EQUIPAMENTOS ELÉTRICOS

Single Phase
Step-Voltage Regulator
Type Transformer
Model RAV-2 with CTR-2 control

Rev 06/2017

INSTRUCTION MANUAL

TABLE OF CONTENTS

TABLE OF CONTENTS....1
INTRODUCTION....1
DESCRIPTION....1
Identification of high voltage terminals....3
Single phase between phase and earthed neutral....4
Two phase....4
Open Delta....4
Closed Delta....4
Star ("Y")....5
EARTH CONNECTION OF A BANK OF REGULTORS....5
CASCADED VOLTAGE REGULATORS....5
Fault Effect....5
Effect of operations avalanche....5
RECEPTION....6
STORAGE....6
RISING....6
INSTALLATION....6
Inspection before installation:....6
HEIGHT....7
Reference voltage....7
SUPORT AND FIXING....8
High tension connections....8
REGULATOR PLACEMENT IN SERVICE....8
Connections....8
Placing in service....8
VERIFYING REGULATORS OPERATIONS....9
REMOVING REGULATOR FROM SERVICE....9
MAINTENANCE....9
General Instructions....9
REGULATOR OPENING....11
TAP CHANGER....11
WINDINGS....12
CONTROL CTR-2....12
Components of Front Panel....14
Set of screens....14
Standard screen....15
Screen Shortcut....15
Direct Command Key....15
Auto Zero....16
Navigation in reading screens....16
SETTINGS IN CONTROL – GENERAL VIEW....17
Navigation through the adjustment screens....17
CONTROL SETTINGS - DETAILS....19
1 – VT relation for control unit....19
2 - CT relation for control unit....19
03 a 36 – Regulation parameters....19
13, 16, 25 e 29 – validity week of map 2 and 3....19
14, 17, 26 e 30 – Time to set active maps 2 and 3....20
15, 18, 27 e 31 – minute to set active maps 2 and 3....20
24 – Month to set active map 3....20
28 – Amount of months where Map 3 is active....20
37 - Activation of automatic load bonus....20
38 e 39 – Position lock and manual load bonus....20
40 and 41 - Voltage lock....20
42 – Overcurrent lock....21
43 - Actuation mode in case of inverse flow....21
44 - Tap changer actuation, insensibility treatment and extreme locks....23
45 - Tap changer position Reading method....23
46 - Phase shift between voltage and current....23
47 - Optional source voltage measurement....24
48 - Enabling Delayed return to automatic mode....24
49 – Locl limit....24
50 - Datalogging period....24
51 - Inverse time enabling....24
52 – Regulator operation mode....25
53 - Serial communication address....25
54 - Port 1 communication mode....25
55 - Port 2 communication mode....25
56 and 57 - Data transmission bound rate....25
58 – Enabling unsolicited message....25
59 - Address for unsolicited message....25
60, 61, 62, 63, 64 and 65 - Clock settings....25
OPERATING WITH EXTERNAL VOLTAGE SOURCE....26
LINE DROP COMPENSATION....26
INDICATOR IRT-1 (OPTIONAL)....27
ALTERNATIVE DRIVE....27
INSOLATING OIL –FISPQ....27
LIFE CYCLE....27

INTRODUCTION

ITB model RAV-2 single phase voltage regulators, with CTR-2 controls, are 32 step type B autotransformers created to measure and correct voltage drop on distribution lines caused by its impedance. They were designed to ensure easy installation and operation and minimum maintenance exceeding those requirements established under ANSI IEEE C57.15 and ABNT NBR 11.809.
All ITB voltage regulators are manufactured, tested and delivered with standard parameters programmed beforehand, establishing this as a suggestion for future operation. To obtain an accurate performance to meet specific needs, user has to make settings to its programming.

IMPORTANT: By reading completely this manual you will follow adequate installation recommendations, ensure secure handling of the product, efficient operation and secure and reliable maintenance .

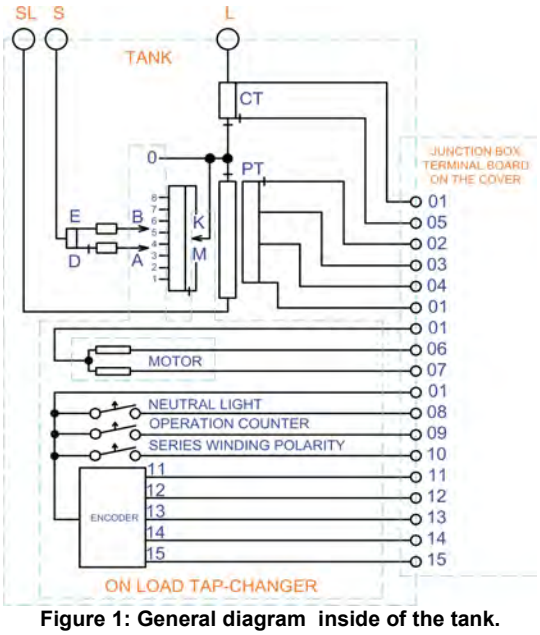


Figure 1: General diagram inside of the tank.

DESCRIPTION

The voltage regulator is a dielectric oil immersed autotransformer with serial winding on source side (type B) equipped with load tap changer which in conjunction with the reactor allows 32 step (neutral, 16 step raise, 16 step lower) voltage regulation achieving a +/- 10% variation with 0,625% steps of nominal voltage variation .

Figure 1 shows internal diagram and in figure 2, Control circuits general diagram is shown .

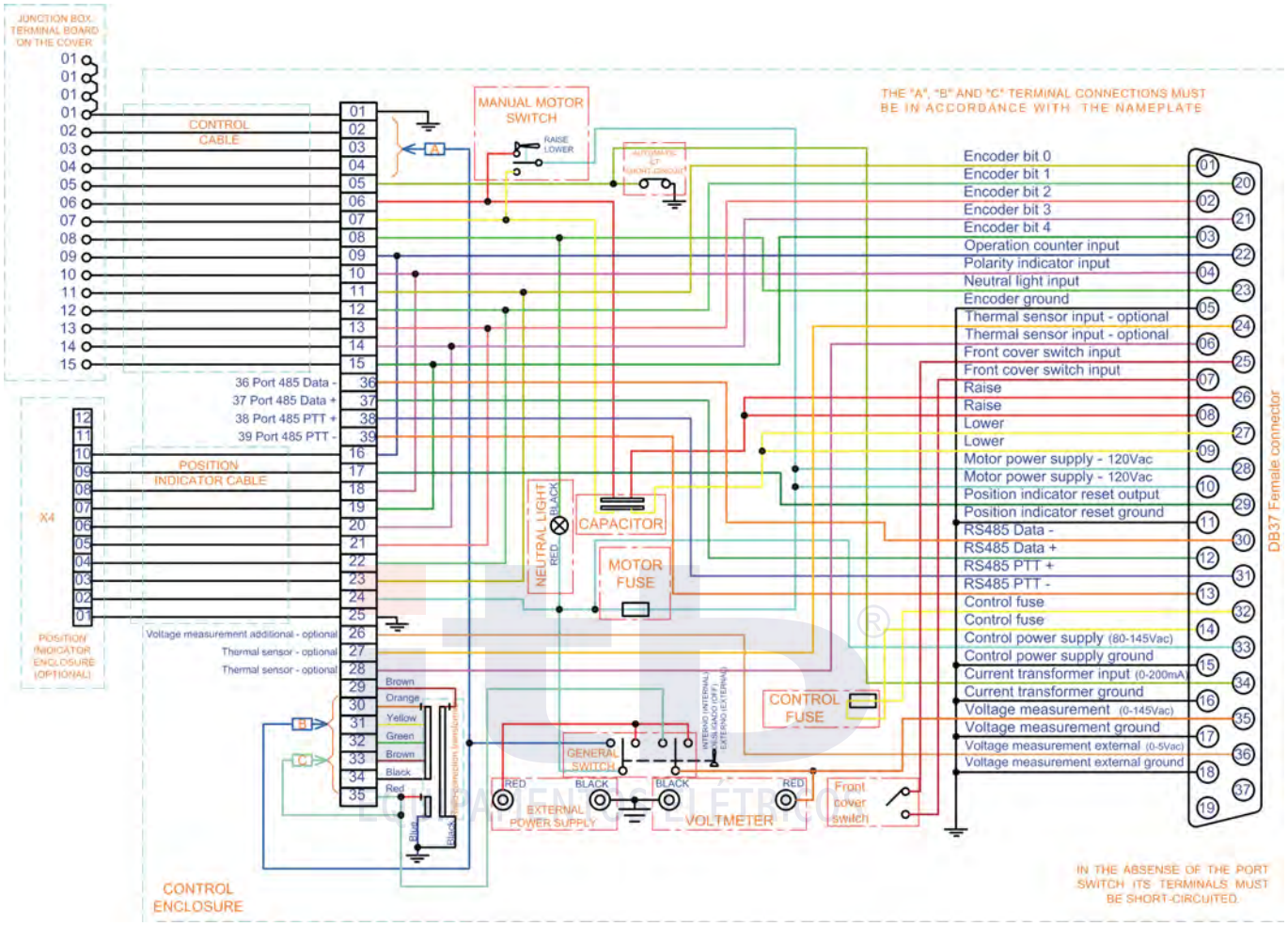


Figure 2: Control general diagram.

Measurements and analysis of line parameters are made by a micro-processed electronic monitoring device model CTR-2, which automatically commands the on load tap changer and also adding other features such as position indicator and data logger.
The voltage regulator is made of a single sealed tank with a pressure relief device, a visual oil level indication, top connection for press filter, drain valve, device for collecting oil sample, anodized aluminum identification plate engraved in low relief, external ZnO with polymeric encapsulation type serial arrester with mounted between "Source" and "Load" insulators. Optional equipment include external tap changer position digital display, alternative device for external on load tap changer actuation, oil temperature meter, additional external source meter Voltage Transformer (VT) (0-5 Vac) or stainless steel identification plate can be supplied.
Power line connections are made through porcelain insulators with clamp type tinned copper connectors.
The actual tap is sensed by an encoder mounted integral with tap changer mechanism which by means of a BCD code is digitally displayed on the LCD screen of the CTR2 control located inside the control box attached to the tank.
The neutral position indication is made by other equipment which is mechanically and electrically independent of the position indication system and is displayed by a green LED type indicator on the bottom panel of the control box.

Identification of high voltage terminals

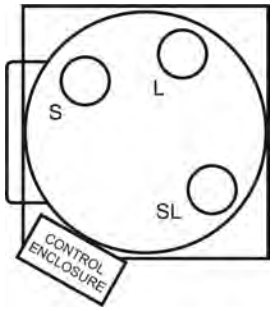


Figure 3: Lay out of the terminals in the regulator's lid.

Table 1: Correspondence between the terminals ABNT and ANSI nomenclature.

TERMINALS	NOMENCLATURE	
	ABNT	ANSI
SOURCE	"F"	"S"
LOAD	"C"	"L"
COMMON	"FC"	"SL"

High Voltage isolators are identified as per ANSI or ABNT standard, as stated on Table 1 (by default as per ABNT standard unless stated otherwise). This is an indelibly identification marked in cover by under relief and reinforced with black paint.

DANGER: Due to possible neutral tension shift and rush in number of tap changings searching for a reference it is not recommended to install voltage regulators in wye on a three phase three wire distribution network unless neutral is connected to the neutral of a wye connected transformer or to the substation transformer secondary neutral. For the connection or removal on service of voltage regulators it is extremely important that the on load tap changer is in the neutral position and this conditions is confirmed by, at least, two different means (position indicator and neutral light).

DANGER: If SL voltage regulator terminal should remain unconnected, which means voltage regulator has no reference, and its on load tap changer is out of neutral position high tensions can be induced depending on actual load current, causing damage to equipment, injuries or even death of personnel. Thus no equipment such as fuses, reclosers, circuit brakes or any other are to be connected on the FC terminals derivations.

SYSTEM CONNECTIONS

Voltage regulators can work on single phase, two phases or in three phases circuits. In the latest possible connections are:

- Two voltage regulators connected in open delta;
- Three voltage regulators connected in delta;
- Three regulators connected in grounded wye;

IMPORTANT: To avoid neutral displacement, three voltage regulators cannot be connected in wye on a three phase three wire distribution network unless neutral is connected to the neutral of a wye connected transformer or to the substation transformer secondary neutral.

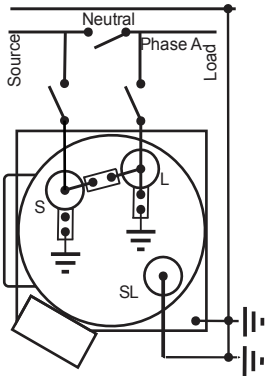


Figure 4: Connection in single phase line.

Type of connection will define regulator's nominal voltage. Typical connection diagrams are shown in figures 4, 5, 6, 7 and 8.

Single phase between phase and earthed neutral

Features:
- Connections as per Figure 4;
- In this case the regulator´s nominal voltage is the nominal voltage between phase and neutral of the supply;
- For a purely resistive load phase shift between voltage and current measured at the regulator would be 0º (zero degrees);
- Regulation achieved is +/- 10% between phase and neutral;
- Current is measured only in phase.

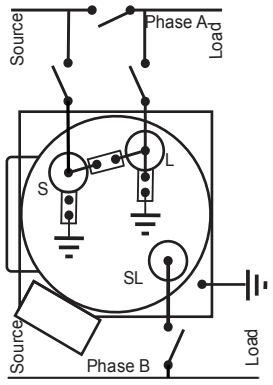


Figure 5: Connection in two phase lines.

Two phase

Features:
- Connection as per Figure 5;
- Regulator´s nominal voltage is the nominal voltage between phases of the supply;
- For a purely resistive load phase shift between current and voltage measured in the regulator would be – 30º o + 30º depending on the phase sequence;
- Regulation: +/- 10% of voltage between phases;
- Current is measured only in one of both phases.
-

Open Delta

Features:
- Connection as per Figure 6;
- Regulator´s nominal voltage is nominal between phases of supply;
- For a purely resistive load phase shift between current and voltage measured in the regulator would be – 30º for one regulator or + 30º on the other;
- Regulation: +/- 10% of voltage between phases for all three phases;
- Current is measured only in two of the three phases.

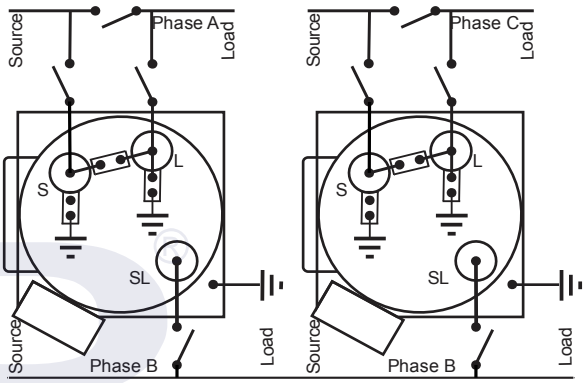


Figure 6: Open delta connection of two single phase regulators in a three phase line.

Closed Delta

Features:
- Connections as per Figure 7;
- Regulator´s nominal voltage is the nominal voltage between phases of the supply;
- For a purely resistive load phase shift between current and voltage measured in the regulator would be – 30º for all regulators;
- Regulation: +/- 15% of phase-phase voltage for direct power flow;
- Current is measured in all three phases but there can be up to a 5.35% error depending on connections done in S or L terminals for the reference tension to the other regulator from the bank;
- For regulators working in closed delta which can operate in inverse power flow, except on those cases where the inverse power flow is caused by cogeneration, an external and independent Voltage Transformer is mandatory with secondary connected to terminal 26 of terminal blocks on regulator and primary connected to terminal S of regulator of reference phase. Reference phase is that where SL of the regulator is connected keeping same phase sequence and polarity of connection for direct flow (more details on “voltage and reference” and item 47 of table 7).

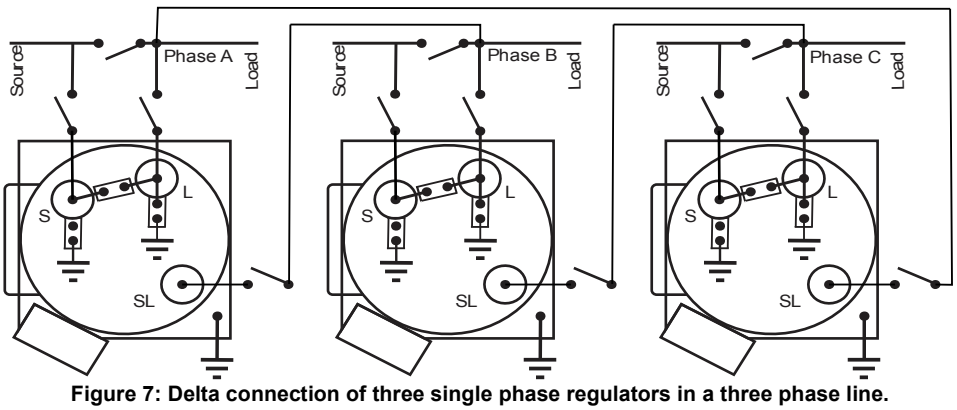


Figure 7: Delta connection of three single phase regulators in a three phase line.

OBSERVATION 1: Input for connection of an independent external Voltage Transformer is optional and has to be requested specifically on purchase order

OBSERVATION 2: Independent external Voltage Transformer is optional and also needs to be requested specifically on purchase order

Star ("Y")

Features:

- Connections as per Figure 8;
- Regulator´s nominal voltage is the nominal voltage between phase and neutral of supply;
- For a purely resistive load phase shift between current and voltage measured in the regulator would be 0º for all regulators;
- Effective regulation: ±10% of voltage between phase and neutral in direct power flow;

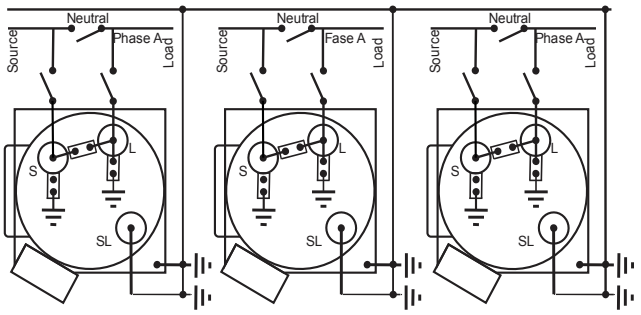


Figure 8: Star connection of three singe phase regulators in three phase line with neutral consistently grounded.

EARTH CONNECTION OF A BANK OF REGULTORS

Proper grounding for a bank of single-phase voltage regulators must ensure resistance according to ABNT NBR 14039 which refers to medium voltage electrical installation between 1.0 kV to 36.2 kV.

ATENTON: If voltage difference between regulator´s tank and earth is bigger than 50V, it is recommended to remove from service the complete bank of regulators from network and amend grounding accordingly.

CASCADED VOLTAGE REGULATORS

We define cascaded voltage regulators when two or more bank of regulators are installed in a same network. This condition can cause problems in the interactive operation between banks which need to be thoroughly studied so as to determine optimal configuration and installation location. Otherwise, it may cause large fluctuations of voltage in the network.

For a correct analysis of cascaded voltage regulation it is necessary to consider that changes in the tap changers of each regulator are perceived both downstream, by voltage variation, and upstream by current variation.

For delta connections there is an additional complexity factor as differences are caused between the phases at the point of location of each bank and its effect depends on the position of the tap changer, of load currents and impedance of the network till that point.

Fault Effect

In a distribution network where there are N cascaded voltage regulators a critical state can be achieved in which all regulators of all banks are boosting (giving the highest elevation), eg. 15% in delta connection. If there is a power failure when energy returns and only for a moment load would be disconnected but as tap changer position will keep as in full load. As losses would be smaller, tensions of up to 1,15N times of source nominal voltage can be present at the last load bank.

A distribution network in which they are installed, cascade, N bank regulators, can stay in critical condition in which all regulators of all banks are promoting the highest elevation, ie over 15% in delta connection. If in this condition, any power failure at the time of return and for a moment, he drew the charge, but the positions of the switches still remain as it were at full load. As the losses would be less, may occur voltages up to 1.15 N times the voltage of the source in the last load bank

Effect of operations avalanche

When analyzing the performance of the 2 banks of regulators, RT1 and RT2, connected in series, according to the scheme of Figure 9, we note that the bank downstreams, RT2, perceived a tap change taps at the rearmost bench, RT1, due to the variation of tension that it causes. Also, tap changes of RT2, is perceived by RT1 due to changes in

current. Current variation depending on network impedance Z1 from source to RT1, produces a voltage variation of RT1.

Taps changes in one of RT2 regulators to boost (raise), for example, can cause a rise in current so significant on the voltage regulator of RT1 bank in that same phase, which can exceed the insensibility programmed in that control unit. If this occurs, the regulator control unit of RT1 detects this imbalance and promotes its correction by changing its tap changer boosting its tap . This change of RT1 , increases the phase voltage which is measured and perceived by the control unit of bank RT2, which once again may be greater than the voltage insensitivity programmed in that control unit inducing a correction which is done by the control unit changing the tap changer so as to buck (decrease) voltage , restarting the cycle of interaction.

Figure 9: Cascade regulation.

What happens then is a large amount of sequential operations between series installed regulators, which we call the operations avalanche. This interaction shows the variations of increasing amplitude of voltage and current along the network and can reach harmful levels of imbalance between phases with possible activation of the neutral current protection .

For banks installed in delta , avalanches can occur between different phases and with greater intensity and frequency due to increased regulation and the interaction between the phases.

Insensitivity coordination eliminates any possibility of operation avalanches.

RECEPTION

Before packing, the voltage regulator is tested and inspected at factory. Upon receipt, another inspection should be performed to identify any possible damage that may have occurred during transport and handling. The optional external position indicator, control box, lightning arresters, heaters, insulators, electrical cables and other external components must be rigidly fixed to the body of the regulator, intact and free of cracks and deformations. The packaging must not show signs of manipulation, impact or a fall. Any irregularities must be reported to ITB immediately and before performing the UNLOADING process.

STORAGE

If the regulator is temporarily unloaded it must be stored in a ventilated, level ground site and away from heat sources, sparks protected as to avoid mechanical damage.

RISING

When rising regulators with steel wire ropes or chains, it has to be done using the lifting lugs located on the side of the tank

ATTENTION: Cover can be damaged if the internal assembling lifting eyes which are located on the cover are used for regulator lifting and handling.

Steel wire ropes or chains used must be on good condition and be certified to withstand voltage regulators weight with enough length to allow the angle between arms, with vertex at the hook, be at least 60 degrees (see Figure 10).

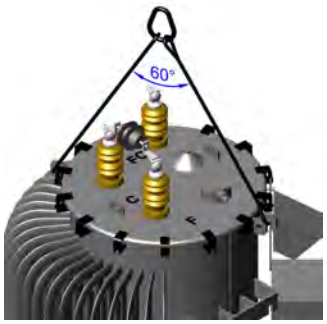


Figure 10: Lifting method

DANGER: Usage of short steel wire ropes or chains causing angles bigger than 60 degrees can cause strain on the regulator´s cover and cause lifting lugs breakdown

In any rising operation regulator should remain leveled.

INSTALLATION

Inspection before installation:

Before connecting the regulator on service, perform the following inspection:

1. Check the oil level. If missing, check visible loss or filtering. In case no cause is identified refill with naphthenic oil,
2. Examine there is no damage in surge arrestors nor its connection cables.
3. Inspect insulators (bushings) to check any possible damage or any indication of leakage at the joints. If there is a filtration suspicion, remove the inspection cover to check for rust indication or water in the oil. If filtration is confirmed contact ITB for appropriate method to solve this

4. If the regulator remains stored for some time, check the dielectric strength of the oil as the NBR 6869. If the resulting value is below 26 kV, treat the oil by and proceed to further analysis so as to verify its integrity.

CAREFUL: If active components need drying or its oil being heated, ensure that on load tap changer does not receive temperatures above 90°C. This can cause damage to the switches that are responsible for the operation, operation counter, polarity indication and confirmation of nominal position. Conferir las demarcaciones de los aisladores en la tapa correspondiente a los terminales del regulador.

5. Check the identification marking of the bushings on the lid correspondent to the terminals of the regulator.
6. Check the dielectric strength between the bushings and the tank using a 2.5 kV or higher insulation resistance meter. This measurement must be performed after connecting shorted all bushings of regulator, measuring between the tank and shorted bushings. The minimum value must be at least 10,000 megohms at ambient temperature;
7. Check that voltage ratio reference for line voltage is properly inputed into the control of the regulator (see parameter 32 of control settings);
8. Check if the CT is correctly programmed into the regulator control (see parameter 33 of control settings);
9. Check if the connections of the voltage transformer is suitable for the voltage of the network as indicated in nameplate as shown in Figure 11.

HEIGHT

Regulators installed over 1000 above sea level have reduced nominal power as indicated in ABNT NBR EB 2108 and IEEE/ANSI C.57.15 standards.

Reference voltage

Most regulators can be used in systems with different nominal voltages. It is necessary that the installer ensures that the regulator is configured to maintain the relationship between system voltage and the reference voltage of the electronic control unit so that the reference voltage is 120V.
The nameplate indicates the proper connection of the terminals "A", "B" and "C" which will be different for each applicable system voltage as shown highlighted in Figure 11.

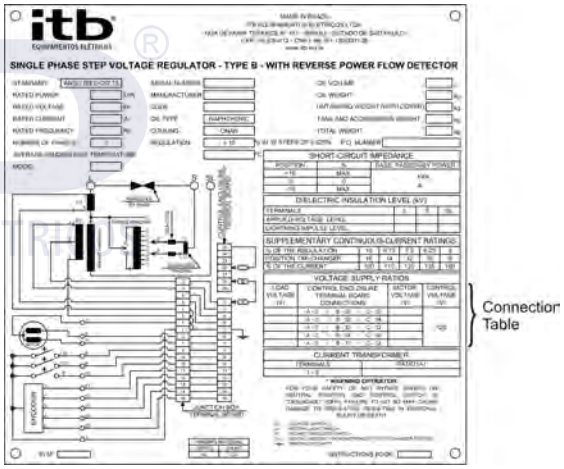


Figure 11: Nameplate

DANGER – Terminal "A" has to be disconnected to manipulate terminals "B" and "C" in secure conditions. Manipulating "B" and "C" with terminal connected can cause electric shock and short-circuit when regulator is being fed by the high voltage terminal

It is important to note that the measurement will always be made between the insulators "L" and " SL" and that measurement shown as source is the voltage between " S " and " SL" which will be used as a reference in case of reverse flow , excluding when caused by cogeneration , is calculated from the measurement of VT and the switch position and, therefore , with accuracy of ± 1.5 % . For banks installed in closed triangle error may reach ± 6.5% , as, beyond the own internal regulator error there is still a difference between the source and the load regulator reference.
To measure with more accuracy, an additional external and independent VT should be used and the primary of the VT which has to be connected between phases on the SOURCE side, and secondary , in which maximum voltage cannot exceed 5VAC., must be connected to terminal block (input for external VT terminal) 26 of terminal blocks located inside the control box (this entry is optional for CTR -2 controls and must be requested when ordering) and grounding system taking care to establish the correct polarity to keep the same phase sequence used in direct flow (Parameter screen 46 DEFVC) and setting "1" option in voltage source metering on Source side (screen parameter 47, OPMEDF).

OBSERVATION1: Voltage on source side, as well as voltage of external Voltage Transformer, won´t be available at the voltmeter terminals in the control cabinet, even when working in inverse power flow.

OBSERVATION 2: For regulators connected in closed delta that may work in inverse power flow the usage of external voltage transformer is mandatory, except when this is caused by cogeneration.

Function on screen 47 (OPMEDF) – Optional metering of voltage on source side, to be configured for use of external voltage transformer on source side.

SUPORT AND FIXING

Regulators with an overall weight of up to 1500 kg may be installed in platforms or poles. Above this weight it has to be installed in platforms. In both cases equipment has to be correctly leveled. Regulators are designed to be air cooled so its refrigeration depends on this. In case of installation indoors ensure adequate ventilation and free space to allow operations, inspection and maintenance.

High tension connections

High tension connections has to be made so as to ensure that nominal voltage in terminals Source “S” or “L”, and Common “SL” does not exceed nominal value indicated on nameplate of regulator. Connections on terminals of bushings have to be tightened so as to avoid hot spots and/or bad contact.

CAREFUL: while mounting or connecting equipment, no mechanical tension has to be transmitted to bushings as it may lead to loosening bushings or its internal connections, breakage of sealing which may cause a bad connection, heating, broken conductors, isolation problems, oil spilling among others

Cables and terminals must be flexible enough to avoid that mechanical stress caused by wind or by the expansion and contraction of metals reach regulators bushings as these effects can damage porcelain insulators which are limited to withstand impact, shock and mechanical stress in general. For the same reason it is not allowed bushings to be connected directly to the network without the intermediation of proper support to keep the wires correctly fixed.

REGULATOR PLACEMENT IN SERVICE

If regulators are mounted with appropriate disconnector blades as suggested in CONNECTION SYSTEM in this manual, placement in service may be executed without power interruption.
The procedures described below are extremely important to ensure that the regulators are ready to be placed in service.

Connections

Identify in cover bushings “S”, “L” and “SL” and make appropriate electrical connections for the regulator/s as detailed in connection diagrams (see “connection systems”)

Placing in service

DANGER: This procedure, when done without regulators being on neutral position, cause short-circuit with severe damage risk for equipment, network and personnel

Proceed with following sequence :

1. As per data on nameplate, verify if control circuit is correctly configured for adequate voltage;
2. Place the “Normal/ Turn off / External” switch of the control panel in “Turn off” position;
3. Only for DELTA connected equipment, close the disconnect blade on “SL”;
4. Close the disconnect blade on “S”;

Note: If using a one-action switch, where opening of source, opening of load and bypass closing is done automatically, this step is not possible. Previous Neutral position confirmation is not possible without an external supply

5. Place the “Normal/ Turn off / External” switch of the control panel in “Normal” position;
6. Press the “Raise” button or “Lower” so as to operate its tap changer two or three steps, then press “Auto Zero” button so as to return tap changer to neutral position. When in neutral position and “Bypass”) LEDs will light and position indicator will show “0” with a (tap changer in neutral position, ready for operation) message displayed;

DANGER: Due to risk of an out-of-position maneuver, the Auto Zero, however automatic, must be obligatorily monitored by the operator who must observe the sequence of modification of indication of the positions checking its sequence and logic.

7. With regulator on the neutral position, change the “Normal/ Turn off / External” switch of the control panel to “Trun off” position;
8. Close disconnect blade of “L” side;
9. Open by pass disconnect blade;
10. Change the “Normal/ Turn off / External” switch of the control panel to “Normal” position;
11. Adjust the control for operation in automatic mode.

Note: With parameter 48 (HRAUT) adjusted in “1”, if CTR2 control keeps in manual mode for more than 15 minutes without any button being pressed nor communications detected by its Comm ports, regulator would change into automatic mode.

VERIFYING REGULATORS OPERATIONS

Observation: To avoid network being subject to voltage variations, tests listed hereafter are to be done with LOAD bushing disconnected from network and “bypass” disconnect blade closed.

1. Adjust control so as to operate in manual mode;
2. Press “Lower” button of control until voltage is out of the regulated voltage, which is identified by the LED “Raise” lit;
3. Adjust the control so as to operate in automatic mode;

Note: Observe that, after some time, regulator will return to operation on regulated voltage which will be identified by the LED “Raise” turning off

4. Adjust the control so as to operate in “Manual”;
5. Press “Raise” button of control until voltage is out of the regulated voltage, which is identified by the LED “Lower” lit;
6. Adjust the control so as to operate in automatic mode;

Note: Observe that, after some time, regulator will return to operation on regulated voltage which will be identified by the LED “Lower” turning off

REMOVING REGULATOR FROM SERVICE

DANGER: This procedure, when done without regulators being on neutral position, cause short-circuit with severe damage risk for equipment, network and personnel

1. Press “Auto Zero” button so as to return tap changer to neutral position (when on neutral position the Neutral and “Bypass” LEDs are lit and position indicator will show “0” in the control. If this elements are coherent simultaneously the “Fail” LED will be off and screen will show (Tap changer in NEUTRAL Position. Ready for operation.) message.

DANGER: Due to a risk of operation out of neutral position the auto zero, although automatic, has to be monitored by the operator which needs to observe the sequence.

2. With regulator on the neutral position, change “Normal/ Turn off / External” switch of the control panel to “Turn off” position;
3. Close the bypass disconnect blade;
4. Open the disconnect blade on “L”;
5. Open the disconnect blade on “S”;
6. Only in delta or byphase connection, open the disconnect blade on “SL”.

MAINTENANCE

Voltage regulator was designed so as to allow certain verifications without having to remove equipment from service. Maintenance, when methodically done, is an essential factor to the durability of the voltage regulator in its best performance and working conditions.

General Instructions

In table 2 some verification elements are described together with its periodicity and evaluation criteria.

Table 2: Maintenance instructions.

Point	Item	Period	Verify	Procedure or verification item	Evaluation / Correction
Control	1	1 year	Manual control, maximum and minimum blocking.	- When selecting control in boost verify that control increases tap changer position, stopping in blocking position set on control unit . - When selecting control in buck verify that control decreases tap changer position, stopping in blocking position set on control unit.	
Control	2	1 year	Reference voltage	With regulator on service adjust Ur = 0 V, Ux=0 V and insensibility in 1 V. Verify if voltmeter output voltage is the same (+/- 1 V) as reference after stabilization is achieved.	
Control	3	1 year	Timing.Automatic operation boosting and bucking	Change the voltage reference value for a bigger value that actual network voltage; - Verify if motor actuates in boost sense after time elapsed; - Change the voltage reference value for a lower value that actual network voltage; - Verify if motor actuates in buck sense after time elapsed.	
Accessories	4	1 year	Isolators	1. Cracks in porcelain; 2. Accumulated impurities in porcelains; 3. Oil filtration; 4. Terminal tightening .	When contamination results excessive clean with cloth containing ammonia or carbon tetrachloride and apply a neutralizer.
Accessories	5	1 year	Surge arrestors	1. Crackings; 2. Accumulated impurities.	Wash with fresh water, dry and clean with dry cloth. Tighten terminals when loose.
Accessories	6	1 year	Oil level indicator	- Crack in the sight glass; - Oil filtration.	- Change the glass display; - Tighten sight glass body or change packing.
Accessories	7	1 year	Oil drain valve	- Oil filtration.	- Tighten, if filtering persist remove equipment.
Insulation Oil	8	1 year	Get an oil sample	- Measure dielectric strenght; - Neutralization index; - Interfacial voltage; - Power factor.	- Oil filtration when bellow 26 kV (NBR 6869) dielectric strength

REGULATOR OPENING

To verify internally open regulator as indicated:

1. Remove regulator from service, follow security instructions indicated on control panel;
2. Place the regulator on a place where energized line cannot interfere. An indoor, flat leveled floor place is preferred. Wait till isolation oil temperature is less than 40 degrees Celsius;
3. Remove bolts that fasten control cabinet box to tank;

Note: Do not disconnect control from regulator cover. Box has to be mechanically connected to box during opening.

4. Remove earth conductor connected between control box and tank;
5. Remove bolts from cover fixation;
6. Remove earth conductor connected between cover and tank;
7. Lift active part by the lifting eye located on cover, guiding control box which will be lifted together with cover;

DANGER: when opening the regulator there will be human and ambiental contact with isolating oil. Usage of adequate security equipment is

TAP CHANGER

Derivation on load tap changer is a simple device with long expected life time when recommended inspections as indicated in table 3 are performed.

Table 3: On load tap changer inspections

FREQUENCY Number of operations	SERVICES DESCRIPTION
Each 125,000	- Measure resistance contact (800μΩ max). - Visual inspection. - Analysis of wear of fix and movable contacts.
Each 250,000	- Substitute fix and movable contacts. - Verify mechanical operation.
Each 1,000,000	- General revision, unmount and change wear parts

Measurement of contact resistance (fixed contact + movable contact + axles + slip ring) must be done by connecting Microohmmeter terminals between terminals of axis and collector ring (central straps of insulating plate switch). Perform measurements on pairs taps from 0 to +16. The measured values for new switches may not exceed 800 μΩ. The natural wear of contacts, misalignments and clearances of mechanisms gradually increase this resistance. Consider the value of 2,500 μΩ as maximum acceptable limit for the tap changers in operation.

Reposition pieces

Reposition pieces of tap changer can be requested as per drawing in Figure 12 and can be requested by its number or name indicated on Table 4.

Table 4: List of parts of the under load tap changer.

It.	Description	It.	Description
01	Collector came	17	Fix contact
02	Absolute Encoder	18	Ring collector
03	Micro Switch of operation counter	19	Brush
04	Assembly plate	20	Screw conductor
05	Micro switch of polarity	21	Axis collector
06	Reverse gear trigger	22	Insulating arm of the main tiger
07	Mobile contacts tiger	23	Mechanical indicator - Crown
08	Insulating arm tiger of the reverse gear	24	Mechanism axis
09	Disk of inertia	25	Trigger / Positioned
10	Mobile contact arm to the axis	26	Spring trigger fixing
11	Mobile contact arm to the to the ring	27	Trigger disk

It.	Description	It.	Description
12	Mobile contacts	28	Neutral motor
13	Supporte and pinion for mechanical indicator	29	Positioned disk
14	Reverse gear contact	30	Assembly plates separator
15	Insulating separator of the assembly plates	31	Micro switch of neutral position
16	Premix plate		

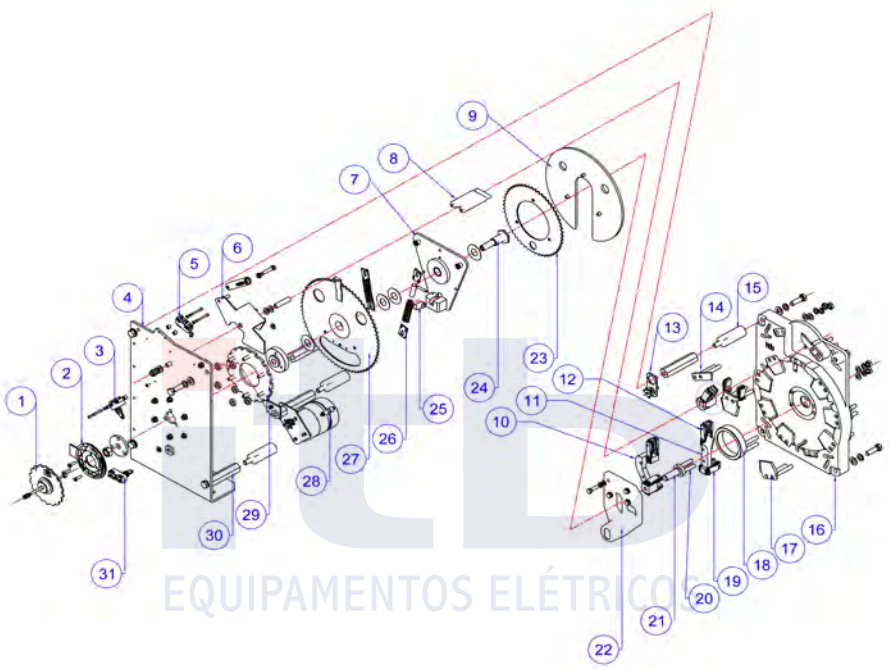


Figure 12: Parts of the under load tap changer.

Verifying points in on load tap changer:

1. All nuts acting on brass straps must be tightened with a torque of 1.2 kgf.m;
2. The drive chain must have minimum clearance of 15 mm and maximum 25 mm;
3. The motor encoder (encoder) must be synchronized with the movable contact such that at the nominal position no contacts are closed ("0" will be displayed on the screen of the control);
4. Mechanical blocks must be tested with supply up to 140 Vac verifying motor acts correctly and inversion switch must be tested with the engine fed with a voltage of 95 Vac. (Engine must be connected to capacitor 20 uF 380 Vac).

WINDINGS

All ITB regulators have 3 sets of independent coils (separate core):

1. A large set of coils mounted in the lower part of the regulator which concentrates measurement voltage transformer, the parallel coil, series coil, derivations and equalization coil;
2. An enrollment located at the top of primary enrollment which is the reactor;
3. A toroidal enrollment located over the reactor which is the current transformer responsible for measuring the load current. Each one of these enrollments is constructed and connected according to specific project features which vary depending on the application and use conditions requested, so regulator id number has to be informed when requesting spare parts.

CONTROL CTR-2

The CTR -2 electronic control is a microprocessor based equipment capable of performing voltage regulation functions, delay of actuation time and data collection for voltage quality control in electrical network which may be

accesed through its incorporated communication ports.
The CTR -2 electronic control possesses the following basic features:

- Measurements of line electrical parameters;
- The control is located inside a metal box with IP54 protection .
- Has a power switch with three positions "Normal / disconnected / external", which selects the way to power up control , and prevents energization of main bushings when supplied through an external power supply ;
- Terminal for external power supply;
- Terminal for voltmeter connection;
- Automatic current transformer short circuit when the panel is opened or removed the CTR- 2 from cabinet
- Tap changer operations digital partial counter;
- Digital total operations counter switch;
- Led indicator of neutral position independent of position indication;
- Led indicator need to boost voltage ;
- Led indicator need to buck voltage ;
- Led fault ;
- Led confirmation neutral position ;
- Protection fuse and motor control fuse;
- Data Acquisition

1. Acquires, stores and shows date and time of last minimum voltage and current demand;
2. Acquires, stores and shows amount of registers in adjustable periods between 1 and 60 minutes, instantaneous voltage, current, power factor, actual tap changer position, date and time of each register until total amount of registers is 9362. From that point onwards, a new record is stored over the oldest log.

Note: This stack is only accessible with the aid of a computer connected to the control in which the program ITBComm3 is installed.

- Work on direct or inverse power flow without the need of a special external voltage transformer, except when in closed delta connection in which inverse flow is determined by infinite busbar. (more details in “connection possibilities delta”, “reference voltage” and ítem 47 of table 7).
- “Auto Zero” function which leads on load tap changer from any position to zero position (neutral)
- Simultaneous communication ports:

1. Allow communication through EIA232, EIA485, USB, optic fiber and (optional) ethernet;
2. Serial communication with a computer can be made by any of the comm ports using DNP3, DNP3 LAN / WAN or ITBComm3 communication program (available for download and installation at http://www.itb .ind.br/ITBSetup3.exe) running on Windows 98 or superior, and a connection media between the computer comm port and CTR2. CTR2 control has on the front one USB type A, and one RS232, through a DB9 connector. Has internal optical comm port (connector ST), R S232 (DB9) and RS 485. In case of serial communication DB9 cable pinout to be used is as shown in Figure 13. Communication ports can also be used for communication via modem by selecting in the communication program ITBComm3 a COM port where modem is connected and that a correctly configured modem is placed in the control;

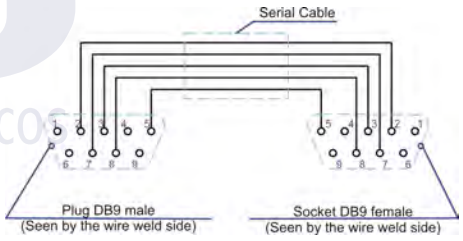


Figure 13: Diagram of the serial communication cable.

- Pine 9 of each DB-9 is active with +5 Vdc;

- DNP 3.0 communication protocol in both comm ports;
- 3 independent setting maps for direct power flow activated depending on date and time;
- Real time clock and calendar;
- On load tap changer protection in case of overload;
- Switch protection in case of overload;
- Accuracy of 0.7% of measured values in a 25°C environment.

Components of Front Panel

With a simplified arrangement, CTR-2 control allows visualization setting of control settings and instantaneous measurements readings of the electrical system without the need for any other additional accessory.

When CTR-2 control is energized all the LEDs and the back light of the LCD screen lights up to test their correct operation and installation.

The front panel has a monochromatic alphanumeric LCD display and a keypad, as shown in Figure 14 and described in Table 5.

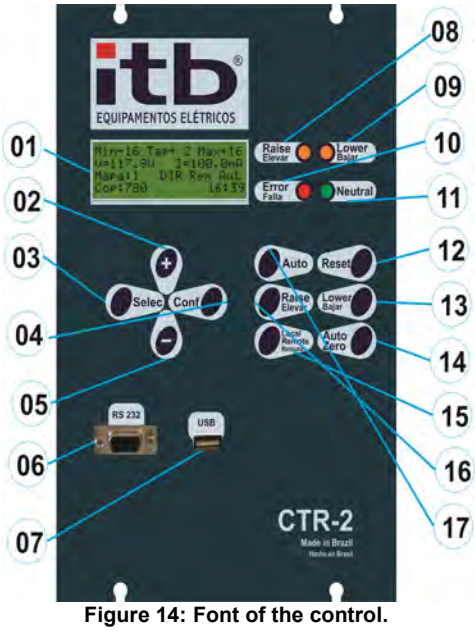


Figure 14: Font of the control.

All controls are individually tested and calibrated at factory and all settings may be manually done through the keypad present on the front of the CTR-2 unit. Through the navigation keys all information can be accessed and displayed and perform setting in configuration .

Table 5: Front panel elements identification.

Item	Description
01	LCD monochromatic display 4 lines 20 characters
02	“+” key allows navigation through screens as selected
03	“Selec” key allows user to select between measurements, adjustment or shortcut screens. When on appropriate condition (configuration mode) it allows to move cursor to the left
04	“Conf” key on main screen changes voltage and current values between low tension and high tension “Conf” key changes to configuration mode when on settings screens “Conf” key confirms selected value of each adjusted digit
05	“-” key allows navigation through screens as selected
06	DB-9 serial comm port EIA-232
07	USB type A comm port
08	LED lit when need of correction to boost voltage
09	LED lit when need of correction to buck voltage
10	LED fault indication
11	LED lit when neutral position is confirmed
12	“Reset” key updates or resets values which allows that condition
13	“Lower” key changes on load tap changer in buck sense when “manual” mode in active
14	“Auto Zero” key takes on load tap changer into zero position (neutral).
15	“Local /Remote” key changes command operations only to local so as to avoid risks
16	“Raise” (Boost) key changes on load tap changer in boost sense when “manual” mode in active.
17	“Auto” key changes operation between automatic and manual mode

Set of screens

Screens of CTR-2 control were organized into 4 groups: standard screen displays measurements, numbered from 66 to 84, settings screen, numbered from 01 to 65, and shortcut screen. The "Select" key toggles between screens of those 4 groups in the order in which they were described, always showing the first screen of each group. In each group user can, from the main screen, press the "+" button to display the first measuring screen (screen 66), or press the "-" key to display the last measurement screen, (84 screen), and from any screen user can browse the group of screens by pressing "+" or "-".

Standard screen

Control shows in its standard screen, figure 15, the following values:

1. The value next to the abbreviation "Min" is the lower driver position ever since the last effective reset;
2. The value next to the abbreviation "Tap" which is the current position of the tap changer;
3. Three. The value next to the abbreviation "Max" is the highest driver position ever since the effective reset;

Note: "Mín" and "Máx" value can be updated pressing "Reset" key. Values will then show actual tap changer position

4. Value of abbreviation "V=" is the instantaneous voltage in load;
5. Value of abbreviation "I=" is the instantaneous current in load;

Note: "Conf" key commutes values of "V =" and "I =" between high tension and low tension

6. Value of "map" is the active map or active set of variables;
7. "Dir" indicates that CTR-2 control detected direct power flue. IF "INV" is displayed inverse power flow has been detected;
8. "Rem" indicates that Com1 and Com2 communication ports are working fully. If "loc" is displayed, no direct commands (automatic, manual, buck, boost) are received by communication;
9. "Aut" informs that CTR-2 control is operating in automatic mode. When in manual mode "Man" is displayed;
10. Value next to "cop" is the number of operations done by the control;
11. "B" indicates a blocking condition is active;
12. "hh:mm" is actual time as defined in control unit.

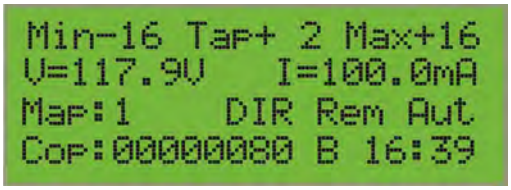


Figure 15: Default screen.

Screen Shortcut

From the standard display, if you press the "Select" key three times the control displays a shortcut screen "atalho de tela" that allows entering directly the number of parameter or screen user wants displayed as shown in columns "Shortcut" in tables 6 and 7.
The shortcut screen will be displayed as shown in figure 16. When "conf" key is pressed this will change as displayed on Figure 17 which allows new value" field to be changed through the following procedure:

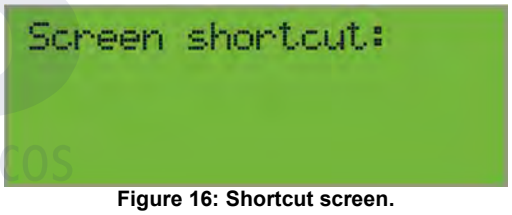


Figure 16: Shortcut screen.

1. Note that under one of the digits on "New value:" field a highlighting cursor is displayed. This means that digit can be modified.
2. Press keys "+" or "-" to change that digit between 0 and 9;
3. Press the "Selec" key or "conf" to allow cursor navigate between different digits of "New value" field
4. Repeat operation until desired parameter (two digits mandatory) is shown on display;

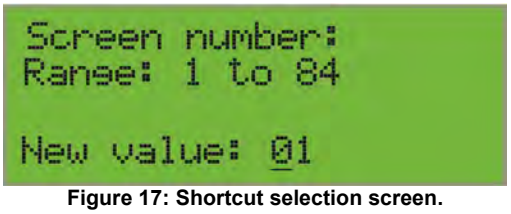


Figure 17: Shortcut selection screen.

5. With cursor under the least significant digit, press "conf" key to validate selected value;
6. The selected screen will be immediately displayed and keeps as in readings and adjustment screen from then;

Note: If adjusted value is outside the range, 1 to 84, message "Invalid number" will be displayed in the bottom line and "new value" will remain as ""actual value" as in settings screen.

7. If "conf" key is pressed while cursor is under the least significant value no actions are adopted by CTR-2 control;
8. To return to standard screen from shortcut screen press "conf" key once.

Direct Command Key

CTR-2 control has 6 direct command keys with specific functions as described here after:

- Key 12, "Reset" key updates values that allow this possibility which is shown as "Resettable" (Able to reset) written in the bottom line of the screen;
- Key 13, "Lower" key operates the tap changer in the sense of decreasing the tap changer position when manual mode is active. Manual mode is identified by "man" in the last field of the third line of the standard screen;
- Key 14, "Auto Zero" key sets regulator to zero position (neutral) from any screen or operation mode;
- Key 15, "Local / Remote" key limits tap changer command to local action only to avoid operation risks;

- Key 16, “Raise” key operates the tap changer in the sense of increasing the tap changer position when manual mode is active. Manual mode is identified by “man” in the last field of the third line of the standard screen;
- Key 17, “Auto” key selects operation mode from automatic to manual.

Auto Zero

The key 14, key, “Auto zero”, is programmed to take the regulator to a secure operation condition for energization and de-energization and once pressed the following actions are done:

a - Verify actual tap changer position;
b - If position is not nominal position, verify if on load tap changer needs to boost or buck;
c - Connect tap changer motor in correct sense so as to take tap changer to nominal position;
d - Wait until zero position is achieved;
e - When zero position is achieved verify redundancy in information comparing encoder Reading with micro switch closed at nominal position which have electrical and mechanical independence;
f - Lit the “Bypass” led if redundancy presents incoherence between nominal position led and encoder;
g -Lights the led “Neutral” in case the redundancy confirms the nominal position.
h - Show in screen “tap changer in neutral position ready for operation”;
i - Lit the “Fail” led if there is difference in redundancy between nominal position led and encoder reading;
j - Show in screen “tap changer blocked. Auto zero fault” in case there is difference in redundancy between nominal position led and encoder reading.

Note: “Auto zero” blocks control keys until next energization and always returns to normal mode

Navigation in reading screens

From the standard screen by pressing the “+” or “-“ key user can navigate between screens, as shown in figure 18, in which detailed system measured values are shown as follow:

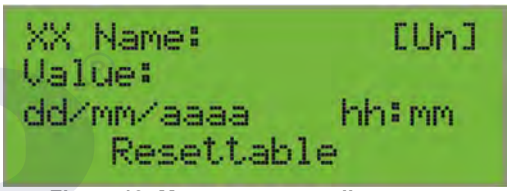


Figure 18: Measurement reading screen.

1. In the “XX” field the number of screen to be used for direct access through shortcut screen is shown;
2. In the “Nome” field (name) the measured identifier will appear as described in “Name” column of table 6;
3. In field between brackets the unit of value (when appropriate) will be displayed;
4. In the “Value” field the instantaneous value for that measurement will be displayed;
5. In the “dd/mm/aaaa hh:mm” field the occurrence moment will be displayed if appropriate;
6. The Word “Resettable” (able to reset) will be displayed on the last row of the screen if variable can be reseted as described in table 6.

Values will be shown in Table 6 sequence to drive straight away using the "+" key and the "-"

Table 6: Sequence of measured values.

S.	Shortcut	Name	Description	Date Time	Unit	Resettable	Remote
01	66	TBLC	Low tension voltage on "Load"	-	V	-	display
02	67	TBLF	Low tension voltage on “Source”	-	V	-	display
03	68	FREQ	Frequency	-	Hz	-	display
04	69	FPOT	Power factor	-	-	-	display
05	70	DMAXTC	Maximum voltage demand on "Load"	Yes	V	Yes	display and resets
06	71	DMINTC	Minimum voltage demand on "Load"	Yes	V	Yes	display and resets
07	72	TLC	Line voltage on "Load"	-	kV	-	display
08	73	CLC	Line current on "Load"	-	A	-	display
09	74	DMAXCC	Maximum current demand on "Load"	Yes	mA	Yes	display and resets
10	75	DMINCC	Minimum current demand on "Load"	Yes	mA	Yes	display and

S.	Shortcut	Name	Description	Date Time	Unit	Resettable	Remote
							resets
11	76	PNOM	Power rating on the "Load"	-	kVA	-	display
12	77	PATV	Active power on the "Load"	-	kW	-	display
13	78	PRTV	Reactive power on the "Load"	-	kVAr	-	display
14	79	COC	Partial operation counter	-	-	Yes	display and resets
15	80	QTREG	Amount of stored registers	-	-	Yes	display
16	81	CBLC	Current on the low side "Load"	-	mA	-	display
17	82	CBLF	Current on the low side "Source"	-	mA	-	display
18	83	DHTV	Rate of harmonic distortion of the voltage	-	%	-	display
18	84	DHTI	Rates of harmonic distortion of the current.	-	%	-	display

Note: when the "QTREG" (shortcut 80) value is reseted stored values are eliminated

SETTINGS IN CONTROL – GENERAL VIEW

CTR-2 control has 3 groups or sets of parameters for operation in direct power flow whose activation will depend of date and time for beginning and ending. Those groups are called MAPS and include parameters that can occasionally change. Also a group of independent parameters for operation in inverse power flow is available

Navigation through the adjustment screens

To adjust control operation parameters:

1. From any screen of measuring parameters, press "Selec" once, the first settings parameter will be displayed in configuration screen (figure 19) as well as its actual value:
   1. In the "XX" field, the number of screen for shortcut Access is displayed;
   2. In the "Name" field the measured identifier will appear as described in "Name" column of table 7;
   3. In field between brackets the unit of value (when appropriate) will be displayed.

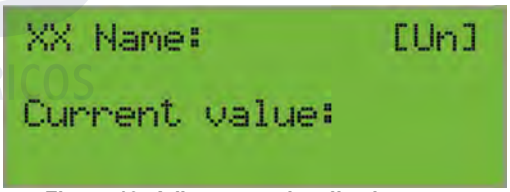


Figure 19: Adjustment visualization screen

2. Press keys "+" or "-" to change that digit between 0 and 9 as shown in figure 7;

From any screen of settings visualization, when "Conf" key is pressed variable settings mode is accessed, as shown in Figure 20 with two additional fields compared to visualization screen:

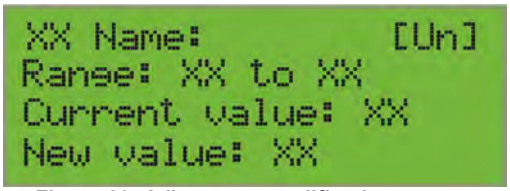


Figure 20: Adjustment modification screen.

1. The range field that shows the máximum and mínimum allowable value for the parameter on display;
2. The "New Value" field that will show the same "Valor actual" (actual value) but with a cursor in the position of the most significant digit

To modify the selected setting of parameter, follow the sequence:

1. Press the "+" o "-" keys to navigate between 0 and 9;
2. Press "Selec" or "Conf" key to navigate between different digits;
3. Repeat operation until all digits are as desired;
4. With cursor under the least significant value, press "Conf" key to accept value for the complete "New value" which will now be displayed in "Current Value" and that will be exhibited in the adjust visualization screen;

Note: If adjusted value is outside the range, 1 to 84, message "Invalid Number" will be displayed in the bottom line and "new value" will remain as "Actual value" as in setting screen

5. If "Conf" key is pressed while cursor is under the most significant value no action will be taken;
6. To return to standard screen from setting visualization screen, press twice "Selec" key;
7. Settings will be displayed in sequence shown in Figure 7.

Table 7: Adjustable parameters sequence

S.	Shortcut	Name	Description	Un.	Range	Increment	Default	Settings	Remote	Local
01	01	RTPC	VT relation for control	-	25.0 a 300.0	0,1	Plate[1]		display	Adjust
02	02	RTCC	CT relation for control	-	250 a 6000	1	Plate[2]		display	Adjust
03	03	VREFM1	Reference voltage map1	V	90 a 135	0,1	120		Adjust	Adjust
04	04	INSM1	Bandwidth map 1	V	0,5 a 6,0	0,1	3		Adjust	Adjust
05	05	TMPM1	Timer map 1	s	10 a 180	1	30		Adjust	Adjust
06	06	DVQLRM1	Drop of resistive voltage on the line map 1	V	-25 a +25	1	0		Adjust	Adjust
07	07	DVQLXM1	Drop of reactive voltage on the line map 1	V	-25 a +25	1	0		Adjust	Adjust
08	08	VREFM2	Reference voltage map 2	V	90 a 135	0,1	120		Adjust	Adjust
09	09	INSM2	Bandwidth map 2	V	0,5 a 6,0	0,1	3		Adjust	Adjust
10	10	TMPM2	Timer map 2	s	10 a 180	1	30		Adjust	Adjust
11	11	DVQLRM2	Drop of resistive voltage on the line map 2	V	-25 a +25	1	0		Adjust	Adjust
12	12	DVQLXM2	Drop of reactive voltage on the line map 2	V	-25 a +25	1	0		Adjust	Adjust
13	13	SEMIM2	Week to initiate the term of map 2	-	0 a 8	1	0		Adjust	Adjust
14	14	HRIM2	Hour to initiate the term of map 2	-	0 a 23	1	0		Adjust	Adjust
15	15	MINIM2	Minute to initiate the term of map 2	-	0 a 59	1	0		Adjust	Adjust
16	16	SEMFM2	Week to end the term of map 2	-	0 a 8	1	0		Adjust	Adjust
17	17	HRFM2	Hour to end the term of map 2	-	0 a 23	1	0		Adjust	Adjust
18	18	MINFM2	Minute to end the term of map 2	-	0 a 59	1	0		Adjust	Adjust
19	19	VREFM3	Reference tension map 3	V	90 a 135	0,1	120		Adjust	Adjust
20	20	INSM3	Bandwidth map 3	V	0,5 a 6,0	0,1	3		Adjust	Adjust
21	21	TMPM3	Timer map 3	s	10 a 180	1	30		Adjust	Adjust
22	22	DVQLRM3	Drop of resistive voltage on the line map 3	V	-25 a +25	1	0		Adjust	Adjust
23	23	DVQLXM3	Drop of reactive voltage on the line map 3	V	-25 a +25	1	0		Adjust	Adjust
24	24	MESIM3	Month to initiate the term of map 3	-	0 a 12	1	0		Adjust	Adjust
25	25	SEMIM3	Week to initiate the term of map 3	-	0 a 8	1	0		Adjust	Adjust
26	26	HRIM3	Hour to initiate the term of map 3	-	0 a 23	1	0		Adjust	Adjust
27	27	MINIM3	Minute to initiate the term of map 3	-	0 a 59	1	0		Adjust	Adjust
28	28	QMESM3	Amount of months of map 3`s term	-	0 a 12	1	0		Adjust	Adjust
29	29	SEMFM3	Week to end the term of map 3	-	0 a 7	1	0		Adjust	Adjust
30	30	HRFM3	Hour to end the term of map 3	-	0 a 23	1	0		Adjust	Adjust
31	31	MINFM3	Minute to end the term of map 3	-	0 a 59	1	0		Adjust	Adjust
32	32	VREFFI	Reference voltage inverse flow	V	90 a 135	0,1	120		Adjust	Adjust
33	33	INSFI	Bandwidth inverse flow	V	0,5 a 6,0	0,1	3		Adjust	Adjust
34	34	TMPFI	Timer inverse flow	s	0 a 180	1	30		Adjust	Adjust
35	35	DVQLRFI	Drop of resistive voltage on the inverse flow line	V	-25 a +25	1	0		Adjust	Adjust
36	36	DVQLXFI	Drop of reactive voltage on the inverse flow line	V	-25 a +25	1	0		Adjust	Adjust
37	37	MODABL	Automatic load bonus	-	0 a 1	1	0		Adjust	Adjust
38	38	BMAX	Maximum position block	-	8 a 16	1	16		Adjust	Adjust
39	39	BMIN	Minimum position block	-	-8 a -16	-1	-16		Adjust	Adjust
40	40	LVMIN	Minimum voltage limiter	V	1 a 15	1	15		Adjust	Adjust
41	41	LVMAX	Maximum voltage limiter	V	1 a 15	1	15		Adjust	Adjust
42	42	BSC	Excess current block	-	0.5 a 2.1	0,1	2		Adjust	Adjust
43	43	MAFI	Actuation mode in case of inverse flow	-	0 a 8	1	0		Adjust	Adjust
44	44	TAC	Type of performance on the commutator	-	0 a 5	1	2		display	Adjust
45	45	MLPCOM	Tap changer position reading method	-	0 a 3	1	0		display	Adjust
46	46	DEFVC	Phase shift between voltage and current	-	0 a 2	1	0		display	Adjust
47	47	OPMEDF	Option of source voltage measurement	-	0 a 1	1	0		display	Adjust

1 *For spare controls or reset to default the value is 115.*
2 *For spare controls or reset to default the value is 1000.*

S.	Shortcut	Name	Description	Un.	Range	Increment	Default	Settings	Remote	Local
48	48	HRAUT	Temporary return to the automatic mode	-	0 a 1	1	1		Adjust	Adjust
49	49	LIMBL	Blocking threshold	%	1 a 5	1	1		Adjust	Adjust
50	50	DTAQ	Data acquisition period	Min.	1 a 60	1	15		Adjust	Adjust
51	51	HTINV	Inverse timer		0 a 1	1	0		Adjust	Adjust
52	52	MODOP	Automatic or manual mode		0 a 1	1	0		Adjust	Adjust
53	53	ESERIAL	Serial communication address	-	0 a 65535	1	0		Adjust	Adjust
54	54	MCPS1	Way of communication in port 1	-	0 a 2	1	0		Adjust	Adjust
55	55	MCPS2	Way of communication in port 2	-	0 a 1	1	1		Adjust	Adjust
56	56	BAUD1	Data transmission rate of port 1	-	0 a 7	1	5		Adjust	Adjust
57	57	BAUD2	Data transmission rate of port 2	-	0 a 7	1	5		Adjust	Adjust
58	58	HESP	Unsolicited answers	-	0 a 1	1	0		Adjust	Adjust
59	59	ENDREM	Address for unsolicited message	-	0 a 65535	1	0		Adjust	Adjust
60	60	MINREL	Clock minute	-	0 a 59	1	Present		Adjust	Adjust
61	61	HREL	Clock hour	-	0 a 23	1	Present		Adjust	Adjust
62	62	DIAREL	Clock month day	-	1 a 31	1	Present		Adjust	Adjust
63	63	MESREL	Clock month	-	1 a 12	1	Present		Adjust	Adjust
64	64	SEMREL	Clock week day	-	1 a 7	1	Present		Adjust	Adjust
65	65	ANOREL	Clock year	-	0 a 99	1	Present		Adjust	Adjust

CONTROL SETTINGS - DETAILS

1 – VT relation for control unit

Setting value has to be the same as relation between line voltage and control´s reference voltage and can be obtained by reading the nameplate attached to regulator and by observing connections on VT inside control box.

2 - CT relation for control unit

The value set must be equal to the total relationship between line current and control reference current (always 200 mA) and can be obtained reading the nameplate in the tag "Current Transformer".

03 a 36 – Regulation parameters

Values set in these functions will be used as control parameters while the corresponding map remains in effect. In all parameters whose unit is Volt, the value will always be set in relation to the reference voltage, not line voltage.
Insensitivity values items 04, 09, 20 and 33) define the boundary around the corresponding reference voltage (items 03, 08, 19 and 32 respectively) into which the voltage will be considered as acceptable. Thus, if the insensitivity of Map 1 (Article 04) is set to 3.0 V and voltage reference of map 1 (article 3) set to 120.0 V, the led "boost" (rise) will lit only if the measured voltage is less than 117 Vac. Similarly, the led "Buck" (Lower) will lit only if the measured voltage is greater than 123 VAC and current map is map 1.

13, 16, 25 e 29 – validity week of map 2 and 3

With this parameters we set the controller which day of week we will like to change active map. This will be coherence between adjusted value and days of week in which active map is changed as per table 8.

Table 8: week option.

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

Note: if setting is done in "0", active map will not change. If inactive it will not activate. If active it will not get deactivated.

Note: if setting is done in "8", active map will change only considering hour and minute and be repeated during all days of the week.

14, 17, 26 e 30 – Time to set active maps 2 and 3

Value set will be used directly as hour and together with parameters 15, 18, 27 and 31 will determine when maps 2 and 3 are active.

15, 18, 27 e 31 – minute to set active maps 2 and 3

Value set will be used directly as minute and together with parameters 14, 17, 26 and 30 will determine when maps 2 and 3 are active.

24 – Month to set active map 3

When this parameter is set to "0" activation of Map 3 will start based on setting of week, hour and minute done and for values different from "0", eg: between 1 and 12, Map 3 will become effective in the first moment of the month corresponding to the value set, disregarding scheduled setting of week, hour and minute, as shown in table 9.

Table 9: Month options

Valor	0	1	2	3	4	5	6	7	8	9	10	11	12
Month	All	January	February	March	April	May	June	July	August	September	October	November	December

28 – Amount of months where Map 3 is active

In this parameter the CTR-2 is set the number of months in which Map 3 remain active when parameter 24 is programmed with a setting different from "0". In that case the parameters of week, hour and minute for deactivation of map 3 not considered and Map 3 is deactivated when the number of months in active is complied.

Note: Observe that amount of months active of map 3 has priority over activation of map 3. And map 2 activation has priority to parameters of map 1. So, map 1 will be active only when none of the other are active

Note: inverse flow map has priority overall others once inverse power flow is detected and will work according to setting of parameter 43

37 - Activation of automatic load bonus

As most of the energy dissipated in a voltage regulator is concentrated in the series winding is based on this enrollment that regulator cooling system is sized for the total load . For this reason if the range of regulation can be reduced, an increase in the line current can be achieved without compromising the expected isolation lifetime.
This parameter when set to " 0" keeps the regulator in normal working condition following programmed locks in parameters 38 and 39 , and if set to 1 , the control will limit the regulation range in relation to current according to table 10. For example , if the line current reaches 1.25 times the rated current CTR -2 regulates the output voltage so as to ensure the position +10 derivation is not surpassed nor less than -10. If in a position outside this range , the tap changer will be brought to the permitted band even though voltage range is not at the desired level.

38 e 39 – Position lock and manual load bonus

Adjusts the electric switch which limits the action range of the tap changer to the programmed positions from -16 to -8 and from +8 to +16. That's the manual method to implement the load bonus. The lock of maximum position set to 8, for example, means that the tap changer will no longer be boosted when that position is achieved. Similarly, if the minimum block is set to position -8, the regulator will buck until that position is reached.
Table 10 indicates the over current allowed for each limitation set of the tap changer.

Table 10: Current bonus.

Range of voltage regulation (%)	**± 10%**	**± 8,75%**	**± 7,5 %**	**± 6,25%**	**± 5%**
Max. Locking position	+16	+14	+12	+10	+8
Min. Locking position	-16	-14	-12	-10	-8
Over current admitted over nominal	0%	10%	20%	35%	60%

Note: If locks are assymetrically set, active load bonus would be that of bigest absolute value

40 and 41 - Voltage lock

When the line voltage drop compensation is used due to line features and current though it, an additional protection to the first consumer may be required. The CTR-2 control can be programmed to perform compensation of voltage drop in line to regulate at the theoretical center of charge, avoiding that the consumer closer to the regulator is not penalized having an excessive voltage level. This is done by seting the minimum and maximum blocking voltage. When the regulator voltage reference achieves these limits exceeding will not be allow by the control.

The lower voltage limit (Vmin) is the result of subtracting the value of the reference voltage to establish the map active (VREFv) the value set for the insensitivity of the active map (INSv) and the lower limit set in function 40 (LVMIN).
So:

$$Vmin = VREFv - INSv – LVMIN$$

Superior voltage limit (Vmax) is the resulting from adding voltage reference to establish the map active (VREFv) with the value set for the insensitivity of the active map (INSv) and the lower limit established in function 41 (LVMAX).

So:

$$Vmáx = VREFv + INSv + LVMAX$$

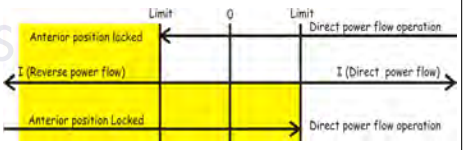
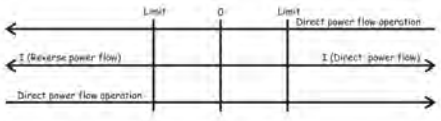
42 – Overcurrent lock

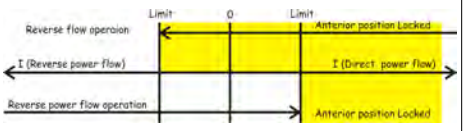
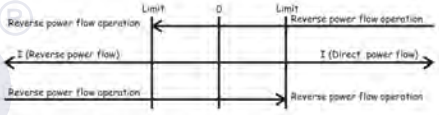
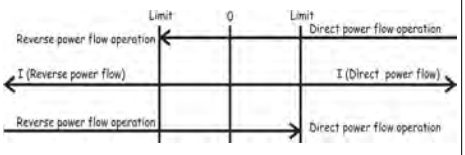
This parameters sets regulator to avoid tap changes in case current is above a desired value so as to avoid damages to drive, contacts, etc. When measured current exceeds nominal current value multiplied by the factor set on this parameter, control will avoid tap changes.

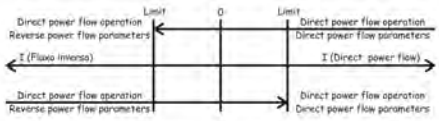
43 - Actuation mode in case of inverse flow

This parameters sets the way CTR-2 control Works when inverse power flow is detected.
Table 11 shows the value of parameter 43 set and the way regulator works.

Table 11: Description of how regulator Works depending on detected flow sense

Firmware			Name	Action	Functional Diagram
>2.5	=2.5	<2.5			
0	0	0	Works on direct flow and locks in inverse flow	Works only in direct flow. To be used only when there is no possibility of inverse flow. For security reasons If CTR-2 detects an inverse current bigger than 1% of regulator nominal current, tap changer is locked until current is once again 1% or bigger but in direct flow	
1	3	3	Works on direct flow and neutralizes when in inverse flow	In case of inverse power flow detection tap changer will automatically go to zero position and lock there. This configuration must be used where direct and inverse power flow can occur, but only want to regulate when direct power flow is detected. When an inverse power flow bigger than the value set on parameter 49 Lock limit (LIMBL) tap changer is taken into neutral position and operations are locked until current is once again equal to or bigger than same value but on direct power flow .where it regulates on direct power flow	
2	5	-	Constant direct power flow	Works only in direct power flow even though an inverse power flow is detected. This has to be used when no inverse power flow can happen	

Firmware			Name	Action	Functional Diagram
>2.5	=2.5	<2.5			
3	1	1	Works on inverse power flow y locks in direct power flow	Works only in inverse power flow. To be used only when there is no possibility of direct flow. For security reasons If CTR-2 detects a direct current bigger than 1% of regulator nominal current, tap changer is locked until current is once again 1% or bigger but in inverse power flow	
4	7	-	Works in inverse power flow and neutralizes in direct flow	In case of direct power flow detection tap changer will automatically go to zero position and lock there. This configuration must be used where direct and inverse power flow can occur, but only want to regulate when inverse power flow is detected. When an direct power flow bigger than the percentage value set on parameter 49 Lock limit (LIMBL) tap changer is taken into neutral position and operations are locked until current is once again equal to or bigger than same value but on inverse power flow .where it regulates on inverse power flow	
5	6	-	Constant inverse flow	Works on inverse power flow, even when a direct power flow is detected. Must be used only when no direct power flow can happen	
6	-	-	Bidirectional locked for currents less than limit	Regulates on both power flow senses. To be used when direct and inverse power flow can happen. IF CTR-2 control detects a current bigger than the percentage value of nominal current set in parameter 49, Lock limit (LIMBL), power flow sense is analyzed and operates regulating according to power flow sense. In currents less than Locl Limit, tap changer is kept without actions and in same tap position that it was when condition si given. For equipments in DELTA, source voltage has to be measured by external VT	
7	2	2	Bidirectional active until the opposite limit	Regulates in both flow ways. It must be used in conditions where there is the possibility of direct and inverse power flow. The controls CTR-2, operate in direct flow until the current in inverse flow is superior to the percentage value of the rated current programmed on screen 49, Blocking Threshold (LIMBL). From this point on they start to work in inverse flow and they stand like this until the current in inverse flow is higher than the blocking threshold programmed on screen 49. For DELTA banks, the voltage on the SOURCE must be measured by external PT.	

Firmware			Name	Action	Functional Diagram
>2.5	=2.5	<2.5			
8	4	4	Co-generation	Regulates only load side on both flow senses and consideres all inverse power flow is due to co-generation. This is to be used when direct and inverse power flow can happen and inverse power flow is caused by a distributed generation set of Little size. CTR-2, when a current in inverse flow is detected bigger than percentage value of nominal current set in parameter 49 Lock Limit (LIMBL) works on inverse flow until current is once again equal to or bigger than same value but on direct power flow where it operates on direct power flow.	

44 - Tap changer actuation, insensibility treatment and extreme locks.

To allow controls CTR-2 of or single phase voltage regulator operate with regulators made by other manufacturers, it is necessary to configure the way the motor needs to work if, continuous or pulse, and whether there are or not switches locking extreme positions. In addition,user can select if CTR-2 will, once motor is activated, change tap until tension exceeds reference tension or if it will change until sensibility limit is achieved.
Adjustments can be made according to table 12.

Table 12: Tap changer working method, insensibility treatment and extreme locking

Valor	Way of actuation and block		
	Motor Actuation	**Bandwidth Tract**	**Extremes blocking**
0	Continuous	For the rated voltage reference	Without switch
1	Pulsed	For the rated voltage reference	Without switch
2	Continuous	For the bandwidth rate	Without switch
3	Pulsed	For the bandwidth rate	Without switch
4	Continuous	For the rated voltage	With switch
5	Continuous	For the bandwidth rate	With switch

Note: For ITB regulators this parameters need to be set in values “0” or “2”.

45 - Tap changer position Reading method

CTR-2 control has two ways to obtain actual tap changer position that can be choosed by programming this parameter as per table 13.

Table 13: tap changer position Reading methods

Value	Method for checking the position of the tap changer	
	Reading Method	**Remote Indication**
0	Absolute BDC encoder real time reading	-16 to +16
1	Absolute BDC encoder real time reading	01 to 33
2	By tracking	-16 to +16
3	By tracking	01 to 33

Note: Options 2 and 3 must be used when absolute encoder cannot be used. It is not 100% secure and thus not reliable for load bonus and máximum/mínimum lock positions

46 - Phase shift between voltage and current

For a regulator to operate properly current dependent operations such as line voltage drop compensation, and display the correct values of power factor CTR-2 is necessary to be adjusted so as to consider the the phase shift between current and voltage that changes depending on the mounting connection. This parameter is set on the control by setting its "DEFVC" function, which can take the "0" (zero) values if there is no lag between voltage and

current, "1" when the current leads ahead by 30 ° in reference to the voltage, or "2", when the current lag was delayed by 30 ° in reference to the voltage.

For regulators installed between phase and neutral.
When connected phase to neutral, the "DEFVC" function must necessarily be set to "0" or that corresponds to the condition that no phase shift between voltage and current when a purely resistive load is considered. This situation occurs in grounded wye and single phase regulation.

Regulators between phases
When the controller is connected between phases as in delta connections , " Def" parameter has to be set by user on CTR -2 to " 1" or "2 " because it cannot be set to "0".
The CTR -2 controls can help user make that determination, being enough to do:
Regulator is connected;
There is enough current to be measured;
The steps described here are followed:
1.Put switch "NORMAL / DISCONNECT / EXTERNAL " key into the " NORMAL" position;
2.SET " DefVC " CTR -2 function control to "1";
3.Read and record the value of the power factor indicated by the CTR -2 control ;
4.Set " DEFVC " CTR -2 function control to "2" ;
5.Read and record the value of the power factor indicated by the CTR -2 control ;
6.Choose between the two values for the power factor that which seems reasonable and set the " DEFVC " function in CTR -2 control to that value (1 or 2).
Repeat the above procedure for the other regulators from the bank and observe that for banks in open delta, one of the regulators keep a " DEFVC " function set to "1" and the other "2" and, for banks closed delta, adjusting the " DEFVC " function for a two regulators will be repeated in the other .

47 - Optional source voltage measurement

In CTR-2 controls, voltage on source side can be measured by setting parameter 47 in “1” or calculated when parameter is set to “0”. If selection is to be measured, an external Voltage Transformer has to be installed in source side with secondary connected between terminal block 26 and earth of terminal blocks in control box. Relation of this VT has to be such that 3Va will be achieved when nominal tension is applied on primary.

Observation 1: when in closed delta, where an inverse power flow condition can exist that is not due to co-generation, the usage of an external VT is mandatory and its primary has to be connected between “S” of regulator of reference phase, understanding that reference phase is that where “FC” of regulator is connected keeping same phase sequence for direct flow

Observation 2: This is optional and has to be requested one purchase order

48 - Enabling Delayed return to automatic mode

In this parameter the CTR-2 has to be teached if to react or not when equipment is abandoned even when energized. With this parameter set to “1” if CTR-2 keeps on service in manual mode operation for more than 15 minutes without accessing front keys or communications ports, operation mode will change to automatic. When this parameter is set to “0” delayed return will keep disabled.

Note: “Auto Zero” (Auto zero) function, if used, disables automatic return to automatic mode. Only when CTR-2 has a new energization will this parameter work again.

49 – Locl limit

This function defines percentage limit over nominal current for which inverse flow is inactive. If effective current over regulators nominal current is less than set value, CTR-2 will not take into consideration modifications of flow sense.

50 - Datalogging period.

The CTR-2 control is capable to obtain and store more than 10000 records of the values hour, minute, day, month, power factor, voltage, current, position of tap changer and operation mode (manual or automatic). Through this parameter, we can adjust the frequency of records logs. The registration period will be equal to the value set in minutes.

51 - Inverse time enabling

You can program the CTR- 2 to reduce time delays in each one of the maps in inverse proportion to the differentiation between the measured voltage and the reference voltage ratio of each map.

If the function is set to " 0", the time delay until the motor is activated for the first tap change is always the same and equal to the time set in functions 05, 10 , 21 and 35 for the active map.
However, if set to "1" , the CTR -2 control will set a new delay timeout depending on what time has been programmed in the active map and the difference between the measured voltage and the reference voltage programmed on the same map according to Tef = T x (Ins / | Vref - Vavg |) equation, where:
" Tef " is equal to the effective time delay of the drive ;
" T" is delay set on active map ;
" Ins" is insensitivity set on active map ;
" Vref " is the programmed voltage to the active map (including securities of LDC) ;
" Vavg " is the instantaneous voltage measurement.

52 – Regulator operation mode

Changing the operation mode from manual to automatic for CTR-2 regulator. If configured in “0” it works on automatic mode, if set to “1” manual mode:

53 - Serial communication address.

As the communication ports allow simultaneous connection of more than one control to a single supervisor system, programming an address on each CTR-2 is needed to ensure there are no communication conflicts. This value can be adjusted between "00000" and "65535" and the communication program ITBComm3 locates the control connected with the selected target address "00000". Regulators with addresses between 00001 and 65535 will have to be seeked manually on ITBComm3.

54 - Port 1 communication mode

The CTR-2 control has 2 simultaneous communication ports doors, including COM1. COM1 can be used in any of 3 possibilities, which are "0", "1" or "2". Using this set to "0" the front door DB9 jack communication port is available for serial EIA 232 communication; Using this set to "1" COM1 the front door USB-A jack communication port is ready for serial connection. Using this parameter set to “2” internal DB9 jack communication port is available for serial EIA 2323 communication.

55 - Port 2 communication mode

The CTR-2 control has a second simultaneous communication port named COM2. Similarly to the COM1, COM2 can be used in two patterns of different outputs which can be programmed through this parameter by selecting an option to "0" or "1". Using this set to "0" COM2 is available for serial EIA 485 communications available in accessible terminals 36 (D-), 37 (D +), 38 (PTT +) and 39 (PTT) of terminal blocks inside control box. Using this set to "1" COM2 is ready for optical connection by ST type sockets located in the internal superior part of control.

56 and 57 - Data transmission bound rate.

COM1 and COM2 of CTR-2 can have independent transmission rate configuration and this are set on parameter 56 for COM1 and 57 for COM2 with values adjusted from 0 to 7 as described in table 14

Table 14: Options of baud rate.

Value	0	1	2	3	4	5	6	7
Rate [kbps]	2,4	4,8	9,6	14,4	19,2	38,4	56	115,2

58 – Enabling unsolicited message

CTR-2 allows unsolicited message generation in DNP-3 and in this parameter control is configured if supervisory system where this is installed accepts this or not. If value is set to “0” no unsolicited messages will be sent. If set to “1” control will send a message any time a digital variable changes state

59 - Address for unsolicited message.

Once parameter 58 is programmed to send unsolicited messages, CTR-2 will send this to the address define don this parameter. Any address between 00000 and 65535 is admitted.

60, 61, 62, 63, 64 and 65 - Clock settings

These parameters allow the adjustment of time: minute, hour, day of month, month, day of week and year of clock respectively. Minute, hour , day of month, month and year are set directly, where year is a two digit value and days of week has to be set from “1” to “7” as shown in table 15

Table 15: Options of days of the week

Valor	1	2	3	4	5	6	7
Week Day	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday

OPERATING WITH EXTERNAL VOLTAGE SOURCE

CTR-2 Control can work with external power source for configuration and testing. External power source needs to be from 90Vac to 145 Vac connected to terminals located on the front panel of control box, identified as

"External supply" keeping phase and neutral indication and placing "Normal / Disconnect / External)" in "External" position.

DANGER: Correct polarity has to be connected on control. Not doing this will cause a short circuit in power supply and damage to control unit

DANGER: Do not connect any power source in terminals of Voltmeter, as it may cause high tensions in bushings with risk to operator and regulator

DANGER: Do not connect any power source in terminals of Voltmeter, as it may damage the VT used for tension reference adjustment

LINE DROP COMPENSATION

Regulators can be installed at some distance from the theoretical load center. This means that the load will not be treated with suitable voltage level as line losses between controller and this point are not considered. Considering line losses are proportional to the load current and the impedance of the line in the segment the voltage drop between the regulator and the theoretical center can be calculated. With this value regulator can increase its voltage such that the regulation occurs as if the reference voltage was measured on the theoretical load center. To grant the regulator the ability to regulate voltage at the theoretical load center, a circuit is incorporated to the control which can be configured to represent an image proportional to the actual reference voltage circuit. Normally this circuit is composed of a current transformer (CT) that produces current proportional to the load current and variable resistive elements (R) and inductive variables (X) through which the current flows. When the load current increases, the resulting current flowing from the CT through these elements produces voltage drop that simulates the voltage drop in the primary line of the TC .
The CTR -2 controls calculated, by internal algorithm, the voltage drop due to resistance and reactance based on proportional to the load current signal obtained by the CT , and the values of voltage drop due to resistance and reactance that can be programmed for each of the maps (1,2,3 and inverse flow) in the functions identified as " Ur - V " and " Ux - V " that can assume values from -25 V to + 25 V .

$$VREft = \sqrt{VREFv^2 - ((Ur * sen\varphi - Ux * cos\varphi) * (I/200))^2 + ((I/200) * (Ur * cos\varphi - UX * sen\varphi))}$$

where:

- "VREft" is effective reference voltage;
- "VREFv" is voltage reference set in actual map;
- "Ur" is the value, in volts, set for resistive voltage drop in active map;
- "φ" is phase shift between current and tension;
- "Ux" is the value, in volts, set for reactive voltage drop in active map;
- "I" is current in mili-ampers measured by CTR-2.

To select adequate values of "Ur – V" and "Ux – V" knowledge of power line to be regulated is needed and to determine theoretically or in fact, voltage drop when current is the nominal current of the regulator and divide by the relation between line tension and control reference.

Note: The possibility of negative values for "Ux - V" happen when a capacitor bank is mounted downstream the regulator and the possibility of negative values for "Ur-V" was kept so you can set the phase shift between current and tension calculated keeping the "Def" function in CTR-2 control to "0". We recall that the definition of lag implies incorrect indication of power factor a, therefore, preferable to use the "Set" function.

INDICATOR IRT-1 (OPTIONAL)

The digital indicator of positions for ITB single-phase step voltage regulator, IRT-1 model, is a microcontrolled device that allows to obtain the position information of the tap changer in real time, through an absolut encoder with 5bits of resolution. It has a display capable of simultaneosly indicate, and visible from the ground, the current position, maximum and minimum reached during regulator operation.
Features such as the absence of moving parts, lack of flexible shafts, untying of the blocking function of the extreme positions and the needlessness to adjust or calibrate, ensure a greater reliability and availability of information. The digital IRT-1 indicator of positions is allocated in a steel cabinet that offers ideal protection to your operation.
The IRT-1 indicator has two power supplies, one is from the electrical network and the other comes from a no-break system, with the ability to indicate the positions within 5 days after de-energized.

Figure 21: IRT-1.

The no-break system comprises a set of 4 rechargeable batteries (1,2V/ 900mAh) AAA size, connected in series. The average battery durability is approximately two years.

It´s not recommend the disposal of batteries in the trash. After use, these items should be disposed of properly, at the risk of occasioning damage to the environment and human health.

ALTERNATIVE DRIVE

Only if formally and expressly required by the customer, through specification and purchase order, the regulator will have at the bottom of the control box, to allow regulator to change tap position without CTR-2 control.
It will be a pulsed three way switch normally disconnected which connects the motor in the boost direction when the lever is in the upper position and to buck when in lower position.

DANGER: As CTR-2 has the position indication function, the usage of alternative switch eliminates the actual tap changer position indication and electrical lock of extreme position, leaving only mechanical lock. The need of redundant lock is needed as, in case of failure, energized regulators may explode

The usage and availability of this is not recommended

DANGER: Usage of this switch is to be done carefully as inside the control box several points have dangerous tensions and changes of tap changer position is done without knowledge of actual position, not having a secure method to know mechanical block has actuated.

INSOLATING OIL –FISPQ

Regulators, as many electrical high voltage devices, have an active inmersed in insulating and cooling mineral oil. Therefore, they are mounted in sealed tanks with pressure relief devices. In operation, these oils can reach high temperatures and also the ambient temperature is a polluter and aggressive agent. We recommend reading the Information Sheet Product Safety Chemical MSDS which contains all necessary information for safe handling, proper disposal, associated risks and actions to make in case of accidents.[1]

LIFE CYCLE

ITB Equipamentos Elétricos Ltda undertakes to receive and dispose properly the equipment produced when it is considered unusable in accordance with the current legislation.

1 *These instructions do not intend to cover all details and possibilities of application, installation, operation or maintenance of the single phase voltage regulators.*
2 *ITB is at your service for further clarification and additional information and reserves the right to promote revisions without prior notification.*

itb®
EQUIPAMENTOS ELÉTRICOS

Rua Devanir Terence, 161 - CEP 16206-012 Birigui - SP
Tel./Fax: 55 18 3643 8000 - www.itb.ind.br - e-mail: itb@itb.ind.br