:** 90 °C.	
HYST – It the difference between the start and stop temperature of the cooling groups. The HIS parameter *(hysteresis)* determines a temperature reduction value below the start temperature of the cooling, in order to turn it off, so the fans are not constantly turned on and off with every small temperature variation. **Adjustment range:** 0 to 9 °C, in steps of 1 °C. **Standard Value:** 5 °C.	
ALTR– Cooling Groups Alternation This parameter will not be shown if the Option 2 (Analog Output) is present, because in this case the second cooling group changes to the analog output. Enables or disables the automatic alternation in the activation of the 2 cooling groups. **Adjustment range:** YES or NO. **Standard Value:** NO.	

TFE– Fan Exercise Time Shown only if Option 3 (Fan Exercise) is available. Adjusts the total daily time during which the forced cooling groups must be activated for the pump or fan exercise. If it is necessary to disable the Cooling Exercise function, it suffices to program this parameter with the value zero. **Adjustment range:** 0 to 999 min., in steps of 1 min. **Standard Value:** 0 *(off)*.	

Configurations for the ALL option.	
CGR1 – Configures the activation temperature of the first forced cooling stage for all RTD's that are used. **Adjustment range:** -55 °C to 200 °C, in 1 °C steps. **Standard Value:** 80 °C.	
CGR2 - Configures the activation temperature of the second forced cooling stage for all RTD's that are used. **Adjustment range:** -55 °C to 200 °C, in 1 °C steps. **Standard Value:** 90 °C.	
HYST – It the difference between the start and stop temperature of the cooling groups. The HIS parameter *(hysteresis)* determines a temperature reduction value below the start temperature of the cooling, in order to turn it off, so the fans are not constantly turned on and off with every small temperature variation. **Adjustment range:** 0 to 9 °C; steps of 1 °C. **Standard Value:** 5 °C.	
ALTR– Cooling Groups Alternation This parameter will not be shown if the Option 2 (Analog Output) is present, because in this case the second cooling group changes to the analog output. Enables or disables the automatic alternation in the activation of the 2 cooling groups. **Adjustment range:** NO or YES. **Standard Value:** NO.	
TFE– Fan Exercise Time Shown only if Option 3 (Fan Exercise) is available. Adjusts the total daily time during which the forced cooling groups must be activated for the pump or fan exercise. If it is necessary to disable the Cooling Exercise function, it suffices to program this parameter with the value zero. **Adjustment range:** 0 to 999 min., in steps of 1 min. **Standard Value:** 0 *(off)*.	

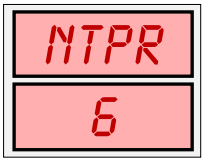
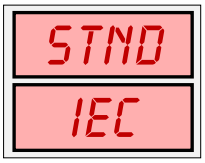
4.4.5 ANOU Submenu – Analog Output

This submenu and its parameters will be displayed only if the Option 2 (Analog Output) is available. Allows the user to access the analog output parameters.

AORG – Analog Output Range (mA) Selects the current loop standard for remote indication. **Adjustment range:** 0-10mA, 0-20mA, 4-20mA. **Standard Value:** 4...20mA.	
BSCA – Configures the value of the variable for the beginning of the analog output scale. **Adjustment range:** -55 °C to 200 °C, in 1 °C steps. **Standard Value:** 0 °C.	
FSCA – Configures the value of the variable for the end of scale of the analog output. **Adjustment range:** -55 °C to 200 °C, in 1 °C steps. **Standard Value:** 200 °C.	
ANIN – Selects the reference variable of the analog output. This parameter displays the following options: - **HIGT**: The highest temperature measured among all the RTD sensors will be displayed; - **TPR1 to TPR6:** The LAD shall indicate the temperature of the selected RTD sensor from 1 to 6. **Adjustment range:** HIGT, TPR1, TPR2, TPR3, TPR4, TPR5, TPR6. **Standard Value:** HIGT.	

4.4.6 AGNG Submenu – Insulation Aging

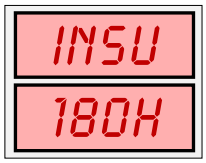
This submenu and its parameters will be shown only if the Option 4 (Insulation Aging) is available. Allows the user to access the parameters used in insulation aging calculations.

NTPR – Total number of bearings to calculate aging **Adjustment range:** 1 to 6 windings. **Standard Value:** 6.	
STND – Configures the standard used in aging calculation Allows the user to choose the standard used in aging calculations. ***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* The standard used in this parameter is the one for the set in which the transformer was built. **Adjustment range:** IEEE, IEC **Standard Value:** IEC.	

INSU – Configures the insulation thermal grade according to the chosen standard.

Adjustment range: According to the standard chosen for the calculation in item **STND**, the following thermal classes can be chosen:

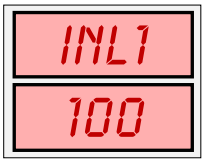
Insulation Thermal Grade			
IEEE Standard (*IEEE C57.96-1999*)		IEC Standard (*IEC 60076-12:2008*)	
Thermal Grade	Temperature	Thermal Grade	Temperature
150	150 °C	105 (A)	95 °C
180	180 °C	120 (E)	110 °C
220	220 °C	130 (B)	120 °C
		155 (F)	145 °C
		180 (H)	170 °C
		200	190 °C
		220	210 °C



INL1 – Percentage of the first winding insulation initial life

The initial winding life is entered in this parameter. o. It is from this value that winding remaining life is calculated.

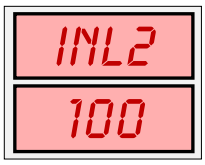
Adjustment range: 100% to 0%.
Standard Value: 100%.



INL2 – Percentage of the second winding insulation initial life

The initial winding life is entered in this parameter. o. It is from this value that winding remaining life is calculated.

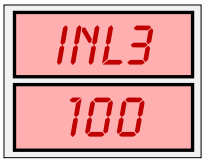
Adjustment range: 100% to 0%.
Standard Value: 100%.



INL3 – Percentage of the third winding insulation initial life.

The initial winding life is entered in this parameter. o. It is from this value that winding remaining life is calculated.

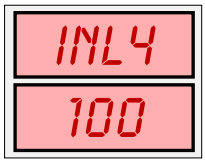
Adjustment range: 100% to 0%.
Standard Value: 100%.



INL4 – Percentage of the fourth winding insulation initial life.

The initial winding life is entered in this parameter. o. It is from this value that winding remaining life is calculated.

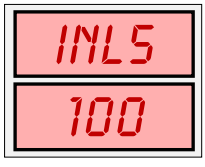
Adjustment range: 100% to 0%.
Standard Value: 100%.



INL5 – Percentage of the fifth winding insulation initial life.

The initial winding life is entered in this parameter. o. It is from this value that winding remaining life is calculated.

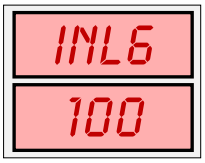
Adjustment range: 100% to 0%.
Standard Value: 100%.



INL6 – Sixth Winding insulation Initial Life Percentage

The initial winding life is entered in this parameter. o. It is from this value that winding remaining life is calculated.

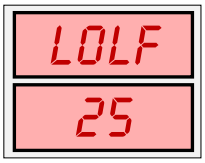
Adjustment range: 100% to 0%.
Standard Value: 100%.



LOLF – Tolerated Minimum Service Life Percentage

In this parameters, the user should enter the value that is considered to be minimum for the correct operation of the insulation. It is considered as a value that in practice indicates the end of the service life of the winding insulation.

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



LOLT – Minimum Tolerated Service Life Time

In this parameter, the minimum value of the remaining life in years is entered so that an end-of-service-life alert is issued.

Adjustment range: 20 to 0, in years.
Standard Value: 1 year.

TRND – Filtering Time Constant

This value is the time constant for the low-pass filter used to stabilize the result of the calculation of time and the percentage of remaining winding insulation life. The behavior of the result of the insulation remaining life time calculation as a function of this parameter is described as follows:

Filtering time constant	
TEND Parameter value	**Calculation behavior**
TRND = 24 hours (*recommended*)	Balancing between result updating speed and result calculation stability.
TRND < 24 hours	Greater speed when updating the result at the cost of a smaller stability of the calculation.
TRND > 24 hours	Greater stability of the calculation at the cost of a slower result updating speed.

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

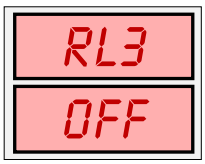
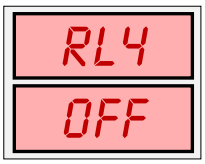
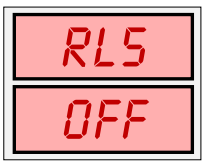
RST – Reset Winding Aging Calculation

With this parameter, it is possible to restart the calculation of the remaining service lifetime of the winding. When this option is chosen, the initial parameters are taken into consideration and all the life loss that has already been calculated is lost and reset to the initial values.

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

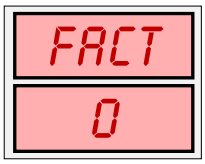
4.4.7 RLYT Submenu – Relay Testing

This submenu allows the user to test the operation of each LAD output relay, forcing it to be activated. Whenever this menu is accessed, all the relays of the LAD go back to the "off" state.

RL1 – Activates or disables the 1st output relay It allows to temporarily alter the state of the selected relay **Adjustment range:** ON, OFF. **Standard Value:** OFF.	
RL2 – Activates or disables 2nd output relay It allows to temporarily alter the state of the selected relay **Adjustment range:** ON, OFF. **Standard Value:** OFF.	
RL3 – Activates or disables the 3rd output relay It allows to temporarily alter the state of the selected relay **Adjustment range:** ON, OFF. **Standard Value:** OFF.	
RL4 – Activates or disables the 4th output relay. It allows to temporarily alter the state of the selected relay **Adjustment range:** ON, OFF. **Standard Value:** OFF.	
RL5 – Activates or disables the 5th output relay. It allows to temporarily alter the state of the selected relay **Adjustment range:** ON, OFF. **Standard Value:** OFF.	

4.4.8 FACT Submenu – Factory Only

This submenu allows access to factory parameters. It can only be used by the Treetech technical support, and is protected by a password, not being accessible by the equipment's operator.

FACT – Menu of Factory Configurations	

5 Procedure to Put the Equipment into Service

Once the equipments were installed according to this manual, and the following basic steps should be followed to put it into service.

1. Make sure no contact operation will interact with other systems, during this phase. If needed, isolate all command, alarm and shutdown contacts.
2. Check the wiring to see if it is according the recommendations in this manual. Check if the wiring is correct (for instance, through continuity tests).
3. Energize the LAD with any voltage in the 38 to 265 Vdc/Vac - 50/60 Hz range.
4. Do all the parameterization of the LAD, according to the instructions in this manual. The parameterization done can be jotted down on the Form on page 58 of the Appendix A – Parameterization Tables.
5. Connect temperature calibrator, resistive decade or check the temperature of the Pt-100 sensor connected to each one of the LAD's measurement inputs, checking whether the measurements are correct.
6. With a DC milliamperimeter, check whether the current loop outputs show values that match the corresponding temperatures.
7. With a continuity indicator, test the activation of the alarm, shutdown and forced cooling alarms. The activation of the contacts can be forced, through the submenu TRLS.
8. Reconnect the contacts that might have been insulated.

6 Troubleshooting

6.1 Understanding Alarm and Event Memory

The LAD has an Alarm memory that records any type of event related to one.
It is a special nonvolatile; cumulative memory that is, if two different events take place the result presented in the position connected to the event is a sum of the two. Therefore, it is possible to know that the events took place, not when they took place.

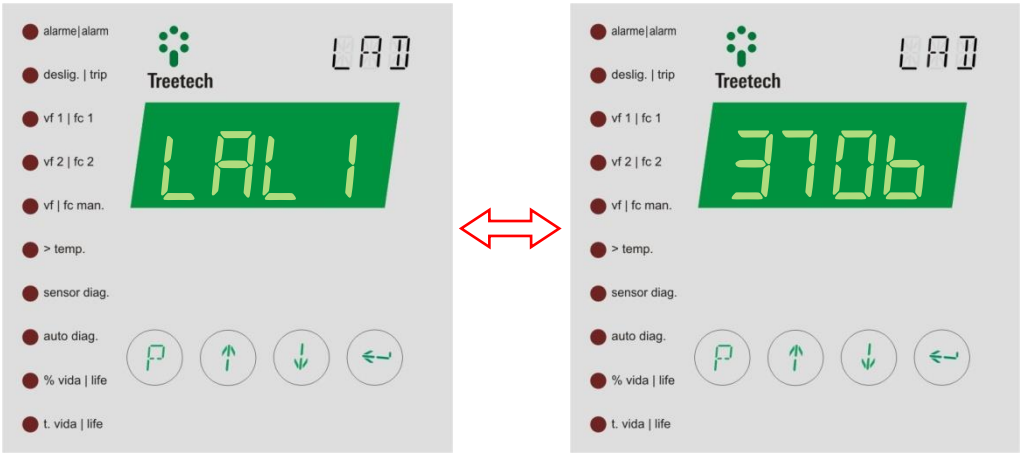


Figure 24: LAD Display showing the Alarm Memory

Table 6 and **Table 7** show the possible base codes, highlighted in bold and their related sums, of the alarm memory.

Using **Table 6**, we can decode **Figure 24**, where we have the following alarm interpretation:

1. Cooling groups 1 and 2 were activated;
2. There were an alarm and a shutdown commanded by the RTD-05 and one alarm commanded by the RTD-06;
3. No alarm reported in the third digit;
4. There were an alarm and a disconnection commanded by the temperature of the RTD-01 and a shutdown commanded by the temperature of the RTD-02.

Table 6: Alarm and Event Memory Codes - LAL1 Screen

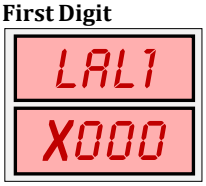
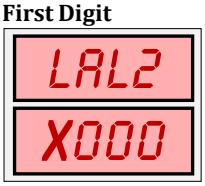
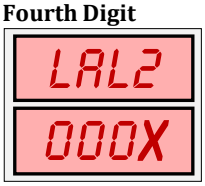
Digit / Value	First Digit 	Second Digit 	Third Digit 	Fourth Digit 
0	No Alarms	No Alarms	No Alarms	No Alarms
1	VF1 On	Alarm through RTD 05	Alarm through RTD 03	Alarm through RTD 01
2	VF2 On	Disconnection through RTD 05	Disconnection through RTD 03	Disconnection through RTD 01
3	Simultaneous occurrence of 2 and 1	*Simultaneous occurrence of 2 and 1*	*Simultaneous occurrence of 2 and 1*	*Simultaneous occurrence of 2 and 1*
4	Low service life alarm (see LAL2)	Alarm through RTD 06	Alarm through RTD 04	Alarm through RTD 02
5	Simultaneous occurrence of 4 and 1	*Simultaneous occurrence of 4 and 1*	*Simultaneous occurrence of 4 and 1*	*Simultaneous occurrence of 4 and 1*
6	*Simultaneous occurrence of 4 and 2*	*Simultaneous occurrence of 4 and 2*	*Simultaneous occurrence of 4 and 2*	*Simultaneous occurrence of 4 and 2*
7	*Simultaneous occurrence of 4, 2 and 1*	*Simultaneous occurrence of 4, 2 and 1*	*Simultaneous occurrence of 4, 2 and 1*	*Simultaneous occurrence of 4, 2 and 1*
8	Low service life percentage alarm (see AL2)	Disconnection through RTD 06	Disconnection through RTD 04	Disconnection through RTD 02
9	*Simultaneous occurrence of 8 and 1*	*Simultaneous occurrence of 8 and 1*	*Simultaneous occurrence of 8 and 1*	*Simultaneous occurrence of 8 and 1*
A	*Simultaneous occurrence of 8 and 2*	*Simultaneous occurrence of 8 and 2*	*Simultaneous occurrence of 8 and 2*	*Simultaneous occurrence of 8 and 2*
B	*Simultaneous occurrence of 8, 2 and 1*	*Simultaneous occurrence of 8, 2 and 1*	*Simultaneous occurrence of 8, 2 and 1*	*Simultaneous occurrence of 8, 2 and 1*
C	*Simultaneous occurrence of 8 and 4*	*Simultaneous occurrence of 8 and 4*	*Simultaneous occurrence of 8 and 4*	*Simultaneous occurrence of 8 and 4*
D	*Simultaneous occurrence of 8, 4 and 1*	*Simultaneous occurrence of 8, 4 and 1*	*Simultaneous occurrence of 8, 4 and 1*	*Simultaneous occurrence of 8, 4 and 1*
E	*Simultaneous occurrence of 8, 4 and 2*	Simultaneous occurrence of 8, 4 and 2	*Simultaneous occurrence of 8, 4 and 2*	*Simultaneous occurrence of 8, 4 and 2*
F	*Simultaneous occurrence of 8, 4, 2 and 1*	*Simultaneous Occurrence of 8, 4, 2 and 1*	*Simultaneous Occurrence of 8, 4, 2 and 1*	*Simultaneous Occurrence of 8, 4, 2 and 1*

Table 7: Alarm and Event Memory Codes - LAL2 Screen

Digit / Value	First Digit 	Second Digit 	Third Digit 	Fourth Digit 
0	**No Alarms**	**No Alarms**	**No Alarms**	**No Alarms**
1	*Not used*	**Fifth Winding low service life alarm**	**Third Winding low service life alarm**	**First Winding low service life alarm**
2	*Not used*	**Fifth Winding low service life percentage alarm**	**Third Winding low service life percentage alarm**	**First Winding low service life percentage alarm**
3	*Not used*	*Simultaneous occurrence of 2 and 1*	*Simultaneous occurrence of 2 and 1*	*Simultaneous occurrence of 2 and 1*
4	*Not used*	**Sixth Winding Low Service life time alarm**	**Fourth Winding Low Service life time alarm**	**Second Winding Low Service life time alarm**
5	*Not used*	*Simultaneous occurrence of 4 and 1*	*Simultaneous occurrence of 4 and 1*	*Simultaneous occurrence of 4 and 1*
6	*Not used*	*Simultaneous occurrence of 4 and 2*	*Simultaneous occurrence of 4 and 2*	*Simultaneous occurrence of 4 and 2*
7	*Not used*	*Simultaneous occurrence of 4, 2 and 1*	*Simultaneous occurrence of 4, 2 and 1*	*Simultaneous occurrence of 4, 2 and 1*
8	*Not used*	**Sixth Winding Low Service Life Percentage Alarm**	**Fourth Winding Low Service Life Percentage Alarm**	**Second Winding Low Service Life Percentage Alarm**
9	*Not used*	*Simultaneous occurrence of 8 and 1*	*Simultaneous occurrence of 8 and 1*	*Simultaneous occurrence of 8 and 1*
A	*Not used*	*Simultaneous occurrence of 8 and 2*	*Simultaneous occurrence of 8 and 2*	*Simultaneous occurrence of 8 and 2*
B	*Not used*	*Simultaneous occurrence of 8, 2 and 1*	*Simultaneous occurrence of 8, 2 and 1*	*Simultaneous occurrence of 8, 2 and 1*
C	*Not used*	*Simultaneous occurrence of 8 and 4*	*Simultaneous occurrence of 8 and 4*	*Simultaneous occurrence of 8 and 4*
D	*Not used*	*Simultaneous occurrence of 8, 4 and 1*	*Simultaneous occurrence of 8, 4 and 1*	*Simultaneous occurrence of 8, 4 and 1*
E	*Not used*	*Simultaneous occurrence of 8, 4 and 2*	*Simultaneous occurrence of 8, 4 and 2*	*Simultaneous occurrence of 8, 4 and 2*
F	*Not used*	*Simultaneous occurrence of 8, 4, 2 and 1*	*Simultaneous occurrence of 8, 4, 2 and 1*	*Simultaneous occurrence of 8, 4, 2 and 1*

6.2 Understanding the LAD's Self-Diagnosis

The LAD's firmware constantly checks the integrity of its functions through its circuits and diagnosis algorithms. Any detected anomaly is signaled through the failed contact and through self-diagnosis messages on the equipment display, helping in diagnosing and solving the problem.

There are two Self-Diagnosis modes:

- **Indication:** It takes place when the error is current. This error is also recorded in the memory. When the error stops, the record of the indication disappears, and remains present only in the memory mode;
- **Memory:** It takes place when the error is not currently active. It shows all the errors accrued since the last reset.

6.2.1 Viewing the Self-Diagnosis Indication

If any anomaly takes place, the corresponding self-diagnosis code will be indicated on the display, as shown in **Figure 25**.

The LAD shows the self-diagnosis mode by blinking slowly (around 0.5 s). The meaning of this code is shown in **Table 8**.

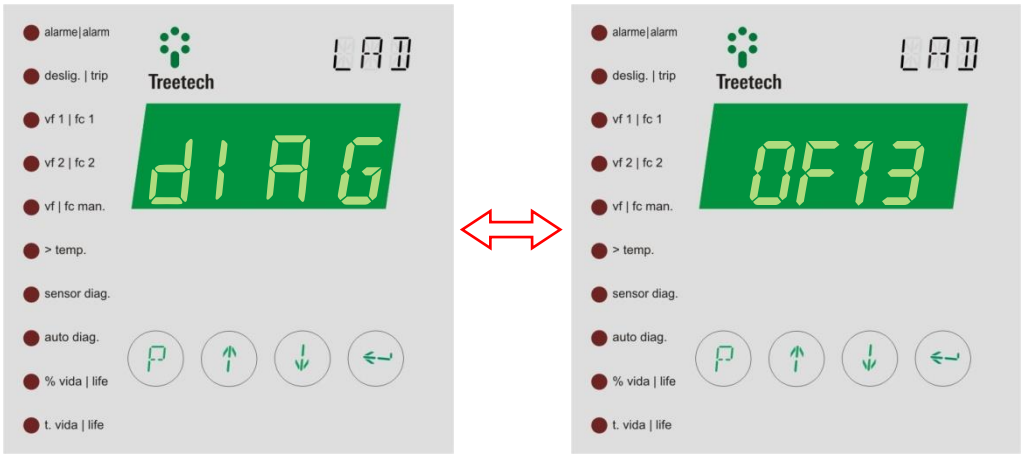


Figure 25: LAD Self-Diagnosis Indication

6.2.2 Viewing the Self-Diagnosis Memory

The Self-Diagnosis memory is accessed by sequentially pressing P and keys ↓.

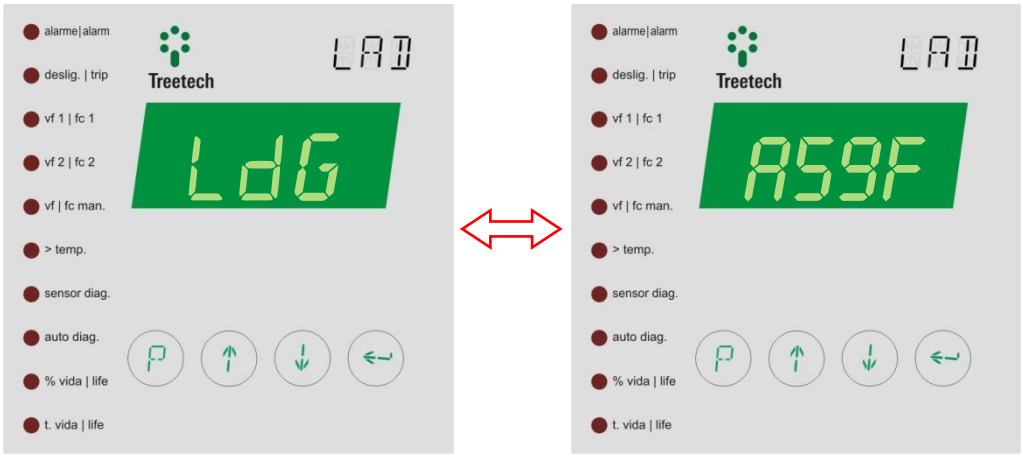


Figure 26: LAD Display showing the Self-Diagnosis Memory

To reset the Self-Diagnostic Memory press the key during 5 s. While some diagnosis is active, this value will not reset.

Press the key to return to the indication screen.

6.2.3 Interpreting the Self-Diagnosis Codes

The self-diagnosis codes shown on the LAD display have four digits. The meanings of each digit are shown on Screen 8.

The basic error codes are highlighted in **bold face**. Inform the self-diagnosis code to Treetech Technical Support.

Using **Table 8**, we can decode **Figure 26**, where we have the following interpretation of the codes:

1. Type 2 anomaly in RTD-04 and RTD-06;
2. Type 1 anomaly in RTD-05 and type 2 anomaly in RTD-01;
3. Type 1 anomaly in RTD-04 and in RTD-01;
4. Failure of the EEPROM of the LAD, Internal error in the RTD input of the LAD, abrupt temperature change read by any of the RTD´s and stack overflow at the LAD.

Table 8: Self-Diagnosis Memory Codes

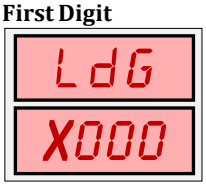
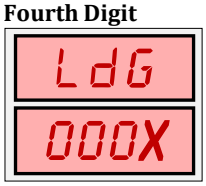
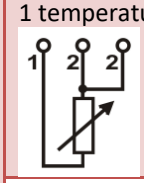
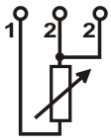
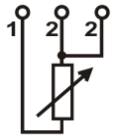
Digit / Value	First Digit 	Second Digit 	Third Digit 	Fourth Digit 
0	**No Anomaly**	**No Anomaly**	**No Anomaly**	**No Anomaly**
1	**Type 2 Failure in RTD-03**	**Type 1 Failure in RTD-05**	**Type 1 Failure in RTD-01**	**Flash memory failure**
2	**Type 2 Failure in RTD-04**	**Type 1 Failure in RTD-06**	**Type 1 Failure in RTD-02**	**Self-Calibration failure**
3	*Simultaneous occurrence of 2 and 1*	*Simultaneous occurrence of 2 and 1*	*Simultaneous occurrence of 2 and 1*	*Simultaneous occurrence of 2 and 1*
4	**Type 2 Failure in RTD-05**	**Type 2 Failure in RTD-01**	**Failure type 1 in the RTD-03**	**Abrupt temperature change read by any of the RTD´s**
5	*Simultaneous occurrence of 4 and 1*	*Simultaneous occurrence of 4 and 1*	*Simultaneous occurrence of 4 and 1*	*Simultaneous occurrence of 4 and 1*
6	*Simultaneous occurrence of 4 and 2*	*Simultaneous occurrence of 4 and 2*	*Simultaneous occurrence of 4 and 2*	*Simultaneous occurrence of 4 and 2*
7	*Simultaneous occurrence of 4, 2 and 1*	*Simultaneous occurrence of 4, 2 and 1*	*Simultaneous occurrence of 4, 2 and 1*	*Simultaneous occurrence of 4, 2 and 1*
8	**Type 2 Failure in RTD-06**	**Type 2 Failure in RTD-02**	**Failure of the type 1 in RTD-04**	**Stack *Overflow***
9	*Simultaneous occurrence of 8 and 1*	*Simultaneous occurrence of 8 and 1*	*Simultaneous occurrence of 8 and 1*	*Simultaneous occurrence of 8 and 1*
A	*Simultaneous occurrence of 8 and 2*	*Simultaneous occurrence of 8 and 2*	*Simultaneous occurrence of 8 and 2*	*Simultaneous occurrence of 8 and 2*
B	*Simultaneous occurrence of 8, 2 and 1*	*Simultaneous occurrence of 8, 2 and 1*	*Simultaneous occurrence of 8, 2 and 1*	*Simultaneous occurrence of 8, 2 and 1*
C	*Simultaneous occurrence of 8 and 4*	*Simultaneous occurrence of 8 and 4*	*Simultaneous occurrence of 8 and 4*	*Simultaneous occurrence of 8 and 4*
D	*Simultaneous occurrence of 8, 4 and 1*	*Simultaneous occurrence of 8, 4 and 1*	*Simultaneous occurrence of 8, 4 and 1*	*Simultaneous occurrence of 8, 4 and 1*
E	*Simultaneous occurrence of 8, 4 and 2*	*Simultaneous occurrence of 8, 4 and 2*	*Simultaneous occurrence of 8, 4 and 2*	*Simultaneous occurrence of 8, 4 and 2*
F	*Simultaneous Occurrence of 8, 4, 2 and 1*	*Simultaneous Occurrence of 8, 4, 2 and 1*	*Simultaneous Occurrence of 8, 4, 2 and 1*	*Simultaneous Occurrence of 8, 4, 2 and 1*

Table 9 shows the probable causes of the problems and a set of recommended actions for each one of them, so the operator checks and solves the problem quickly, before Treetech's support team or its authorized representative needs to be contacted.

Table 9: Probably causes and recommended actions for each type of self-diagnosis message

Description	Probable cause	Recommended actions
Type 1 failure in temperature measuring by the RTD sensor (RTD reading)	Bad contact or disconnection of the cable connected to the terminal 1 temperature sensor. 	Check for bad contacts or disconnections in the whole path of the cable connected to the terminal 1 of the temperature sensor, including the connection to the LAD, to the feed-through terminal blocks and the connection to the sensor.
	Use of an unshielded cable at the connection between the Pt-100.	Check whether a shielded cable was used to connect the temperature sensor to the LAD.
	Shielding of the connecting cables of the LAD to the Pt-100 sensor was not grounded or it was grounded at more than one point.	Check whether the shielding of the cable connecting the LAD to the temperature sensor is grounded only on one side of the connection and the other end is insulated.
	The sensor is not being used, but its measuring is enabled at the RTDS parameter.	Disable measuring in the sensors that are not being used, by changing the RTDS parameter.
	Temperature sensor internal failure.	Replace the defective temperature sensor.
Type 2 Failure at the RTD sensor temperature measurement (Calibration of the RTD)	Bad contact or disconnection of the cables connected to the terminals #2 of the temperature sensor. 	Check for bad contacts or disconnections along the whole path of the cables connected to the #2 terminals of the temperature sensor, including the connection to the LAD to the feed-through terminal blocks and the connection to the sensor.
	Use of an unshielded cable at the connection between the Pt-100.	Check whether a shielded cable was used to connect the temperature sensor to the LAD.
	Shielding of the connecting cables of the LAD to the Pt-100 sensor was not grounded or it was grounded at more than one point.	Check whether the shielding of the cable connecting the LAD to the temperature sensor is grounded only on one side of the connection and the other end is insulated.
	The sensor is not being used, but its measuring is enabled at the RTDS parameter.	Disable measuring in the sensors that are not being used, by changing the RTDS parameter.
	Temperature sensor internal failure.	Replace the defective temperature sensor.

Description	Probable cause	Recommended actions
Stack Overflow	LAD internal failure.	Restart the LAD (pull the plug off the power supply for someseconds and reconnect it) and contact Treetech's Technical Support. If the defect still persists after that, replace the defective LAD.
Abrupt temperature change read by any of the RTD´s[1] (*Over 5 °C*)	Bad contact or disconnection of one of the cables connected to terminals 1 or 2 of the temperature sensor. 	Check for bad contacts or disconnections along the whole path of the cables connected to terminal #1 or 2 of the temperature sensor, including the connection to the LAD, to the feed-through terminal blocks and the connection to the sensor.
	Use of an unshielded cable at the connection between the Pt-100.	Check whether a shielded cable was used to connect the temperature sensor to the LAD.
	The shielding of the LAD connecting cables linking it to the Pt-100 sensor is not grounded or is grounded in more than one point.	Check whether the shielding of the cable connecting the LAD to the temperature sensor is grounded only on one side of the connection and the other end is insulated.
	Temperature sensor internal failure.	Replace the defective temperature sensor.
Self-Calibration failure	LAD internal failure.	Restart the LAD (remove the plug from the power supply) for some seconds and reconnect it) and contact Treetech's technical support. If the defect still persists after that, replace the defective LAD.
Flash memory failure	LAD internal failure.	Restart the LAD (remove the plug from the power supply) for some seconds and reconnect it) and contact Treetech's technical support. If the defect still persists after that, replace the defective LAD.

[1] After the anomaly occurs, follow the instructions below, very carefully.

After checking and correcting the cause of the measurement failure, reset the error by pressing the keys P and ↑ and keeping them pressed down.

When the user resets the error, the LAD will receive the message that the current temperature measurement is correct. If the instrument is reset with an incorrect temperature measurement, a shutdown alarm may be incorrectly go off.

6.3 Troubleshooting of Problems not Related to the LAD's Self-Diagnosis

If there are any difficulties or problems while operating the LAD which are not related to no situation of self-diagnosis, we suggest that you check the possible causes and simple solutions listed below:

If this information is not sufficient to solve the problem, please get in contact with the Treetech Technical Support or its authorized representative.

Table 10: Troubleshooting of problems not related to Self-Diagnosis

Probable Causes	Recommended Actions
The LAD does not communicate with the data acquisition system	
Incorrect programming of the serial communication port in the LAD	Check the correct programming of the following parameters in the submenu CONF: Baud-rate – parameter BDR Address – parameter ADDR Protocol – parameter PROT
Bad contact, disconnection or reversal of one of the serial communication cables.	Check if there are any bad contacts, disconnections or reversals along the whole path of the communication cable, including the connection to the
Use of unshielded cable, ungrounded shielding, or with wrong grounding at the connection of the DTL acquisition system.	Use shielded cable, connected according to the recommendations of this manual.
The wrong type of cable was used	The communication cable must be the shielded twisted-pair type.
Distance between network extremities is over 1,300 meters	If the circuit exceeds the distance of 1,300 meters, it is necessary to use repeaters or apply fiber optics.
The LAD does not activate the forced cooling correctly.	
Incorrect programming of the forced cooling parameters.	Correct the programming of the forced cooling control parameters.
Incorrect Current Loop Output Indication (mA)	
The maximum allowed load for current output was exceeded.	Verify which is the maximum allowed load for each selected output standard.
Wrong programming of current output parameters.	Check the following programming parameters: AORG (mA Output Scale), BSCA (beginning of the Scale), FSCA (End of Scale) and ANIN (Analog Variable).
Wrong connection of mA output cable.	Check for a correct connection between cables and feed-through terminal blocks (polarity, eventual short circuits, and open links) between the LAD and themA output measuring system.
Shielding is not grounded, has gaps or cable shielding has been grounded in both ends of the circuit.	Grounding failure or incorrect grounding can allow noise and induced transients to get in the way and make it impossible to measure the current loop. Verify the cable and connections (pass through terminal blocks and grounding points.

7 Appendices

7.1 Appendix A – LAD Parameterization Tables

Table 11 was made for equipment with the Firmware 1.00 version and higher. The purpose of this table is to help in documenting the parameters used in the equipment, helping the operator in his work and ultimately assisting the technical support team.

Some submenus and parameters will be shown only if the respective optional functions are available.

Always have the parameterization table at hand when operating the LAD.
Is a very useful tool for the installation, maintenance and assistance to the LAD.

Table 11: Auxiliary table for LAD parameterization

LAD Temperature Monitor – Parameterization Sheet			
Nº. Series:		**Date:**	
Identification:		**Person in Charge:**	
Submenu	**Parameter**	**Description**	**Adjusted Value**
ALR	AL1	RTD-01 Temperature Alarm	°C
	TRP1	RTD-01 temperature shutdown	°C
	AL2	RTD-02 Temperature alarm	°C
	TRP2	RTD-02 temperature shutdown	°C
	AL3	RTD-03 temperature alarm	°C
	TRP3	RTD-03 Temperature shutdown	°C
	AL4	RTD-04 Temperature Alarm	°C
	TRP4	RTD-04 temperature shutdown	°C
	AL5	RTD-05 temperature shutdown	°C
	TRP5	RTD-05 temperature shutdown	°C
	AL6	RTD-06 temperature shutdown	°C
	TRP6	RTD-06 temperature shutdown	°C
	TPDL	Temperature shutdown delay	min.
RELA	***Relay #01***		
	RLNC	Default Relay status between REST and ENER	
	ALR	Associates the relay to the alarm event	
	TRIP	Associates the relay to the shutdown event	
	FAIL	Associates the relay to the self-diagnosis event	
	CG1	Associates the relay to the 1st Forced Cooling stage	
	CG2	Associates the relay to the 2nd Forced Cooling stage	
	INSA	Associates the relay to the aging alarms	
	Relay #02		
	RLNC	Default Relay status between REST and ENER	
	ALR	Associates the relay to the alarm event	
	TRIP	Associates the relay to the shutdown event	
	FAIL	Associates the relay to the self-diagnosis event	
	CG1	Associates the relay to the 1st Forced Cooling stage	
	CG2	Associates the relay to the 2nd Forced Cooling stage	
	INSA	Associates the relay to the aging alarms	

Submenu	Parameter	Description	Adjusted Value
RELA	***Relay #03***		
	RLNC	Default Relay status between REST and ENER	
	ALR	Associates the relay to the alarm event	
	TRIP	Associates the relay to the shutdown event	
	FAIL	Associates the relay to the self-diagnosis event	
	CG1	Associates the relay to the 1st Forced Cooling stage	
	CG2	Associates the relay to the 2nd Forced Cooling stage	
	INSA	Associates the relay to the aging alarms	
	Relay #04		
	RLNC	Default Relay status between REST and ENER	
	ALR	Associates the relay to the alarm event	
	TRIP	Associates the relay to the shutdown event	
	FAIL	Associates the relay to the self-diagnosis event	
	CG1	Associates the relay to the 1st Forced Cooling stage	
	CG2	Associates the relay to the 2nd Forced Cooling stage	
	INSA	Associates the relay to the aging alarms	
	Relay #05		
	RLNC	Default Relay status between REST and ENER	
	ALR	Associates the relay to the alarm event	
	TRIP	Associates the relay to the shutdown event	
	FAIL	Associates the relay to the self-diagnosis event	
	CG1	Associates the relay to the 1st Forced Cooling stage	
	CG2	Associates the relay to the 2nd Forced Cooling stage	
	INSA	Associates the relay to the aging alarms	
CONF	RTD	Quantity of temperature sensors	
	PSD	New access password to the menus	
	DISP	Display indication mode	
	BDR	Baud-rate of the serial communication	bps
	ADDR	Address in the serial communication	
	PROT (*Opt.*)	Communication Protocol	
FAN	**IND - *Individual***		
	CG11	Temperature 1st Forced Cooling stage of the RTD-01	°C
	CG21	Temperature 2nd Forced Cooling stage of the RTD-01	°C
	CG12	Temperature 1st Forced Cooling stage of the RTD-02	°C
	CG22	Temperature 2nd Forced Cooling stage of the RTD-02	°C
	CG13	Temperature 1st Forced Cooling stage of the RTD-03	°C
	CG23	Temperature 2nd Forced Cooling stage of the RTD-03	°C
	CG14	Temperature 1st Forced Cooling stage of the RTD-04	°C
	CG24	Temperature 2nd Forced Cooling stage of the RTD-04	°C
	CG15	Temperature 1st Forced Cooling stage of the RTD-05	°C
	CG25	Temperature 2nd Forced Cooling stage of the RTD-05	°C
	CG16	Temperature 1st Forced Cooling stage of the RTD-06	°C
	CG26	Temperature 2nd Forced Cooling stage of the RTD-06	°C
	HYST	Hysteresis of the cooling groups	°C

Submenu	Parameter	Description	Adjusted Value
FAN	**ALL - *All***		
	CGR1	Temperature 1st Forced Cooling for all the RTD's	°C
	CGR2	Temperature 2nd Forced Cooling for all the RTD's	°C
	HYST	Hysteresis of the cooling groups	°C
	ALTR	Alternation of the cooling groups	
	TFE	Fan Exercise Time	min.
ANOU (*Optional*)	AORG	Analog output range (mA)	
	BSCA	Beginning of the scale of the analog output	
	FSCA	End of the scale of the analog output	
	ANIN	Reference variable of the analog output	
AGNG (*Optional*)	NTPR	Number of Windings	
	STND	Standard used when calculating aging.	
	INSU	Insulation thermal grade	
	INL1	First Winding initial life percentage	%
	INL2	Second Winding initial life percentage	%
	INL3	Third Winding initial life percentage	%
	INL4	Fourth Winding initial life percentage	%
	INL5	Fifth Winding initial life percentage	%
	INL6	Sixth Winding initial life percentage	%
	LOLF	Minimum Tolerated Service Life Percentage	%
	LOLT	Minimum Tolerated Service Life Time	years
	TRND	Filtering time constant	h

7.2 Appendix B – Technical Data

Power Supply Voltage:	38 to 265 Vac/Vdc 50/60Hz
Maximum consumption:	< 5 W
Operating Temperature :	-10 to +70 °C
Degree of Protection:	Frontal Panel IP 50 Back plate IP 20
Electrical Connections	0.3 to 2.5mm^2, 22 to 12 AWG
Mounting:	Flush mounted with panel
Analog Outputs – only in the version with the "Analog Output" Option : **Maximum error:** **Options (selectable) and maximum load:**	 One 0,5 % of the end of scale 0-10 mA, 1kΩ 0-20 mA, 500Ω 4-20 mA, 500Ω
Outputs to relays: **Type and functions (standard):** **Maximum switching capacity:**	Potential free contacts Three Configurable Reversible Relays Two Normally Closed Configurable Relays (standard Forced Cooling). 250 Vac 5A / 30 Vdc 5 A
Temperature Direct Measurements (for instance, windings, oil, ambient, stators, etc.): **Sensor:** **Measurement Range:** **Maximum error at 20ºC:** **Deviation per temperature variation:** **Connection type**	Six inputs to RTD sensors with continuous self-calibration (five in the Analog Output version). Pt-100 Ω at 0 °C -55...200 °C 0.5% of the end of scale 20ppm/ºC Three wires
Remaining Service Life 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 (default) DNP3 Level 1 (optional)
Serial Communication Ports:	1 RS-485 for supervisory system

7.3 Appendix C – Ordering Specifications

The LAD is a multifunction equipment, with its characteristics selected in its programming menus. These adjustments can be done directly on its frontal panel or through the RS-485 serial communication door.

The power supply input is universal (38 to 265 Vdc/Vac 50/60 Hz).

To order the equipment, the only specifications needed are:

- Product required quantity;
- Option 1: DNP3 Protocol (yes or no);
- Option 2: Analog Output (yes or no);
- Option 3: Pump and Fan Exercise (Yes or No);
- Option 4: Online calculation of the winding aging (Yes or No);
- Accessories for the LAD, all **Treetech** quality.

The quantity of optional items that were required for each piece of equipment can be specified at will.

7.3.1 Options available in the LAD

Option 1 - DNP3 Protocol:

User-selectable communication protocol; the user can choose between Modbus- RTU and DNP3 level 1, with timestamp support with 1ms accuracy.

Option 2 - Analog Output

Programmable analog output for remote temperature indication, selectable by the user, for the indication of the highest temperature or a predetermined temperature.

Programmable output range: 0-10, 0-20 or 4-20 mA.

Note: when the Analog Option is specified, the RTD 06 measurement input will be unavailable.

Option 3 - Fan Exercise

The Cooling or Fan Exercise function prevents lack of fan activity for long periods of time, in equipment operating with a low load or during low ambient temperature seasons. Therefore, the axis will not be blocked by buildup of dirt or dust or dry grease. The cooling equipment will be activated daily for the time selected by the user, from 0 to 999 minutes.

Option 4 - Winding Insulation Aging Online Calculation:

The Aging Calculation Function performs the online monitoring of the loss of service life of the winding insulation, therefore making important information available for the diagnosis and prognosis of the equipment state:

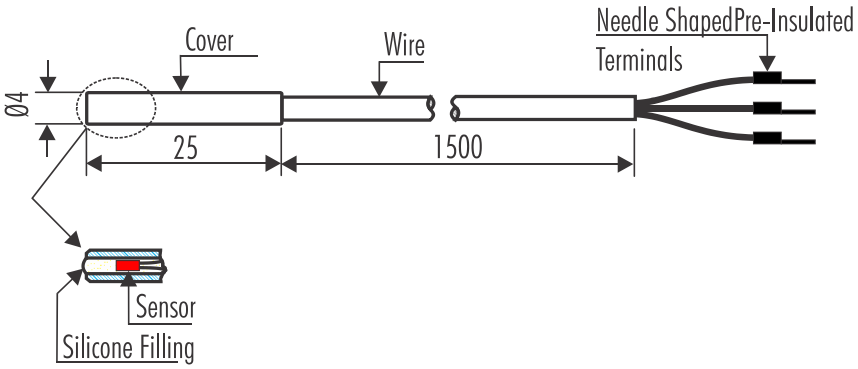
- Current percentage of remaining service life, from 100% (new insulation) to 0% (end of insulation service life);
- Average loss of insulation life, in % a day, calculated for a period of time chosen by the user;
- Estimate of the remaining service life of the insulation, calculated as a function of the aforementioned variables (remaining life percentage and average loss of life rate).

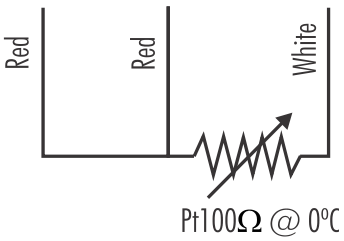
7.3.2 Available accessories for the LAD

Treetech recommends that accessories for the LAD come with origin certification, such as those shown here.
Therefore, the LAD will perform its functions in the most efficient and safe way.

Temperature Sensor for Dry Transformers, Motors and generators

Pt-100 Ω sensor at 0 °C to measure the temperature of the windings in dry transformers.

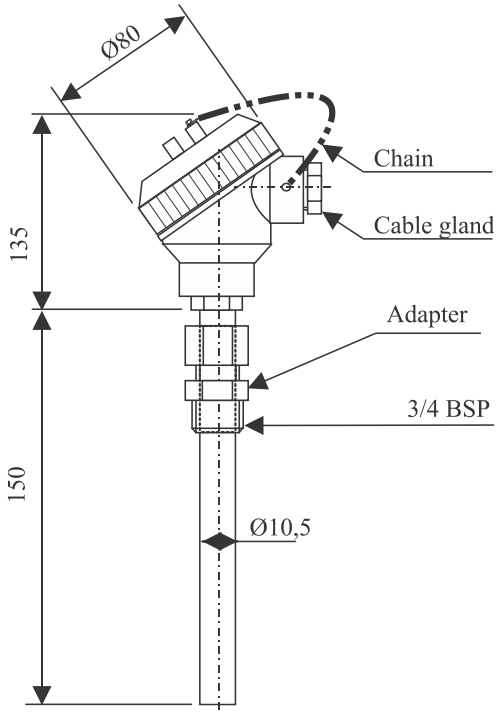




Characteristics:	Specification:
Sensor element:	Pt-100 Ω to 0 °C, 3 wires, according to ASTM E1137 class B
Variation Coefficient	0,385 Ω/ºC
Connector cable	Flexible 3 x 11 AWG Tinplated Copper. Teflon insulation
Sensor protection	Teflon tubing
Protection Grade (sensor)	IP-68
Aging	2 kV 50/60 Hz for 1 minute

Temperature Sensor for Oil-Immersed Transformers

Temperature measurement of top oil in power transformers is usually done through a temperature sensor installed in a thermowell on the transformer's cover. The sensors used with the LAD must be of the Pt-100Ω at 0ºC type. If needed, Treetech has a sensor that is appropriate to be installed in a thermowell, as per the drawing below (special sizes on demand), supplied as optional accessory.



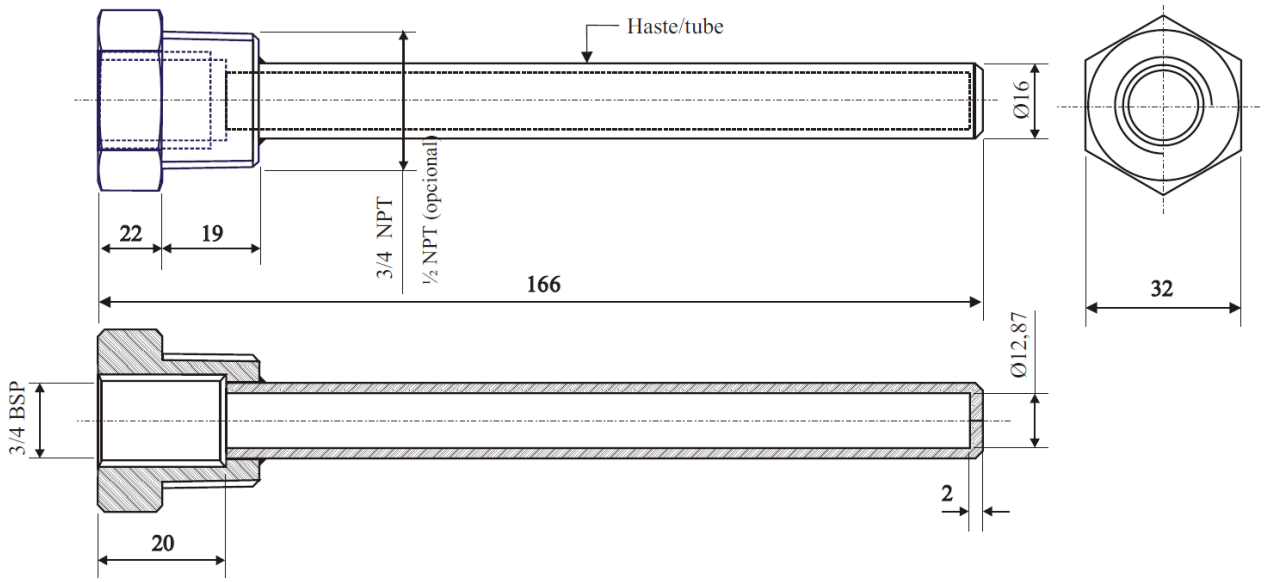
Characteristics	Specification:
Sensor element:	Pt-100 Ω to 0 °C, 4 wires, according to ASTM E1137 class B
Measurement range	-100 to +300ºC
Variation Coefficient	0,385 Ω/ºC
Head	Cast Aluminum painted yellow
Stem, Gland and Screws	Stainless Steel
Cable Fittings and Chain	Nickel-plated Tin
Washer	PTFE (Teflon).
Protection Grade	IP-55
Insulation:	2.5 kV 50/60 Hz for 1 minute

Thermowells for Pt-100

The thermowells are used for total protection to sensors at the points where they are installed. They are also used to completely seal the process against pressure losses, leaks or possible contamination.

Assembling the sensors with thermowells is needed where the safety and installation conditions are crucial.

In addition to that, the sensor is easily removed for maintenance, without the inconvenience of needing to stop the process.



The thermowells are made of 304 Stainless Steel, one of the most used materials to protect from temperatures up to 900 °C, that resists corrosion very well.

Characteristics	Specification:
Inside Thread	¾ BSP
Outside Thread	¾ NPT or ½ NPT

Outdoor cable

Treetech makes a specially developed cable, manufactured to be used outdoors, that does not require any kind of protection. With this cable, the Pt-100 connection is much faster.

Characteristics	Specification:
Conductors	3 x1.5 mm^2
Aging	EPR – EPR
Shielding	Copper Mail Sleeve

Weather Shelter

Through any of the inputs of the Dry Transformer Temperature Monitor – LAD the ambient temperature can be measured.

The weather shelter must be used together with a temperature sensor of the Pt-100 Ω at 0 °C kind. This arrangement minimizes the influences that weather may have on the measurement.

Treetech has sensor and weather shelter that are adequate for this kind of measurement.

Outdoor cabinets

The LAD Temperature Monitor must be installed always sheltered from the weather. The LAD Temperature Monitor must be installed in a weatherproof place, and therefore it is usually kept protected inside a control panel or inside a building.

If needed, the LAD can be supplied in a weatherproof Rapid Installation Panel.

Characteristics	Specification:
Panel fastening	Bolted or with high load capacity magnets.
LAD Mounting	On a sliding rack
Wiring connection	Multipolar removable plug, at the bottom of the cabinet.
Protection Grade	IP-55
Aging	2 kV, 50/60 Hz, 1 minute.

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