USER MANUAL

Treetech

AVR

Automatic Voltage Regulator

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1 Foreword

1.1 Legal information

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1.1.1 Disclaimer

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1.2 Presentation

This manual presents all the recommendations and instructions for installation, operation and maintenance of the Automatic Voltage Regulator – AVR.

1.3 Typographical conventions

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

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

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

<u>Underlined</u>: References to external documents.

1.4 General and safety information

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

1.4.1 Safety symbols

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

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

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

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

1.4.2 General symbology

This manual uses the following general purpose symbols:

Important
This symbol is used to highlight information.

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

1.4.3 Recommended minimum profile for AVR operator and maintainer

Installation, maintenance and operation of equipment in electrical power substations require special care and therefore all recommendations in this manual, applicable standards, safety procedures, safe work practices and good judgment must be used during all steps of handling the Automatic Voltage Regulator - AVR.

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

To handle the AVR, the professional must:

1. Be trained and authorized to operate, ground, turn on and off the AVR, following the maintenance procedures in accordance with established safety practices, which are under the sole responsibility of the operator and maintainer of the AVR;

2. Be trained in the use of PPEs, CPEs and first aid;

3. Be trained in the operating principles of the AVR, as well as its configuration;

4. Follow the normative recommendations regarding interventions in any type of equipment inserted in an electrical power system.

1.4.4 Environmental and voltage conditions required for installation and operation

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

Table 1 - Operating conditions

Condition	Range/description
Application	Equipment for indoor use in substations, industrial and similar environments.
Indoor/outdoor use	Indoor use
Degree of protection (IEC 60529)	IP20

1.4.5 Testing and installation instructions

This manual must be available to those responsible for the installation, maintenance and users of the Automatic Voltage Regulator – AVR.

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

1. Read this manual carefully before installation, operation and maintenance of the AVR. Errors in the installation, maintenance or adjustments of the AVR may cause undue alarms, fail to issue relevant alarms and thus cause a poor understanding of the actual state of health and operation of the transformer.

2. Installation, adjustments and operation of the AVR must be carried out by trained personnel familiar with power transformers with mineral or vegetable oil insulation, control devices and control circuits of substation equipment.

3. Special attention must be given to the installation of the AVR, including the type and gauge of the cables, place of installation and putting into service, including the correct parameterization of the equipment.

4. When carrying out dielectric strength tests on the wiring (applied voltage), disconnect the ground cables connected to terminal 01 of the Automatic Voltage Regulator AVR in order to avoid destroying the protections against overvoltages inside the devices due to the application of high voltages over a long period (eg 2 kV for 1 minute).These protections are internally connected between the input/output terminals and ground, clamping the voltage at about 300 V.

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

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

If the panel in which the AVR has been installed has a window, use a G20 film - or higher - to prevent the direct incidence of sunlight (ultraviolet rays) on the equipment.If the glass of this window is dark, such procedure is not necessary.

1.4.6 Cleaning and decontamination instructions

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

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

1.4.7 Inspection and maintenance instructions

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

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

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

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

1.5 Customer service

Are you familiar with our online customer service platform?

CS

A quick and direct communication channel with our support team is available on the CS page. Ask questions, solve problems and keep up with the application of your Treetech product.

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

In some cases, it will be necessary to send the equipment to Treetech Technical Assistance. In the Customer Service, we present all the necessary procedures and contacts.

This manual corresponds to firmware version 1.04.

1.6 Termo de garantia

The Automatic Voltage Regulator AVR will be guaranteed by Treetech for a period of 2 (two) years, counted from the acquisition date, exclusively against any manufacturing defects or quality defects that make it unfit for regular use.

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

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

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

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

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

2 Introduction

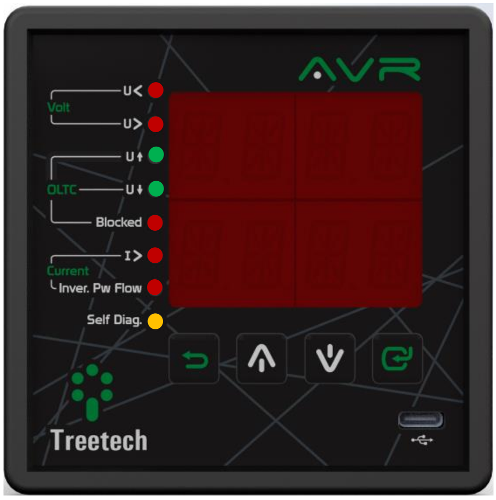


Figure 1 – AVR front display

In an increasingly demanding market regarding Electricity Quality, and with more and more strict rules for the definition of acceptable parameters and supply limits, there is a pressing need for tools capable of adapting to this reality and allowing adequate voltage regulation.

In this context, Treetech's Automatic Voltage Regulator AVR offers a solution that goes beyond the traditional and well-known "90" relays, endowed with unprecedented features to provide better control of voltage limits in the load, allowing the most demanding regulations in this sector to be met (such as ANEEL resolution 505).

2.1 Basic Operating Philosophy

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

The AVR performs the transformer output voltage and load current measurements and uses them together with the programmed line voltage drop parameters to calculate the load voltage, which in turn is the voltage that must be effectively maintained within the desired limits as shown in the figure below.

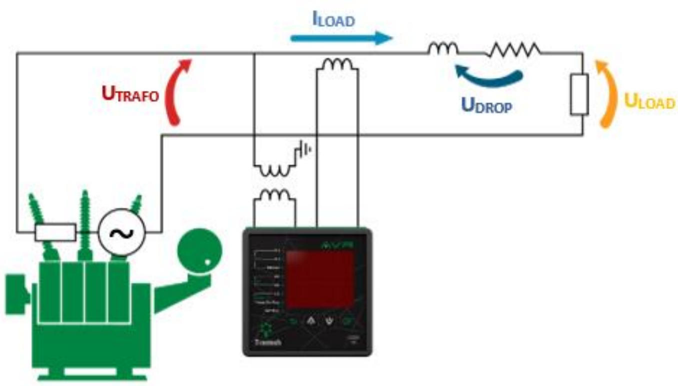


Figure 2 - Application diagram of the Automatic Voltage Regulator - AVR

In addition to the basic voltage regulation function, the AVR also performs protection functions for the on-load tap changer, blocking its operation in adverse conditions, such as a short circuit in the line (overcurrent/undervoltage) and protection for the load (overvoltage).

2.2 Intended use

The intended use of the Automatic Voltage Regulator – AVR is to offer a solution that goes beyond the traditional and well-known "90" relays, endowed with unprecedented features to provide better control of voltage limits in the load, aiming to maintain the voltage in the load within a range of values determined by the parameters programmed by the user.

It performs the transformer output voltage and load current measurements and uses them together with the programmed line voltage drop parameters to calculate the load voltage, which in turn is the voltage that must be effectively maintained within the desired limits.

2.3 Key Features

IED (Intelligent Electronic Device)

This IED has a modern and compact design, specifically planned for transformer applications in substations and industrial or commercial facilities.

Alarms and self-diagnosis

Issuance of alarms in case of abnormalities and self-diagnosis for detection of internal failures and integration with other sensors.

Communication protocol

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

Relays

Six signaling relays with NO (normally open) functions and operations and one NC (normally closed) self-diagnosis relay.

Voltage drop compensation

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

OLTC blocking

The OLTC may be blocked in cases of overcurrent, overvoltage, undervoltage, tap changer triggered, and/or power flow reversal.

OLTC command

The user selects the tap changer command mode between Local/Remote and Manual/Automatic.

Mass memory (default)

Non-volatile memory for storing measurements and alarm events.

LED display

The AVR has a 4-digit LED display, which guarantees high brightness and is readable under any lighting and temperature conditions.

2.4 Functions

OLTC position measurement

An input for measuring the OLTC position by a potentiometric transmitter, with cable resistance compensation and error detection.

Associated functions:

- ✓ Current output programming for remote tap indication;
- ✓ Manual command of the local OLTC (front panel) and by communication via protocol;
- ✓ Limitation of the OLTC excursion range (minimum and maximum taps allowed) and memorization of the minimum and maximum positions reached;
- ✓ OLTC blocking in case of operations not initiated by the AVR.

Digital inputs

Four digital inputs for OLTC command mode switching control between manual/automatic and local/remote. They can also be used for the tap up/down command.

OLTC maintenance assistant

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

Verification of successful tap changing enabled

This function allows the AVR to verify the success of the tap changing by means of the voltage changes after the regulation command (increase/decrease voltage).It works through algorithms that identify voltage levels corresponding to the sensitivity of the circuit, confirming tap changing activity or not. In case of inactivity of the tap changer, it generates warnings of failure in the regulation.

Adjustable CT/PT phase difference

Angle adjustments from 0 to 330 degrees available, making it possible to use any type of connection between PT and CT.

Multimeter

Indication of voltages in the transformer and load, voltage deviation, current, active, reactive and apparent power, load percentage, power factor and frequency are some of the monitoring features offered by the equipment.

Voltage drop compensation

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

OLTC blocking

The OLTC may be blocked in cases of overcurrent, overvoltage, undervoltage, tap changer triggered, and/or power flow reversal.

OLTC command

The user selects the tap changer command mode between Local/Remote and Manual/Automatic.

3 Design and Installation

3.1 System Topology

Basically, the Automatic Voltage Regulator - AVR's system is composed of:

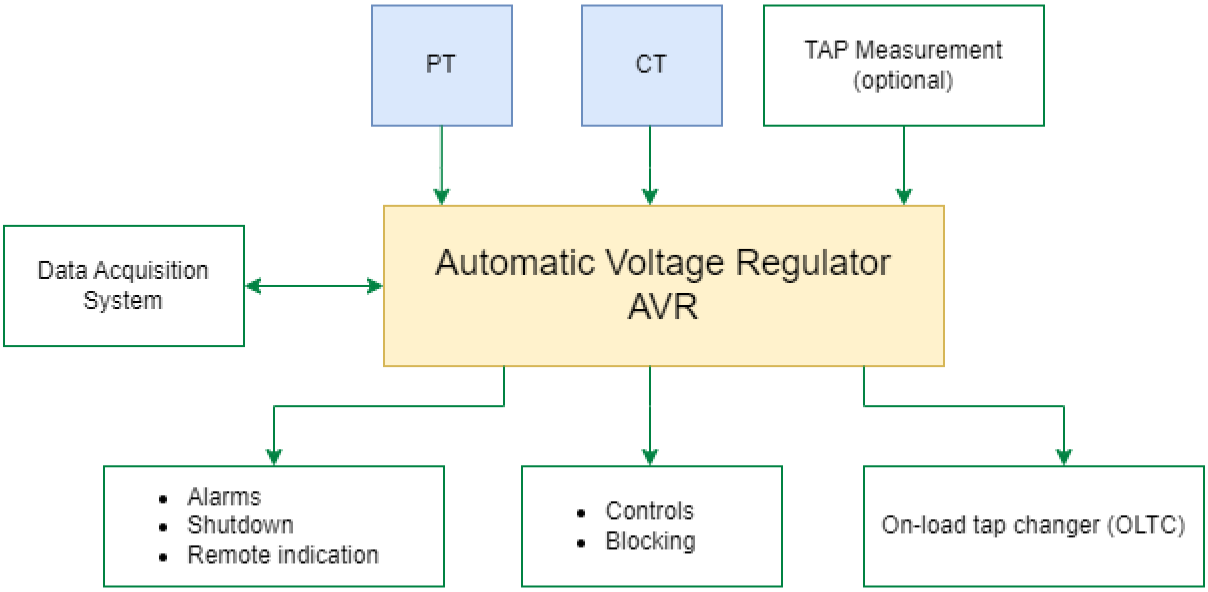


Figure 3 – Composition of the Voltage Regulation system

The items required for system installation are:

- Automatic Voltage Regulator – AVR;
- External split-core window CTs (clip-on);
- Auxiliary PT (single-phase or three-phase);
- Three-way shielded cable for tap measurement;
- Two-way shielded par-twisted cable for RS-485 serial communication;

3.2 Electrical Installation

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

Study and understand the application in which you want to use the AVR. Know the functional, electrical and configuration characteristics of the AVR. This way you will be able to take full advantage of the equipment and minimize the risks to your safety.

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

A circuit breaker should be used immediately before the power input (Universal power - 85 ~ 265 Vac/Vdc, <12 W, 50/60 Hz), which corresponds to pins 02 and 03 of the AVR.

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

In addition, it must have an indelible identification showing that it is the electrical disconnection device of the AVR.

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

The minimum insulation for circuits connected to the AVR is 300 Vrms for auxiliary equipment and transducers, such as clip-on CTs powered by the AVR and for equipment with its own power up to 50 Vrms.

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

These values are relative to the intrinsic insulation of the devices connected to the AVR.Cases where these values do not apply to equipment or devices connected to the AVR will be explicitly stated in this manual.

3.2.1 Cables specification

Table 2 - Cables specfication

Cables specification		
Function	***Specification***	***Note***
Power	1,5mm^2 to 2,5mm^2	-
Potentiometric transmitter	-	Recommended to consult the topic TAP Measurement - Potentiometric transmitter for recommended cable specifications and installation guide.
Window CT (Clip-on)	1,5mm^2 to 2,5mm^2	-
PT (measurement)	1,5mm^2 to 2,5mm^2	-
Relays	**1,5 mm^2:** Minimum gauge for signaling (self-diagnosis, alarms...)	Recommended in accordance with the NBR 5410 standard
RS485	2x18AWG PVC Cable	Recommended to consult the topic RS-485 Communication for instalation guide.

3.2.2 Connection diagram

The standard schematic diagram of the AVR connection shows all the possibilities of connections, identifying them, as shown in the figure below.

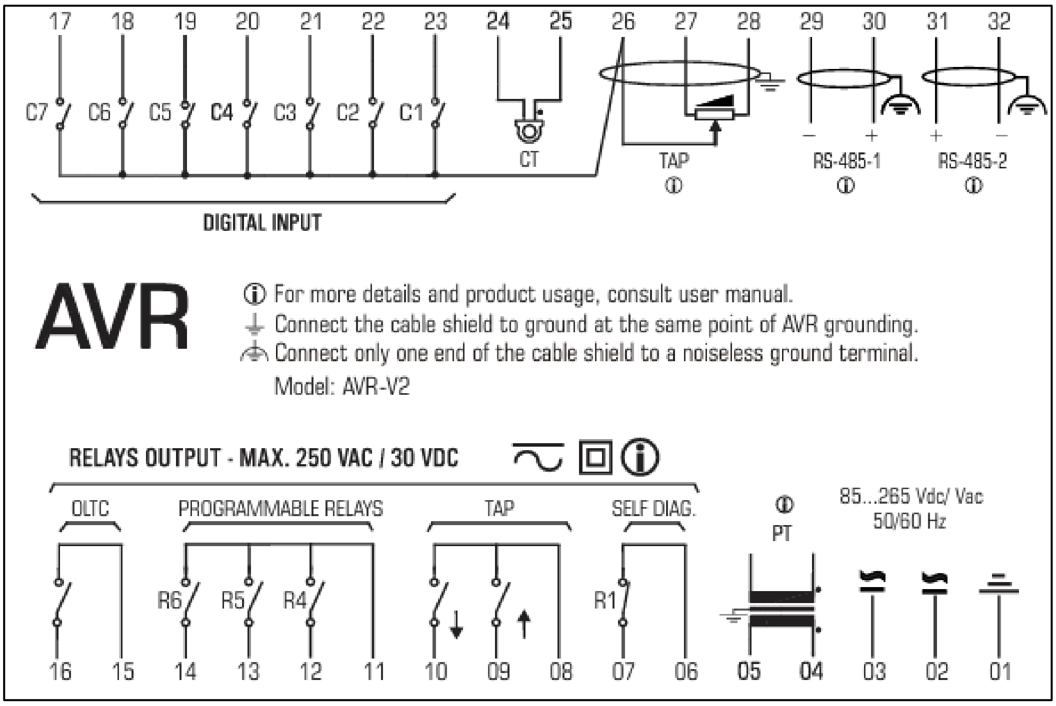


Figure 4 - AVR input and output terminals

3.2.3 Input and output terminals

The Automatic Voltage Regulator has the following inputs and outputs:

Table 3 - AVR Input Terminals

Inputs	Terminals
Power and ground Power input 85 to 265 Vdc/Vac, 50/60 Hz, <12 W.	01 — Ground 02 — dc/ac 03 — dc/ac
Type-C USB port Connection to external computer, for log download only.	Located in the lower right corner of the device's front display.
RS-485 Ports — Serial communication network with monitoring or supervisory system Connection for monitoring or supervisory system, using Modbus® RTU or DNP3 protocol. Use twisted pair and shielded cable.	**RS-485 (1)** 29 — (-) 30 — (+) **RS-485 (2)** 31 — (+) 32 — (-)

Clip-on CT input Current measurement input for clip-on window CT secondary. Measuring range: 0 to 10 A.	24 and 25
Digital inputs Input for remote selection of the Regulation Set (1 to 6) to be used in voltage regulation.	23 — I_{wind} 1 22 — I_{wind} 2 21 — I_{wind} 3 20 — I_{wind} 4 26 – Common
Voltage input The input for measuring one of the transformer voltages is important for the execution of functions related to voltage regulation.	04 - V_L 05 - Common
Tap measurement by potentiometric transmitter For the tap position measurement to work correctly, it is necessary to connect a potentiometric transmitter or an analog signal to the AVR. If the first option is chosen, this item describes where and how the transmitter should be connected.	26 – Cursor 27 – Start 28 – End

Table 4 - AVR output terminals

Outputs	Terminals
Relay 01 — Self-diagnosis One potential-free NC (Normally Closed) relay for self-diagnosis.	06 and 07
Relay 02 — Increase voltage One potential-free NO (Normally Open) relay to increase voltage.	08 and 09
Relay 03 — Decrease voltage One potential-free NO (Normally Open) relay to decrease voltage.	08 and 10
Relay 04 — Parameterizable One potential-free and configurable NO (Normally Open) relay.	11 and 12
Relay 05 — Parameterizable One potential-free and configurable NO (Normally Open) relay.	11 and 13
Relay 06 — Parameterizable One potential-free and configurable NO (Normally Open) relay.	11 and 14
Relay 07 — OLTC blocking One potential-free NO (Normally Open) relay for OLTC blocking.	15 and 16

3.2.4 Power and ground

The AVR has universal auxiliary power input (85 to 265Vdc/Vac 50/60Hz) independent of the PT measurement input. It is possible, however, to use the PT's own secondary voltage to power the equipment through an external jumper, connecting in parallel the measurement input and the power supply. In this case, the consumption of the equipment (<12W) and the power of the PT must be taken into account.

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

3.2.5 Communication ports

3.2.5.1 Type-C USB

The AVR has a type-C USB communication port located on its front. This port has a fixed address of 247 and the available communication protocols are Modbus® RTU and DNP3 in only 1 instance.

3.2.5.2 RS-485 Communication

The AVR provides 2 serial communication ports that can be connected to a data acquisition system (supervisory or monitoring system).

Up to 31 pieces of equipment can be interconnected in the same communication network. The available communication protocols are Modbus® RTU and DNP3.

Although the DNP3 protocol is available on all communication ports, its use is limited to only one of them, selectable by the user.

The interconnection between the AVR and the data acquisition system must be carried out by means of a shielded twisted pair cable, maintaining the mesh without interruption throughout the route. If there is a need for intermediate terminals to interconnect the serial communication, also pass the shield of the cable by terminal, avoiding its interruption. The unshielded cable section due to splicing should be as short as possible, and it is advisable for the cable shield to be grounded at only one end. The maximum distance of 1300 meters between the ends of the communication network must be obeyed.

A 120 ohm termination resistor must be installed at each end of the serial communication, as well as pull-up and pull-down resistors at only one point in the network, as shown in the figure below. The 5V continuous voltage for supplying the pull-up and pull-down resistors may be internal to the data acquisition system; note that some communication equipment may already have these resistors installed internally, eliminating the use of external resistors.

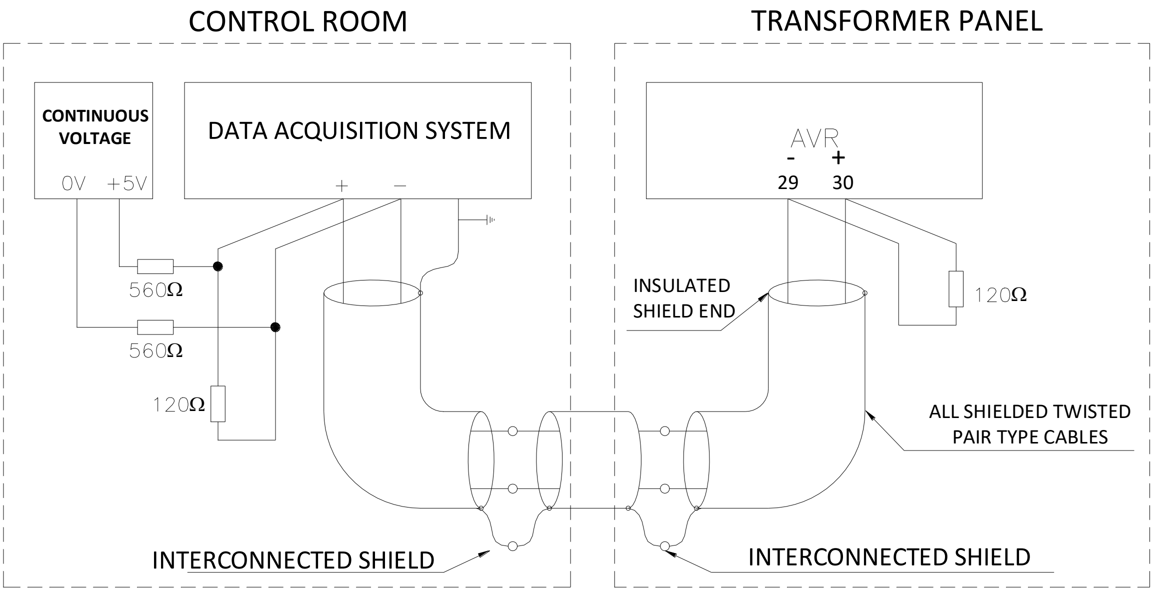


Figure 5 - Connection and grounding of the RS-485 serial communication shield

All AVRs that participate or may participate in parallelism must be interconnected simply by connecting their RS-485 interconnection. ports in parallel by means of a shielded twisted pair cable, maintaining the mesh without interruption throughout the route.

If there is a need for intermediate terminals to interconnect the serial communication, also pass the shield of the cable by terminal, avoiding its interruption. The unshielded cable section due to splicing should be as short as possible. It is advisable for the cable shield to be grounded at only one end, and for a 120 ohm termination resistor to be installed at each end of the serial communication, as shown below. The RS-485 ports for interconnection already have pull-up and pull-down resistors internal to the AVRs, eliminating the use of external resistors. The maximum distance of 1300 meters between the ends of the communication network must be obeyed.

3.2.6 PT and CT measurement inputs

The equipment uses external CTs with non-sectionable core. The measuring ranges of the PT (power transformer) inputs are from 0 to 185 Vrms and of the CT (current transformer) are from 0 to 10 Ac rms respectively. Both inputs perform the TRUE RMS mode measurements.

Due care must be taken for the connection of the CT input, in order to ensure that it does not remain open during the operation of the transformer. If interventions are carried out on this circuit with the transformer energized, check that the CT is short-circuited and grounded on the terminals of the panel, removing the short-circuit only after making sure that the CT input of the AVR is correctly connected.

If the AVR has the regulation function, it is important to inform in the configuration which input the external CT is connected to. This external CT is of the window type with non-sectionable core and has a measuring range from 0 to 10 Ac rms, with an error of 1% of the measurement for loads up to 300 Ω.

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

The following are examples of some possible combinations of PT and CT connections. Other combinations are possible, and the phase angle can be easily determined by drawing the phasor diagram as indicated in the examples.

1∅ 0 ° PHASE DIFFERENCE

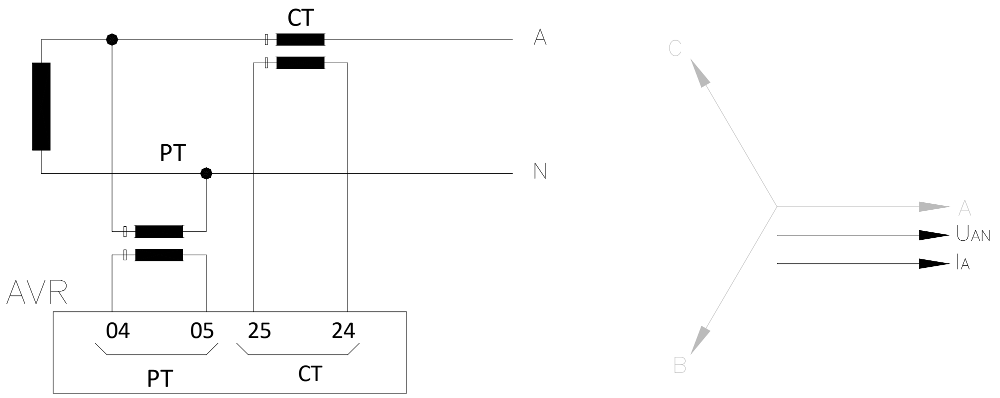


Figure 6 - Single-phase transformer connection, 0 ° phase difference

3∅ 0 ° PHASE DIFFERENCE

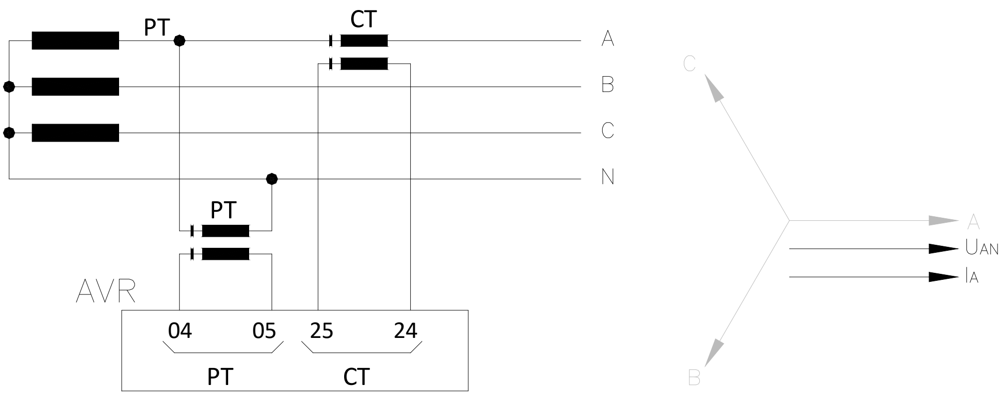


Figure 7 - Phase-neutral PT connection, 0° phase difference

3∅ 0 ° PHASE DIFFERENCE

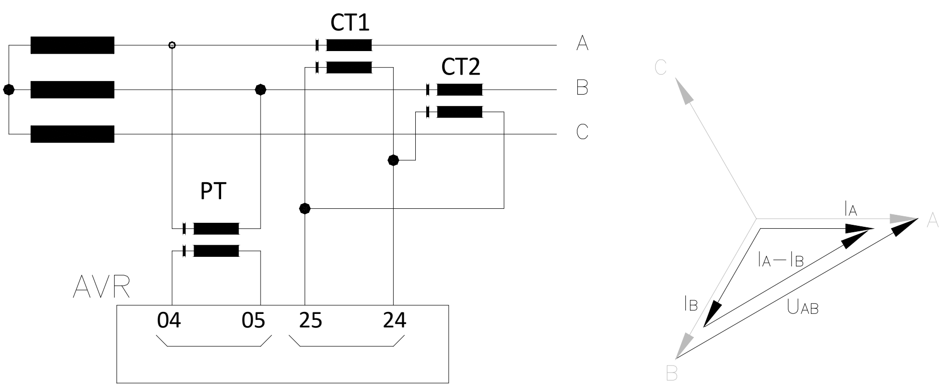


Figure 8 - Phase-phase PT connection, 0° phase difference

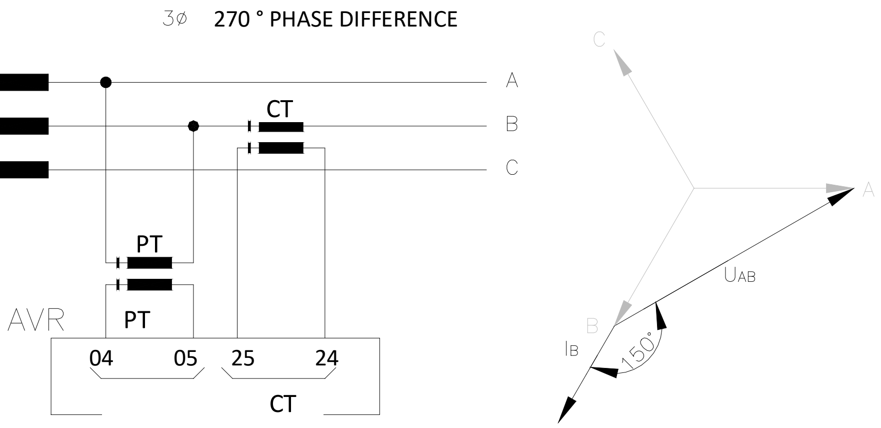


Figure 9 - Phase-phase PT connection, 150° phase difference

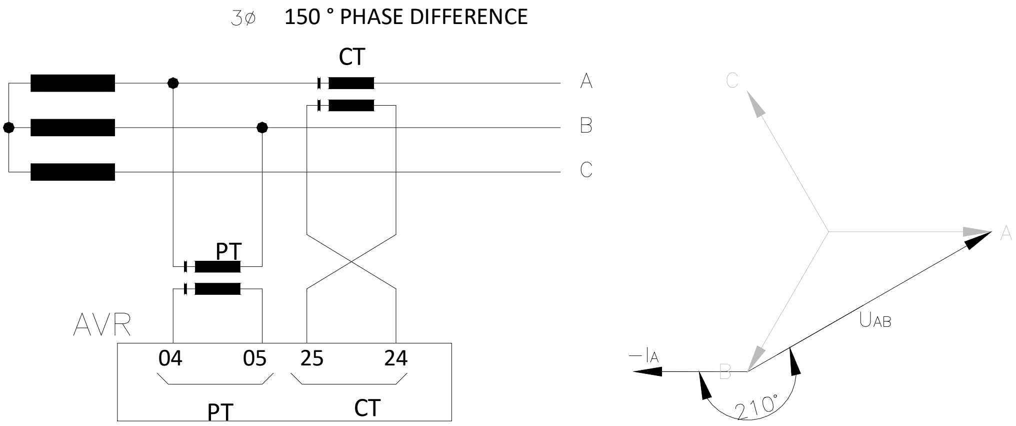


Figure 10 - Phase-phase PT connection, 210° phase difference

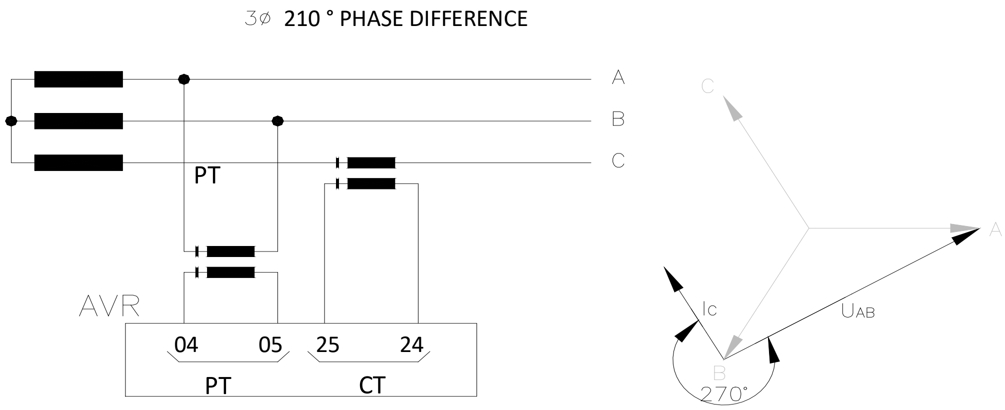


Figure 11 - Phase-phase PT connection, 270 ° phase difference

3.2.7 TAP Measurement - Potentiometric transmitter

It allows the user to use the AVR to track the tap position of the tap changer and manual command of the on-load tap changer. Tap measurement is performed by means of an AVR input specific for connection of an on-load tap changer potentiometric position transmitter.

The connection of the potentiometric transmitter of the on-load tap changer (OLTC) to the AVR is made through three wires: the cursor, the start and the end of the potentiometric transmitter. Shielded cable must be used for this connection along the entire route from the OLTC cabinet to the AVR with the shield grounded at a single point.

If a single shielded cable is not used for the entire route, due, for example, to intermediate connection terminals, the continuity of the shield must be ensured, through the connection of the ends of the shields of the various cables, as can be seen in the figure below. The unshielded cable section due to splicing should be as short as possible.

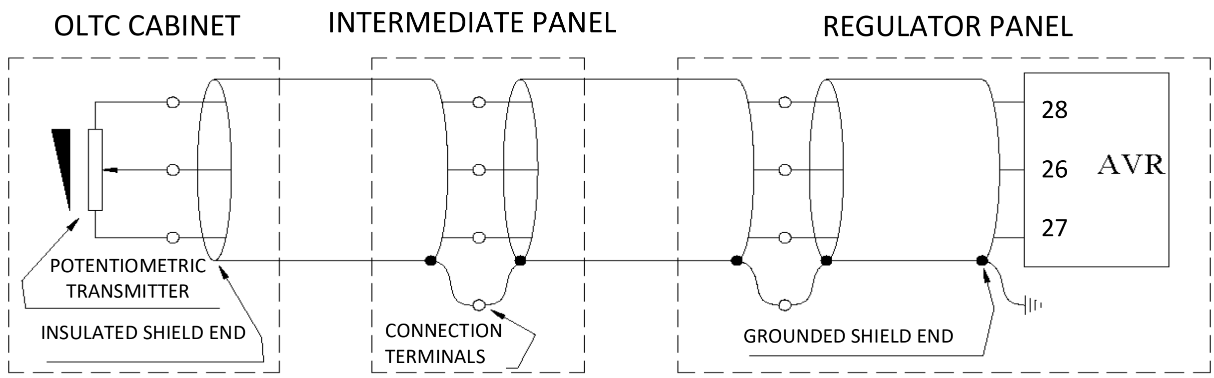


Figure 12 - Connecting the shielding of the TAP measuring cables

The AVR automatically compensates the resistance of the connection cables from the potentiometric transmitter to the AVR and, for this, the three wires must have the same length and gauge, the maximum permissible resistance for each of the wires being 8 Ω. Depending on this maximum resistance and the gauge of the cables used, the maximum length allowed for these can be obtained. Considering cables with typical resistances of 13.3 Ω/km, 7.98 Ω/km and 4.95 Ω/km for the 1.5 mm^2, 2.5 mm^2 and 4 mm^2 gauges respectively (non-tinned cables, stranding class 4), we have the maximum lengths presented in the following table.

Table 5 - Maximum length for tap measuring cable gauges

Cable gauge	Typical resistance	Maximum length
0,5 mm^2	39,0 Ω/km	200 m
0,75 mm^2	26,0 Ω/km	300 m
1 mm^2	19,5 Ω/km	400 m
1,5 mm^2	13,3 Ω/km	600 m
2,5 mm^2	7,98 Ω/km	1000 m
4 mm^2	4,95 Ω/km	1600 m

The tap position transmitter of the on-load tap changer must be of the potentiometric type, with its resistance ranging from zero to the maximum value for the initial and final position of the tap changer respectively.

In the case of tap changers with intermediate positions, that is, transition positions that have the same voltage as other adjacent positions, as exemplified in the following table, the resistors of the potentiometric transmitter referring to these positions must be removed and/or short-circuited.

Table 6 - Cursor resistance indicative of TAP position

TAP position	Voltage (V)	Current (A)	Resistance between cursor/and initial position
1	12420	3220,6	0
2	12696	3150,6	10
3	12972	3083,6	20
4	13248	3019,3	30
5	13524	2957,7	40
6A			50
6	13800	2898,6	50
6B			50
7	14076	2841,7	60
8	14352	2787,1	70
9	14628	2734,5	80
10	14904	2683,8	90
11	15180	2635,0	100

The AVR assumes that the resistance per step of the potentiometric transmitter is in the range of 4.7 to 20 Ω, and the total resistance of the transmitter from 9.4 to 1000 Ω. The value of each individual resistor is shown in the following figure. The mobile contact (cursor) of the potentiometric transmitter can be either "close before open" or "open before close", indifferently. The resistances of the potentiometric transmitter must be accurate, that is, with error tolerances of a maximum of 1%.

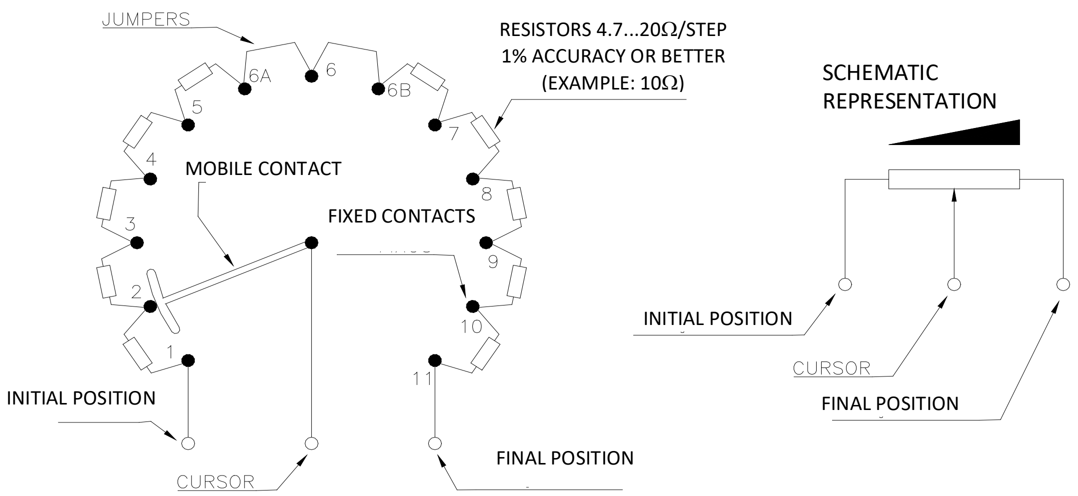


Figure 13 - Configuration of the resistors of the potentiometric transmitter in the intermediate positions of the on-load tap changer

The ongoing position of the on-load tap changer TAP associated therewith may be informed in simple numeric, bilateral numeric or alphanumeric formats (e.g., 1...17, -8...0...8, or 8L...N...8R respectively).

3.2.8 Self-diagnosis relay

The self-diagnosis relay with potential-free NC contact, available on relay 01, signals auxiliary power failures or any internal failure detected by the self-diagnosis system. When energizing the AVR, this contact changes state (opens), returning to the rest position (closed) in case of internal failure or lack of power.

3.2.9 Output contacts for increasing and decreasing voltage

The output contacts for the AVR tap-up and tap-down commands are connected directly to the corresponding on-load tap changer control circuit, and will generally act by energizing the coils of the Tap Up/Down contactors, which in turn energize the drive motor.

All tap changing commands, whether sourced locally via the front of the AVR, or remote via dry contacts or serial communication, are relayed to the on-load tap changer via the Tap Up/Down output contacts.

These contacts have momentary actuation, so that for each tap change command issued by the AVR they will close only once for a time of approximately 0.5 seconds. For this reason, on-load tap changers equipped with intermediate positions, that is, transition positions that have the same voltage as other adjacent positions, must have automatic passage of the intermediate positions.

Considering this example, if the tap changer is in position 5, and the AVR emits a single Tap Up command, the on-load tap changer must move from position 5 to 6A and then from 6A to 6 automatically.

3.2.10 Parameterizable relays

The parameterizable relays with potential-free contacts, normally open (NO), available in relays 04, 05 and 06, can be operated by more than one of the configurations when any of the alarms is triggered.

3.2.11 OLTC Blocking Relay

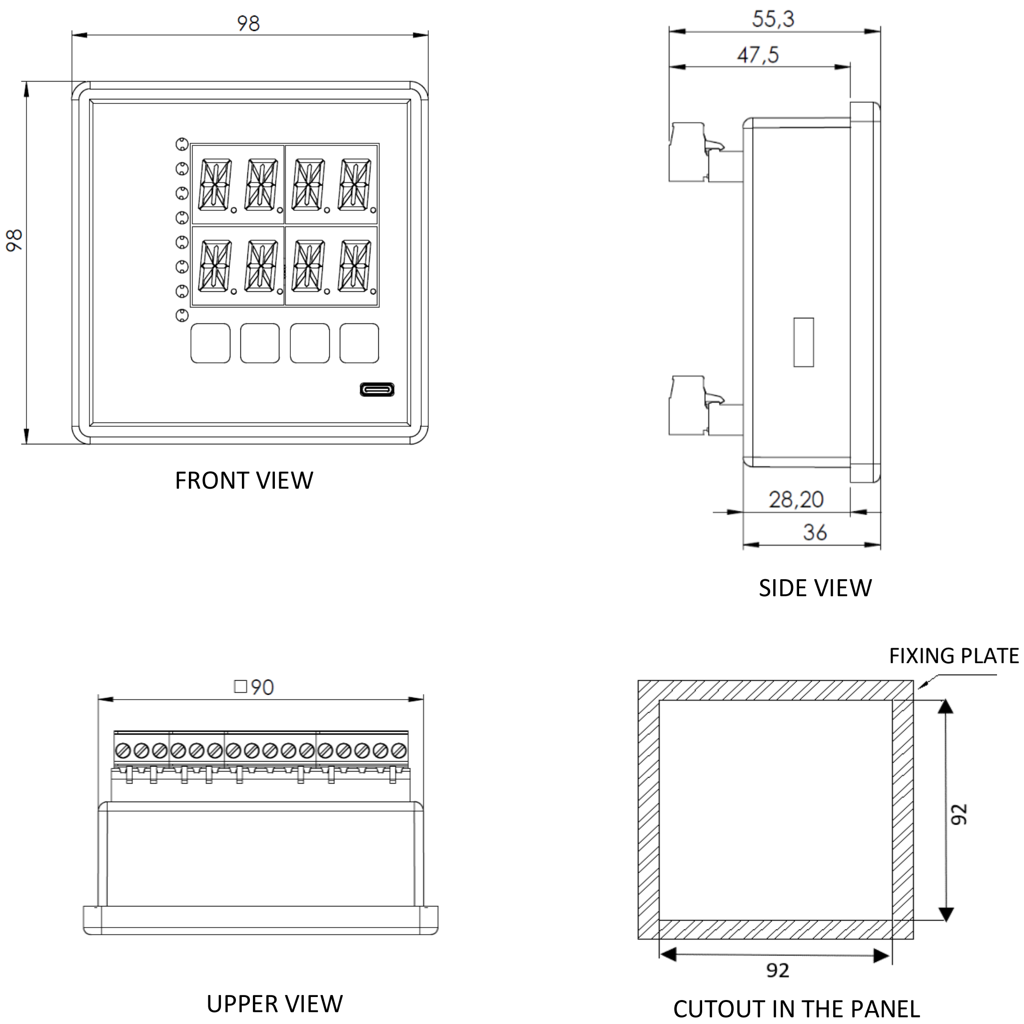
The potential-free contact OLTC blocking relay is programmed for the on-load tap changer block function, available only on relay 07. The conditions that will cause the tap changer blocking actuation (according to a logical OR) are selected by the user from the events of: undervoltage, overcurrent, overvoltage, triggered OLTC and reversal of power flow.

3.3 Mechanical Installation

The Automatic Voltage Regulator - AVR must be installed protected from the weather, either inside panels or sheltered inside buildings. In any of the situations, an anti-condensation system must be installed.

The AVR is suitable for the built-in type installation, and can be fixed, for example, on doors or front panel plates. Clips for fastening are provided together with the AVR.

Figure **14** shows the main dimensions of the equipment. Special attention should be paid to the thickness of the paint layers of the plate where the cut is made, because in some cases, when high thickness paint is used, the decrease in the area of the cut can even prevent the insertion of the equipment. Two removable connectors are installed on the back of the AVR in order to facilitate the connections. In those removable terminals, cables from 0.5 to 2.5mm^2 can be used, bare or with "pin" (or "needle") type terminals.



ALL DIMENSIONS IN mm

Figure 14 - Equipment dimensions - AVR

4 Operation

All measurement queries and programming of the Automatic Voltage Regulator – AVR can be performed through the display and keyboard on its front panel. Also any Increase/Decrease voltage, OLTC block, overcurrent (I>), undervoltage (U<), overvoltage (U>) and on-load tap changer alarms will be indicated on the displays.

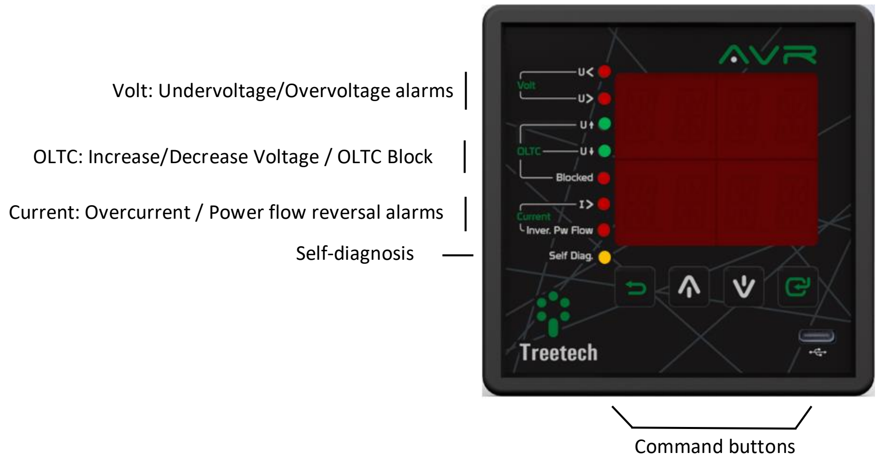


Figure 15 – AVR Indications

4.1 Key Function

The keys have the following functions:

Table 7 - AVR key functions

Key	Functions
	**Programming key:** On the measurement screens, it allows access to the password to enter the programming menu. On the programming menus, it leaves the current menu and returns to the previous level menu. If activated while changing a parameter, it returns to the previous level menu without saving the change made.
	**Up key:** Navigation between measurement screens and between programming menus and parameters. When editing a parameter, it increments the programmed value.
	**Down key:** Navigation between measurement screens and between programming menus and parameters. When editing a parameter, it decreases the programmed value.
	**Enter key:** Selects the menu option and parameters shown on the display, saves programmed values.

4.1.1 Accessing a submenu

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

After accessing the desired submenu:

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

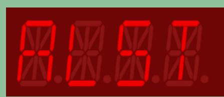
4.2 Query screens

The Automatic Voltage Regulator provides various information for guidance on the working conditions of the transformer. This information is accessed via the keys, and during normal working mode.

4.3 General screen

The following information will be indicated on the displays of the appliance. Pressing the key has the reverse order as indicated below:

Table 8 - AVR query screens

AVR query screens	
Status (ALST) Equipment status indication.	
Active set (SET) Indicates which set is currently active.	
Operating mode (OPMD) Indicates the AVR operating mode (local or remote) and the command mode (automatic or manual).	
Load voltage (LD V) Indicates the equipment load voltage.	
Regulation deviation (RDEV) Indicates the regulation deviation relative to the nominal voltage.	

Active power (ACTP) Indicates the active power of the transformer.	
Apparent power (APPP) Indicates the apparent power of the transformer.	
Reactive power (RCTP) Indicates the reactive power of the transformer.	
Load percentage (LDPC) Indicates the transformer load percentage.	
Ongoing tap (TAP) Indicates the ongoing tap of the transformer.	
Previous tap (PTAP) Indicates the previous tap of the transformer.	
Minimum tap (MNTP) Indicates the minimum tap of the transformer.	
Maximum tap (MXTP) Indicates the maximum tap of the transformer.	

Table 9 - SEC submenu information

SEC submenu information	
SEC submenu Use the arrows to continue browsing through other information or press on this screen to access the submenu and consult the secondary screens. Once inside, navigate using the arrows and . To return to the previous level press .	 
Line voltage (LV) Displays the line voltage of the transformer.	
Line current (LC) Displays the line current of the transformer.	
Frequency (FREQ) Displays the transformer frequency.	
Power factor (PF) Displays the capacitive or inductive power factor.	
Voltage (VOLT) Displays the voltage at the PT secondary of the transformer.	
Current (CURR) Displays the current in the secondary of the measuring CT.	

Table 10 - CLCK submenu information

CLCK submenu information	
CLCK submenu Use the arrows to continue browsing through other information or press on this screen to access the submenu and consult data about date and time. Once inside, navigate using the arrows and . To return to the previous level press .	 
Month indication (MNTH) Indication of the month of the device's internal calendar.	
Day indication (DAY) Indication of the day of the device's internal calendar.	
Year indication (YEAR) Indication of the year of the device's internal calendar.	
Hour indication (HOUR) Indication of the hour of the device's internal clock.	
Minute indication (MIN) Indication of minutes on the device's internal clock.	

4.4 Equipment Information

By simultaneously pressing the keys and it is possible to consult equipment information, the following data will be presented by the equipment display: name, firmware versioning (FW), release, bootloader (BL), bootloader release, serial number 1 and 2.

Equipment name:

Figure 16 - Command to access equipment information

Firmware version:

Figure 17 - Display indicating firmware version

Firmware release:

Figure 18 - Display indicating firmware release version

Bootloader version:

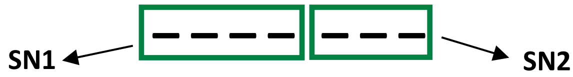
Figure 19 - Display indicating bootloader version

Bootloader release:

Figure 20 - Display indicating bootloader release version

Serial number:

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



Example:

If the serial number is 1234567, **SN1** is 1234 and **SN2** is 567.

Figure 21 - Display indicating part 1 and part 2 of serial number

4.5 Command screens

The Voltage Regulator Relay allows you to carry out commands such as raising/lowering the TAP, resetting the minimum and maximum TAP registers, as well as configuring the operating mode and command.

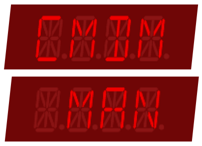
To access, quickly press the key to enter parameter editing.

4.5.1 Operating mode

This screen allows the user to choose the CDC's operating mode between "Local" or "Remote". If the first option is chosen, the source of commands for the CDC will be the device itself. In the other case, the commands will come from an external source, such as another device connected to the network or signals on an input contact.

Adjustment range: Local (LOC), Remote (REM).
Default value: Remote (REM).

4.5.2 Command mode



This screen allows the user to choose the CDC command mode between "Manual" or "Automatic".

If the first option is chosen, the commands to raise and lower the TAP will be given automatically according to the criteria evaluated by the equipment's algorithms. In the other case, they will come from manual commands.

Note: In order to configure this mode via the front panel, the TCOP parameter must be configured in local mode.

Adjustment range: Manual (MAN), Automatic (AUTO).
Default value: Automatic (AUTO).

4.5.3 Minimum TAP reset

Resets the historical value of the recorded minimum TAP.

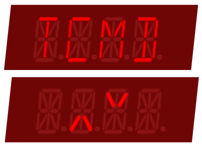
Adjustment range: YES, NO;
Default value: NO.

4.5.4 Maximum TAP reset

Resets the historical value of the recorded maximum TAP.

Adjustment range: YES, NO;
Default value: NO.

4.5.5 Voltage up/down command



For the AVR to be able to execute this command, it must have the following settings:

- ✓ TMES parameter set to YES;
- ✓ Operating mode (TCOP) set to local (LOC);
- ✓ Command mode (CMDM) set to manual (MAN);

Once these settings have been applied, you can access the switch control screen (TCMD) by pressing the and keys simultaneously.

Pressing the key enables the command to raise the TAP;

Pressing the key enables the command to lower the TAP;

If the operating mode is set to remote or the command mode to automatic, the command will not be accepted by the AVR. The device will display one of the screens below, indicating which configuration is not allowing the command.

Figura 22 – *Display* indicating configuration not allowed for the command

5 Parameterization Menus

To ensure the correct operation of the system, several parameters must be adjusted in the AVR that will provide the equipment with the information necessary for its operation. The adjustments can be made through its front keyboard, with the aid of the display, or through the RS-485 communication ports available to the user on the rear panel of the device. The programmable parameters are organized in menus with password-protected access. In the main menu, the user will have access to the programming submenus, where they will be able to navigate and adjust the values according to the characteristics of the transformer and the needs of the users.

5.1 Access to programming menus

To access the Automatic Voltage Regulator - AVR programming menus, follow the procedure below:

1) To access the programming menu, press and hold the key for 5 seconds.

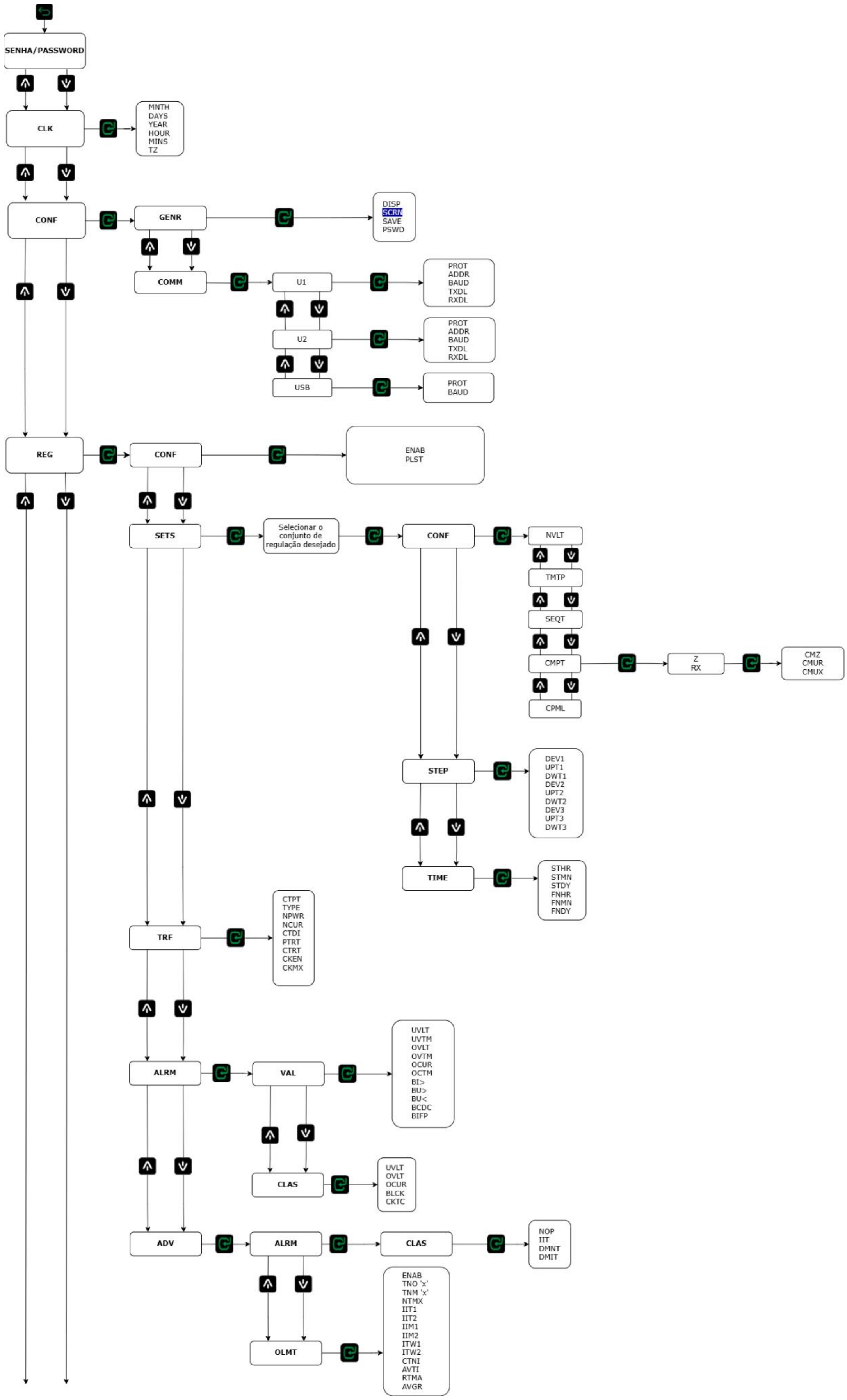
2) The password screen will be displayed.

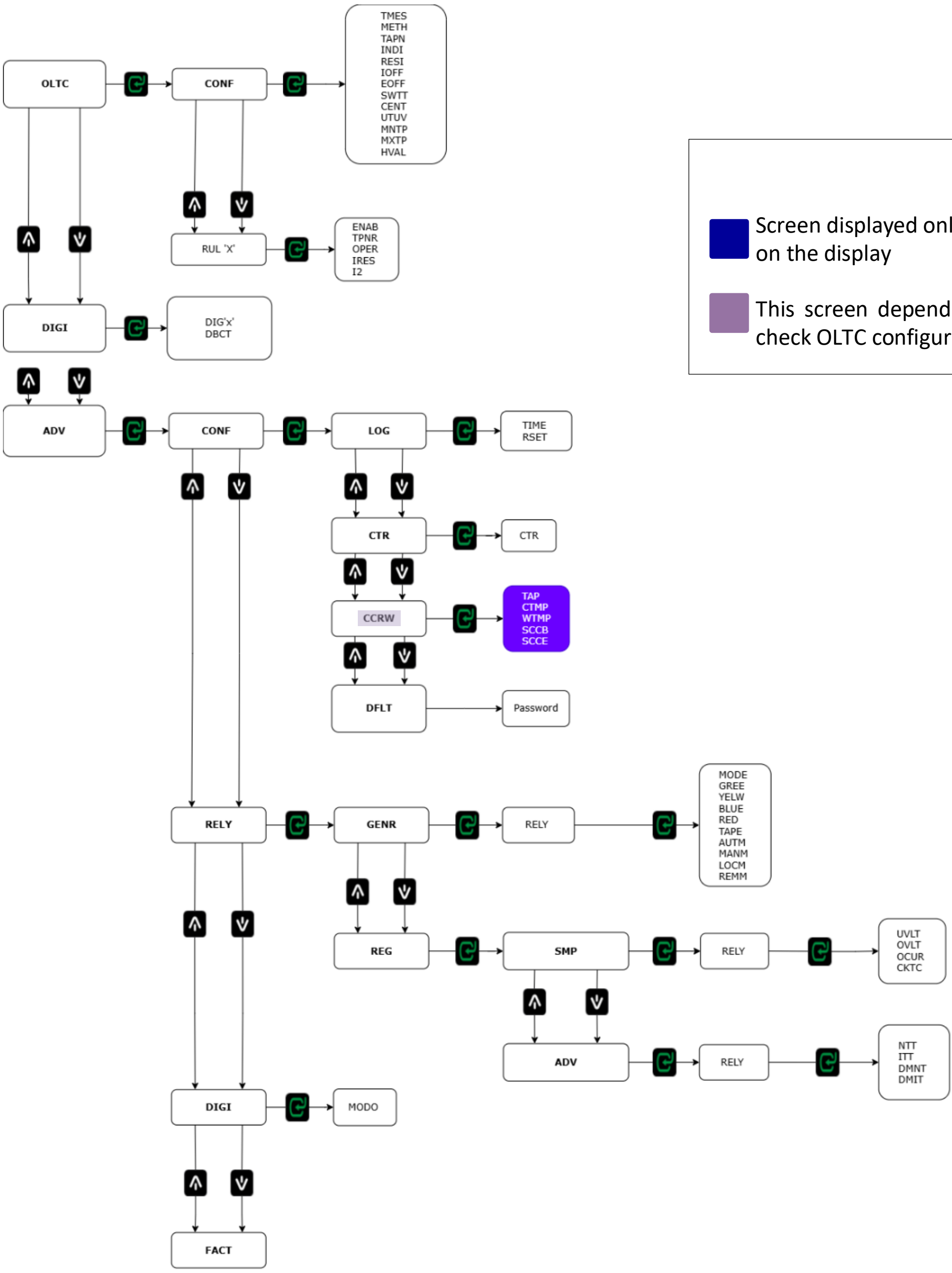
3) Use the and keys to adjust the password (range = 0 to 9999).
If the initial indication is 4210, then the password will be 0, which is the original factory value.

4) After adjusting the password, press and release the key to enter the programming menu.

5) Main menu screen, on which you can navigate to the programming submenus.

5.2 Parameter map





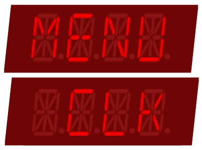
Caption:

Screen displayed only when enabling STAY mode on the display

This screen depends on a condition to appear; check OLTC configuration.

Figure 23 - Access to parameterization submenus

5.3 CLK menu - Clock



Allows the user to adjust the device's clock and calendar.

MNTH - Month

Adjusting the current month on the device’s calendar.

Adjustment range: 1 to 12, in 1 month steps.
Default value: 0.

DAYS - Day

Adjusting the current day on the device’s calendar.

Adjustment range: 1 to 31, in 1 day steps.
Default value: 0.

YEAR - Year

Adjusting the current year on the device’s calendar.

Adjustment range: 0 to 99, in 1 year steps.
Default value: 0.

HOUR - Hour

Adjusting the current hour on the device’s clock.

Adjustment range: 0 to 23, in 1 hour steps.
Default value: 0.

MINS - Minute

Adjusting the minutes on the device clock.

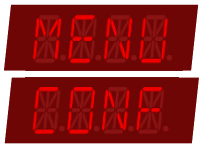
Adjustment range: 0 to 59, in 1 minute steps.
Default value: 0.

TZ - Time Zone

Adjusting the time zone, in hours, on the device’s clock.

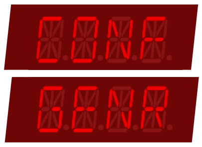
Adjustment range: -12 to +12, in 1 hour steps.
Default value: -3.

5.4 CONF menu – Configuration



Allows access to the parameters related to the basic usability settings of the AVR.

5.4.1 GENR submenu - General



This submenu allows you to perform general AVR settings.

DISP - Display

Display mode of the query screens on the AVR display.

Adjustment range:

- **SCRL =** Alternate display, the AVR displays each of the query screens for 15 seconds, cyclically;
- **STAY =** The display remains fixed on the standard screen (SCRN).

Default value: SCRL.

SCRN - Standard Screen

This screen will only be displayed when enabling STAY mode on the AVR display.

Adjustment range:

- TAP (Ongoing tap);
- LDPC (Load percentage);
- RCTP (Reactive power);
- APPP (Apparent power);
- ACTP (Active power);
- RDEV (Regulation deviation);
- LD V (Voltage on load);
- OPMD (Operating mode);
- SET (Active set);
- ALST (Alarm status);
- NONE.

Default value: ALST.

SAVE – Screen saver

Time parameter to activate the screen saver.

After the parameterized time, the display will behave as configured in the DISP parameter.

Adjustment range: 1 to 15, in 1 minute steps.
Default value: 5 minutes.

PSWD - Password

Changes the password to access the AVR settings menu.

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

5.4.2 COMM submenu – Communication

Allows access to parameters related to serial communication.

Faixa de juste:

- U1 (RS-485 1);
- U2 (RS-485 2);
- USB (front USB type C).

Default value: U1.

PROT – Serial communication protocol

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

Note: The equipment supports that only one of the three ports is configured in DNP3.

Adjustment range:

- MDB = Modbus® RTU;
- DNP3.

Default value: MDB.

ADDR - Address

Selection of the device's address in the communication network, used for data acquisition.

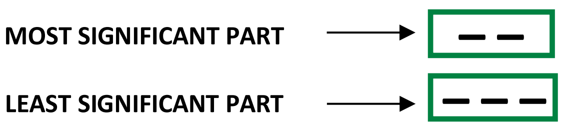
Note: The USB-C port has a fixed address 247.

If the Modbus® RTU protocol is selected in the **PROT** parameter.

Adjustment range: 1 to 247.
Default value: 247.

DNP3 Address Presentation on Display

In the DNP3 address, it will be considered as follows:



When the value is above 9999, the most significant part will be available in the top two displays, and the least significant in the bottom displays.

Suppose the address is 65519.In this case, the most significant portion would be 65 and the least significant portion would be 519.

Adjustment range: 0 to 65519, in steps of 1.
Default value: 247.

BAUD – Transmission speed

Data transmission speed selection.

Adjustment range:

- 4.8 kbps;
- 9.6 kbps;
- 19.2 kbps;
- 38.4 kbps;
- 57.6 kbps;
- 115.2 kbps.

Default value: 9.6 kbps.

TXDL – Tx Delay

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

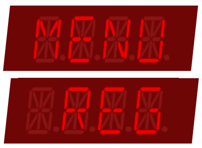
Adjustment range: 5 to 500, in 1 millisecond steps.
Default value: 25 ms.

RXDL – Rx Delay

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

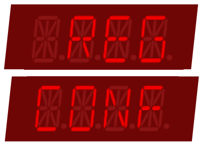
Adjustment range: 5 to 500, in 1 millisecond steps.
Default value: 5 ms.

5.5 REG Menu - Regulation



Allows access to the voltage regulation submenus.

5.5.1 CONF submenu – Configuration



Allows access to initial voltage regulation settings.

Allows access to all parameters related to the mass memory log.

ENAB – Enable regulation

This parameter allows you to enable or disable the regulation function for maintenance reasons, temporary non-use or any other applicable reasons, when the AVR model with regulation is purchased. When disabled, the equipment stops performing any function related to voltage regulation.

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

PLST – Command pulse time

This parameter defines the pulse duration of the up and down voltage command relays.

Adjustment range: 0.5 to 2.0, in 1 second steps.
Default value: 1.0 second.

5.5.2 SETS submenu – Regulation set

Allows access to the Regulation Set submenu.

Select the desired set using the keys and , then press the key . Once selected, the set number (1, 2, 3, 4, 5 or 6) will be fixed at the beginning of the line of the value to be adjusted, in all parameters of this Menu.

The AVR provides 6 sets of settings for voltage regulation. These sets are numbered from 1 to 6.

This allows the AVR to pre-program regulation parameters for different demand conditions in the electrical system. For example, different regulation levels can be programmed for peak consumption times and for periods with low load.

The parameters of Regulation Set 1 (SET1) must be programmed, since this set of parameters is used as default by the AVR whenever another set is not selected. Programming the other Regulation Sets (2 to 6) is optional.

5.5.2.1 CONF submenu - Configuration

Allows access to all parameters relating to the AVR's working settings.

NVLT – Nominal voltage

It is the theoretical voltage value that you want to maintain in the load, referring to the secondary of the measuring PT, that is:

$$Rated\ Voltage = \frac{Desired\ voltage\ at\ load}{PT\ Ratio}$$

Example:

$$Desired\ voltage\ at\ load = 13200V$$

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

$$Rated\ Voltage = \frac{13200V}{120V} = 110V$$

Adjustment range: 10.0 to 175.0, in 0.1V steps.
Default value: 115.0 V.

TMTP – Timing type

The timing feature is used to avoid unnecessary operations of the on-load tap changer during momentary line voltage fluctuations, as may occur, for example, during the starting of a large motor.

In this parameter we can select between two types of timing:

- **DEF (Linear):** where the time to start an on-load tap changer operation (after detecting a voltage deviation greater than the insensitivity) is always equal to the values set in the "Timing step" parameter, following the selected deviation ranges;

- **INV (Inverse):** in which the time to start an on-load tap changer operation varies inversely proportional to the deviation of the measured voltage in relation to the Nominal Voltage (the greater the difference between the Measured Voltage and the Nominal Voltage, the shorter the time for the on-load tap changer operation). It is used for faster voltage regulation in case of large voltage deviations.

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

$$Effective\ Time = Adjusted\ Time \cdot \left(\frac{Adjusted\ Deviation}{Measured\ Deviation}\right)$$

Where,

- Adjusted Time: will be the value programmed in the "Time to increase (UPT1)" parameter if the Measured Deviation is negative. Or it will be the adjustment in "Time to decrease (DWT1)" if the Measured Deviation is positive, both in timing step 1 (DEV1);

- Adjusted Deviation: is the value programmed in the "Deviation" parameter of timing step 1 (DEV1).

Default value: DEF (Linear).

SEQT – Subsequent time

The time for the first operation of the on-load tap changer will be set in the "Timing step (STEP)" parameter. If a single tap changer operation is not sufficient for the voltage to return to the adjusted limits, the AVR will use the Subsequent Time setting as the interval for the other commands to the on-load tap-changer.

Adjustment range: 2 to 180, in 1 second steps.
Default value: 10 seconds.

CMPT – Drop compensation type

Line drop compensation is an AVR feature that allows the load voltage (not the transformer output voltage) to be maintained within set limits by taking into account the line voltage drop between the transformer and the load due to line resistance and reactance. The AVR calculates the load voltage using the transformer output voltage and load current measurements, as well as the programmed line parameters. Two user-programmable line drop compensation methods are available in the AVR:

- **RX:** normally used in systems where the voltage drop in the line is more significant, therefore requiring better compensation accuracy. It is necessary to know the two parameters of the line: its Resistance (R) and Reactance (X). When the RX method is selected, the parameters "Ur" and "Ux" must be programmed (see below). The "Z Compensation" parameter will not have any influence on the voltage regulation;

- **Z:** This is a simplified method in which a percentage of overall voltage drop in the line is simply programmed instead of the individual parameters R and X. It does not have the same precision as the RX method because it does not take into account possible variations in the load power factor, variations that cause changes in the voltage drop percentage. However, in applications where the load power factor does not undergo significant changes, or if the voltage drop is small, this method can present satisfactory results, with the advantage of simplicity of adjustments. When the Z method is selected, the "Z Compensation" parameter must be programmed (see below). The "Ur" and "Ux" parameters will not have any influence on voltage regulation.

Adjustment range: Z, RX.
Default value: Z.

CMUR – Voltage drop UR

This parameter will only be used in voltage regulation if the "Drop Compensation Type (CMPT)" parameter has been selected for RX. It is the resistive component of the line voltage drop, in volts, referred to the secondary of the PT and adjusted to the nominal current of the AVR (5A).

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

Where,

R is the resistance of the line from the transformer to the load in ohms;

Adjustment range: - 25 to + 25V, in 0.1V steps.
Default value: 10.0 V.

CMUX – Voltage drop UX

This parameter will only be used in voltage regulation if the "Drop Compensation Type (CMPT)" parameter has been selected for RX. It is the reactive component of the line voltage drop, in volts, referred to the PT secondary and adjusted to the nominal current of the AVR (5A).

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

Where,

X is the reactance of the line between the transformer and the load in ohms.

Adjustment range*:* -25 to +25V, in 0.1V steps.
Default value: 10.0 V.

CMZ – Z compensation

This parameter will only be used in voltage regulation if the "Drop Compensation Type (CMPT)" parameter has been selected for Z Compensation. It is the line voltage drop as a percentage of the transformer output voltage, adjusted to the AVR nominal current (5A). The Z Compensation setting can be obtained experimentally, if the Transformer Output Voltage, Load Voltage and Load Current are measured simultaneously, then applying the formula below:

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

Adjustment range: 0 to 15%, in 0.1% steps.
Default value: 0.0.

CPML – Compensation limit

When line drop compensation is in operation, the AVR will cause a voltage rise at the transformer output in order to keep the load voltage within limits. This voltage rise will be proportional to the load current, so that very high load currents could cause a large voltage rise at the transformer output. To avoid this occurrence, the Compensation Limit parameter is programmed, which establishes an upper voltage rise level expressed as a percentage of the Nominal Voltage.

Adjustment range: 0 to 25%, in 0.1% steps.
Default value: 10.0%.

5.5.2.2 STEP submenu - Timing step

In this submenu, we adjust the insensitivity (or dead band) allowed for voltage regulation, that is, the load voltage deviation limit, expressed as a percentage of the nominal voltage, which, if exceeded, will start the time count for the first operation of the on-load tap changer (Time to Increase and Time to Decrease Voltage).

The AVR allows up to 3 different Deviation Steps to be programmed, each with its own Time to Increase and Time to Decrease voltage settings.

When accessing the Timing Step (STEP) submenu, the Select Step submenu will be displayed on the screen, where the user will select the step to be programmed from options 1, 2 and 3. Parameter programming must start with Step 1 (DEV1). The following parameters will be programmed for each of the steps:

DEV1 – Deviation step 1

It is the percentage of deviation 1 between the Voltage measured at the Load and the Nominal Voltage (programmed) which, if exceeded, starts counting the times to Increase or Decrease voltage.

Adjustment range: 0.1 to 9.8, in 1% steps.
Default value: 2.5%.

UPT1 – Time to increase 1

Timing for the first increase voltage command to the on-load tap changer (according to the TMTP - Timing Type parameter).

Adjustment range: 0 to 180, in 1 second steps.
Default value: 15 seconds.

DWT1 – Time to decrease 1

Timing for the first decrease voltage command to the on-load tap changer (see also parameter TMTP - Timing Type).

Adjustment range: 0 to 180, in 1 second steps.
Default value: 15 seconds.

DEV2 – Deviation step 2

It is the percentage of deviation 2 between the Voltage measured at the Load and the Nominal Voltage (programmed) which, if exceeded, starts counting the times to Increase or Decrease voltage.

Adjustment range: 0.2 to 9.9, in 1% steps.
Default value: 5.0%.

UPT2 – Time to increase 2

Timing for the second increase voltage command to the on-load tap changer (according to the TMTP - Timing Type parameter).

Adjustment range: 0 to 180, in 1 second steps.
Default value: 10 seconds.

DWT2 – Time to decrease 2

Timing for the second decrease voltage command to the on-load tap changer (see also parameter TMTP - Timing Type).

Adjustment range: 0 to 180, in 1 second steps.
Default value: 10 seconds.

DEV3 – Deviation step 3

It is the percentage of deviation 3 between the Voltage measured at the Load and the Nominal Voltage (programmed) which, if exceeded, starts counting the times to Increase or Decrease voltage.

Adjustment range: 0.3 to 10.0, in 1% steps.
Default value: 10.0%.

UPT3 – Time to increase 3

Timing for the third increase voltage command to the on-load tap changer (according to the TMTP - Timing Type parameter).

Adjustment range: 0 to 180 in 1 second steps.
Default value: 5 seconds.

DWT3 – Time to decrease 3

Timing for the third decrease voltage command to the on-load tap changer (see also parameter TMTP - Timing Type).

Adjustment range: 0 to 180 in 1 second steps.
Default value: 5 seconds.

The Deviation in the Timing Step (STEP) setting must not be less than half the voltage step (voltage difference between two consecutive TAPs) of the on-load tap changer, in order to avoid instability of the tap changer:

$$Deviation\ 1 > 50\% \cdot \frac{Voltage\ Step}{Rated\ Voltage \cdot PT\ Ratio}$$

Example:

$$OLTC\ Timing\ Step = 172.5V$$

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

$$Rated\ Voltage = \frac{13200V}{120} = 110V$$

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

$$Deviation\ 1 > 0{,}65\%$$

The Deviation settings for Timing Steps 1, 2, and 3 interact with each other as follows:

By adjusting the Deviation for Step 1 (DEV1), the start of the adjustment range for the Deviation for Step 2 (DEV2) is determined, which in turn will determine the start of the adjustment range for the Deviation for Step 3. For example:

Initially, the Deviation of Step 1 (DEV1) is adjusted, which has an adjustment range of 0 to 10%. Let's say the adjustment was fixed at 3%;

Next, the Deviation of Step 2 (DEV2) will be adjusted, which will have its adjustment range starting at 3% and going up to 10%. Let's say the adjustment was fixed at 5%.

Finally, the Deviation of Step 3 (DEV3) is adjusted, which will have its adjustment range starting at 5% and going up to 10%. Let's say the adjustment was fixed at 8%.

Once the adjustments of the 3 Steps have been made as exemplified above, let's say we return to Step 2 (DEV2) to change the Deviation value, initially set at 5%. Since the deviations of steps 1 and 3 are set at 3% and 8% respectively, this time the adjustment range of the Deviation of Step 2 is limited to the range between 3% and 8%. Let's say it is necessary to adjust a value lower than 3%, for example, 2%. In this case, it is necessary to first change the adjustment of the Deviation of Step 1, decreasing it to a value lower than 2%.

In this way, we create different timing ranges for the on-load tap changer operation depending on the amplitude of the voltage deviation. Note that the 3 Timing Steps will only be effective if the Timing Type parameter is selected for Linear Timing (DEF). Otherwise, if Inverse Timing (INV) is selected, only the settings of Timing Step 1 will be effectively used for AVR operation.

5.5.2.3 TIME – Time slot

Activation of Regulation Sets 2 to 6 can be done by programming a time slot for each set.

STHR – Setting the start hour

Select the hour you want to start the regulation set.

Adjustment range: 0 to 23, in 1 hour steps.
Default value: 0.

STMN – Setting the start minute

Select the minute you want to start the regulation set.

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

STDY – Setting the start day of the week

Select the day of the week you want to start the regulation set.

Adjustment range:

- MON (Monday);
- TUE (Tuesday);
- WED (Wednesday);
- THU (Thursday);
- FRI (Friday);
- SAT (Saturday);
- SUN (Sunday).

Default value: --

FNHR – Setting the end hour

Select the hour you want to end the regulation set.

Adjustment range: 0 to 23, in 1 hour steps.
Default value: 0.

FNMN – Setting the end minute

Select the minute you want to end the regulation set.

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

FNDY – Setting the end day of the week

Select the day of the week you want to end the regulation set.

Adjustment range:

- MON (Monday);
- TUE (Tuesday);
- WED (Wednesday);
- THU (Thursday);
- FRI (Friday);
- SAT (Saturday);
- SUN (Sunday).

Default value: --

5.5.3 TRF submenu – Transformer

Allows access to all parameters relating to the characteristics of the transformer and the PT and CT circuits used for measurement.

CTPT - CT/PT phase difference

There are several possible combinations for connecting the PT and CT to the AVR, and each combination produces an angular phase difference between the voltage and current signals. This parameter adjusts the phase difference angle between the voltage measured by the PT and the current measured by the CT. This value will be used to correctly calculate the power factor.

Adjustment range: 0 to 330, in 30°C steps.
Default value: 0.

TYPE – Number of phases

For the purposes of calculating active, reactive and apparent power, it is necessary to inform the type of transformer that is connected to the AVR.

Adjustment range: MONO (Single Phase) and THRE (Three Phase).
Default value: THRE (Three Phase).

In the case of a bank of 3 single-phase transformers, the option *Three-phase* must be selected so that the AVR informs the bank's powers, and not just one of the phases.

NPWR – Nominal voltage

To calculate the transformer loading percentage, it is necessary to inform the AVR of the nominal voltage of the transformer (or transformer bank).

Adjustment range: 0.0 to 999.9, in 0.1MVA steps.
Default value: 10.0 MVA.

NCUR – Nominal current

To calculate the transformer loading percentage, it is necessary to inform the AVR of the nominal current of the transformer (or bank of transformers).

Adjustment range: 0.01 to 655.35, in 0.01 kA steps.
Default value: 5.00 kA.

CTDI - CT sense used for regulation

Set the connection polarity of the CT selected for regulation (1, 2 or 3).

Adjustment range: NORM (normal) or INV (inverted).
Default value: NORM (normal).

PTRT – Measuring PT ratio

Adjustment of the transformation ratio of the measuring PT being obtained by dividing the voltage in the primary winding of the VT by the voltage in the secondary winding.

Example:

Considering the voltage of the primary winding of the PT being equal to 138 kV and the voltage of the secondary winding being equal to 115 V, we arrive at the value of the voltage ratio of the PT:

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

Adjustment range: 1 to 9999.
Default value: 100.

CTRT – Measuring CT ratio

Adjustment of the transformation ratio of the measuring CT, obtained by dividing the CT primary winding current by the secondary current.

Example:

Considering the primary winding current of the CT being equal to 250 A and the secondary current equal to 5 A, we arrive at the value of the CT current ratio:

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

Adjustment range: 1 to 9999.
Default value: 100.

CKEN – Enable OLTC checking

This parameter allows the user to activate the **OLTC checking.**

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

CKMX – OLTC check limit

Select the number of times the AVR should check the OLTC before generating an alarm.

Adjustment range: 1 to 99.
Default value: 5.

5.5.4 ALRM submenu – Alarm

Allows you to adjust the trigger values for alarms and define how the signaling relays will operate.

5.5.4.1 VAL submenu – Value

UVLT - Undervoltage alarm

The undervoltage alarm indicates an excessive drop in the voltage measured by the VT. This drop may be caused, for example, by a short circuit.
This alarm is triggered when the voltage measured on the VT secondary is less than or equal to the configured value, expressed as a percentage of the **Nominal Voltage (NVLT)**, which must be previously configured by the user.

To prevent false alarms during transformer de-energization, this alarm will not be triggered if the measured voltage is below 10% of the rated voltage.

Adjustment range: 10 to 99 nominal voltage, in 1% steps.
Default value: 80%.

> To prevent the AVR from operating the on-load tap changer to increase the voltage during a short circuit, the user can select the undervoltage alarm as a condition for blocking the tap changer in the OLTC Blocking due to undervoltage parameter.

UVTM – Undervoltage alarm timing

Allows you to set a time delay for the Undervoltage Alarm, which will only be triggered if the voltage remains below the level established in the undervoltage alarm parameter for a period longer than the set time.

This prevents unnecessary alarm triggering due to short-term events such as transients in the power system, for example. The timing is not applied to the undervoltage on-load tap changer blocking, if selected, which occurs instantly.

Adjustment range: 0 to 200, in 1 second steps.
Default value: 10 seconds.

OVLT – Overvoltage alarm

Defines the activation value of the overvoltage alarm. The value of this parameter is expressed as a percentage of the **Nominal Voltage (NVLT)**, which must be previously configured by the user. This alarm is triggered when the voltage measured on the PT secondary is greater than or equal to the configured value.

Adjustment range: 101 to 199% of nominal voltage, in 1% steps.
Default value: 120%.

> When an overvoltage condition occurs, the AVR may immediately operate the on-load tap changer to lower the voltage, disregarding the configured timing settings. If this fast operation is to be prevented, the user can select the overvoltage alarm as a condition for blocking the tap changer in the OLTC Blocking due overvoltage parameter.

OVTM – Overvoltage alarm timing

Allows you to set a time delay for the Overvoltage Alarm, which will only be triggered if the voltage remains above the level established in the overvoltage Alarm parameter for a longer time than the set time.

This prevents unnecessary alarm activation due to short-term events such as transients in the power system, for example. The timing is not applied to the blocking of the on-load tap changer due to overvoltage, if selected, nor to the rapid voltage reduction operation, which occur instantly.

Adjustment range: 0 to 200, in 1 second steps.
Default value: 10 seconds.

OCUR – Overcurrent alarm

Defines the activation value of the overcurrent alarm. The value of this parameter is expressed as a percentage of the **Rated Current (NCUR)**, which must be previously configured by the user. The alarm is triggered when, due to an overload or short circuit, the current measured on the CT secondary reaches or exceeds the configured value.

Example:

If the **Rated Current (NCUR)** is configured to **1.5 kA** and this parameter is set to **200%**, the alarm will be activated when the measured current reaches or exceeds **3.0 kA**.

Adjustment range: 10 to 200% of the rated current, in 1% increments.

Default value: 200%.

> Operating the on-load tap changer under high current conditions can be harmful to its contacts. To prevent the AVR from operating the tap changer to increase the voltage during a short circuit, the user can select the overcurrent alarm as a condition for blocking the tap changer in the OLTC blocking due to overcurrent parameter.

OCTM – Overcurrent alarm timing

Allows you to set a time delay for the Overcurrent Alarm, which will only be activated if the measured current remains above the value established in the overcurrent Alarm parameter for a period longer than the set time.

This prevents unnecessary alarm triggering due to short-term events. The timing is not applied to the overcurrent load tap changer blocking, if selected, which occurs instantly.

Adjustment range: 0 to 200, in 1 second steps.
Default value: 5 seconds.

BI> - OLTC blocking due to overcurrent

Overcurrent blocking condition.

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

BU> - OLTC blocking due to overvoltage

Overvoltage blocking condition.

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

BU< - OLTC blocking due to undervoltage

Undervoltage blocking condition.

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

BCDC – OLTC blocking due to tripped tap changer

Blocking due to tripped tap changer, a situation in which the OLTC keeps changing the tap without having been commanded by a known source, which may mean, among other things, a problem in the mechanism.

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

BIFP – OLTC blocking due to power flow inversion

Power flow reversal blocking condition.

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

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

5.5.4.2 CLAS submenu – Classification

Allows the user to classify the priority level of alarms according to the color code described below.

Table 11 - Alarm color chart

Color	Code
Blue	Maintenance warning
Yellow	Minor alarm. Check occurrence.
Red	Serious alarm. Requires immediate attention.

UVLT – Undervoltage alarm classification

Classify this alarm into one of the categories listed in the adjustment range or disable alarm classification.

Adjustment range: RED, YELW (yellow), BLUE, DSBL (disabled).
Default value: YELW (yellow).

OVLT – Overvoltage alarm classification

Classify this alarm into one of the categories listed in the adjustment range or disable alarm classification.

Adjustment range: RED, YELW (yellow), BLUE, DSBL (disabled).
Default value: YELW (yellow).

OCUR – Overcurrent alarm classification

Classify this alarm into one of the categories listed in the adjustment range or disable alarm classification.

Adjustment range: RED, YELW (yellow), BLUE, DSBL (disabled).
Default value: YELW (yellow).

BLCK – Classification of OLTC blocking events

Classify this alarm into one of the categories listed in the adjustment range or disable alarm classification.

Adjustment range: RED, YELW (yellow), BLUE, DSBL (disabled).
Default value: RED (yellow).

CKTC – Classification of OLTC checking events

Classify this alarm into one of the categories listed in the adjustment range or disable alarm classification.

Adjustment range: RED, YELW (yellow), BLUE, DSBL (disabled).
Default value: RED.

5.5.5 ADV submenu – Advanced

To access the advanced settings submenu, press .

5.5.5.1 ALRM submenu – Alarm

The alarm configuration submenu features the “CLAS” menu, which allows the user to classify the priority level of the alarms according to the color code explained in table 10.

5.5.5.1.1 CLAS – Alarm classification

By pressing enter, we have:

NOP – OLTC maximum number of operations alarm classification

Allows the user to classify the priority level of alarms according to the color code explained in table 10.

Adjustment range: RED, YELW (yellow), BLUE, DSBL (disabled).
Default value: BLUE.

IIT – Switched current integral alarm classification

Allows the user to classify the priority level of alarms according to the color code explained in table 10.

Adjustment range: RED, YELW (yellow), BLUE, DSBL (disabled).
Default value: BLUE.

DMNT – Classification of OLTC maximum number of operations warning

Allows the user to classify the priority level of alarms according to the color code explained in table 10.

Adjustment range: RED, YELW (yellow), BLUE, DSBL (disabled).
Default value: BLUE.

DMIT – Switched current integral warning classification

Allows the user to classify the priority level of alarms according to the color code explained in table 10.

Adjustment range: RED, YELW (yellow), BLUE, DSBL (disabled).
Default value: BLUE.

5.5.5.2 OLMT – On-load tap changer maintenance

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

ENAB – Enable OLTC maintenance function

Enables the tap changer maintenance function.

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

> This submenu contains settings for tap changers 1 and 2. These settings are repeated for them both.
> The 'x' indicates the tap changer number.
>
> **Example:** (TNO1) and (TNO2).

TNO 'x' – Initial operation number 'x'

Sets the total number of operations of OLTC ‘x’ since the start of its operation. Allows you to adjust the current number of tap changer operations so that the AVR count matches the mechanical counter found in most OLTCs.

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

Adjustment range: 0 to 999.
Default value: 0.

TNM ‘x’ – Number of operations since last maintenance ‘x’

Sets the partial number of operations of OLTC ‘x’ since the last maintenance or inspection carried out on it. Allows you to adjust the number of operations since maintenance on tap changers that were already in operation when the AVR was installed.

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

Adjustment range: 0 to 999.
Default value: 0.

NTMX – Maintenance warning by number of operations

Defines the number of operations for OLTC maintenance, as indicated by its manufacturer. When the “TNM ‘x’” counter reaches the configured value, the AVR issues a warning indicating that maintenance on the tap changer must be performed. The warning can be signaled on a programmable output relay.

The maintenance warning indication remains active in the AVR and the programmed warning contacts will remain activated until the user manually acknowledges the warnings. This procedure informs the AVR that maintenance has been performed. Once this acknowledgement has been performed, the “TNM ‘x’” register is reset and the maintenance warnings are deactivated.

Adjustment range: 0 to 999k.
Default value: 150k.

IIT1 – Integral of the square of the total switched current 1

Defines the sum of the current switched by the OLTC squared (Ipu^2) since the beginning of its operation 1 and allows you to adjust the current value of this sum in tap changers that were already in operation when the AVR was installed.

The sum is incremented by the measured load current value, converted to p.u. (per unit) and squared, at the instant a change in the OLTC tap position occurs.

Adjustment range: 0 to 2000.
Default value: 0.

IIT2 – Integral of the square of the total switched current 2

Defines the sum of the current switched by the OLTC squared (Ipu²) since the beginning of its operation 2 and allows you to adjust the current value of this sum in tap changers that were already in operation when the AVR was installed.

The sum is incremented by the measured load current value, converted to p.u. (per unit) and squared, at the instant a change in the OLTC tap position occurs.

Adjustment range: 0 to 999.
Default value: 0.

IIM1 – Total switched current after maintenance 1

Defines the sum of the current switched by the OLTC squared (Ipu²) since the last maintenance 1 carried out on the tap changer and allows you to adjust the current value of this sum in tap changers that were already in operation when the AVR was installed.

The sum is incremented by the measured load current value, converted to p.u. (per unit) and squared, at the instant a change in the OLTC tap position occurs.

Adjustment range: 0 to 2000.
Default value: 0.

IIM2 - Total switched current after maintenance 2

Defines the sum of the current switched by the OLTC squared (Ipu²) since the last maintenance 2 carried out on the tap changer and allows you to adjust the current value of this sum in tap changers that were already in operation when the AVR was installed.

The sum is incremented by the measured load current value, converted to p.u. (per unit) and squared, at the instant a change in the OLTC tap position occurs.

Adjustment range: 0 to 999.
Default value: 0.

ITW1 – Maintenance warning for switched current integral 1

Defines the value of the sum of the current switched by the OLTC squared (Ipu^2) for OLTC maintenance, as indicated by its manufacturer. When the I^2 counter after maintenance 1 (IIM1) reaches the configured value, the AVR issues a warning indicating that maintenance on the tap changer must be performed.

The maintenance warning indication remains active in the AVR, and the programmed warning contacts will remain activated until the user manually acknowledges the warnings. This procedure informs the AVR that maintenance has been performed. Once this acknowledgement has been performed, the "I² after Maintenance" register is reset and the maintenance warnings are deactivated.

Adjustment range: 0 to 2000.

Default value: 2000.

ITW2 - Maintenance warning for switched current integral 2

Defines the value of the sum of the current switched by the OLTC squared (Ipu^2) for OLTC maintenance, as indicated by its manufacturer. When the I^2 counter after maintenance 2 (IIM2) reaches the configured value, the AVR issues a warning indicating that maintenance on the tap changer must be performed.

The maintenance warning indication remains active in the AVR, and the programmed warning contacts will remain activated until the user manually acknowledges the warnings. This procedure informs the AVR that maintenance has been performed. Once this acknowledgement has been performed, the “I^2 after Maintenance” register is reset and the maintenance warnings are deactivated.

Adjustment range: 0 to 2000.
Default value: 2000.

CTNI – OLTC nominal current

Sets the nominal on-load tap changer current referred to the secondary of the measuring CT. The setting is used as a basis for converting the measured load current during tap changing from amps to p.u. (per unit).

Adjustment range: 0.10 to 10.00, in 0.1A steps.
Default value: 5.0 A.

AVTI – Days for calculating averages

Defines the number of days that will be used for both the calculation of the average daily switching and the daily average of the squared switched current Ipu^2.

Adjustment range: 10 to 365, in 1-day steps.
Default value: 10 days.

RTMA – Maintenance warning

To make planning easier, the AVR considers the trend of the various criteria and gives advance warning of when maintenance is due.

The lead time is set in this parameter.

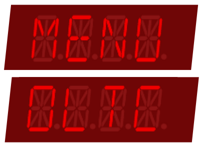
Adjustment range: 0 to 365, in 1-day steps.
Default value: 30 days.

AVGR – Average reset

Performs reset of averages of number of tap changer operations and switched current.

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

5.6 OLTC Menu



To access the on-load tap changer parameterization menu, press .

5.6.1 CONF submenu

Allows configuration of the on-load tap changer.

TMES – Tap position measurement

Choose whether to enable the tap position measurement function.

Adjustment range: YES, NO;
Default value: NO.

METH – Tap position measurement method

Select the tap position measurement method between normal, simple calibration or advanced calibration. If the selected measurement method is simple or advanced calibration, potentiometric transmitter calibration parameters will be enabled in the “ADV” menu.

Adjustment range:

- ADVC (advanced calibration);
- SMPC (simple calibration);
- NORM (normal).

Default value: NORM (normal).

TAPN – Number of OLTC taps

Select the number of tap changer taps the AVR should monitor.

Adjustment range: 1 to 49.
Default value: 33.

INDI – Position indication type

Adjustment range:

- SMPL (simple numeric);
- ALFI (inverse alphanumeric);
- ALF (alphanumeric);
- BLTI (inverse bilateral);
- BLT (bilateral).

Default value: SMPL (simple numeric).

RESI – Potentiometric transmitter step resistance

Enter here the value of the step resistance of the potentiometric transmitter used in measuring the tap position.

Adjustment range: 4.7 to 20.0, in 0.1 Ohm steps.
Default value: 10.0 Ohm.

IOFF – Initial offset

Choose the value of the initial step of the resistance of the transmitter, proportional to the "Resistance" parameter, that is, Initial Resistance = Initial Offset * Resistance.

Adjustment range: 0 to 5.
Default value: 0.

EOFF – Final offset

Choose the value of the initial step of the resistance of the transmitter, proportional to the "Resistance" parameter, that is, Final Resistance = Final Offset * Resistance.

Adjustment range: 0 to 5.
Default value: 0.

SWTT – Tap changing time

Parameterize the time required for the OLTC to change a tap position.

Adjustment range: 1 to 100, in 1 second steps.
Default value: 10 seconds.

CENT – Central tap

Enter here which is the central tap of the OLTC.

Adjustment range: 2 to 34.
Default value: 17.

UTUV – Correlation between tap rise and voltage change

In some switches, raising the tap can be an operation that increases or decreases the voltage. This parameter must indicate the type of OLTC used.

Adjustment range:

- UPV (up voltage);
- DOWV (down voltage).

Default value: UPV (up voltage).

MNTP – Minimum tap allowed

Enter the number of the smallest tap to be allowed.

Adjustment range: 1 to 49.
Default value: 1.

MXTP – Maximum tap allowed

Enter the number of the largest tap to be allowed.

Adjustment range: 1 to 49.
Default value: 33.

HVAL – Tension on the cursor

If applicable, select the voltage value from the potentiometric cursor.

Adjustment range: 3.3 to 15.0, in 0.1V steps.
Default value: 6.0 V.

5.6.2 RUL'x'

Select the intermediate tap number to be parameterized.

The following parameters contain settings for intermediate tap numbers 1, 2 and 3. These settings are repeated for all of them.
The 'x' indicates the intermediate tap number.
Example: (RUL1), (RUL2) and (RUL3).

ENAB – Enable intermediate tap

Enable or disable parameterization for the previously selected intermediate tap.

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

TPNR – Location of intermediate tap(s)

Enter the starting tap position of the switch that has an intermediate transition, **n**. **N+1** will be updated automatically and the starting position must be between 1 and 48 (when the number of taps of the switch is 49).

Adjustment range: 1 to 48.
Default value: 1.

OPER – Number of operations per intermediate tap variation

Enter the number of operations that occur until the transition between the initial and final tap is complete.

Adjustment range: 2 to 5.
Default value: 2.

IRES – Presence of resistance between intermediate taps

Indicates whether or not the intermediate taps have step resistance.

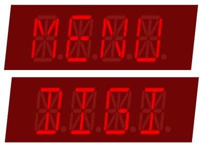
Adjustment range: YES, NO.
Default value: NO.

I2 – Switched current multiplication factor

Definition of the multiplier factor of the integral of the square of the switched current (I^2).

Adjustment range: 1 to 5.
Default value: 1.

5.7 Menu DIGI – Contatos de entrada



O AVR pode receber diversos tipos de comando de fontes externas, como painéis de controle e botões instalados em locais distantes do aparelho.

The following parameters contain settings for input contacts 1, 2, 3 and 4. These settings are repeated for all of them.
The ‘x’ indicates the input contact number.

Example: (DIG1), (DIG2), (DIG3) and (DIG4).

DIG’x’

AVR input contacts 1 through 4 can be configured to receive different types of commands. When entering this option, select the contact you wish to configure and assign its function.

Adjustment range:

- ATMN (automatic/manual): Configures the selected input contact to receive a signal indicating whether the device should provide automatic or manual voltage regulation;
- LCRM (local/remote): Allows you to remotely define whether the device should receive commands locally or from a remote source;
- NONE.

Default value: NONE.

DBCT – Read debounce

Time to debounce digital inputs.

Adjustment range: 10 to 100, in 1 millisecond steps.
Default value: 10 ms.

5.8 ADV Menu

Allows access to submenus relating to advanced settings, output relays and the factory menu.

5.8.1 CONF submenu

Allows access to all parameters relating to the AVR's working settings.

5.8.1.1 LOG – Mass memory

Allows access to all parameters related to the mass memory log.

The Mass Memory log records alarm triggers and other information with the date and time of the events.

TIME - Recording interval

Selects the time between the moments in which recordings will be made. The AVR has 23,000 positions for recording variables. To know how long the memory will take to be completely occupied, simply do:

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

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

$$Total\ time\ = 32767.60 = 1966020\ minuts\ \cong 1365\ days$$

When the maximum number of records is reached, the oldest records are overwritten by the new ones.

Adjustment range: 1 to 9999, in 1 minute steps.
Default value: 60 minutes.

RSET – Recording reset

“YES” should be selected if the intention is to erase the memory contents up to that point. Otherwise, keep “NO” selected.

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

When attempting to access the factory menu with an incorrect password, the AVR will display the message VOID for a few seconds. The display time for this message increases as new attempts are made with an incorrect password.

After 5 attempts with the wrong password, the AVR will completely block access to this menu and the message "VOID" will be displayed permanently. Although the operation of the equipment will not be affected, this will void the warranty.

5.8.1.2 CTR – CT ratio

In this submenu, parameters for configuring the transformation ratio of the external sectionable window CT (clip-on CT) will be available.

Enter the transformation ratio value of the external sectional window CT (the accessory sold by Treetech has a ratio of 3100).

Adjustment range: 1 to 10000.
Default value: 3030.

5.8.1.3 CCRW – Potentiometric Transmitter Calibration

This screen will only be displayed if SMPC or ADVC is selected in the "METH" parameter, check OLTC Menu.

TAP - Ongoing TAP number

Indication of the ongoing TAP number for potentiometric transmitter calibration.

Adjustment range: 1 to 49
Default value: 1

SCCB - Short circuit between Cursor and potentiometric transmitter Start

Select the "CAL" command after connecting a short circuit between the Cursor and the potentiometric transmitter Start to begin the potentiometric transmitter calibration.

Adjustment range: -, CAL
Default value: -

For complete potentiometric transmitter calibration, the SCCB and SCCE commands must be performed in sequence.

SCCE - Short circuit between Cursor and potentiometric transmitter End

Select the "CAL" command after connecting a short circuit between the Cursor and the potentiometric transmitter End to start the potentiometric transmitter calibration.

Adjustment range: -, CAL
Default value: -

For complete potentiometric transmitter calibration, the SCCB and SCCE commands must be performed in sequence.

The parameters shown below are only displayed if “ADVC” is selected in the “METH” parameter.

CTMP – Potentiometric transmitter temperature

Potentiometric transmitter temperature during calibration.

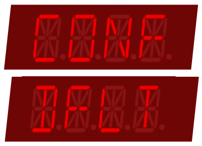
Adjustment range: -55 to 200 °C, in 1 °C steps
Default value: 25 °C

WTMP - Wire temperature

Temperature of the connecting cables from the potentiometric transmitter to the IED during calibration.

Adjustment range: -55 to 200 °C, in 1 °C steps
Default value: 25 °C

5.8.1.4 DFLT – Default settings

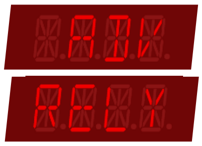


When changing the password, “YES” should be selected if the intention is to restore the factory settings. Otherwise, keep “NO” selected;

Then press the button , all equipment parameters will return to the factory default values.

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

5.8.2 RELY submenu



This menu allows access to all parameters relating to the operation of the AVR output relays.

5.8.2.1 GENR submenu - General

Allows access to parameters to configure relays for general functions.

RELY – Relay selection

Choose which relay you want to parameterize.

Adjustment range: 4, 5 or 6.
Default value: 4.

MODE - Operating mode

Contacts 4, 5, 6 can be configured to operate in normal mode **(NORM)** or inverted mode **(INVE).**

Relay 7 is reserved for OLTC Blocking.

Adjustment range:

- **NORM (normal):** The relay changes state when activated.
- **INVE (inverted):** When the equipment is energized, the contact will change state. When the relay is activated, the contacts will return to the rest state.

Default value: NORM (normal).

GREE – Activation in green state

Activates the relay when the general alarm status is green, that is, when no abnormality is detected.

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

YELW – Activation in yellow state

Activates the relay when the general alarm status is yellow.

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

BLUE - Activation in the blue state

Activates the relay when the general alarm status is blue.

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

RED – Activation in the red state

Activates the relay when the general alarm status is red.

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

Note: There are many more alarms than relays to signal them, but a relay can be triggered for more than one reason and this allows you to know the status of the alarms by category.

TAPE – TAP reading error

Activates the relay when there is an active tap reading error.

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

AUTM – Automatic mode signaling

Activates the relay when the AVR operating mode is in automatic.

Adjustment range: YES, NO.

Default value: NO.

MANM – Manual mode signaling

Activates the relay when the AVR operating mode is in manual.

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

LOCM – Local mode signaling

Activates the relay when the AVR operating mode is in local.

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

REMM – Remote mode signaling

Activates the relay when the AVR operating mode is in remote.

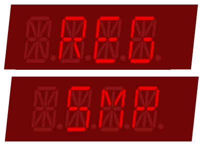
Adjustment range: YES, NO.
Default value: NO.

5.8.2.2 REG – Regulation

The regulation submenu is divided into two categories. In the first, you configure the relays for basic functions.

In the second, configure the relays for advanced regulation functions.

5.8.2.2.1 SMP - Basic



Allows you to configure relays for basic functions.

RELY – Relay selection

Choose which relay you want to parameterize.

Adjustment range: 4, 5 or 6.
Default value: 4.

UVLT – Undervoltage alarm

Activates relay when there is an undervoltage alarm.

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

OVLT – Overvoltage alarm

Activates relay when there is an overvoltage alarm.

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

OCUR – Overcurrent alarm

Activates relay when there is an overcurrent alarm.

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

CKTC – OLTC blocking

Activates the relay when a command is issued to block the OLTC.

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

5.8.2.2.2 ADV – Advanced

Allows you to configure relays for advanced regulation functions.

RELY – Relay selection

Choose which relay you want to parameterize.

Adjustment range: 4, 5 or 6.
Default value: 4.

NTT – Maintenance by number of OLTC operations

Activates the relay when the number of operations for OLTC maintenance, defined in the parameter “TNM’x’ - Number of operations since last maintenance ‘x’” is reached.

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

ITT – Integral of the square of switched current

Activates the relay when the sum of the squares of the currents at the time of OLTC operation has reached the value for maintenance by switched current, defined in the parameter “NTMX - Maintenance warning by number of operations”, indicating contact wear.

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

DMNT – Advance warning for maintenance by number of operations

Defines the relay actuation in case of advance warning for maintenance by number of OLTC operations, considering the counter “TNO ‘x’ – Initial operation number ‘x’”, the average daily tap changing and the number of days of advance warning for maintenance.

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

DMIT – Advance warning for maintenance by sum value of switched current

Defines the relay actuation in the event of a warning by the value of the sum of the current switched by the OLTC squared (Ipu²), considering the counter “IIT1 – Integral of the square of the total switched current 1”, the daily average of the switched current squared and the number of days for advance warning for maintenance.

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

5.8.3 DIGI submenu

This menu allows you to configure the OLTC command mode between manual/automatic and local/remote.

MODE - Operating mode

Indicates the operating mode of the AVR.

Adjustment range:

- **LATC (status):** local/remote and automatic/manual regulation settings follow the status of the digital inputs;
- **PULS (pulses)**: the local/remote and automatic/manual regulation settings are now alternated on the signal rise ramp (contact closing).
  The tap commands are not affected by this parameter and are always pulse-driven.

Default value: LATC.

5.8.4 FACT submenu

Allows access to factory parameters. It is for exclusive use by Treetech technical support and is password protected, not being accessible to the equipment operator.

6 Commissioning for entry into service

Once the equipment has been installed, commissioning must follow the basic steps below:

- ✓ Check the mechanical and electrical installations, in accordance with the recommendations in chapter 3 of this manual. Also check that the electrical connections are correct (for example, by means of continuity tests);
- ✓ Ensure that no current transformer (CT) secondary is open during installation and operation of voltage regulators;
- ✓ If dielectric strength tests are performed on the wiring (voltage applied), disconnect the wires connected to the AVR's ground terminal to avoid destroying the surge protections inside the unit. These protections are internally connected between the input/output terminals and ground, clamping the voltage at about 300 V. Applying high voltages for a long period of time (e.g. 2 kV for 1 minute) would destroy these protections;
- ✓ Reconnect the ground wires to the AVR terminals if they were disconnected for applied voltage testing;
- ✓ Power the AVR with any voltage in the range of 85 to 265V DC/V AC 50/60Hz;
- ✓ Perform all the AVR parameterization according to the instructions in this manual;
- ✓ Using a continuity tester, test the actuation of the alarm, shutdown and forced cooling contacts. The actuation of the contacts can be forced, for example, by reducing the respective settings to values lower than the ongoing measurements;
- ✓ Make sure that no contact operation will interact with other systems during this phase. If necessary, isolate all control and alarm contacts by simply uncoupling the lower removable connector (terminals 1...16);
- ✓ Reconnect any contacts that may have been isolated, reconnecting the lower connector (terminals 1...16).

> The user has the option of unblocking the OLTC with the power flow reversal alarm active. However, Treetech does not recommend the use of this function. Its use and the consequences generated by it on voltage regulation are the sole responsibility of the user. Unblocking is done via communication protocol (see "AVR communication protocol").

7 Troubleshooting

The Automatic Voltage Regulator - AVR constantly checks the integrity of its functions and the sensors and modules connected to it. Any anomaly detected is signaled through its fault contact. In addition, messages indicating the fault will be displayed on the AVR display, assisting in the diagnostic process.

If you encounter difficulties or problems with the system operation, we suggest that you consult the possible causes and simple solutions presented in the following items. If this information is not sufficient to resolve the difficulty, please contact Treetech Customer Service or its authorized representative.

7.1 Equipment displays self-diagnosis messages

The self-diagnosis function implemented in the AVR device allows any problems external to the equipment, or even internal failures, to be detected and diagnosed, allowing the user to quickly identify and correct the problems in most cases.

When a self-diagnosis is identified, it is displayed via an 'SDG' screen with its code in hexadecimal. This screen is displayed periodically if the self-diagnosis is active.

Figure 24 - Self-diagnosis indication on AVR

When the self-diagnosis refers to the crown reading, the AVR shows the text 'CROW' in the upper display and 'ERR' in the lower display.

Figura 25 – Potentiometric crown self-diagnosis *display*

7.1.1 Viewing self-diagnosis memory and alarm memory

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

The Self-Diagnosis Memory function allows you to know all diagnostic events that occurred in the AVR, such as bad contacts or internal faults.

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

The Self-Diagnosis Memory and the Alarm Memory are accessed by pressing the keys and sequentially. There are two Self-diagnosis Memory screens, identified by the acronym DGM, and one Alarm Memory screen, identified by the acronym ALM, which can be consulted by pressing the keys and . On the screen the acronym DGM is indicated alternately with a numerical code that identifies the events that have occurred.

Figure 26 – Querying the self-diagnosis memory

Figure 27 – Alarm memory query screen

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

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

Self-diagnosis:

Alarm Memory:

8 Technical data and type tests

8.1 Technical data

Table 12 – Technical data

Hardware	Range/Description
Power supply voltage	85...265 Vac/Vdc
Frequency	50/60 Hz
Maximum consumption	<12 W
Operating temperature	-40...85 °C
Degree of protection	IP20
Fastening	Panel
Measurement inputs	
1 Voltage measurement (PT)	0...185 Vrms
1 Current reading (CT)	External clip-on CT 0...10 Aca rms
1 Potentiometric transmitter	2...49 taps
4 Digital inputs	Dry, potential-free contacts
Outputs	
Relay output	6 NO (Normally Open) relays + 1 NC (Normally Closed) relay
Dielectric strength	300 Vrms in normally open 400 Vrms in normally closed
Maximum switching voltage	277 Vac / 125 Vdc in normally open 400 Vac / 300 Vdc in normally closed
Maximum switching current	5.0 A @ 250 Vac; 1250 VA normally open 6.0 / 5.0 A @ 250 Vac; 1250 / 1500 VA normally closed
Resistive load	0.4 A @ 125 Vdc; 50 W normally open 0.50 A @ 125 Vdc; 62.5 W normally closed
Communication Interface	
Communication protocols	DNP3 Modbus® RTU
Communication ports	2 RS-485 (based on TIA-485-A standard) 1 USB Type-C Device
Dimension and weight	**Description**
Dimension	98mm x 98 mm x 36 mm
Weight	230 grams

8.2 Type tests

Table 13 - Type tests

Type tests	
Conducted emission (IEC 60255-26:2013)	
Conducted emission thresholds (Class A)	79 dB(µV) @ 150 kHz...500kHz (QP) 73 dB(µV) @ 500 kHz...30MHz (QP) 66 dB(µV) @ 150 kHz...500kHz (AV) 60 dB(µV) @ 500 kHz...30MHz (AV)
Radiated emission (IEC 60255-26:2013)	
Conducted emission thresholds (Class B)	40 dB(µV) @ 30 MHz...230 MHz (QP) 47 dB(µV) @ 230 MHz...1 GHz (QP)
Immunity to irradiated emissions (IEC 60255-26:2013)	
Level	3
Field strength for testing	10 V/m
Immunity to conducted emissions (IEC 60255-26:2013)	
Level	3
Voltage level	10 V
Immunity to voltage variations, short interruptions and voltage dips (IEC 61000-4-11/2020)	
Amplitude variation	0...80%
Affected cycles	½...300 cycles
Power supply	127 V...220 V – 60 Hz
Immunity to 60Hz magnetic field (IEC-61000-4-8/2009)	
Class	4
Magnetic field strength	30 A/m
Immunity to fast electrical transients (IEC 60255-26:2013)	
Level	X
Power supply and grounding	4 kV
Input and output ports	4 kV
Communication ports	2 kV
Immunity to surges (IEC 60255-26:2013)	
Level	3
Line to line	1 kV
Line to ground	2 kV
Immunity to electrostatic discharge - ESD (IEC 60255-26:2013)	
Level	3
Discharge by contact	6 kV (+/-)
Discharge through air	8 kV (+/-)
Impulse voltage test (IEC 60255-27:2005/COR1:2007)	
Impulsive voltage applied by the surge generator	5 kV
External CDN	500 Ω
Cold withstand capability (IEC 60068-2-1/2007)	
Temperature	-40ºC
Test time	16 hours
Dry heat withstand capability (IEC 60068-2-2/2007)	
Temperature	+85ºC
Test time	16 hours
Moist heat withstand capability (IEC 60068-2-2/2007)	
Temperature and relative humidity	+40ºC...85% UR
Test time	24 hours
Thermal cycle (IEC 60068-2-14)	
Temperature range	-40...85 ºC
Total test time	72 hours

Response to vibration (IEC 60255-21-1:1988)	
Application mode	Sinusoidal
Amplitude and frequency range	0,075 mm (10…58 Hz) 1 G (58…150 Hz)
Duration	8 min/axle
Resistance to vibration (IEC 60255-21-1:1988)	
Application mode	Sinusoidal
Amplitude and frequency range	2 G (10…150 Hz)
Duration	160 min/axle

9 Ordering specification

1. Product name

- Automatic Voltage Reguator - AVR.

2. Quantity

- Number of units.

3. Accessories

- Inform which accessories and the quantity.

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