VOLTAGE REGULATOR BANK
ELECTRONIC CONTROL MODEL CTR-3



INSTRUCTION MANUAL

MIC-004 | EN

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COMMITMENT TO SAFETY

ITB, as a manufacturer of electrical equipment, takes all measures to guarantee the safety of people who may be in contact with its products, of the other equipment that may be connected to them and the environment in which they are installed.

Our main references for guaranteeing these levels of security are International standards, which represent experiences accumulated in various different conditions and for periods of time long enough to be adopted as good operational, contingency and effectiveness safety.

We consider our obligation to actively promote conscious and safe practices, both in choosing the most suitable equipment for each application as well as in its correct handling and proper Maintenance. We understand that distributing the accumulated knowledge, through technical service literature and Training programs, constitute the most efficient means of continuous improvement of such best practices of both, our products and services.

We recommend observing all safety procedures approved, instituted or requested by local regulations, as well as stressing the use of all safety devices and equipment, individual or collective, recommended for activities around high voltage equipment and power lines.

SAFETY INFORMATION

The instructions contained in this manual are not intended as a substitute for proper training and/or accumulation of experience necessary for safe installation, bypass switching and operation of single-phase voltage regulators. Only competent technicians who are familiar with medium voltage electrical network equipment should install, operate and maintain them.

A competent technician for such functions must meet at least the following qualifications:

- Be familiar with these instructions;
- Be trained in operation, procedures, and safe practices accepted by the high and low voltage industry;
- Be trained and authorized to energize, de-energize and manipulate equipment once connected to power distribution grid;
- Be trained on the proper care and use of personal protective equipment, such as: flameproof clothing, glasses, visors, helmets, insulating gloves, operation devices, etc.;
- Be trained in the installation and use of ladders in columns, necessary signs on public roads and local legislation.

For the installation and operation of this equipment be sure to read and understand all information, notices and warnings in this manual.

This manual contains three types of alert phrases:



DANGER: Indicates an imminently hazardous situation that, if not avoided, will result in death or injury of any nature to the operator or to people close to the network or equipment.



CAUTION: Indicate a potentially critical situation that, if not avoided, may result in operational damage to the equipment, the network, or its surroundings.



NOTICE: Indicates a potentially unwanted situation that, if not avoided, may result in equipment malfunction.

General Safety Instructions

We suggest considering the following information when installing, operating, maintaining, or maneuvering devices installed in high-voltage networks:



DANGER: Dangerous voltage. Contact or proximity to high voltage will cause death or very serious injury. Follow all approved safety procedures when working in high voltage line and equipment surroundings.



NOTICE: Before installing, operating, maintaining, or testing the equipment, read and understand the contents of this manual carefully. Improper operation, use or maintenance can result in damage to the equipment or the network where it is installed.



DANGER: Power distribution equipment must be properly selected for the intended application. It must be installed and maintained by competent personnel, trained and aware of the appropriate safety procedures. These instructions are written for such persons and are not a substitute for proper formal training and experience in safety procedures. Lack of proper selection, installation, setup, and maintenance of electrical power distribution equipment can result in death, serious body injuries, and / or equipment damage.

INTRODUCTION

The ITB control for single-phase voltage regulator bank, model CTR-3, is a measurement and activation device, equipped with a microcontroller, **capable of monitoring and commanding up to 3 single-phase step voltage regulators** type A or type B, de 33 positions (32 steps) designed as per ABNT® NBR 11809 or IEEE Std C57.15™. They allow the operation of the bank with single or three-phase regulation with references taken by the master or by average, and are applicable in star, open delta or closed delta connections.

CTR-3 controls are capable of monitoring in real time the position of the on-load tap changers of ITB single phase voltage regulators models, RAV-1 and RAV-2 which have an absolute encoder coupled to their on load tap changers and, therefore, offer full functionality and operational safety.

Through the sensors installed in the motor drive circuit together with the operations counter device, it can monitor the position of any on load tap changer even without an absolute encoder, making it compatible with any brand and model of single phase step voltage regulator.



CAUTION: The on-load tap changer position tracking mode, which detects the motor's rotation direction and uses the operation counter, makes the position indication unreliable due to the inability to read it in real time.



DANGER: The on load tap changer position tracking mode is not recommended when the voltage regulator does not have a mechanical position indicator or 5-bit absolute encoder coupled to it and a microswitch to read polarity reversal of the series winding.

All ITB controls are factory tested and are pre-adjusted based on standardized parameters that are given as a suggestion for operation. In order to obtain an adequate operation to the specific needs of user application, it is necessary that users configure the control with appropriate parametrization.



NOTICE: Reading and understanding all the present manual will help proper installation, safe handling, efficient equipment operation and its maintenance in safe and reliable conditions.

DESCRIPTION

CTR-3 control is presented in a cabinet or cubicle containing a control device and three sets of configurable interface for all single phase step voltage regulators in accordance with ABNT® NBR 11809 or IEEE Std C57.15TM.

The control offers full functionality and handles efficiently active parts useful life either in single phase step voltage regulator produced by ITB, due to the real time on load tap changer position monitor, or due to the operational resources it includes for any brand or model of step voltage regulators.

ITB model CTR-3 control has 3 voltages and 3 currents independent true rms voltage and current measurement devices with a maximum error limited to 1.0% for 120Vac (voltage) and 200mA (current). This means measurement of voltages and currents of each of the connected voltage regulators are made in real time.

Supply of the on load tap changer motor is made by the voltage regulator itself, which, together with the monitoring algorithm, forms an architecture that enables CTR-3 control to promote and monitor simultaneous tap changes without data loss and without overloading the PTs (potential transformers) of any voltage regulator.

All analog inputs are galvanically isolated through isolating Transformers and all digital inputs are galvanically isolated through optocouplers.

Voltage and current on source side of each regulator are always calculated based on the position of all regulators in the bank, without the need of installing additional PT or CT (current transformer) at the source side even on delta connections.

Voltage regulator identified VR-1 is solely responsible for power supply the CTR-3 control.

Connections with regulators' transition boxes are made through cables with multiple plugs on both ends, which facilitates transport and handling.

Neutral position signaling is electric and independent of the tap changer position monitoring system and is signaled by lighting a green LED for each regulator on the secondary panel of the control box. This operates even when the CTR-3 control is removed.



DANGER: When monitoring is done by tracking, a single physical reference is used to determine the neutral position and, consequently, the other tap changer positions. To guarantee that the equipment is safe to bypass switching, whether being put into operation or removed, the redundancy necessary to guarantee the neutral position in regulators is obtained by verifying the reading of the external mechanical position indicator by the operator.

RECEPTION

Before packaging, the control is tested and inspected at the factory. Upon receipt, another inspection must be conducted to identify any damage that may have occurred during transportation. The control enclosure, electrical cables, outlets, and other external components must be intact and free from cracks and deformations. The packaging should also show no signs of tampering, impact, or drops.

Any irregularity must be reported to ITB as soon as possible and even before proceeding with the unloading.

STORAGE

Storage must be done in an indoor, covered, protected, ventilated, dry place, away from heat sources, protected from sparks, with a maximum stacking of two (2) packages and where there is no possibility of mechanical damage.

CONTROL BOX CTR-3 – OVERVIEW

CTR-3 electronic control unit is housed in a metal box made of carbon steel and coated with liquid or powder paint in light gray color, MUNSELL N. 6.5 notation.

Two different control box models are currently available for the CTR-3.

One model, identified as STANDARD, as show in Figure 1, and another model, identified as NOBREAK[1], as show in Figure 2.

Model will be supplied in accordance with customer's purchase order.

Upon request, or in accordance with the customer's technical specification, it is possible to change the finish system and material of the box.

Dimensions, approximate weights and mounting details were illustrated in the next two figures.

Note: Weight and dimensions are for reference only. Final construction details will be issued after the purchase order in agreement between the manufacturer and the customer.



CAUTION: To avoid equipment damage always use the upper handles of the control box for lifting.

[1] *For more information about the UPS, see the topic* ***Neutralization system via UPS.***

Figure 1: External dimensional diagram of STANDARD control box (dimensions in mm).

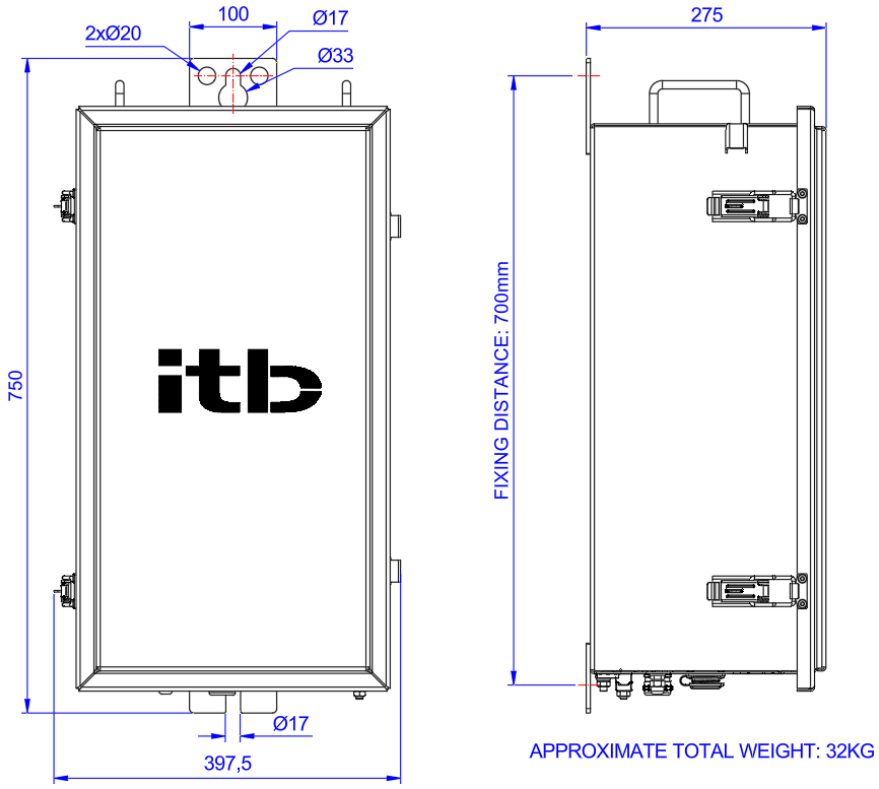
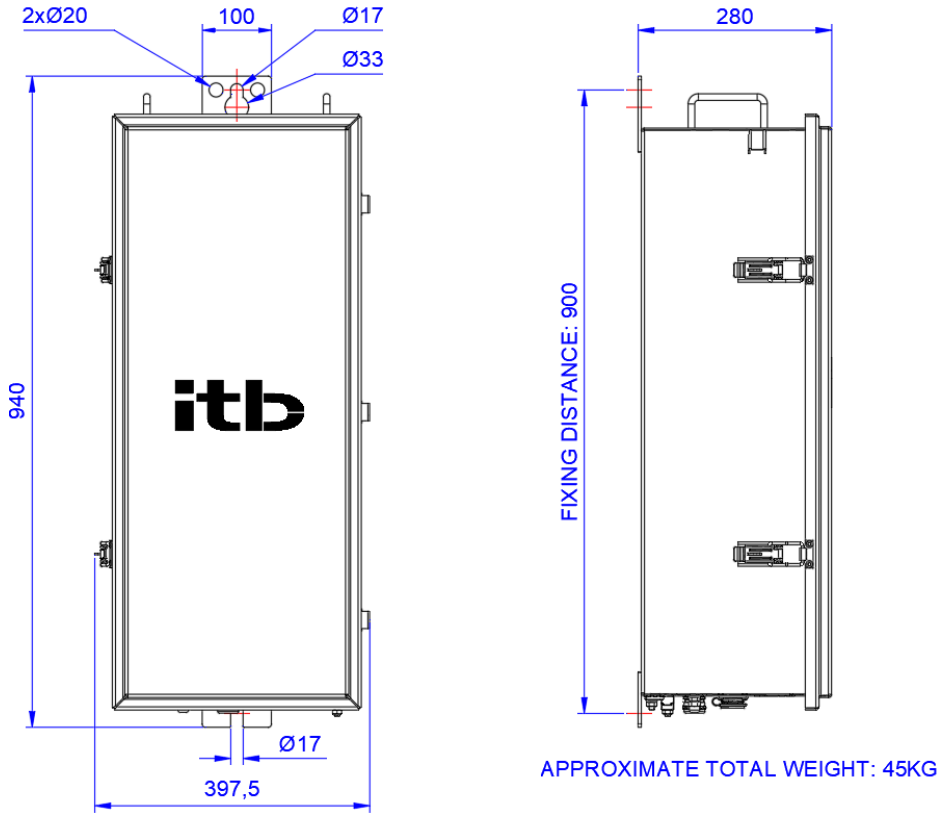


Figure 2: External dimensional diagram of UPS control box (dimensions in mm).



Both CTR-3 control box models have the following features:

- IP54 protection degree suitable for outdoors;
- IK9 protection degree against external mechanical impacts;
- Power plug 90 to 145Vac (up to 4A) as per NBR 14136 standard with 2 poles and 1 ground for field equipment supply;
- Independent fuse protection system (with protruding unit) for field power plug, control, motor, remote terminal unit (RTU) and heating system or hygrostat against condensation circuits;
- *"INTERNAL / OFF / EXTERNAL"* supply switch, which selects the control power mode and avoids energizing the bushing terminals during an external power supply, one for each voltage regulator;
- Terminals for external source (90 to 145Vac);
- Voltmeter connection terminals, one for each regulator;
- Motor overvoltage protection system (varistors), one for each regulator;
- Knife-type switch for short-circuiting the CTs, ensuring the CTR-3 cabinet can be safely removed, one for each regulator;
- Motor current sensors, one for each regulator;
- Manual motor activation keys, one for each regulator;
- Selector switches for Reseting the external position indicator, which can be by phase or neutral, one for each regulator;
- Neutral light actuation selectors, which can be by phase or neutral, one for each regulator;
- Control power switching selector (regulator or UPS);
- Drawer for accommodating a remote terminal unit (RTU);
- Terminal block for programmable input and output auxiliary contacts;
- Forged brass grounding terminal for copper or aluminum cables of up to 70mm^2;
- Cable glandes for the passag of additional signals (antenna, logic contacts, etc.).

Secondary Panels Components

With a simple and intuitive design, secondary panels which are fixed to the front of the control box, have all the essential components for power supply, operation and signaling of the voltage regulators connected to the control.

Each panel has its denomination *VR-1, VR-2* and *VR-3* arranged on the right side of the panels to identify the regulator to be controlled.

The location and description of each of these components can be seen Figure 3 and Table 1.

Figure 3: Secondary panel components.

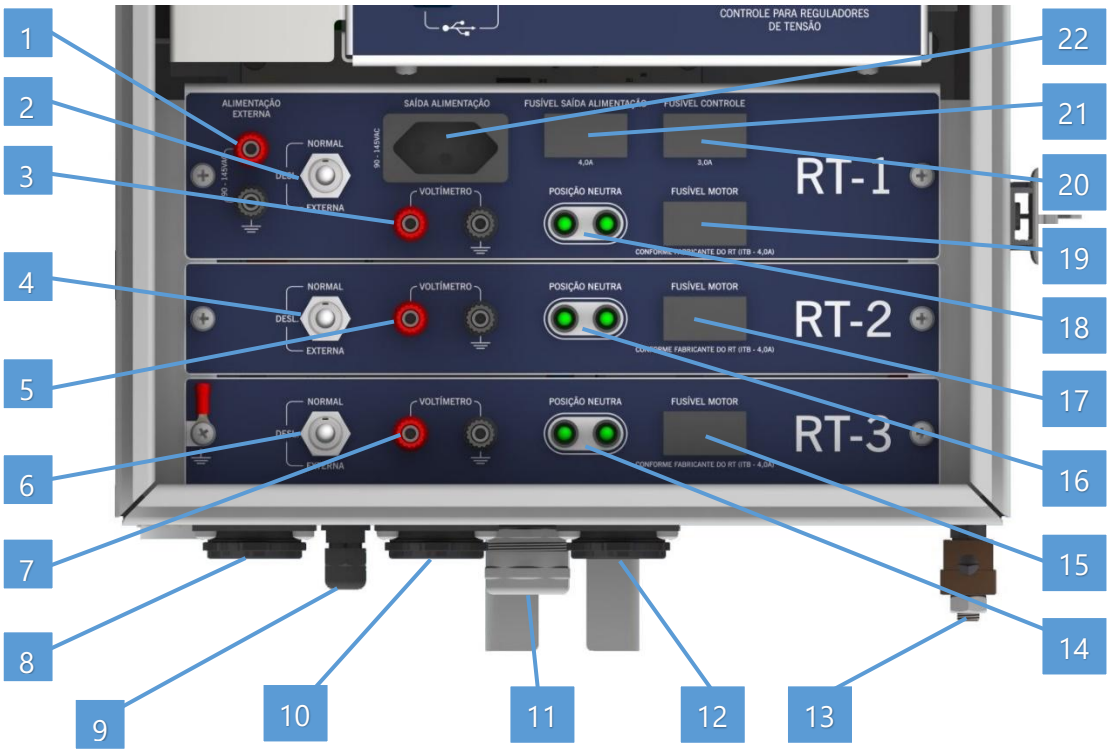


Table 1: Secondary panel components.

Item	Description
1	External source terminals (90 to 145Vac)
2	*"NORMAL / OFF / EXTERNAL"* Power selector key for VR-1
3	Load side measurement voltmeter connection Terminals for VR-1
4	*"NORMAL / OFF / EXTERNAL"* Power selector key for VR-2
5	Load side measurement voltmeter connection Terminals for VR-2
6	*"NORMAL / OFF / EXTERNA"* Power selector key for VR-3
7	Load side measurement voltmeter connection Terminals for VR-3
8	18-way male circular plug for connection of VR-1
9	PG-7 Cable gland
10	18-way male circular plug for connection of VR-2
11	PG21 Cable gland
12	18-way male circular plug for connection of VR-3
13	Grounding terminal for copper or aluminum cables of section up to 70mm^2
14	Neutral position indicator Leds of VR-3
15	Motor protection fuse (for ITB regulators 4A) of VR-3
16	Neutral position indicator Leds of VR-2
17	Motor protection fuse (for ITB regulators 4A) of VR-2
18	Neutral position indicator Leds of VR-1
19	Motor protection fuse (for ITB regulators 4A) of VR-1
20	Control protection fuse of CTR-3 control (3A)
21	Accessory Power Plug Protection Fuse (4A)
22	Field equipment power supply plug (90 to 145Vac), NBR 14136 standard, 2 poles and 1 ground

Connection of Control to Voltage Regulator

The connection between CTR-3 control box and single-phase regulator pass-through box is made through a multi-conductor cable with 18 conductors and female plugs at the ends. Figure 4 illustrates the standard plug and Table 2 details the position of each terminal.

Figure 4: Multiple plug conecctting the CTR-3 to the regulator pass-through box..



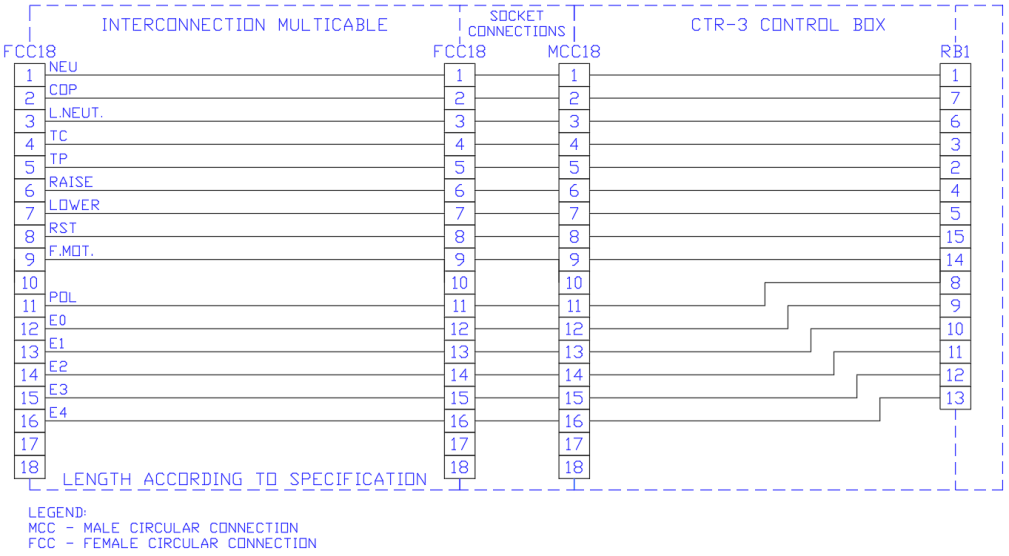
Table 2: Multiple plug terminal.

Pin	Description
1	Neutral (connected to earth)
2	Operation counter
3	Neutral light
4	Current measurement phase
5	Voltage measurement phase
6	Motor drive in the raise direction (increase tap)
7	Motor drive in the lower direction (decrease tap)
8	Indicator position reset
9	Motor retention
10	- No connection -
11	Polarity indicator
12	Bit 0 from encoder reading
13	Bit 1 from encoder reading
14	Bit 2 from encoder reading
15	Bit 3 from encoder reading
16	Bit 4 from encoder reading
17	Voltage measurement phase for auxiliary PT
18	Current measurement phase for auxiliare CT

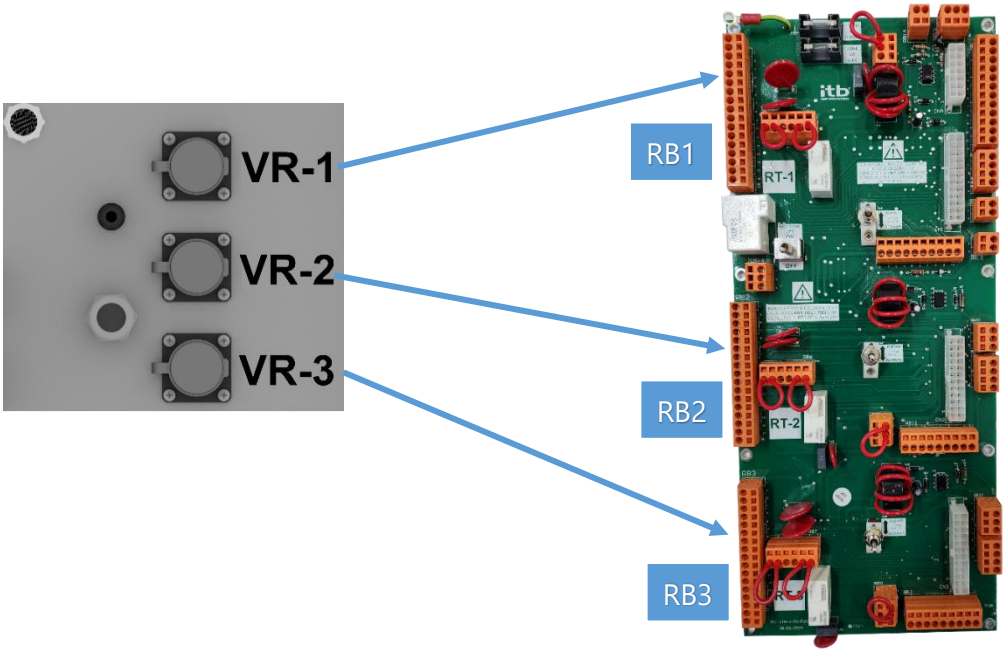
To avoid issues, including potential damage to the control, the cables responsible for the encoder communication must be disconnected from the *RB1*, *RB2*, and *RB3* terminals on the backplate, if the CTR-3 control is used in voltage regulators from other manufacturers.

Figure 5 shows the wiring diagram between the male circular socket, located at the bottom of the control box (items 8, 10, and 12 of Table 1), and the PCI board *CTR-3-P3-FUNDO*, at terminals *RB1 (VR-1)*, *RB2 (VR-2)*, and *RB3 (VR-3)*.

Figure 5: Connection diagram of the socket with RB1



Note: The diagram shows only RB1; however, the guidance is valid and should be applied to terminals RB2 and RB3 as well.



In this way, the cables connected to terminals 8, 9, 10, 11, 12, and 13 of *RB1*, *RB2*, and *RB3*, which are responsible for the encoder's communication with the control system, must be disconnected if the CTR-3 is used in a voltage regulator from other manufacturers.

CAUTION: The instruction to disconnect the encoder cables must be followed in order to avoid damage to the control system.

The interconnection cables from the CTR-3 control box to the regulators can be specified between 3 and 10 meters long. Its connection is oriented by the descriptions *VR-1, VR-2* and *VR-3* engraved on the bottom of the box, as illustrated by Figure 6.

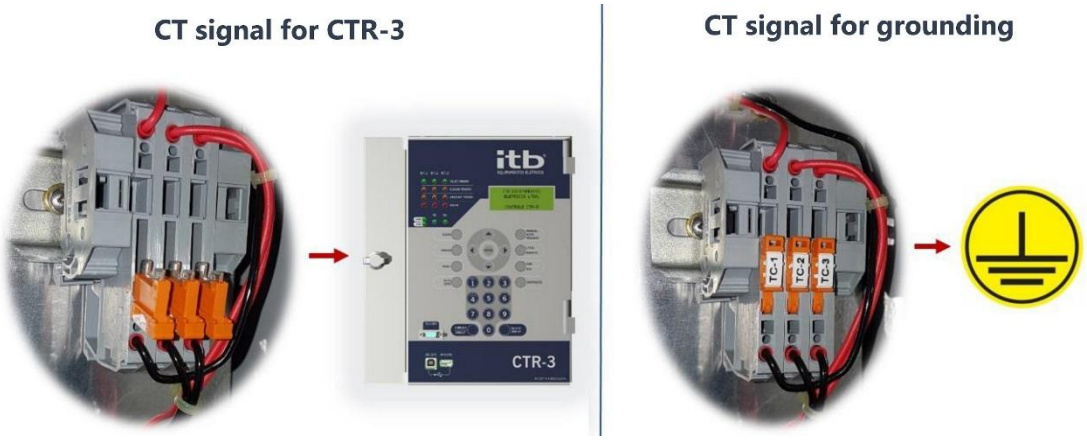
Figure 6: Connection between the CTR-3 control and the regulator.



Short-circuiting of Current Transformer (CT)

Before removing the CTR-3 control cabinet, it is necessary to short-circuit the current signals from the CT of each regulator to avoid overvoltage in the secondary. This operation must be carried out using the CT short-circuiting knife switches located at the bottom of the control box, behind the main panel. Figure 7 illustrates that procedure.

Figure 7: Procedure to short circuit the CTs.



CAUTION: Do not remove the circular connectors from the CTR-3 control without first short-circuiting the CTs. CT circuits MUST be shorted when removal or disconnection of the CTR-3 control occurs. Failure to follow these instructions will result in damage to the equipment.

Neutral Position LED Activation Adjustment

The CTR-3 control system is designed to operate with single-phase voltage regulators that comply with ABNT® NBR 11809 or IEEE Std C57.15™, regardless of brand. Due to the lack of standardization of specific construction details in these standards, it is necessary to select the method for activating the neutral position LED circuit, which can be done using either phase or neutral.

Inside, on the bottom of the control box is the circuit board identified as *PCI CTR-3-P3-FUNDO*. On this board, in positions RB5, RB6 and RB7 respectively for the voltage regulators identified as *VR-1*, *VR-2* and *VR-3*, a six-terminal block is located for manual activation or deactivation as detailed in Table 3.

To close or open the terminals, it is necessary to use a small screwdriver of the terminal block type (1/8"x4") to remove and reconnect the jumper.

Table 3: Neutral position LED handling.

Terminals	Description
1-2 5-6	When the neutral position LED is connected to neutral
2-3 4-5	When the neutral position LED is connected to phase (90 to 145 VAC)



CAUTION: In regulators produced by ITB phase activation must NEVER BE USED. For more information, consult the instruction manual of the voltage regulators to be controlled by the CTR-3.

Adjust the Activation of Indicator Reset

CTR-3 control system has the possibility of resetting the position indicator by activating the circuit by phase or neutral.

Inside, on the bottom of the control box is the circuit board identified as *PCI CTR-3-P3-FUNDO*. On that board, in positions RB8, RB9 and RB10 respectively for the voltage regulators *VR-1*, *VR-2* and *VR-3*, three-terminal blocks are located for manual activation or deactivation, as described in Table 4.

To close or open the terminals, it is necessary to use a small screwdriver of the terminal block type (1/8"x4") to remove and reconnect the jumper.

Table 4: Indicator reset handling

Terminals	Description
1-2	A phase signal will be emitted on the reset pin (90 to 145Vac)
2-3	A neutral signal will be emitted on the reset pin



CAUTION: Do not use phase activation in voltage regulator with digital indicator.

Auxiliary Contacts (I/O)

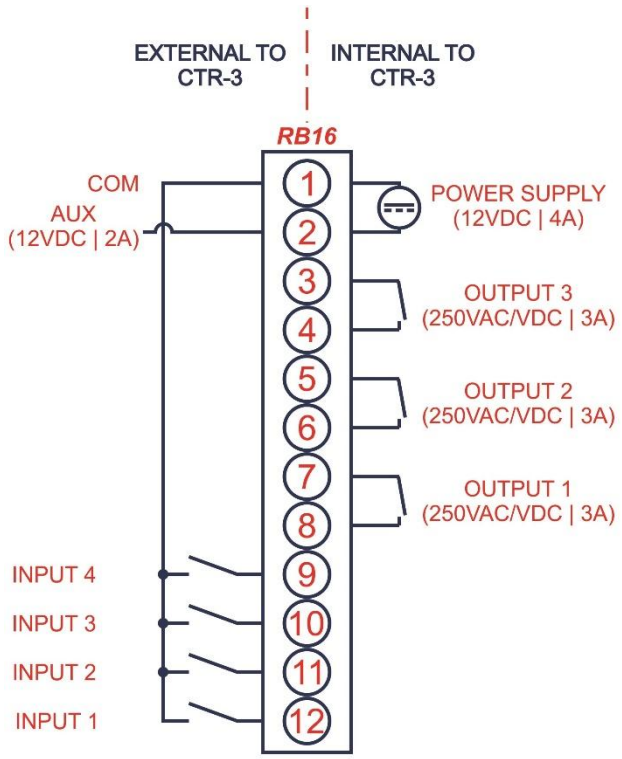
CTR-3 control systems feature programmable logic inputs that allow the connection of devices such as thermometers, oil level indicators, pressure relief valves, and/or other devices with contact outputs. It also includes programmable outputs through dry relays with potential-free contacts to activate devices such as alarms, lamps, relays, fans, fire-fighting systems, and others

On the printed circuit board named *PCI CTR-3-P3-FUNDO*, at position *RB16*, there are four digital inputs (triggered by COM) and three dry contact outputs (up to 250Vac or Vdc / 3A).

Use the **CTR-3Comm** communication software (available for free download and installation at *http://www.itb.ind.br*) to configure the programmable inputs and outputs. Consult the ***CTR-3Comm Communication Software Manual***, accessible in the "*Help*" tab of that program for additional information on the configuration of the control logic.

The connection diagram of the I / O gates is available on the main door of the CTR-3 control. A representation of that diagram can be seen in da Figure 8.

Figure 8: Auxiliary contacts diagram.



CAUTION: we recommended users read the logic gates connection and configuration information available in the *CTR-3Comm Communication Software Manual.*

Neutralization System Via Nobreak *(UPS)**

Figure 9: Control CTR-3 with nobreak (UPS)



Voltage regulators banks can be connected in series in the extension of a feeder. When there is lack of power to the main system and consequently the disconnection of all the loads in such system, voltage regulators remain in the operative position in which they were regulating before the failure. In these conditions, upon returning the main power supply and due to the inertia of the load itself, overvoltages could occur throughout the feeder due to the position of the tap changer. This overvoltage can cause damage to consumers connected to the system.

To avoid such problem, CTR-3 control can include, if requested by client, a UPS (uninterruptible power supply) that can tapping to the neutral position the bank of voltage regulators in case of a power failure.

Upon detecting the lack of power being the detection and actuation functions adequately enabled, the CTR-3 control will initiate the tapping process (move tap changer to neutral position) which will be done sequentially, in other words *VR-1*, *VR- 2*, and *VR-3*.

The CTR-3 was supplied with a UPS system consisting of an independent battery charger and inverter. This system is currently obsolete and is no longer manufactured; however, it remains in operation on previously installed voltage regulators.

Starting with the latest versions, the CTR-3 began to be supplied with an integrated UPS architecture, in which the battery charger and inverter are incorporated into a single unit, maintaining the same operational function while providing constructional and operational improvements.

Commissioning *UPS* – Independent Charger and Inverter

Figure 10: UPS – Independent Charger and Inverters

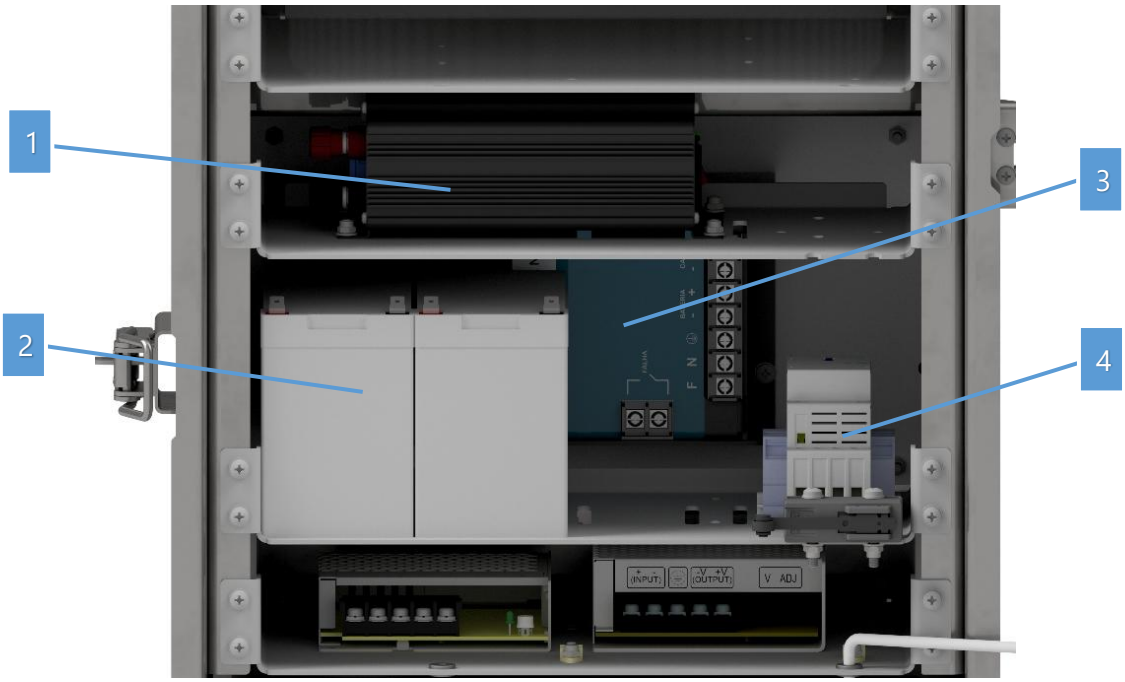


Table 5: UPS Description – Independent Charger and Inverter

Item	Description
1	DC/AC Inverter 12 VDC/120 VAC
2	12 Vdc Batteries
3	12 Vdc Battery charger
4	Mains Switching relay

To use the *UPS* system with an independent battery charger and inverter, the following steps must be followed:

- Connect the positive (+) terminals of the batteries, using the cables identified with ring marker No. 1, as shown in Figure 11;
- Set the *"NOBREAK UPS"* switch to *"ON"*, as shown in Figure 12. The switch is located on the printed circuit board identified as *PCI CTR-3-P3-FUNDO*, which is mounted inside the control cabinet;
- Turn on the inverter switch located on the side, as shown in Figure 13;
- Set function *75 – Time to switch to neutral position (UPS)* [2] to a value greater than zero.

WARNING: For extended periods of inactivity of the control, during which no power supply voltage will be present, it is recommended to remove the cables connected to the positive (+) terminals of the batteries. This will protect the battery from deep discharge and help maintain its ability to recharge when used in the future.

[2] *For more information about this function, see section* ***P75 – TNOBREAK****.*

Figure 11: Positive (+) battery terminals

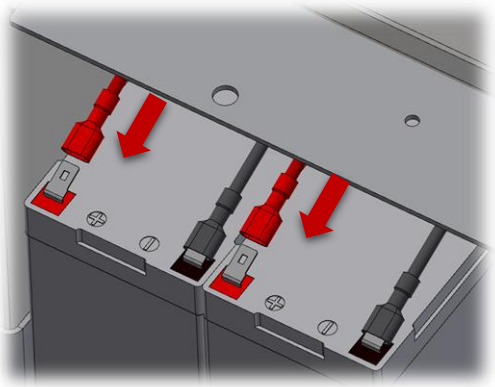


Figure 12: NOBREAK UPS switch

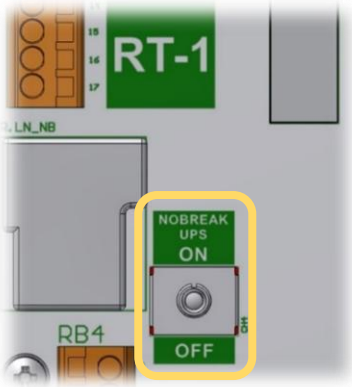


Figure 13: Location of the inverter power switch



Commissioning *UPS* – Integrated Charger and Inverter

Figure 14: Integrated Charger and Inverter

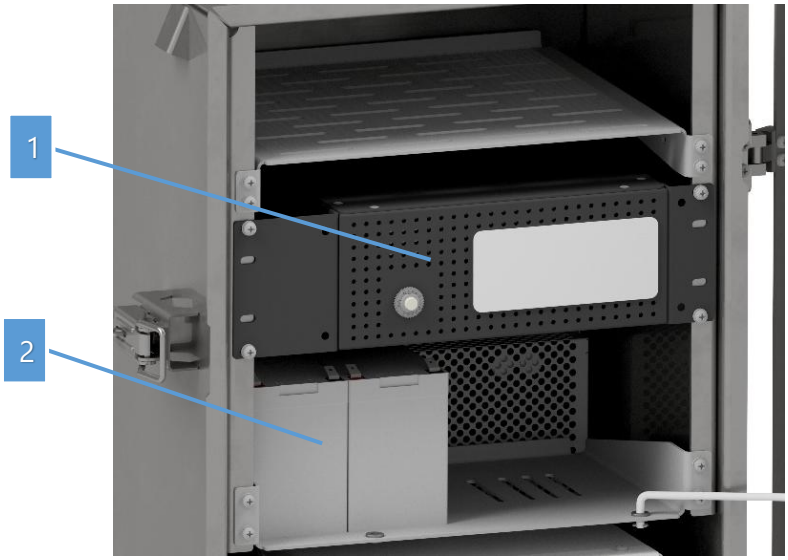


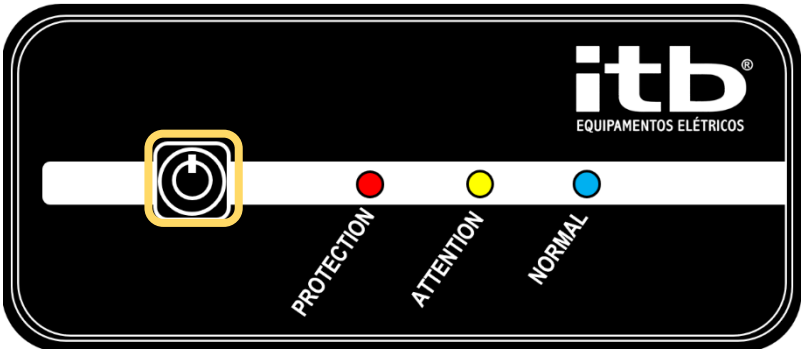
Table 6: UPS Description – Integrated Charger and Inverter

Item	Description
1	Integrated UPS/Charger
2	12 Vdc Batteries

To use the *UPS* system with an integrated battery charger and inverter, the following steps must be followed:

- Set the *"NOBREAK UPS"* switch to *"ON"*, as shown in Figure 12;
- Turn on the UPS by pressing the front button once, as shown in Figure 15;
- Set function *75 – Time to switch to neutral position (UPS)* [3] to a value greater than zero.

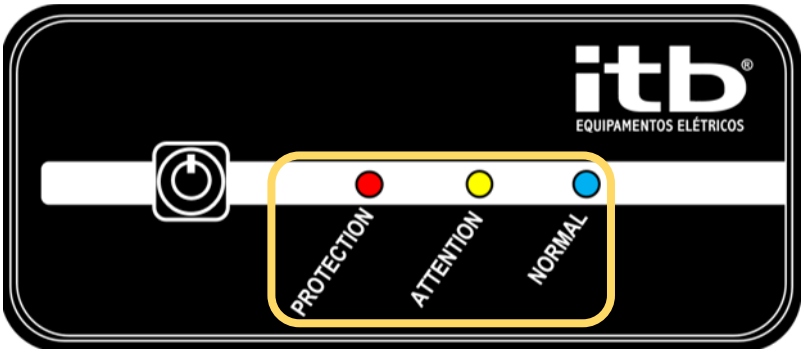
Figure 15 - UPS Power Button



Front UPS LED Status and Audible Signaling

The UPS has three LEDs located on the front of the unit, as shown in Figure 16 and also features an audible alarm.

Figure 16 - UPS LEDs



Each LED, together with specific audible alarm patterns, indicates a particular warning or the current operating condition, as described below:

[3] *For more information about this function, see section* ***P75 – TNOBREAK****.*

Table 7 - Normal LED (Blue)

NORMAL LED (BLUE)	
GRID OK	Steady: Indicates that the electrical grid is present and the battery is fully charged.
	Flashing: Indicates that the electrical grid is present and the battery is charging.

In battery mode, it indicates the power consumed by the loads connected to the UPS output, as shown in Table 8 below:

Table 8 - Normal LED (Blue) – Battery Status

NORMAL LED (BLUE)		
	NUMBER OF FLASHES	LOAD CONSUMPTION
GRID NOT OK	2	20%
	4	40%
	6	60%
	8	80%
	10	100%

Table 9 - Attention LED (Yellow)

ATTENTION LED (YELLOW)	
Nº OF FLASHES	INDICATION
1	Low or absent electrical grid voltage
2	UPS has no load
3	High electrical grid voltage
4	Overheating
4	Synchronized with the buzzer, indicates an overload at the UPS output sockets
5	Battery discharged
6	Shutdown due to output overvoltage; the UPS must be switched off and then switched on again
Steady	Battery has no backup autonomy

Table 10 - Protection LED (Red)

PROTECTION LED (RED)	
Nº OF FLASHES	INDICATION
1	Synchronized with the buzzer, indicates an overload or short circuit at the UPS output. Switch off the UPS, remove the connected load, and switch it on again.

Table 11 - Audible Signaling

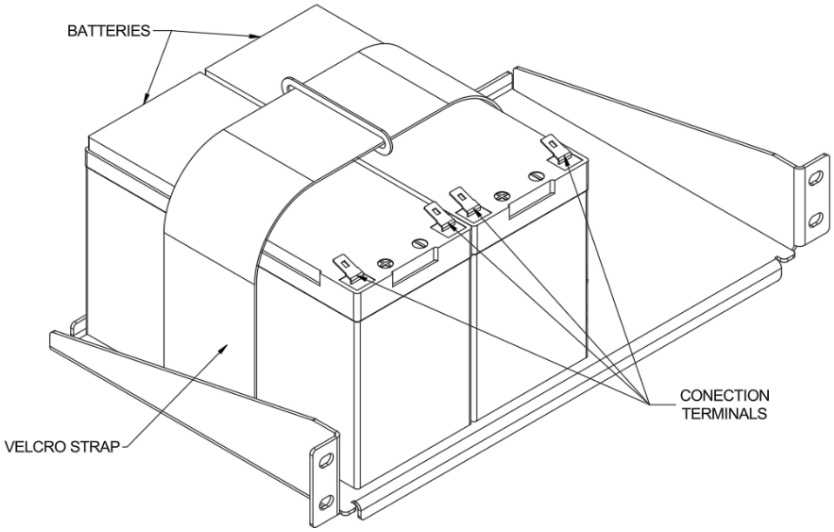
PROTECTION LED (RED)	
DESCRIPTION	INDICATION
Excessive power indication	Beeps in synchronization with the yellow LED until the excessive load is removed from the UPS.
Shutdown due to short-circuit or overload protection	Beeps in synchronization with the red LED. Switch off the UPS and switch it on again.
UPS in battery mode	Beeps at 30-second intervals, indicating that the UPS is operating in battery mode.
UPS with critically low battery	Rapid and continuous beeps indicate that shutdown is imminent because the battery is depleted.

The *UPS* system consists of a set of two 12 V, 7 Ah lead-acid batteries (VRLA-AGM) connected in parallel (or as specified in the technical proposal). The average battery service life is approximately 2 years.

For battery replacement, the following procedures are recommended:

- Set the *"NOBREAK UPS"* switch to *"OFF"*, as shown in Figure 12;
- For the UPS system with an integrated charger and inverter, press the front button for slightly more than 1 second to switch off the equipment. For models with an independent inverter and charger, switch off the switch indicated in Figure 13.
- Disconnect the battery connection terminals;
- Partially loosen the Velcro strap;
- Remove the old batteries (if necessary, remove the shelf from the cabinet);
- Position the new batteries;
- Fasten the Velcro strap;
- Connect the battery connection terminals;
- Set the *"NOBREAK UPS"* switch to *"ON"*, as shown in Figure 12;
- Turn the inverter on again.

Figure 17: Battery Shelf



CAUTION: It is not advisable to dispose batteries in regular garbage due to the risk of causing damage to the environment and health. Once life time is achieved, they must be properly disposed according to current environmental regulations.

Alternative Drive

The alternative motor drive switches are located at the bottom of the control box, on the circuit board named *PCI CTR-3-P3-FUNDO*. There, in positions *CH1*, *CH2* and *CH3* are the switches to manually drive voltage regulators *VR-1*, *VR-2* and *VR-3* respectively.

These switches allow the operation to boost (increase tap position) or buck (decrease tap position) the on load tap changer even without the presence of the CTR-3 control.

They are 3-position momentary switches, normally off, that activate the motor in the direction indicated according to the silkscreen on the *PCI CTR-3-P3-FUNDO*.



DANGER: Do not operate this function on voltage regulators without external mechanical position indicator.



DANGER: Alternative drive of motors must be done with care, as there are several energized points inside the control box.

Operation Through External Source

The CTR-3 control can be powered through an external voltage source between 90 and 145Vac for configuration and testing. This external source will be connected to the terminals on the front panel of the control box identified as "*EXTERNAL SOURCE*" verifying correct connection of phase and neutral as marked and switching the "*INTERNAL / OFF / EXTERNAL*" switch towards the "*EXTERNAL*" position.



CAUTION: Correct polarity must be connected to the control. Failure to follow this recommendation can cause a short circuit in the power supply and damage the control.



DANGER: Do not connect any voltage source to the "*VOLTMETER*" terminals, because this may induce high voltages at the high power terminals of the regulator, constituting a serious risk of accident to the operator and damage to the regulator.



CAUTION: Do not connect any loads to the "*VOLTMETER*" terminals.

CTR-3 CONTROL – OVERVIEW

The CTR-3 control is a micro-controlled equipment capable of performing functions inherent to voltage regulation, timed delay actuation and data acquisition to control the voltage level in electrical power systems, making them available through its built-in communication system to be accessed remotely.

The CTR-3 electronic control has the following resources:

- Real time, continuous measurement of electrical line magnitudes, independently for each of the 3 phases;
- Digital resettable on load tap changer operations counter, independent for each one of the 3 phases;
- Indicator LEDs to identify the selection of each regulator in the bank;
- Indicator LEDs to identify the need to increase the voltage for each regulator in the bank;
- Indicator LEDs to identify the need to lower the voltage for each regulator in the bank;
- Indicator LEDs to identify a fault, one for each regulator in the bank;
- Data acquisition:
    - Obtain, store and display the number of data log, in adjustable periods between 1 and 60 min, the instantaneous values of voltage, current, power fator, actual on load tap changer position, date and time of each data log until the total number of data logs of 6.180. From that point on, a new data log is made in each period of time configured, overwriting the oldest data log.
- Operation in direct, reverse and cogeneration power flow without the need for a special PT for this purpose;
- "Auto Zero" and "Remote Return to Neutral Position" function that takes the on load tap changer from any position to zero or neutral position;
- Three simultaneous communication ports;
- Allows communication via EIA232, EIA485, USB, fiber optics and / or Ethernet;
- Serial communication with a computer can be done through any of the DNP3.0 communication ports or through the communication program, **CTR-3Comm** (available for free download and installation at *http://www.itb.ind.br*) running on Microsoft® Windows® 7 or newer operating system. If you use the software, you must have a connection between the serial, USB or optical port of the computer and the EIA232, DB-9 port of the front of the control through a serial cable or USB type A or ST optical available in the CTR-3. If the serial port of the computer is a DB-9 Male, the cable to be used must be direct, that is, pin to pin;
- The communication ports can also be used for communication using cellular modem, simply by using **CTR-3Comm** communication program and setting the "*Connection type*" to "*TCP / IP*" and configuring the "*IP*" address and "*Port*" corresponding to the modem connected to the control you wish to access;
- Pin 9 of each of the DB-9s are active with + 5Vdc (optionally this function can be disabled at factory);
- DNP3.0 Communication Protocol through all communication ports;
- Independent adjustments for direct, reverse and cogeneration power flows;
- Clock and calendar in real time;
- On load tap changer protection in case of overload;
- Voltage limiting function to protect first consumers downstream;



NOTICE: Access to the log stack can be done with the help of a computer connected to the control in which the CTR-3Comm communication program is installed and running or using a pen drive.

Control Panel Components

CTR-3 control allow users to view, adjust configuration and read instantaneous electrical quantities of electrical system without the need of any other accessories.

When the CTR-3 control is powered on, all the LEDs and the display panel will light to test the operation of these components.

Its front panel has a monochromatic liquid Crystal alphanumeric display and a keyboard as show in Figure 18 and as detailed in Table 12.



NOTICE: The CTR-3 control display has a screen protection function to save energy and extend its life. After 15 minutes without any access through keyboard, the display turns off and turns on again only when there is a new access..

All controls are individually tested and calibrated at the factory and all parameter adjustments can be made manually through the front interface.

Through the navigation keys and keyboard it is possible to access the functions and thus adjust them to meet requirements.

Figure 18: CTR-3 control front panel.

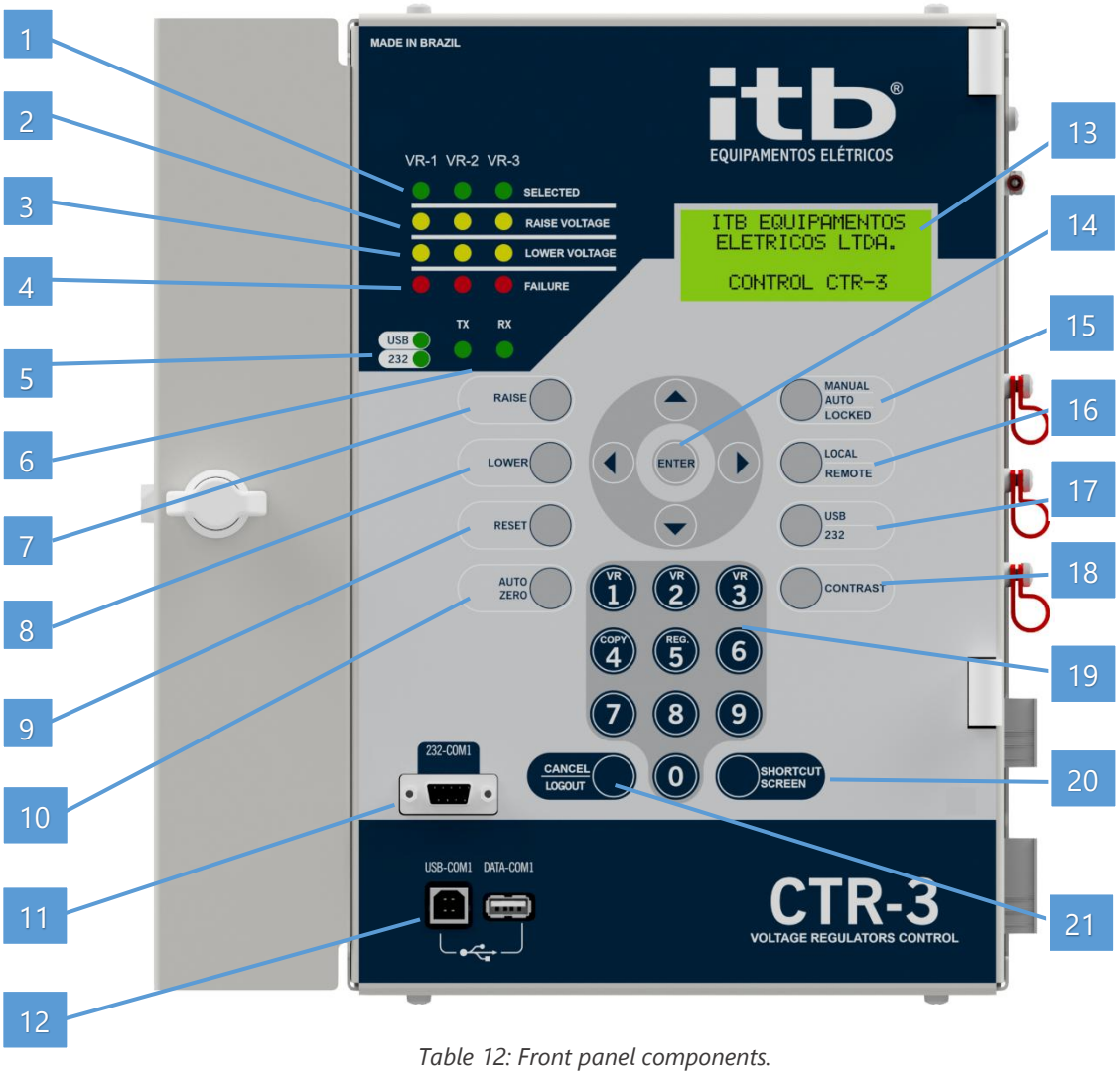


Table 12: Front panel components.

Item	Description
1	Selected voltage regulator is active indicator LEDs
2	*"Raise voltage"* indicator LEDs (increase voltage)
3	*"Lower voltage"* indicator LEDs (decrease voltage)
4	*"Fault"* indicator LEDs
5	*"USB/232"* indicator LED
6	*"Tx/Rx"* indicator LED
7	*"Raise"* key moves on load tap changer boosting when "Manual" mode is active
8	*"Lower"* key moves tap changer bucking when "Manual " mode is active
9	*"Reset"* key updates or set to zero values of reading when operation is possible
10	*"Auto Zero"* key returns tap changer/s to neutral position or position zero
11	DB-9 232-COM-1 connector
12	USB A DATA-COM1 and USB B USB-COM1 connectors
13	Monochrome liquid crystal display 4 lines of 20 characters
14	*"Navigation"* and *"Enter"* keys
15	*"Mode"* key selects operation mode of each voltage regulator between automatic, manual or locked
16	*"Local/Remote"* key toggles between blocking or accepting remote commands
17	*"USB/232"* key to select communication interface
18	*"Contrast"* key of display
19	*"Numeric"* keys for quick parameter adjustment
20	*"Shortcut Screen"* key for quick parameter access
21	*"Cancel/Logout"* key

At the rear of the control the inputs to the additional communication modules (COM-2 and COM-3 ports), power, digital and analog signals from each voltage regulator are located.

Figure 19: CTR-3 control rear panel.



Table 13: Rear panel components.

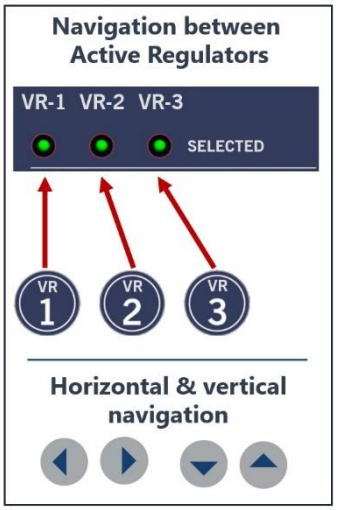
Item	Description
1	Fiber optic ST Slot COM-2 (by default, can be altered according to specifications)
2	DB-9 EIA232 Slot COM-3 (by default, can be altered according to specifications)
3	VR-1 signal inputs and outputs (CN1)
4	VR-2 signal inputs and outputs (CN2)
5	VR-3 signal inputs and outputs (CN3)
6	I/Os signal inputs (CNA)
7	Supply input (CNF)

Screen Group Navigation

CTR-3 control screens were organized with the aim of providing fast and precise navigation. Screens were divided into 8 groups: main screens, access screen, measurement screens (numbered from 01 to 20), parameter screens (numbered from 21 to 77), motor drive screen, date and time screen, file management screen by means of *pen drive* and shortcut screen. The ◄ or ► keys toggle between those screen groups, in the order in which they were described, always showing the first screen of each group. On the measurement and parameter screens you can navigate between the numbered points according to Table 14, Table 16 or Table 17 respectively, using the ▼ or ▲ keys.

Navigation between the active regulators of the bank can be done through the numeric keys 1, 2 and 3 for the regulators *VR-1*, *VR-2* and *VR-3* respectively. From the main screens, measurement screens and parameter screens you can toggle the bank's active regulator.

Figure 20: Navigation keys.



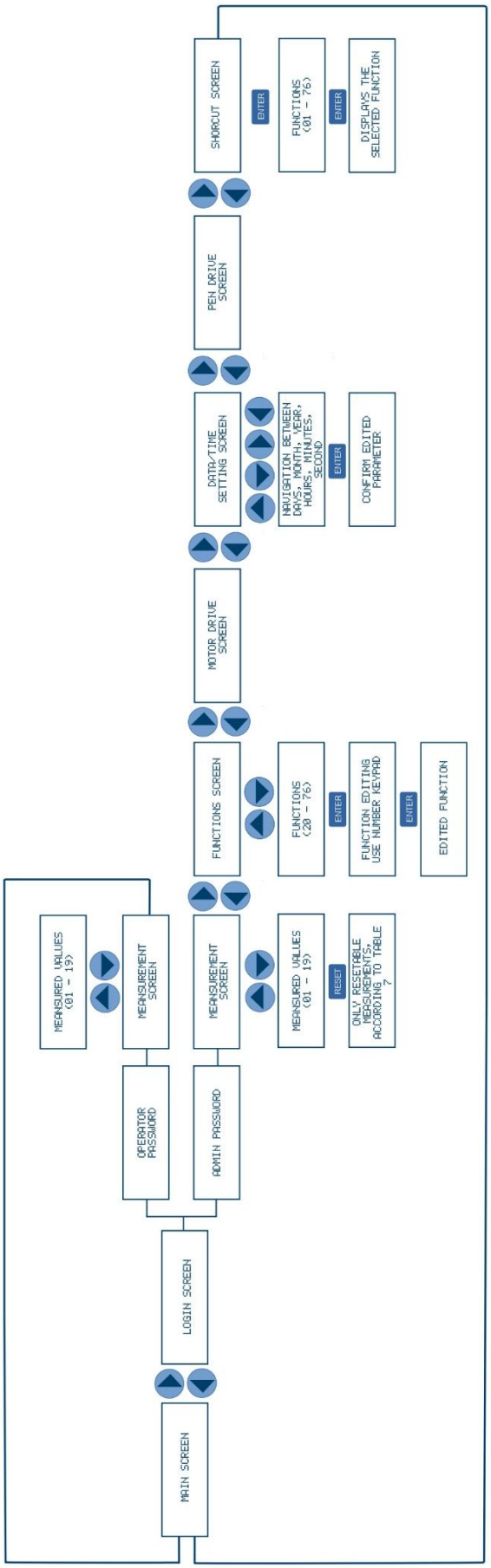
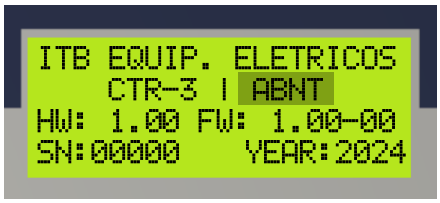


Figure 21: Navigation between screens.

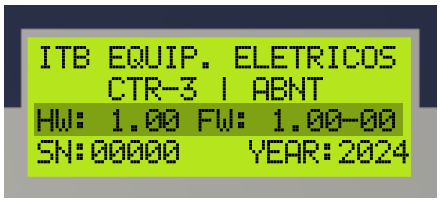
Welcome Screen

When initialized, the CTR-3 control will perform a functional test as described in the *"Control Panel Components"* section. During this test, the screen will display information about the control.
Figure 22 explains each line and function displayed on the screen.

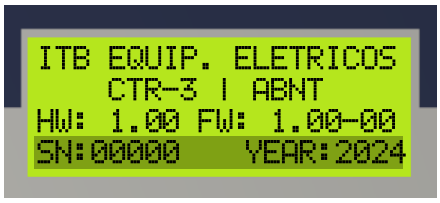
Figure 22: Welcome screen



Line 2 – Firmware standard
- ✓ ABNT: as per ABNT® NBR 11809 standard;
- ✓ IEEE: as per IEEE Std C57.15™ standard.



Line 3 – Hardware and firmware version
- ✓ HW: Hardware version;
- ✓ FW: Firmware version.

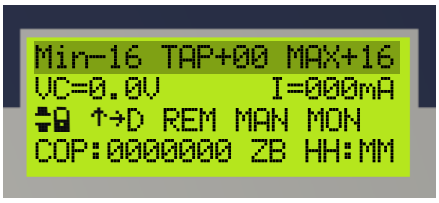


Line 4 – Serial number and manufactured year
- ✓ SN: Serial number;
- ✓ YEAR: Manufactured year

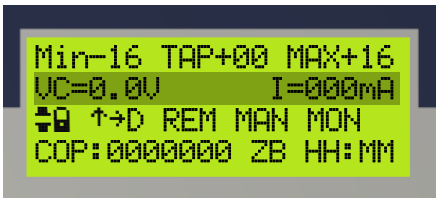
Main Screen

CTR-3 control includes an easy-to-read main screen that displays at the same time the most important information inherent in the voltage regulation. Figure 23 describes each line and function displayed on the main screen by each regulator.

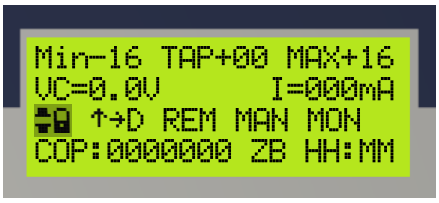
Figure 23: Main screen information.



Line 1 – Tap changer position indicator (taps)
- ✓ MIN: Minimum tap achieved since last reset;
- ✓ TAP: Actual tap changer position;
- ✓ MAX: Maximum tap achieved since last reset.

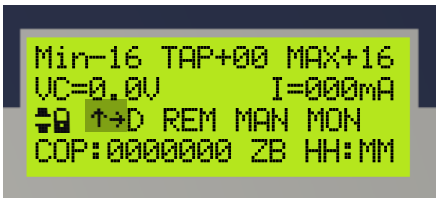


Line 2 – Measurements
- ✓ VC: Line voltage on the load side;
- ✓ VF: Line voltage on the source side (bidirectional);
- ✓ I: Line current on the load side.



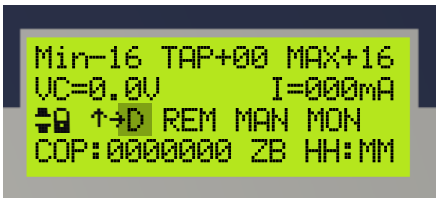
Line 3 – Visual indicator

- ✓ : *Reading PCB* connection indicator;
- ✓ : Login and logout indicator.



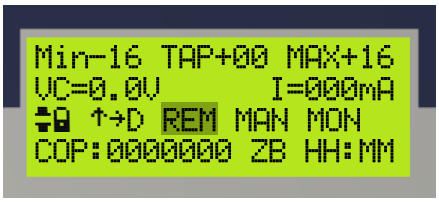
Line 3 – Power flow

- ✓ Vector indication of the direction (forwartd or reverse) and characteristics (inductive of capacitive) of the power flow.



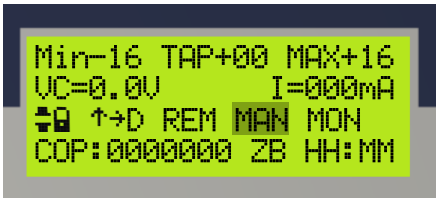
Line 3 – Active work group

- ✓ C: Cogeneration mode group;
- ✓ F: Forward power flow group;
- ✓ R: Reverse power flow group.



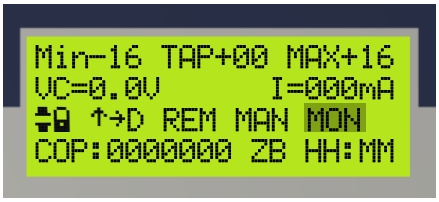
Line 3 – Remote access

- ✓ LOC: Local (NO remote commands accepted).
- ✓ REM: Remote (accepts remote commands);



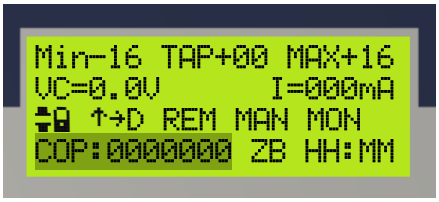
Line 3 – Operation mode

- ✓ AUT: Automatic operation;
- ✓ MAN: Manual operation;
- ✓ INT: Inactive regulator;
- ✓ LCK: Locked operation (inhibited motor).



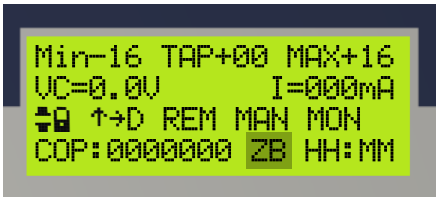
Line 3 – Regulation mode

- ✓ MON: Operating in single-phase mode;
- ✓ TAB: Operating in table mode;
- ✓ TMD: Operating in three-phase average mode;
- ✓ TMT: Operating in three-phase máster mode;



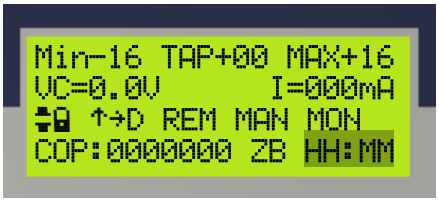
Line 4 – Operation counter

- ✓ COP: Totalizer operations conter.



Line 4 – *On load ta changer motor status*

- ✓ AN: UPS Auto Zero
- ✓ BA: Motor blocked for bucking;
- ✓ BE: Motor blocked for boosting;
- ✓ BT: Motor blocked for both boosting and bucking;
- ✓ CT: Performing *check-tap*;
- ✓ FI: Neutralizing by reverse flow;
- ✓ MI: Master voltage regulator inactive;
- ✓ S: Synchronizing;
- ✓ ZB: All regulator tapping to neutral position.



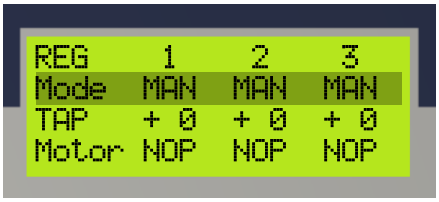
Line 4 – Clock/Timer

- ✓ Clock;
- ✓ Timer: When the voltage extrapolates the insensitivity range, that area of the display changes to a progressive chronometer. After the value reaches the set value, the control operates the on load tap changer to carry out the regulation.
- ✓ Timer: Auto Zero using UPS

Motors Drive Screen

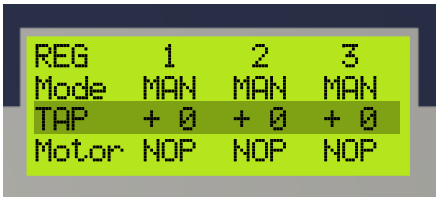
To facilitate the visualization of the operating mode, tap changer position and operative status of motors of each active regulator in the bank, CTR-3 control has a screen that gathers all this information and displays them together in one screen in real time.

Figure 24: Motor drive screen information.



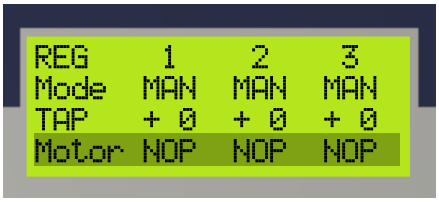
Line 2 – Mode

- ✓ MAN: Manual operation;
- ✓ AUT: Automatic operation;
- ✓ LCK: Locked operation (inhibited motor);
- ✓ INT: Inactive regulator.



Line 3 – Tap changer position indicator (taps)

- ✓ Show in real time the position of tap changer of all regulators active in the bank.



Line 4 – Tap changer motor status

- ✓ NOP: Motor not running;
- ✓ TAP+: Motor active boosting;
- ✓ TAP-: Motor active bucking;
- ✓ BT: Motor locked in boht directions;
- ✓ BA: Motor blocked for bucking;
- ✓ BE: Motor blocked for boosting.

Motor Unlocking Screen

Starting from version 1.08, the CTR-3 control, when operating in automatic mode and with this function enabled via software, features an exclusive routine for unlocking the motor. The routine operates as follows:

Tap Change Failure Detection: During automatic operation, if the CTR-3 commands the motor to step up or step down and does not detect the expected tap change within 30 seconds, the unlocking routine is initiated.

Unlocking Attempt: The system then attempts to drive the motor in the opposite direction from the one initially commanded. This action is an attempt to undo any possible blockage or obstruction that may be preventing the normal movement of the motor.

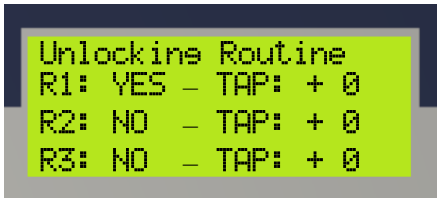
Return to Original Motion: After attempting to drive the motor in the opposite direction, the control system will then try to move it in the originally commanded direction.

Routine Conclusion:

Success: If the tap change is detected after these actions, the routine is successfully completed, indicating that the motor has been unlocked and is operating correctly.

Failure: If the tap change is not detected even after these attempts, the system will display a failure indication. This signals that the motor locking issue may require manual intervention or further analysis.

Figure 25: Motor screen information.



Unlocking Routine

- ✓ *R1,R2* e *R3*: Regulator concected to channels VR-*1, VR-2* and VR-*3* respectively;
- ✓ YES: Indicates that the unlocking routine is being executed on this regulator;
- ✓ TAP: Current motor tap status.

Date/time Setting Screen

The CTR-3 control has an exclusive screen for viewing and setting date and time.

Use the navigation arrows, numeric keys, and the Enter key to modify the values.

Figure 26: Date/Time screen information.



Line 2 – Date

✓ Configure date in day (DD), month (MM) and year (YY) format.



Line 3 – Time

✓ Configure hour in hour (HH), minute (MM) and seconds (SS) format.



Line 4 – Day of week

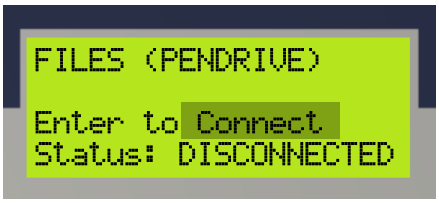
✓ Configure day of week Sunday, Monday, Tuesday, Wednesday, Thursday, Friday or Saturday.

Pen Drive Screen

CTR-3 control has an active USB port for pen drive connection. Through this resource it is possible to import or export the parameter settings and export data log from the mass memory.

Before connecting a pen drive user must access the pen drive file screen and follow the steps detailed in Figure 27.

Figure 27: Pen drive screen information



Connect a *pen drive device*
- ✓ Wait until connect status changes to Open.



Connect a *pen drive device*
- ✓ When status is Open, press ENTER.



Choose from one of the options
- ✓ 1) Parameters;
- ✓ 2) Data logs;
- ✓ Choose desired option and press ENTER.



1) Parameters, select between import or export
- ✓ 1) Import;
- ✓ 2) Export;
- ✓ Choose desired option and press ENTER



2) Data logs
- ✓ Choose the amount of data logs to Exporte and press ENTER

CTR-3 control saves and opens only files that are in the **ITB_CTR3** directory. If that directory does not exist at the time of export, the control will create that directory at the root of the pen drive.

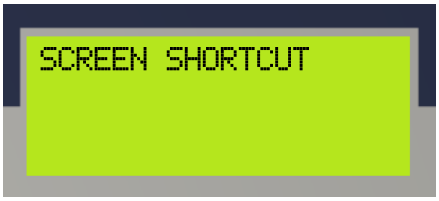


NOTICE: The CTR-3 control accepts only pen drives formatted with FAT32 file partition of up to 8 GB size.

Shortcut Screen

From the default screen, you can press the ***"SHORTCUT SCREEN"*** key or to switch the control the screen that allows you to enter the corresponding number for the parameter or measurement you wish to view, as show in the *"SHORCUT"* columns of Table 14, Table 16 ou Table 17.

Figure 28: Shortcut screen.



The shortcut selection screen is shown according to Figure 28 and, when the **ENTER** button is pressed, it is modified, remaining as in Figure 29, which allows the modification of the "*Choose screen*" box through the following procedure:

Under one of the digits of the box *"Choose the screen"* there is a cursor that will indicate the adjustable digit;

Press the numeric keys, 0 to 9 to change the value of this digit;

Press the ◄ or ► keys to make the cursor navigate between the digits;

Repeat the operation until filling the two digits obtaining the desired value;

With the cursor on the least significant digit, press the **ENTER** key to confirm the entered value, and the requested screen will be displayed immediately.

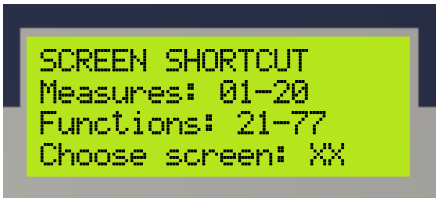


NOTICE: If the adjusted value is outside the ranges indicated in Figure 29 the message *"Invalid number"* will be shown on the bottom line of the screen and the shortcut screen will once again be the same as Figure 28, requiring the repetition of the described steps.

If the ◄ key is pressed while the cursor is under the most significant digit, the CTR-3 controller will take no action;

To return to the standard screen from the shortcut screen, just press the **CANCEL/LOGOUT** key once.

Figure 29: Shortcut screen – Inputd data.



Direct Command Key

CTR-3 control has 10 direct command keys with specific functions that are described below:

- **RAISE** key: Operates the motor of tap changer to boost (raise tap changer) voltage;
- **LOWER** key: Operates the motor of tap changer to buck (lower tap changer) voltage;
- **RESET** key: Updates or resets values of parameters or variables that allow this operation, which are indicated by the word *"Resettable"* written on the bottom line of the display;
- **AUTO ZERO** key: Commands the tap changer towards the *"NEUTRAL"* position from any screen or operation mode (see the topic Auto Zero, available in this manual);
- **MANUAL/AUTO/LOCKED** key: Selects the manual, automatic or locked operation modes for commutations for each voltage regulator;
- **LOCAL/REMOTE** key: Enables priority communication modes for modifying parameter settings locally or remotely;
- **USB/232** key: Toggles the communication interfaces between USB or RS232;
- **CONTRAST** key: Enters the display contrast calibration mode, which can be modified using the ◄ or ► keys;
- Numeric keys **1, 2 and 3:** Modify the display between the active regulators in the bank between the main screens, measurement screens and parameter screens;
- Numeric key **4:** From any parameter screen, this function allows users to copy all the parameters from a reference regulator and paste into a destination regulator;;



NOTICE: The copy and paste function modifies all the parameters of the target regulator based on the settings of the reference regulator, except for function *58 - HREG*.

- Numeric key **5:** From the main screen of any active regulator in the bank, once key 5 is pressed, the control records values of voltage, current, power factor, date and time, among other parameters that can be recordable in the mass memory;
- **CANCEL / LOGOUT** key: Returns to the main screen or cancels a certain value that is being edited or ends the section by blocking access, indicated by a padlock symbol. The control can be accessed again by entering the user or administrator password;
- **SHORTCU**T screen key: Displays the quick access screen of the functions on the display, according to Table 14 e Table 16.

Auto Zero function

AUTO ZERO key has the function of preparing the control for energizing or de-energizing switching and, once activated, executes the following algorithm:

1. It displays the message *"To confirm AUTO ZERO, keep pressing"*, hold for about 4 seconds;
2. If tap changer is not in the neutral (zero) position, the control checks if there is a need to command the switch to raise (boost) or lower (buck) taps;
3. Start the tap changer motor in the direction needed of bringing tap changer to the neutral (zero) position;
4. Waits until the ta changer reaches neutral position, verified by the change of state of the polarity reversing key;
5. When the neutral (zero) position is reached, the control verifies if the redundancy of this information is consistent, comparing the Reading from the encoder with the closed status of the zero position microswitch, which have electrically and mechanically independent systems;
6. The display shows, following the regulator information, the message *"NEUTRALIZED"* for the regulator that has reached the neutral position, *"INACTIVE"* when the regulator is deactivated, and *"FAULT"* for the regulator that has an inconsistency between the *"Neutral Position"* LED and the encoder reading and/or the position tracked by the position tracking algorithm. In this case, the *"Fault"* LED on the front control panel will illuminate.
7. When the routine ends, the message *"AUTO ZERO COMPLETED*" is displayed on the last line of the display. Only proceed with bypassing switching after individual verification of neutral position on each of the bank's active regulators.

Starting from version 1.08, the *Auto Zero* function has been updated for regulators that are not ITB. It now uses the pulse from the neutral light microswitch as the main reference, functioning as follows:

1. Neutral Light Search: The *Auto Zero* function attempts to locate the pulse from the microswitch associated with the neutral light, performing the necessary switching according to the current tap indicated.
2. Operation Cycle: If the neutral light is not initially found, the system starts an operation cycle to try to detect it.
3. Faut indication: If the neutral light remains absent after the operation cycle, the system displays a *"FAULT"* indication.



NOTICE: The *"AUTO ZERO"* function blocks the control commands until the next reset of the control. After resetting the control, it returns to manual mode



NOTICE: The *"AUTO ZERO"* function brings the tap changer of all active regulators of the bank to neutral position simultaneously.



DANGER: The *"AUTO ZERO"* function has no means of verifying redundancies for safe operation on voltage regulators that do not have a digital monitoring facility for the tap changer position. Therefore, after return to neutral position, it must be visually verified if the mechanical position indicator is in position 0 (zero), otherwise, do not carry out the bypass switching without de-energizing the system.



DANGER: Before executing bypass switching for insertion or removal of the voltage regulators from the network, consult the instruction manuals of the voltage regulators or the relevant technical specifications.

CTR-3 CONTROL – MEASUREMENTS AND FUNCTION SETTINGS

The CTR-3 control has a group of measurement screens with the main electrical magnitudes related to distribution network and voltage regulation, and another group of parameters screen where it is possible to configure the parameters to allow operation in direct, reverse and cogeneration flow.

Navigation between measurements screens

The ◄ and ► keys navigate through screens where the system measured values can be viewed as follows:

Figure 30: Measurement screen example.



In the *"XX"* field, the number of the screen to be used to access directly to it through the shortcut screen will be presented;

In the "*Name:*" field, the measurement identifier will appear according to the "Name" column in Table 14;

In the *"UN"* field in between square brackets, the unit of the referred measurement will be displayed when applies;

In the field "*Value:*" the instantaneous value for that measurement will be displayed;

The *"dd/mm/yyyy hh:mm"* field will display the time of occurrence, when applies;

The word "*Resettable*" will be seen on the bottom line of the screen, when applies to that parameter, according to the "*Resettable*" column in Table 14.

The values will be displayed in the sequence of Table 14 To advance press the ▼ key and to return to the previous value use the ▲ key.

Table 14: Sequence of measured values

Shortcut[4]	Name	Description	Unit	Reset	Remote
1	FREQ	Frequency	Hz	No	Show
2	FPOT	Power factor	-	No	Show
3	TBLC	Voltage referred to low voltage, "*LOAD*" side	V	No	Show
4	ICb	Current referred to low voltage, "*LOAD*" side	mA	No	Show
5	VC	Line voltage "*LOAD*" side	kV	No	Show
6	IC	Line current "*LOAD*" side	A	No	Show
7	TBLF	Voltage referred to low voltage, "*SOURCE*" side	V	No	Show
8	IFb	Current referred to low voltage, "*SOURCE*" side	mA	No	Show
9	VF	Line voltage "*SOURCE*" side	kV	No	Show
10	IF	Line current "*SOURCE*" side	A	No	Show
11	P	Apparent Power	kVA	No	Show
12	PA	Active power	kW	No	Show
13	PR	Reactive power	kvar	No	Show
14	TEMP	Internal regulator temperature[5]	°C	No	Show
15	INEUT	Neutral current	A	No	Show
16	DHTV	Total harmonic distortion of voltage	%	No	Show
16	1ª	1st Harmonic	%	No	Show
16	3ª	3rd Harmonic	%	No	Show
16	5ª	5th Harmonic	%	No	Show
16	7ª	7th Harmonic	%	No	Show
16	9ª	9th Harmonic	%	No	Show
16	11ª	11th Harmonic	%	No	Show
16	13ª	13th Harmonic	%	No	Show
16	15ª	15th Harmonic	%	No	Show
17	DHTI	Total harmonic distortion of current	%	No	Show
17	1ª	1th Harmonic	%	No	Show
17	3ª	3th Harmonic	%	No	Show
17	5ª	5th Harmonic	%	No	Show
17	7ª	7th Harmonic	%	No	Show
17	9ª	9th Harmonic	%	No	Show
17	11ª	11th Harmonic	%	No	Show
17	13ª	13th Harmonic	%	No	Show
17	15ª	15th Harmonic	%	No	Show
18	QTREG	Amount of data logs stored	-	Yes	Show and Reset
19	CEMT	Input counter in three-phase mode	-	Yes	Show and Reset
20	CFAL[6]	Fault code	-	Yes	Show



NOTICE: When the value of *"QTREG"* has been resetting, stored data is deleted.

[4] *The shortcut numbering in this table is valid only for firmware versions 1.07 or higher*
[5] *If the voltage regulator has an internal temperature sensor.*
[6] *Starting from firmware version 1.09-00. Due to the addition of this item, shortcuts to subsequent screens have been shifted.*

Navigation between functions screens

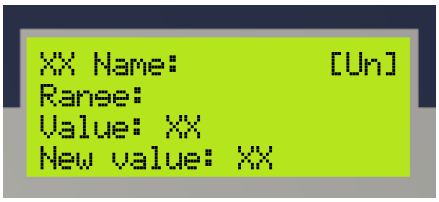
The number of the screen to be adjusted will be presented in the field "*XX*" displayed in the upper left corner. This number corresponds to the function code and can be used through the "*Screen Shortcut*" resource to reduce browsing time.

The "*Name*" field presents an acronym that identifies the parameter displayed according to the "*Name*" column of Table 16 and Table 17 for IEEE® and ABNT® standard firmware, respectively.

The current value box presents the adjusted value for that parameter and, in the upper right corner, in between square brackets, the measurement unit.

To adjust the control's operating parameters:

Figure 31: Settings modification screen.



Press the ◄ or ► key until the function screen is displayed, as shown in Figure 31.

Press the ▼ or ▲ keys to navigate throught the configurable functions, which are sequenced as per Table 16 and Table 17. Navigation is sequential and cyclic.

Press the **Enter** key to enable editing of the current value, as shown in conforme Figure 31.

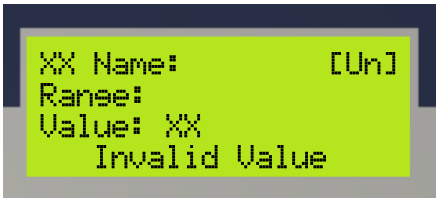
A "*Range*" field will display the minimum and maximum configurable values for the function.

A "*New value*" field will initially show the same "*Current value*", but with a cursor positioned at the most significant digit.

To modify the value of the selected setting, use the numeric keypad and press the **Enter** key to save it.

NOTICE: If the adjusted value is outside the *"Range"*, the message *"Invalid value"* is displayed on the bottom line, according to Figure 32, and the screen returns to the same as that shown in Figure 30.

Figure 32: Settings modification screen



20 – CFAL: Fault Code

This function is responsible for indicating the fault code detected by the control. Each displayed value corresponds to a specific error condition. The available fault codes range from 1 to 8, and their descriptions can be found in Table 15:

Table 15: CFAL: Fault Code

Number	Description
1	Neutral light
2	Motor failure in the raise direction
3	Motor failure in the lower direction
4	Communication failure with the measurement board
5	No voltage
6	Checktap failure
7	Master inactive
8	Synchronization timeout

CTR-3 functions with IEEE® standard firmware are in accordance with Table 16.

Table 16: Adjustable functions sequence – Firmware IEEE®.

Shortcut	Function Name	Function Description	Und.	Range	Incr.	Std Value	Type of Adj.
21	RTPC	PT ratio for control	-	25 to 500	0,1	115	By phase
22	RTCC	CT ratio for control	-	25 to 6000	1	1000	By phase
23	VREF	Set voltage - FG[7]	[V]	90 to 135	0,1	120	By phase
24	INS	Bandwidth - FG	[V]	0,8 to 5,0	0,1	3	By phase
25	TMP	Time delay - FG	[s]	10 to 180	1	30	By phase
26	UR	Line drop compensation R - FG	[V]	-25 to 25	1	0	By phase
27	UX	Line drop compensation X - FG	[V]	-25 to 25	1	0	By phase
28	LVMIN	Low voltage limit – FG	[V]	1 to 15	1	15	By phase
29	LVMAX	High voltage limit – FG	[V]	1 to 15	1	15	By phase
30	VREFI	Set voltage – RG[8]	[V]	90 to 135	0,1	120	By phase
31	INSI	Bandwidth - RG	[V]	0,8 to 5,0	0,1	3	By phase
32	TMPI	Time delay - RG	[s]	10 to 180	1	30	By phase
33	RI	Line drop compensation R - RG	[V]	-25 to 25	1	0	By phase
34	XI	Line drop compensation X - RG	[V]	-25 to 25	1	0	By phase
35	LVMINI	Low voltage limit – RG	[V]	1 to 15	1	15	By phase
36	LVMAXI	High voltage limit – RG	[V]	1 to 15	1	15	By phase
37	VREFC	Set voltage - CG[9]	[V]	90 to 135	0,1	120	By phase
38	INSC	Bandwidth - CG	[V]	0,8 to 5,0	0,1	3	By phase
39	TMPC	Time delay - CG	[s]	10 to 180	1	30	By phase
40	RC	Line drop compensation R - CG	[V]	-25 to 25	1	0	By phase
41	XC	Line drop compensation X - CG	[V]	-25 to 25	1	0	By phase
42	LVMINC	Low voltage limit – CG	[V]	1 to 15	1	15	By phase
43	LVMAXC	High voltage limit – CG	[V]	1 to 15	1	15	By phase
44	MODABL	Load bonus automatic	-	0 to 1	1	0	By phase
45	BMAX	High limit tap position	-	8 to 16	1	16	By phase
46	BMIN	Low limit tap position	-	-8 to -16	1	-16	By phase
47	BSC	Current limit setting	[%]	50 to 210	1	200	By phase
48	CC	Short-circuit current[10]	[x In]	2 to 25	1	2	Single

[7] *FG: Forward direction power flow settings group.*
[8] *RG: Reverse direction power flow settings group.*
[9] *CG: Cogeneration mode settings group*
[10] *Starting from firmware version 1.07-00, due to the addition of this item, there are shifts in the shortcuts of subsequente screens.*

Shortcut	Function Name	Function Description	Und.	Range	Incr.	Std Value	Type of Adj.
49	MAFP	Power flow operating mode	-	0 to 10	1	2	By phase
50	LIM	Reverse current sense threshold	[%]	1 to 5	0,1	2	By phase
51	HTINV	Reverse time delay	-	0 to 1	1	0	By phase
52	DTAQ	Data logs acquisition time	[min]	1 to 60	1	15	Single
53	MODREG	Regulation mode	-	0 to 4	1	0	Single
54	CON	Regulator bank connection type	-	0 to 3	1	0	Single
55	GDL	Degree of freedom	-	0 to 33	1	33	Single
56	DTAP	Fixed difference for the master	-	-5 to 5	1	0	By phase
57	DEFVC	Phase angle setting	-	0 to 5	1	0	By phase
58	HREG	Enable regulator	-	0 to 1	1	1	By phase
59	MTR	Select máster regulator	-	1 to 3	1	1	Single
60	MIPCOM	Reading and indication mode OLTC	-	0 to 9[11]	1	0	By phase
61	TAC	Tap changer action mode	-	0 to 1	1	0	By phase
62	TREG	Regulator type "A" or "B"	-	0 to 1	1	1	By phase
63	TPM	Motor pulse time	[ms]	10 to 5000	1	100	By phase
64	HCMP	Time for tracking audits	[h]	0 to 23	1	0	Single
65	SCMP	Day for tracking audit	-	0 to 8	1	0	Single
66	TPES	Synchronism time duration	[min]	10 to 2880	1	1440	Single
67	HESP_P2	Enable unsolicited messages P2	-	0 to 1	1	0	Single
68	ENDREM_P2	Unsolicited messages address P2	-	0 to 65519	1	0	Single
69	HESP_P3	Enable unsolicited messages P3	-	0 to 1	1	0	Single
70	ENDREM_P3	Unsolicited messages address P3	-	0 to 65519	1	0	Single
71	ESERIAL	Serial communication address	-	0 to 65519	1	0	Single
72	BAUD1	Data transmission baud rate P1	-	0 to 8	1	2	Single
73	BAUD2	Data transmission baud rate P2	-	0 to 8	1	2	Single
74	BAUD3	Data transmission baud rate P3	-	0 to 8	1	2	Single
75	TNOBREAK	Time do switch to neutral position *(UPS)*	[s]	0 to 600	1	0	Single
76	PASSW V/R	Operator password	-	0 to 999999	1	000000	Single
77	PASSW ADMIN	Administrator password	-	0 to 999999	1	999999	Single

CTR-3 functions with ABNT® standard firmware are in accordance with Table 17.

Table 17: Adjustable functions sequence – Firmware ABNT®.

Shortcut	Function Name	Function Description	Und.	Range	Incr.	Std Value	Type of Adj.
21	RTPC	PT ratio for control	-	25 to 500	0,1	115	By phase
22	RTCC	CT ratio for control	-	25 to 6000	1	1000	By phase
23	VREF	Set voltage - FG[12]	[V]	4000 to 38000	1	13800	By phase
24	INS	Bandwidth - FG	[%]	0,8 to 5,0	0,1	3	By phase
25	TMP	Time delay - FG	[s]	10 to 180	1	30	By phase
26	UR	Line drop compensation R - FG	[%]	-25 to 25	1	0	By phase
27	UX	Line drop compensation X - FG	[%]	-25 to 25	1	0	By phase
28	LVMIN	Low voltage limit – FG	[%]	1 to 15	1	15	By phase
29	LVMAX	High voltage limit – FG	[%]	1 to 15	1	15	By phase
30	VREFI	Set voltage – RG[13]	[V]	4000 to 38000	1	13800	By phase
31	INSI	Bandwidth - RG	[%]	0,8 to 5,0	0,1	3	By phase
32	TMPI	Time delay - RG	[s]	10 to 180	1	30	By phase
33	RI	Line drop compensation R - RG	[%]	-25 to 25	1	0	By phase
34	XI	Line drop compensation X - RG	[%]	-25 to 25	1	0	By phase
35	LVMINI	Low voltage limit – RG	[%]	1 to 15	1	15	By phase
36	LVMAXI	High voltage limit – RG	[%]	1 to 15	1	15	By phase
37	VREFC	Set voltage - CG[14]	[V]	4000 to 38000	1	13800	By phase
38	INSC	Bandwidth - CG	[%]	0,8 to 5,0	0,1	3	By phase
39	TMPC	Time delay - CG	[s]	10 to 180	1	30	By phase
40	RC	Line drop compensation R - CG	[%]	-25 to 25	1	0	By phase
41	XC	Line drop compensation X - CG	[%]	-25 to 25	1	0	By phase
42	LVMINC	Low voltage limit – CG	[%]	1 to 15	1	15	By phase
43	LVMAXC	High voltage limit – CG	[%]	1 to 15	1	15	By phase

[11] *Starting from firmware version 1.08-00, two additional values wre added to this range.*
[12] *FG: Forward direction power flow settings group.*
[13] *RG: Reverse direction power flow settings group.*
[14] *CG: Cogeneration mode settings group*

Shortcut	Function Name	Function Description	Und.	Range	Incr.	Std Value	Type of Adj.
44	MODABL	Load bonus automatic	-	0 to 1	1	0	By phase
45	BMAX	High limit tap position	-	8 to 16	1	16	By phase
46	BMIN	Low limit tap position	-	-8 to -16	1	-16	By phase
47	BSC	Current limit setting	[%]	50 to 210	1	200	By phase
48	CC	Short-circuit current[15]	[x In]	2 to 25	1	2	Single
49	MAFP	Power Flow Handling Mode	-	0 to 10	1	2	By phase
50	LIM	Reverse current sense threshold	[%]	1 to 5	0,1	2	By phase
51	HTINV	Reverse time delay	-	0 to 1	1	0	By phase
52	DTAQ	Data logs acquisition time	[min]	1 to 60	1	15	Single
53	MODREG	Regulation mode	-	0 to 4	1	0	Single
54	CON	Regulator bank connection type	-	0 to 3	1	0	Single
55	GDL	Degree of freedom	-	0 to 33	1	33	Single
56	DTAP	Fixed difference for the master	-	-5 to 5	1	0	By phase
57	DEFVC	Phase angle setting	-	0 to 5	1	0	By phase
58	HREG	Enable regulator	-	0 to 1	1	1	By phase
59	MTR	Select máster regulator	-	1 to 3	1	1	Single
60	MIPCOM	Reading and indication mode OLTC	-	0 to 9[16]	1	0	By phase
61	TAC	Tap changer action mode	-	0 to 1	1	0	By phase
62	TREG	Regulator type “A” or “B”	-	0 to 1	1	1	By phase
63	TPM	Motor pulse time	[ms]	10 to 5000	1	100	By phase
64	HCMP	Time for tracking audits	[h]	0 to 23	1	0	Single
65	SCMP	Day for tracking audit	-	0 to 8	1	0	Single
66	TPES	Sunchronism time duration	[min]	10 to 2880	1	1440	Single
67	HESP_P2	Enable unsolicited messages P2	-	0 to 1	1	0	Single
68	ENDREM_P2	Unsolicited messages address P2	-	0 to 65519	1	0	Single
69	HESP_P3	Enable unsolicited messages P3	-	0 to 1	1	0	Single
70	ENDREM_P3	Unsolicited messages address P3	-	0 to 65519	1	0	Single
71	ESERIAL	Serial communication address	-	0 to 65519	1	0	Single
72	BAUD1	Data transmission baud rate P1	-	0 to 8	1	2	Single
73	BAUD2	Data transmission baud rate P2	-	0 to 8	1	2	Single
74	BAUD3	Data transmission baud rate P3	-	0 to 8	1	2	Single
75	TNOBREAK	Time do switch to neutral position *(UPS)*	[s]	0 to 600	1	0	Single
76	PASSW V/R	Operator password	-	0 to 999999	1	000000	Single
77	PASSW DMIN	Administrator password	-	0 to 999999	1	999999	Single

[15] Starting from firmware version 1.07-00, due to the addition of this item, there are shifts in the shortcuts of subsequente screens.
[16] As of firmware version 1.08-00, two additional values have been added to this range.

CTR-3 CONTROL – FUNCTION DESCRIPTION

21 – RTPC: PT ratio for control

Configured value must be equal to the ratio between voltage in the load and voltage in the control obtained through the data engraved on the nameplate of the voltage regulator Example: 13800/120 = 115.

22 – RTCC: CT ratio for control

Configured value must be equal to the ratio between the nominal current of the regulator and the secondary nominal current of the CT (0.2A) obtained through the data engraved on the nameplate of the voltage regulator. Example: 200/0.2 = 1000.

23, 30 e 37 – VREF: Set voltage

The value set in this function is used as a regulation parameter. When the power flow is forward, or by cogeneration (parameters 23 and 37 respectively), this value determines the output voltage level on the load side. When the power flow is reverse (parameter 30), this value determines the output voltage level of the source side.



NOTICE: he value to set this parameter is different for the IEEE® and ABNT® standard firmware. See Table 16 and Table 17 for more information.

24, 31 e 38 – INS: Bandwidth

The value set in this function defines a symmetrical insensitive limit band around the set voltage. When the value of the measured voltage is within the limits of the band, the control considers that there is no need to correct. In such case, the **RAISE VOLTAGE** or **LOWER VOLTAGE** indicator LEDs available on the front panel of the control will remain off. When the measured voltage is outside the band ranges, the **RAISE VOLTAGE** or **LOWER VOLTAGE** indicator LEDs will light, indicating the direction that the control will cause in regulation.



NOTICE: The value to set this parameter is different for the IEEE® and ABNT® standard firmware. See Table 16 and Table 17 for more information.



CAUTION: Coordination of bandwidth and time delay functions should be made to minimize contact erosion of the tap changer and therefore decrease the maintenance frequency.

25, 32 e 39 – TMP: Time delay

The value set in this function defines the period, in seconds, that the control waits before starting regulation. Its purpose is to avoid switching due to short-term voltage variations in the system, such as the starting of electrical machines.



CAUTION: Banks of voltage regulators connected in series (cascade) must have a coordinated time delay in order to minimize interactions between them (tap changing excess operations). It is recommended that the regulator closest to the source respond to variations in less time and the others, downstream of the circuit, have time delay adjustments with a minimum difference of 15 seconds more than its predecessor.



CAUTION: Coordination of bandwidth and time delay functions should be made to minimize contact erosion of the tap changer and therefore decrease the maintenance frequency.

26, 27, 33, 34, 40 e 41 – R & X: R & X: Line drop compensation (LDC)

The configured values in these functions simulate the impedance of the line creating a real image of the circuit from the regulators to the theoretical center of loads. Together with the value of the load current, this function establishes a new regulation parameter referred to the parameter already established in the reference voltage box (parameters 23, 30 and 37). When the power flow is forward, or by cogeneration (parameters 26, 27, 40 and 41 respectively), these R and X values determine the output voltage level on the load side. When the power flow is reverse (parameters 33 and 34), these values determine the output voltage level on the source side.



NOTICE: The value to set this parameter is different for the IEEE® and ABNT® standard firmware. See Table 16 and Table 17 for more information.

28, 29, 35, 36, 42 e 43 – LVMIN & LVMAX: Voltage limiters

When using the line drop compensation functions it may be necessary to limit the voltage so as not to harm the first consumers. The way to do this is to use the high and low voltage limits. When the regulators voltage level reaches one of those limits, the control will not allow this limit to be exceeded.

IEEE® Standar *Firmware*: The values of the voltage limiters are determined using the following functions:

UPPER LIMIT = VREF + INS + LVMAX

LOWER LIMIT = VREF – INS – LVMIN

Where:

VREF is the set voltage, in volts, of the active work group;

INS is the bandwidth, in volts, of the active work group;

LVMAX is high voltage limit, in volts, of the active work group;

LVMIN is low voltage limit, in volts, of the active work group.

ABNT® Standard *Firmware*: The values of the voltage limiters are determined using the following functions:

UPPER LIMIT = VREF + (VREF * INS) + (VREF * LVMAX)

LOWER LIMIT = VREF - (VREF * INS) - (VREF * LVMIN)

Where:

VREF is the set voltage, in volts, of the active work group;

INS is the bandwidth, in percentage, of the active work group;

LVMAX is high voltage limit, in percentage, of the active work group;

LVMIN is low voltage limit, in percentage, of the active work group.



NOTICE: The value to set this parameter is different for the IEEE® and ABNT® standard firmware. See Table 16 and Table 17 for more information.

44 – MODABL: Automatic load bonus

Single-phase voltage regulators manufactured in accordance with ABNT® NBR 11809 or IEEE Std C57.15TM standards, with the exception of those whose nominal current is greater than 668A, allow operation with currents higher than that declared in the nameplate without violating the guaranteed temperature elevation limit, but with restricted regulation range according to Table 19.

Table 18: Automatic load bônus control.

Value	Description
0	Disable – Manual Load Bonus
1	Enable – Automatic Load Bonus

This function set to "*0*" keeps the regulator in normal function following the tap position locks programmed in parameters 45 and 46. If it is set to "*1*", it makes the CTR-3 control limit the regulator regulation range according to current measured passing through the regulator in accordance with Table 19. Thus, if for example the line current reaches 1.25 times the nominal current, the CTR-3 will regulate the output voltage while the tap changer position does not pass the +10 derivation or is less than -10. If the tap changer is in a position outside the configured range the switch will go into configured range even when the voltage is not at the desired level.

45 e 46 – BMAX & BMIN: Tap position limits and Manual Load Bonus

These functions define the limits of the maximum and minimum positions that the on-load tap changer can reach. Reducing the regulation range allows an increase in the current without violating the temperature rise limits according to Table 19.

Table 19: Load bonus.

Range of voltage regulation	± 10%	± 8,75%	± 7,5 %	± 6,25%	± 5%
High limit tap position	16	14	12	10	8
Low limit tap position	-16	-14	-12	-10	-8
Increase continuous-current rating	0%	10%	20%	35%	60%



NOTICE: If the tap position limits are programmed asymmetrically, the effective load bonus will correspond to that of the limit with the highest absolute value.



AVISO: Data in Table 19 is defined by IEEE Std C57.15TM and by ABNT® NBR 11809 for regulators with currents up to 668A. It is important that the current values are verified on the nameplate of the single-phase regulator commanded by the CTR-3.

47 – BSC: Current limit setting

This function inhibits on load tap changing when the measured current exceeds the value of the nominal current multiplied by the chosen percentage. With that, the tap changer will be blocked for switching when there are overcurrents in the network, possibly generated by a short circuit.



CAUTION: When the nominal current of the voltage regulators that are part of the bank are not the same and choosing three-phase mode regulation, blocking the tap changer of one of the regulators will cause blocking the other units.

48 – CC: Short-circuit current

It is possible to define a multiplier factor relative to the nominal current at which the control will detect the passage of a short-circuit current. This single adjustment function monitors and records (via alarm, stack, or DNP events), individually by phase, the passage of symmetrical short-circuit current through the regulators.



WARNING: The control system of a voltage regulator is designed with components intended for the quality and stabilization of the network voltage levels. It does not include components typically used in the design of network protection systems. Therefore, the data collected is for reference purposes only and should not be categorized as reliable for decision-making.

49 – MAFP: Power Flow Handling Mode

This function determines how CTR-3 control will operate according to the power flow imposed by the network.

Table 20 shows the treatment options that the CTR-3 control has, the work group and the direction of regulation for each of the alternatives chosen.

Detailed description of each of the settings and their respective functional diagrams is below the table.

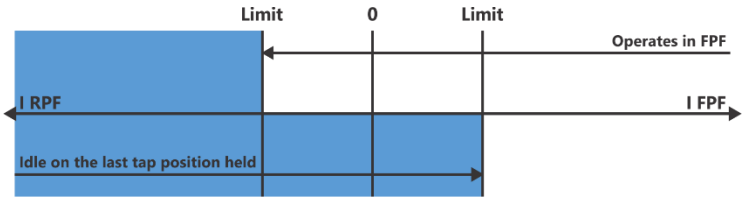
Table 20: Handling of operational modes for power flow.

Value	Description	Operating Map	Regulation Direction
0	Forward flow and blocking in case of reverse flow | Blocked I=0	Forward	Load
1	Forward flow and neutralization in case of reverse flow | Reverse flow TAP=0	Forward	Load
2	Constant forward flow | Unidirectional	Forward	Load
3	Reverse flow and blocking in case of forward flow |	Reverse	Source
4	Reverse flow and neutralization in case of forward flow |	Reverse	Source
5	Reverse flow |	Reverse	Source
6	Bidirectional flow blocked for current below threshold	Forward / Reverse	Load / Source
7	Bidirectional flow active up to the opposite threshold | Bidirectional I=0	Forward / Reverse	Load / Source
8	Individual cogeneration	Forward / Cogeneration	Load
9[17]	Combined generation	Forward / Cogeneration	Load
10	Automatic bidirectional power flow detection for full regulation	Forward / Reserve / Cogeneration	Load / Source

0 – Forward flow and blocking in case of reverse flow

It operates in forward flow and blocks switching in case of reverse flow detection. The CTR-3 control, when detecting a reverse current higher than the percentage value of the nominal current programmed in function *50 – Reverse current sense threshold (LIM)* held the tap position until the current is equal to or greater than the same value, but in a forward direction.

Figure 33: Forward flow and blocking in case of reverse flow.

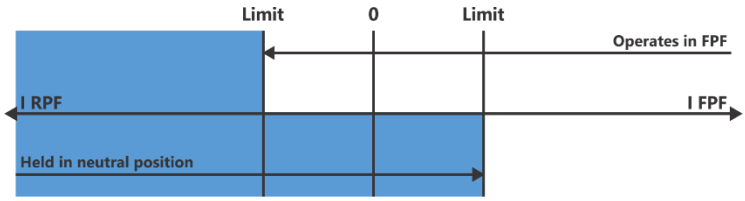


[17] *Parameter 9 is available only for firmware version 1.08.*

1 – Forward flow and neutralization in case of reverse flow | Reverse flow TAP=0

It operates in forward power flow and tapping to neutral position in case of detection of reverse power flow. The CTR-3 control, when detecting a reverse current higher than the percentage value of the nominal current programmed in function *50 – Reverse current sense threshold (LIM)* takes the voltage regulator to the neutral position and blocks operations until the current is equal to or greater than the same value, but in the forward direction.

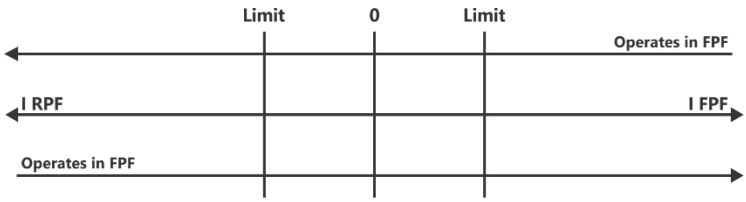
Figure 34: Forward flow and neutralization in case of reverse flow



2 – Constant forward flow | Unidirectional

It operates only in forward power flow even when detecting reverse power flow. The use of this parameter is not indicated where there is the possibility of reverse power flow caused by switching sources.

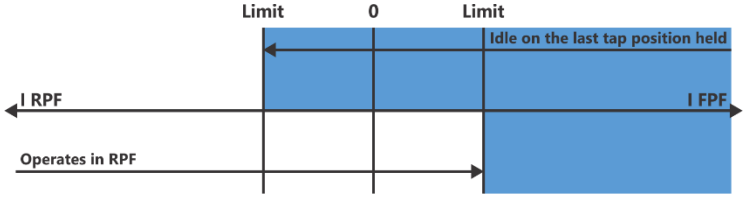
Figure 35: Constant forward flow



3 – Reverse flow and blocking in case of forward flow

It operates in reverse flow and blocks switching in case of detection of forward flow. The CTR-3 control, upon detecting a forward current higher than the percentage value of the nominal current programmed in function *50 – Reverse flow detection threshold (LIM)*, blocks switching until the current returns to being equal to or greater than the same value, but in the reverse direction.

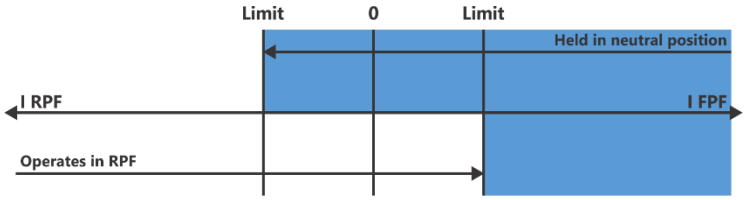
Figure 36: Reverse flow and blocking in case of forward flow



4 – Reverse flow and neutralization in case of forward flow

It operates in reverse power flow and tapping to neutral position in case of detection of forward power flow. The CTR-3 control, when detecting a forward current higher than the percentage value of the nominal current programmed in function *50 – Reverse current sense threshold (LIM)* takes the voltage regulator to the neutral position and blocks operations until the current is equal to or greater than the same value, but in the reverse direction.

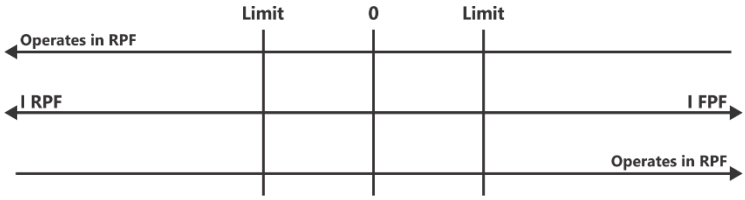
Figure 37: Reverse flow and neutralization in case of forward flow



5 – Reverse flow

It operates only in reverse power flow even when detecting forward power flow. The use of this parameters not indicated where there is the possibility of forward power flow caused by switching sources.

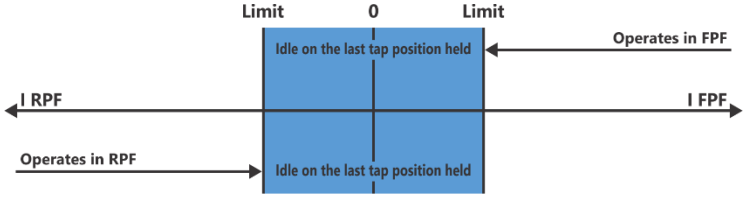
Figure 38: Reverse flow.



6 – Bidirectional flow blocked for current below threshold

Regulates in both directions of power flow. The use of this parameter is recommended when there is possibility of forward and reverse power flow caused by switching of sources. CTR-3 control when detecting a current higher than the percentage value of the nominal current programmed in function *50 – Reverse current sense threshold (LIM)* analyzes the flow direction and operates in the detected flow direction. When the detected current is between the detection limit values, the control remains at the last held tap position until the current exceeds the limits in either direction, at which point it resumes operation.

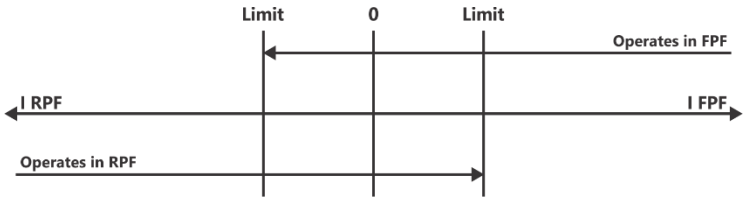
Figure 39: Bidirectional flow blocked for current below threshold



7 – Bidirectional flow active up to the opposite threshold | Bidirectional I=0

Regulates in both directions of power flow. The use of this parameter is recommended when there is possibility of forward and reverse power flow caused by switching of sources. CTR-3 control operates in forward flow until the reverse flow current is greater than the percentage value of the nominal current programmed in function *50 – Reverse current sense threshold (LIM)*. From that point on, it will work in reverse flow, remaining in such condition until the forward flow current is higher than the percentage value of the nominal current programmed in function *50 – Reverse current sense threshold (LIM)*.

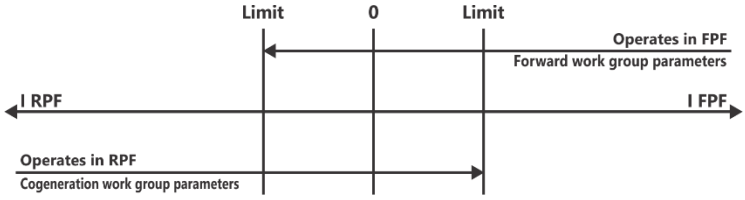
Figure 40: Bidirectional flow active up to the opposite threshold



8 – Individual cogeneration

It regulates only the load side in both directions of flow and assumes that all reverse flow is caused by cogeneration. However, this regulation is applied only to the phase where reverse flow is observed. Therefore, equipment operating with forward flow continues to follow the main regulation map, while those with reverse flow are regulated according to the specific cogeneration map. This function is recommended when there is a possibility of both forward and reverse power flow, and when reverse flow is generated by a small-scale power plant. The CTR-3 control, upon detecting a reverse current higher than the percentage value of the nominal current programmed in function *50 – Reverse Flow Detection Threshold (LIM)*, switches to reverse flow for cogeneration, remaining in this mode until the forward current exceeds the percentage value of the nominal current programmed in function *50 – Reverse Flow Detection Threshold (LIM)*.

Figure 41: Reverse flow due to cogeneration.



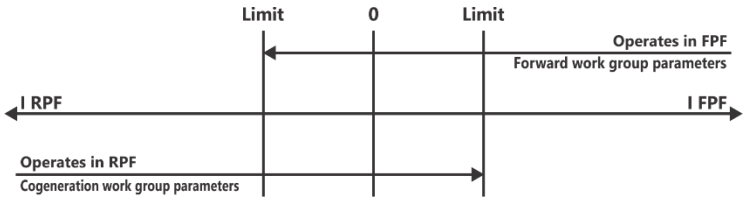


NOTICE: In the three-phase mode (vusing voltage averaging or the master regulator) with individual cogeneration active, only when the Master regulator detects reverse flow will all equipment be regulated by the cogeneration map; otherwise, they will continue following the main map.

9 – Combined generation

It regulates only the load side in both directions of flow and assumes that all reverse flow is caused by cogeneration. The specific feature of this function is that if any equipment in the system detects reverse flow, all equipment will be regulated by the cogeneration map, regardless of the direction of their individual flow. This function is recommended when there is a possibility of both forward and reverse power flow, and when reverse flow is generated by a small-scale power plant. The CTR-3 control, upon detecting a reverse current higher than the percentage value of the nominal current programmed in function *50 – Reverse Flow Detection Threshold (LIM)*, switches to reverse flow for cogeneration, remaining in this mode until the forward current exceeds the percentage value of the nominal current programmed in function *50 – Reverse Flow Detection Threshold (LIM)*.

Figure 42: Reverse flow due to cogeneration.



10 – Automatic bidirectional power flow detection for full regulation

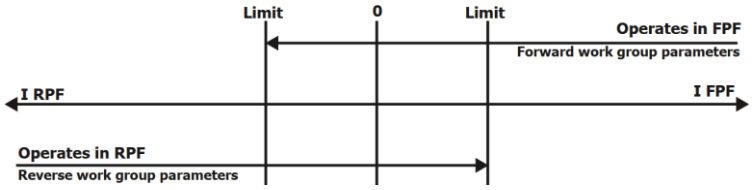
This parameter is intended for applications in which the voltage regulator may operate with forward or reverse power flow, according to system conditions, including situations in which changes in the direction of power flow result from network switching operations or the presence of distributed generation/cogeneration. Whenever a change in power flow is detected, the controller will automatically determine its direction and, based on this analysis, select the regulation map corresponding to the system operating condition: Forward Flow Map, Reverse Flow Map, or Cogeneration Map.

Thus, the Full Regulation function allows automatic voltage regulation to be maintained in both directions of power flow, ensuring proper regulation even in systems subject to changes in topology and operating conditions.

When reverse power flow is detected, the controller will identify the source of the reversal. If it is determined that the reverse power flow was caused by a network switching operation, the controller will automatically select the Reverse Flow Map.

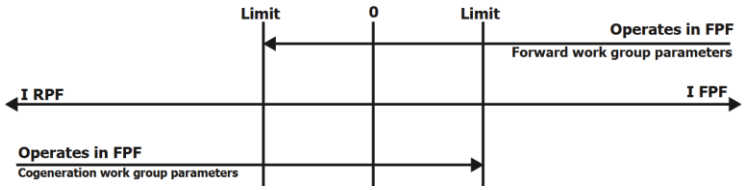
If the voltage regulator is operating under reverse power flow and detects the occurrence of forward power flow, the controller will identify the source of this flow. If it is determined that the forward power flow was caused by a network switching operation, the controller will automatically select the Forward Flow Map.

Figure 43: Forward/Reverse Flow due to Network Switching



If the voltage regulator is operating under forward power flow and detects a reversal of power flow, the controller will identify the source of the reversal. If it is determined that the reverse power flow was caused by cogeneration, the controller will automatically select the Cogeneration Map.

Figure 44: Reverse Flow due to Cogeneration



If the voltage regulator is operating under reverse power flow and detects the occurrence of forward power flow, the controller will identify the source of this flow. If it is determined that the forward power flow was caused by cogeneration, the controller will automatically select the Cogeneration Map.

Figure 45: Forward Flow due to Cogeneration

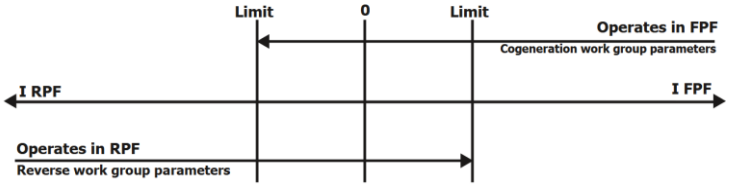


Table 21: Summary table

Flow	Maps
Forward	Forward flow map
Reverse due to switching	Reverse flow map
Reverse due to cogeneration	Cogeneration map
Forward due to cogeneration	Cogeneration map



CAUTION: The control dismisses the voltage and current measurements of the follower regulators when operating in three-phase mode by master, leaving them subject to overvoltages and power flow reversal without proper treatment by the control.

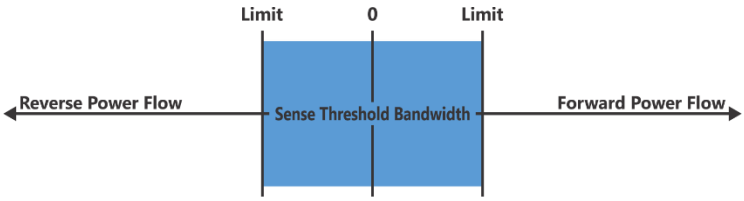
CAUTION: The control overrides individual voltage and current measurements of the active regulators when operating in three-phase mode by voltage averaging when operating in three-phase mode, leaving them subject to overvoltages and reverse power flow without proper treatment by the control.

NOTICE: In three-phase mode by voltage averaging or by voltage master, the CTR-3 control uses only the master regulator as a reference for detecting power flow. If necessary individual treatment per phase, single-phase regulation should be used.

50 – LIM: Reverse current sense threshold

This function is the current threshold at which the control recognizes current flow direction. This defines the current limit as a percentage of the rated current If the current in the effective load over the regulator nominal load is in percentage lower than the programmed value, the CTR-3 will not take into account changes in the flow direction and its regulation will be according to what is programmed in parameter *49 – Power flow operating mode (MAFP)*.

Figure 46: Reverse current sense threshold bandwidth.



51 – HTINV: Inverse time delay

Reverse time delay reduces the programmed time of the current work group based on the voltage variation.

Table 22: Reverse time delay.

Value	Description
0	Disable reverse time delay
1	Enable reverse time delay

If this function is configured with *"0"* the time delay is linear and according to functions 25, 32 and 39. However, if this function is configured with *"1"*, CTR-3 control will define a new timing under the equation:

Tef = T x [1 - ({Vref-Vmed} / Vref)]

Where:

Tef is the effective time delay recalculation;

T is the time delay configured for current work group;

Vref is the set voltage configured for current work group;

Vmed éis the instantaneous measured voltage.

52 – DTAQ: Data logs acquisition time

DTAQ function determines the acquisition period of the data logs in the mass memory and has an adjustment range from 1 to 60 minutes. CTR-3 control is capable of obtaining and storing up to 6,180 records[18] of the values of hour, minute, day, month, power factor, voltage, current, position of tap changer, number of operations and operation mode (Manual, Automatic or Locked) of each regulator in the bank.

53 – MODREG: Regulation mode

CTR-3 control has five modes of regulation, as Table 23. The parameters set in functions 53, 54 e 57 are also taken into account for regulation. A detailed description of each parameters is after the table.

Table 23: Regulation mode.

Value	Description
0	Single-phase with three-phase alignment by voltage master
1	Single-phase with three-phase alignment by voltage averaging
2	Time position table
3	Three-phase by voltage master
4	Three-phase by voltage averaging of active regulators

0 – Single-phase with three-phase alignment by voltage master

System works in single-phase mode and when the regulator taps difference exceeds the *55 – Degree of freedom (GDL)* it changes to three-phase regulation following the master regulator configured in *59 – Select master regulator (MTR)*. It remains in three-phase mode until the time set in function *66 – Synchronism time duration (TPES)* elapses.

1 – Single-phase with three-phase alignment by voltage averaging

System works in single-phase mode and when the regulator taps difference exceeds the *55 – Degree of freedom (GDL)* it changes to three-phase regulation using voltage averaging of active regulators. It remains in three-phase mode until the time set in function *66 – Synchronism time duration (TPES)* elapses.

[18] *The number of records may vary depending on the applied firmware, based on the customization of acquired variable values, as per the agreement between the manufacturer and the customer.*



NOTICE: For single-phase modes, the function *59 – Select master regulator (MTR), 55 – Degree of freedom (GDL), 56 – Fixed difference for the master (DTAP)* and *66 – Synchronism time duration (TPES)* must be adjusted. For independent operation (pure single-phase) m the function *55 – Degree of freedom (GDL)* must be set to 33.

2 – Time position table

The operation by time position table regulates according to the tap changer position curve gathered during the last week of operation, with 5 minutes interval. Therefore, this function should only be used after gathering one week of work condition data.

3 – Three-phase by voltage master

The three-phase operation by the voltage master regulator makes all the active regulators of the bank follow the voltage variations and the consequent regulation imposed by the regulator programmed as master. This function takes into account the fixed difference in taps programmed in function *56 – Fixed difference for the master (DTAP)*.

4 – Three-phase by voltage averaging of active regulators

It uses the voltage averaging of all active regulators as set regulation parameter. This function takes into account the fix difference in taps programmed in function *56 – Fixed difference for the master (DTAP)*.



NOTICE For three-phase modes, the functions *59 – Select master regulator (MTR)* and *56 – Fixed difference for the master (DTAP)* must be adjusted.



NOTICE: In regulation by voltage averaging or by voltage master in three-phase mode, CTR-3 control uses only the master regulator as a reference for power flow detection. If necessary individual treatment per phase, single-phase regulation should be used.



CAUTION: The control overrides individual voltage and current measurements of the follower regulators when operating in three-phase mode by voltage master or voltage averaging when operating in three-phase mode, leaving them subject to overvoltages and reverse power flow without proper treatment by the control.

54 – CON: Regulator bank connection type

Since the way to calculate the voltage between the source (S or F) and common (SL or FC) terminals using the measured voltage between the load (L or C) and common (SL or FC) terminals is different for each connection scheme of the regulator bank due to the variation of the reference point, it is necessary to inform the CTR-3 control the type of bank it is commanding. Table 24 reports the values to be adjusted.

Table 24: Adjustments for correction depending on the banm connection.

Value	Description
0	Wye
1	Open delta
2	Leading closed delta
3	Lagging closed delta

55 – GDL: Degree of freedom

When the bank operation is programmed for any single-phase regulation mode, it is necessary to inform the CTR-3 control of the maximum allowed distance between taps of the active regulators. This function allows adjusting such difference ranging from 0 to 33 positions.

If the distance between the tap changer positions reaches a value greater than the value programmed in this parameter, CTR-3 proceeds to align the bank and starts operating in three-phase mode, using voltage master or voltage averaging as reference, as to what is programmed in function *53 – Regulation mode (MODREG)* and for a period according to what is programmed in function *66 – Synchronism time duration (TPES)*. Once this period has elapsed, the CTR-3 returns to single-phase mode regulation according to what is programmed in function *53 – Regulation mode (MODREG)*.



NOTICE: For independent operation (pure single-phase mode) this function must be set to 33.

56 – DTAP: Fixed tap offset relative to the master regulator

When the bank operation is programmed in any three-phase regulation mode, it is possible to inform the CTR-3 control the fixed difference of positions between the followers and the master regulators. This function allows the fixed difference to be adjusted from -5 to +5 positions, respectively, for all regulators in the bank.



NOTICE: The setting of this function is not considered for the regulator chosen as master.

57 – DEFVC: Phase angle setting

The angle phase between voltage and current need to be configured to ensure functions such as compensation of line voltage drop, power factor and power indications work properly. This adjustment is different depending on the type of connection of the regulators in the bank. Table 25 shows values that can be adjusted.

Table 25: Phase angle setting.

Value	Description
0	No phase shift(0°)
1	Lagging current in reference to voltage (-30°)
2	Leading current in reference to voltage (+30°)
3	No phase shift (0°) | When CT is inverted
4	Lagging current in reference to voltage (-30°) | When CT is inverted
5	Leading current in reference to voltage (+30°) | When CT is inverted

0 – For voltage regulator connected between phase and neutral

When voltage regulator is connected between phase and neutral, as in single-phase or three-phase star connection function *57 – Phase angle setting (DEFVC)* must be configured to *"0"*. This corresponds to the non-existent phase shift condition between voltage and current when the load is purely resistive. This situation occurs and is to be used in the grounded wye (earth to ground) and single-phase connections

1 and 2 – For voltage regulators connected between phases

When voltage regulator is connected between phases (phase to phase), as in Delta connection, we need to determine if function *57 – Phase angle setting (DEFVC) of* CTR-3 to be configured in *"1"* or *"2"*, as it cannot be configured in *"0"*.

CTR-3 itself will help determine how to configure when perfoming the following

1. Voltage regulator is powered on;
2. There is enough current so that it can be measured;
3. This steps are followed:

- Place the switch"/es *"INTERNAL / OFF / EXTERNAL"* at position *"NORMAL";*
- Set the *"DEFVC"* function of the CTR-3 control to *"1"*;
- Read and record the power factor value indicated by CTR-3 control;
- Set the *"DEFVC"* function of the CTR-3 control to *"2"*;
- Read and record the power factor value indicated by CTR-3 control;
- Set the *"DEFVC"* function to the value (*"1"* or *"2"*) that corresponds to value read that seems reasonable.

Repeat the above procedure for the other bank regulators.



NOTICE: For wye (star) connected regulator banks, this function will always be set to *"0"*. For open delta regulator banks, one of the regulators will have the function set to *"1"* and the other to *"2"*. For closed delta regulator banks, the setting for this function will be *"1"* or *"2"* for all regulators that make up the bank.



NOTICE: Adjustment parameters *"3"*, *"4"* and *"5"* should only be used by physically reversing the regulator CT connection. It is necessary to be sure that the detection of power flow is really wrong in relation to what is presented by the network..

58 – HREG: Enable regulator

The CTR-3 control can operate up to 3 regulators at the same time. To achieve this, it is necessary to enable regulators 2 and 3. Regulator 1 cannot be disabled.

Table 26: Enable regulator.

Value	Description
0	Disable regulator
1	Enable regulator

When *"0"* is set for this function, CTR-3 considers that the referred voltage regulator is inactive and its monitoring, measurements and commands will be dismissed.

If the option is set to *"1"* then CTR-3 will consider monitoring, measurements and commands for the referred voltage regulator.



NOTICE: The voltage regulator, identified VR-1, is responsible for power supply to the CTR-3 control system, therefore, it is not possible to disable it.

59 – MTR: Select master regulator

CTR-3 control can be programmed to operate in three-phase mode, and in such case it is necessary to define which will be the master regulator. This function determines which of the active regulators in the bank will be the master regulator.



NOTICE: The value configured in this parameter will be rejected if CTR-3 control is operating with only one regulator or if the selected value is from a disabled regulator. The master regulator must always be active in the bank!

60 – MIPCOM: Reading and indication mode of OLTC

CTR-3 control was developed to work with voltage regulators of any brand and also to remotely inform to the operation center the tap changer position of each regulator in two different ways. Table 27 describes the adjustment value to be used in each working condition.

Table 27: Reading and indication mode of OLTC.

Value	Tap Changer Position Reading Mode	Indication Mode
0	Real time Reading through encoder	-16 a +16
1	Real time Reading through encoder	0 a 32
2	Holding switch tracking position	-16 a +16
3	Holding switch tracking position	0 a 32
4	Status change operation counter tracking position	-16 a +16
5	Status change operation counter tracking position	0 a 32
6	Pulsed operation counter tracking position	-16 a +16
7	Pulsed operation counter tracking position	0 a 32
8	Tracking by operation counter using a pulse-type timer with off-delay	-16 a +16
9	Tracking by operation counter using a pulse-type timer with off-delay	0 a 32



NOTICE: For ITB manufacturing voltage regulators this parameter must be set to *"0"*, *"1"*, *"6"* or *"7"*.

61 – TAC: Tap changer action mode

Since the CTR-3 control is suitable for working with voltage regulators of other brands, it is necessary to inform the system the operation mode of each tap changer motor, as follows:

Table 28: Tap changer action mode..

Value	Description
0	Continuous operation
1	Pulse operation

If value is set to *"0"*, motor will be continuously energized after the adjusted time delay is achieved and will remain energized until the CTR-3 control detects that the operation must be interrupted on such regulator. The position monitoring of such regulator will be done in real time through the analysis of the digital output of the absolute encoder and the polarity reverse switch.

If value is set to *"1"*, motor will be energized after the adjusted time delay is achieved and the pulse duration will be a function of the value configured in parameter *63 – Motor pulse time (TPM*). The motor will re-energize only if the holding switch device opens and if the CTR-3 control detects that there is a need for a new tap changer adjustment. In such mode, tracking algorithm understands that the tap changing is complete when the holding switch device completes its cycle.



NOTICE: For ITB manufacturing voltage regulators this parameter must be set to *"0"*.



NOTICE: For regulators that work in a pulsed mode, it is necessary to configure the reading method to holding switch tracking position in function 60 – *Reading and indication mode of OLTC (MIPCOM)* and the motor pulse time in function *63 – Motor pulse time (TPM)*.



DANGER: The use of the tracking position method is not recommended as a permanent method due to the additional contact erosion caused by the tap changer position auditing routine and the loss of reliability.

62 – TREG: Regulator type *"A"* or *"B"*

Since the way to calculate the voltage between the source (S or F) and common (SL or FC) terminals using the measured voltage between the load (L or C) and common (SL or FC) terminals is different for regulators of type *"A"* and *"B"*, the CTR-3 control must receive the information of what type of regulator it is commanding. The constructive type can be programmed in this parameter, for all active regulators, being:

Table 29: Regulator type.

Value	Description
0	*"Type A"* regulator
1	*"Type B"* regulator

63 – TPM: Motor pulse time

This parameter has distinct functions based on the configurations of parameters *60 (MIPCOM: Switch Position Reading and Indication Mode)* and *61 (TAC: Switch Actuation Mode)*.

When parameter 60 is set to *"2"* or *"3"* (hold-switch) and parameter 61 is defined as *"1"* (pulsed actuation):

This parameter is applied in voltage regulators that have motor power hold devices. The time should be adjusted according to the on-load tap changer model, which may range from 10 to 5000 ms. The configured time must be a value that allows the motor to initialize and complete a switching operation. The adjusted time should not exceed the switching time to avoid failures in tracking the switch position.

When parameter 60 is set to *"8"* or *"9"* (Operation Counter Tracking of Pulsed Switch with Delay in De-energization):

In this configuration, parameter 61 is disregarded. Here, the TPM adjusts the delay time that the motor remains energized after receiving the pulse from the operation conter, indicating the completion of the switch operation.

64 e 65 – HCMP & SCMP: Time and Day for tracking audits

If CTR-3 control is used on regulators without absolute encoder for real-time reading of the tap changer, tracking position tap can be used, adjusting the method of reading the position of tap changer of each active regulator in the bank, in parameter *60 – Reading and indication mode of OLTC (MIPCOM)*. It is recommended to schedule day of the week and time in which the CTR-3 will operate a tap changer position Audit routine.

On the scheduled day and time, the bank's active regulators that operate by tracking will be simultaneously brought to the neutral position to check the neutral led turns on and, after that audit, the regulation continues in the mode programmed in parameter *53 – Regulation mode (MODREG)*.

The value programmed in function 64 can be from 0h to 23h, value corresponding to the start time of the tap changer position audit execution.

Value configured in parameter 65 has to be as shown in Table 30.

Table 30: Day of the week option for tacking audit.

Value	0	1	2	3	4	5	6	7	8
Day of the week	None	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Every day



NOTICE: Voltage regulator with absolute encoder will not perform this position monitoring audit routine.



DANGER: The use of the tracking position method is not recommended as a permanent method due to the additional contact erosion caused by the tap changer position auditing routine and the loss of reliability.

66 – TPES: Synchronism time duration

If the distance between the positions of the regulator tap changers reach a value greater than that programmed in parameter *55 – Degree of freedom (GDL)*, CTR-3 proceeds to synchronize the bank and starts operating in three-phase mode using as reference the voltage master voltage or the averaging voltage, according to the configuration of parameter *53 – Regulation mode (MODREG)*, for a period that can range from 10 to 2880[19] minutes After this period elapses, CTR-3 returns to the mode selected in parameter 53 – *Regulation mode (MODREG)*.

67 e 69 – HESP_P2 & HESP_P3: Enable unsolicited messages

CTR-3 control allows the generation of unsolicited messages (events) in DNP3.0 and using these function it is possible to define whether unsolicited messages are to be sent or not. Function 67 corresponds to COM-2 additional communication port and function 69 for COM-3 additional communication port.

[19] *The value of 2880 minutes is available starting from firmware version 1.08-00. For previous versions, consider 1440 minutes.*

Table 31: Unsolicited messages.

Value	Description
0	Disable unsolicited messages
1	Enable unsolicited messages

NOTICE: It is recommended to read in full the additional configuration information for the unsolicited messages available in the *CTR-3Comm Communication Software Manual*.

68 e 70 – ENDREM_P2 & ENDREM_P3: Unsolicited messages address

Once parameters 68 and/or 70 have been programmed to send unsolicited mEssages, the CTR-3 will elaborate the messages (events) in DNP3.0 and send to a configured system address any status change of any variable according to the configuration done in the **CTR-3Comm** communication software. These functions define the addresses to which it must be sent, which can be programmed between 0 and 65519.

71 – ESERIAL: Serial communication address

Since communication ports allow the simultaneous connection of more than one control to a single or remote computer, address configuration is necessary so that there are no communication conflicts. This value can be adjusted between 0 and 65519 and the only recommendation is that different values be programmed for equipment connected to the same data network. Starting from firmware version 1.08, it is possible to add 1 additional address for each port.

72, 73 e 74 – BAUD1, BAUD2 & BAUD3: Data transmission baud rate

CTR-3 control have 3 communication ports that can be used simultaneously using DNP3.0 protocol. COM-1 port has two interfaces (EIA-232 and USB), COM-2 and COM-3 ports are optional and can be supplied with EIA-232, EIA-485, fiber optic (ST) or Ethernet (RJ45) interfaces.

COM-1, COM-2 and COM-3 communication ports of CTR-3 may have independently adjusted data transfer rates using functions 72 for COM-1, 73 for COM-2 and 74 for COM-3.

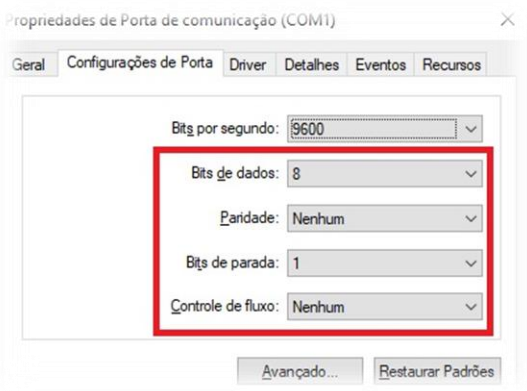
Data transmission baud rate can be adjusted according to Table 32.

Table 32: Data transmission baud rate option

Value	0	1	2	3	4	5	6	7	8
Baud rate [kbps]	Disable	2400	4800	9600	14400	19200	38400	56000	115200

In addition to the values in Table 32, the communication ports of the personal computer or server must be configured as highlighted in Figure 47:

Figure 47: Communication port configuration.



75 – TNOBREAK: Time to switch to neutral position *(UPS)*

This function must be adjusted to determine the UPS actuation time after main system lack of power (failure that is monitored only by VR-1 measurement) to initiate the tapping process to the neutral position of all regulators in the bank. The setting of this function is between 0 (function disabled, the UPS will not act in case of failure) to 600 seconds. For more information see the topic **Take the regulators to the neutral position through UPS.**



NOTICE: Function implemented from firmware version 1.04 and compatible with hardware version 1.01. Hardware version 1.00 with firmware version greater than or equal to 1.04 will have this function disabled.

76 – PASSW V/R: Operator password

Modify the password for the "*Operator*" profile. This user level only allows viewing measurements, downloading and deleting records.

77 – PASSW ADM: Administrator password

Modify the password of the "*Administrator*" profile. This user level has full control of the system.

DNP3.0

The CTR-3 voltage regulators control is communicated through DNP3.0 protocol according to the general table of objects (device profile), being that the specification of the points when there are no remapping is done in the specific items of each object.

All the points of the static objects (1, 12, 20 and 30) can be remapped and assigned in classes (1, 2 or 3) using the communication software to carry out adjustments. The generated events are stored in a row containing 100 positions that overwrites the oldest records in case the records are not obtained by the master. In the case of overwriting, the control will indicate Buffer Overflow in the Internal Indications.

Each of the points of the respective objects (1, 20 and 30) may or may not be monitored, that is, generate events according to what is programmed via communication software. Each of them can be attributed to a user-configurable class. Events that occur will be indicated through the Internal Indications. In the case of object 30, only monitoring measures are possible and said parameters cannot be monitored.

The date and time synchronism between the master and slave can also be adjusted via communication software within a range of 1 to 65535 minutes. The synchronism request will be indicated in the Internal Indications through the Flag Need Time. The Need Time Flag is also restored when the computer is restarted.

The Flag Device restart is set whenever the equipment is restarted and must be reset via Clear Restart.

Life Cycle

ITB Equipamentos Elétricos Ltda. Undertakes to receive and give adequate treatment in accordance with current legislation on manufactured equipment when these are considered unusable.

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