

Technical Manual

Index

Section	Title	Page
	Security and Warranty	ii
I	Operation Philosophy	I – 1
II	Parallelism System Operation	II – 1
III	Project and Installation	III – 1
IV	Start-up	IV – 1
V	Troubleshooting	V – 1
VI	Appendixes	VI – 1

Note: There is a detailed index of each section in the beginning of them.

Revision History

Rev.	Issued	By	Description
1.00	11-29-2002	-	Original Issue
2.00	11-03-2016	João Victor Miranda	Parameterization update / Access procedure through password / COMM-04 inclusion - Applicable to firmware versions from 1.08 onwards.

SECURITY AND WARRANTY

This manual must be available for technicians responsible for the installation and for Synchronous Parallelism Supervisor (SPS) users.

The Synchronous Parallelism Supervisor (SPS) installation and operation generally does not offer danger for the operators, however the power transformers operation requests special caution and all the applicable standards, safety proceedings, safe working practice and good sense must be used during the equipment installation, operation and maintenance.

WARNING

To assure users safety, equipment protection and correct operation, the following cautions must be taken during the SPS installation and maintenance:

- 1) Read this manual carefully before the SPS installation, operation and maintenance. Faults happened during the installation and adjustments can cause unsafe operation, implicating risks to the equipment, damage and undue trip of the transformer.
- 2) Instructed people who are proficient with control device and power transformers command circuits must do the SPS installation, adjustments and operation.
- 3) Special attention must be taken to the SPS installation (see Section III), including the type and size of the cables used, even as to the procedure during the start-up (Section IV), including the equipment parameterization.

TERM OF WARRANTY

The Synchronous Parallelism Supervisor shall be warranted by Treetech during 2 (two) years, counting from the acquisition date, exclusively for instances of eventual manufacture defects or quality flaws that can turn the equipment incapable to regular usage.

The warranty does not include damages caused to the product, upon accidents, maltreatment, improper handling, improper installation and application, improper testing and disruption of the warranty label.

The eventual requirement of technical assistance must be reported to TREETECH, or to a technical assistance designed by TREETECH.

None warranty, expressed or implied, further those mentioned above is provided by Treetech. Treetech does not provide any warranty of SPS adequacy for a particular application.

The seller shall not be liable for any property damages whatsoever or for any loss or damage arising out of, connected with, or resulting from this contract, or from the performance or breach thereof, or from all services possibly furnished together with the equipment.

In no event shall the seller be liable for special, incidental, exemplary, or consequential damages, including but not limited to, loss of profits or revenue, loss of use of the equipment or any associated equipment, cost of capital, cost of purchased power, cost of substitute equipment, facilities or services, downtime costs, or claims or damages of customers or employees of the Buyer for such damages, regardless of whether said claim or damages is based on contract, warranty, tort including negligence, or otherwise.

Under no circumstance shall the Seller be liable for any personal injury whatsoever.

Section I – Operation Philosophy

Index of Subjects

Chapter	Title	Page
1	Introduction	I - 2
2	Parallelism Basic Philosophy	I - 3
2.1	Parallel operation of single-phase transformers banks	I - 4
2.2	Manual/Automatic Command Modes	I - 7
2.3	Local/Remote Command Modes	I - 7

Index of Pictures

Picture	Title	Page
1.1	Synchronous Parallelism Supervisor and Communication Module COMM	I - 2
2.1	Parallel operation of three-phase transformers	I - 4
2.2	Parallel operation of three-phase banks composed by single-phase units	I - 5
2.3.a	Individual bank operation in “Bank” mode	I – 6
2.3.b	Individual bank operation in “Individual Phase” mode	I - 6

1. Introduction

The synchronous parallelism supervisor SPS is a device developed by Treetech to control and to supervise the parallel operation of the power transformers equipped with on-load tap changer.

Based on microcontrollers, the SPS incorporates the functions of several equipment gears that were used in past times for controlling the transformers parallelism, such as selector switches Master/Follower/Individual, Manual/Automatic and Local/Remote, indicators of tap position, auxiliary relay for electromechanical logic, among others. For this reason, the command wiring and the number of components are strongly reduced, raising substantially the general reliability and reducing the tests and installation work time, besides that it greatly simplifies the equipment maintenance.

The SPS is even provided by signaling output contacts, indication of tap position by current loop output, dry contacts input for remote command and serial port RS485, allowing complete data acquirement and total control of the parallelism system by distance through the Communication Module COMM-04, integrant part of the parallelism system SPS.

The equipment was totally projected and tested for operating in the most unfavorable conditions found in electric substations, such as surges, impulses, electromagnetic interference and extreme temperatures.

Its operation philosophy is based on the Master-Follower method, as described in the chapter "Parallelism Basic Philosophy".



Figure 1.1 – Synchronous Parallelism Supervisor SPS and Communication Module COMM-04

2. Parallelism Basic Philosophy

Several reasons can lead to the parallel operation option of power transformers. For example, the necessity of increase the load power or increasing the reliability in the power supply, among others.

To enable the parallel option, one of the principal preoccupations must be to prevent the occurrence of circulation currents among the parallel windings, what occurs, for example, if they have distinct voltages. In transformers with fixed transformation ratio, this preoccupation is limited to the project stage, which once correctly performed assures the perfect equipment operation.

It does not occur the same in transformers supplied with On-Load Tap Changer (OLTC), once these last can change it's transformation ratio freely during the operation. Therefore, there must be the preoccupation during the project step that there is correspondence between the taps of both transformers, however, there also must be the caution that, once in operation, the OLTCs of the parallel transformers be in equivalent tap positions, in such manner that the circulation current be next to zero.

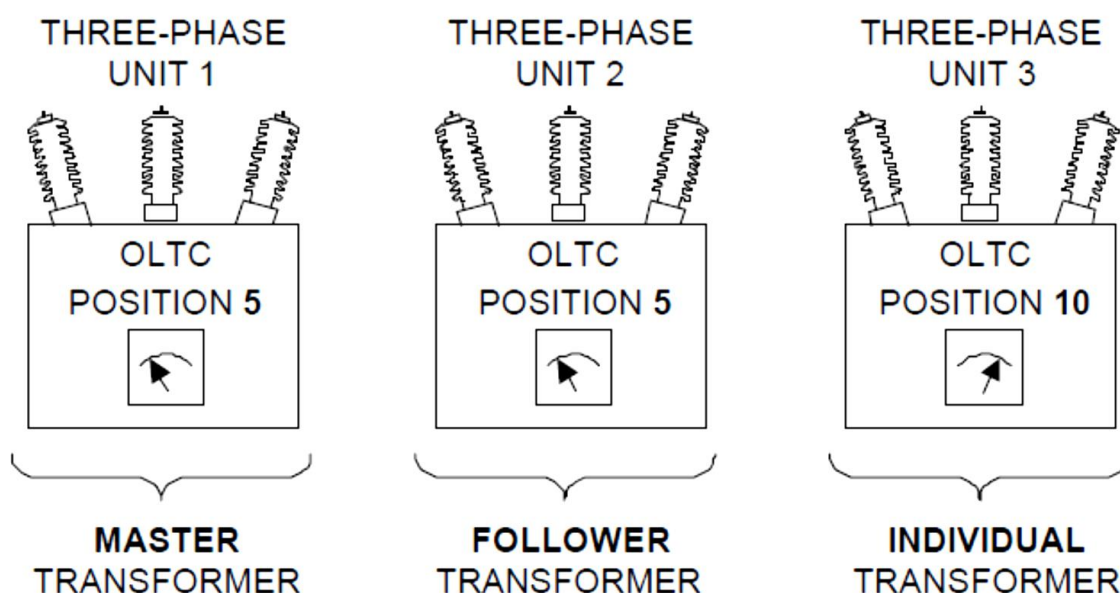
Commonly, the transformers operated in parallel have the same number of tap positions, directly corresponding between the several OLTCs, it means, the OLTCs must operate in equal numeric positions for obtaining the minimal circulation current.

In these instances, the parallelism control philosophy commonly used is called "Master-Follower" (or Master-Slave), where one of the transformers is selected as Master and the others as Followers. This is the philosophy adopted by the SPS, and according to it all the commands of position change performed by the Master must be reproduced by the Followers, keeping the taps conformity.

If any of the OLTCs do not follow the command, the full system must stay blocked, blocking new position changes, and there must be emitted an alarm signaling the occurrence.

If necessary, any transformer can be removed of the parallel operation, selecting it as Individual. In this case, your OLTC will not keep position synchronism with the

Master, will not even reproduce any blockade or alarm by position unconformity.
See Picture 2.1.



Picture 2.1 – Parallel operation of three-phase transformers

Any of the transformers can be freely selected as Master, Follower or Individual, since there is not more than one Master and there are not Followers without a Master. The lay displayed in the Picture 2.1 is an example of one of the possible distributions of the Master, Followed or Individual selections. These selections can be changed at any time during the parallel operation.

2.1 Parallel operation of single-phase transformer banks

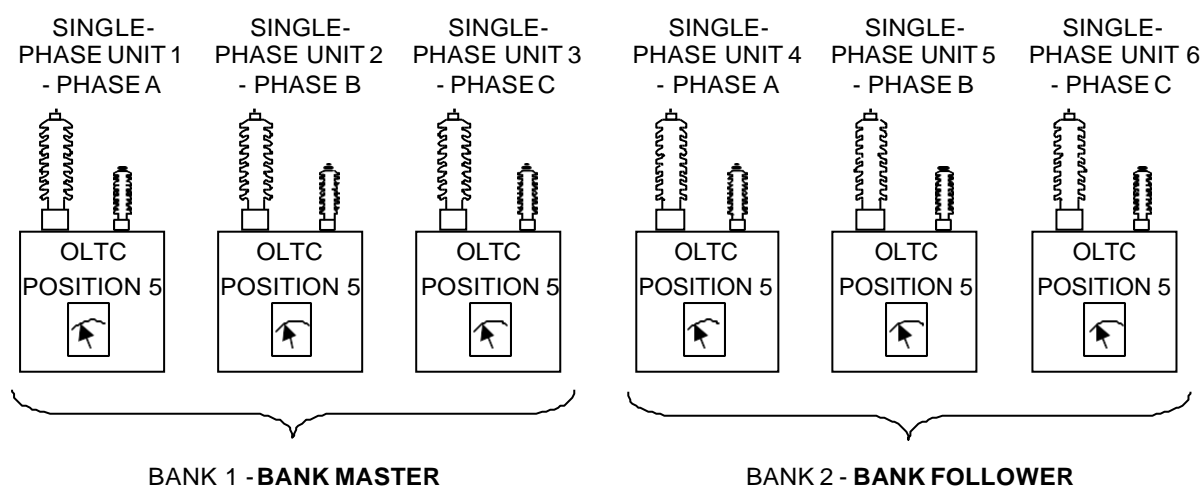
The parallel operation of three-phase banks composed by independent single-phase units is an specific case of transformers parallelism, that despite follows the same basic philosophy mentioned above for three-phase transformers, has same peculiarities

Each single-phase unity that composes three-phase bank is supplied by it's own On-Load Tap Changer, what requires that two conditions be followed for the correct system operation:

- a) That all the phases of a given bank be in the same tap position, so that there is not voltage unbalance in the three-phase system;
- b) That the OLTCs positions of the different banks be concordant, in such manner that there is not circulation current among the banks.

Particularly in this manual, the three single-phase units of a three-phase bank are regarded, when applicable, as they were only one three-phase transformer, in such manner that the Master, Followed and Individual selections are applied always referring to the bank condition as a whole, never referring separately to a single-phase unity condition. See Picture 2.2.

In fact, in common operation conditions, the three single-phase units of a bank will behave as they were a single three-phase transformer.



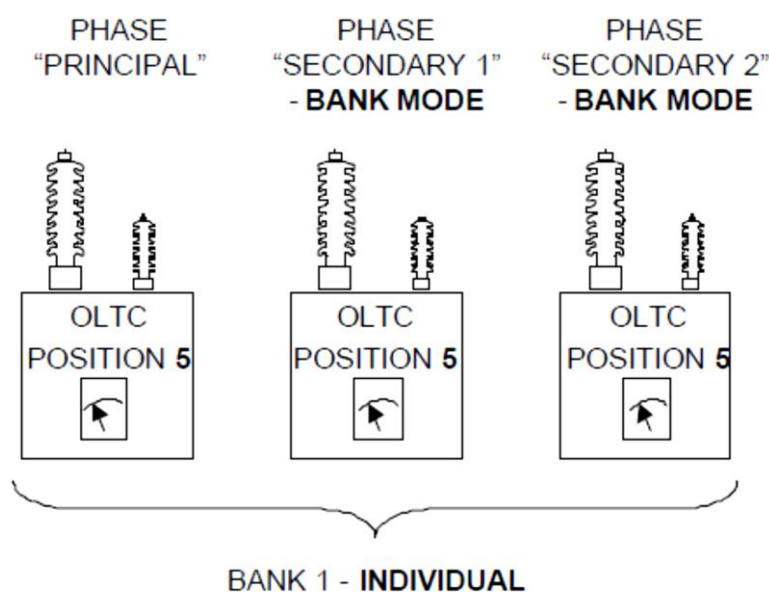
Picture 2.2 – Three-phase banks parallel operation composed by single-phase units.

Inside in a same bank, the three phases are identified as "Principal", "Secondary 1" and "Secondary 2". If the bank is selected to Individual mode, there are two possible operation conditions:

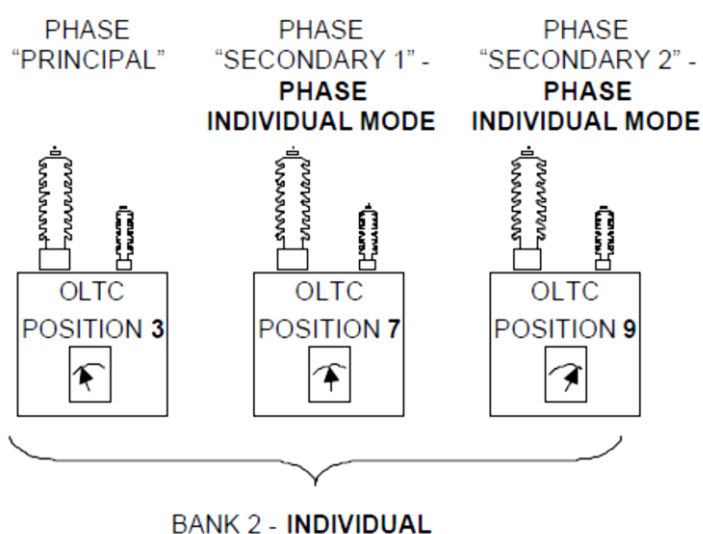
- a) The operation as "Bank", in other words, as it was an only three-phase transformer, keeping the synchronism of the positions between the bank phases. This is the most common operation possibility, and in this case the

"Secondary 1" and "Secondary 2" phases use the "Principal" phase of OLTC position as reference for synchronism verification between the bank phases. See Picture 2.3.a;

b) The operation as "Individual phase", commonly used just for maintenance and tests purposes. In this mode a given phase can be operated singly in the manual mode. This operation mode is only possible if the bank is not in parallel with any other and if it's not in automatic command mode. See Picture 2.3.b.



Picture 2.3.a - Individual bank operation in "Bank" mode.



Picture 2.3.b - Individual bank operation in "Individual Phase" mode.

2.2 Manual/Automatic Command Modes

Regarding to the type raise/lower tap command for the OLTCs, there are two possibilities: Manual Command or Automatic Command. By selecting the Manual Command mode, the tap changes occur only when requested by the operator, while in the Automatic Mode they are able the raise/lower tap commands sent by an Automatic Voltage Regulator Relay (relay 90).

The Automatic or Manual commands selection only have practical effect in the transformers (or banks) that are in Master or Individual mode. In the Follower mode, the Manual/Automatic selection is indifferent, because the Follower only keeps its OLTC synchronized with the Master, and it does not have a command by itself.

Such as for the Master, Follower and Individual selections, in the transformers banks, the Manual/Automatic selections are applied always referring to the global bank condition, never referring singly to a single-phase unity condition.

2.3 Local/Remote Command Modes

Regarding to the local from where can be performed the selections Master/Follower/Individual and Automatic/Manual and the commands raise/lower tap, there are three possibilities:

- a) Local Command, by the SPS front switches;
- b) Remote Command, by external dry contacts connected to the SPS;
- c) Remote Command, by the serial communication RS485, from a supervisor system.

If the Local Command is selected, both of the remote command modes remain blocked (in case of serial communication, only the information acquisition is possible). If the Remote command be selected, the system operation by the front keyboard remains blocked, liberating both of the remote command modes. In general, only one of the both remote command options is used, because one eliminates other's necessity. Even as for Master, Follower and Individual

selections, in case of transformers banks, the Local/Remote selections are applied always referring to the bank condition as a whole, never been referred singly to the single-phase unity condition.

Section II – Parallelism System Operation

Index of Subjects

Chapter	Title	Page
3	Local Operation of the SPS Parallelism System	II – 3
3.1	Primary indications in the display	II – 3
3.2	Local/Remote, Master/Follower/Individual and Manual/Automatic Selections	II – 4
3.3	Bank/Individual Phase Selection	II – 6
3.4	Raise/Lower Tap manual command	II – 7
3.5	Examples of Raise/Lower Tap command	II – 8
3.5.1	Three-phase Transformer	II – 8
3.5.2	Single-phase TransformersBank	II – 10
3.6	Error Conditions Alarms	II – 11
3.6.1	Synchronism Error (E01)	II – 12
3.6.2	COMM-04 and SPS Communication Error (E02)	II – 13
3.6.3	Programming Error (E04)	II – 14
3.6.4	Tap Position Reading Error (E08)	II – 15
3.7	Blockades due to error conditions	II – 16
3.8	System Operation during errors presence	II – 17
3.8.1	Three-phase Transformers	II – 18
3.8.1.1	E01 – Synchronism Error	II – 18
3.8.1.2	E02 - COMM-04 and SPS Communication Error	II – 19
3.8.1.3	E04 - Programming Error	II – 20
3.8.1.4	E08 - Tap Position Reading Error	II – 20
3.8.2	Three-phase Banks composed by Single-phase Transformers	II – 22

Index of Subjects (continues)

Chapter	Title	Page
3.8.2.1	E01 - Synchronism Error	II – 22
3.8.2.2	E02 - COMM-04 and SPS Communication Error	II – 24
3.8.2.3	E04 - Programming Error	II – 25
3.8.2.4	E08 - Tap Position Reading Error	II – 26

Index of Pictures

Picture	Title	Page
3.1	Indication of the tap changer current position	II - 3
3.2	Indication during a change of a position in progress	II - 3
3.3	Indication during an error condition occurrence	II - 4
3.4.a	Raise command example – Initial status (before the command)	II - 8
3.4.b	Raise command example – Final status (after the command)	II – 8
3.5.a	Lower command example - Initial status (before the command)	II – 9
3.5.b	Lower command example - Final status (after the command)	II – 9
3.6.a	Raise command example – Initial status (before the command)	II – 10
3.6.b	Raise command example – Final status (after the command)	II – 10
3.7.a	Command example - Initial status (before the commands raise/lower)	II – 11
3.7.b	Command example - Final status (before the commands raise/lower)	II – 11

3. Local Operation of the SPS Parallelism System

The local operation of the parallelism system is done by the SPS front panel, using the P, ↑ and ↓ keys, with the support of the equipment display.

3.1 Primary indications in the display

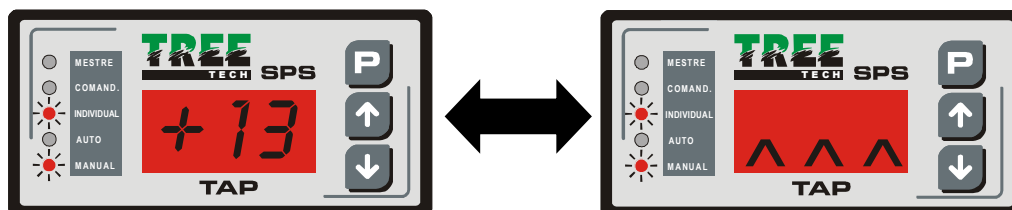
During the system autonomous operation, without the operator intervention by the front keys, the SPS display can accomplish one of the following indications:

- a) Current position of the on-load tap changer associated to it. The display indicates permanently this information, which can be shown by simple numeric, bilateral numeric or alphanumeric formats (for example: 1...17, - 8...0...+8 or 8L...N...8R respectively). See picture 3.1;



Picture 3.1 – Indication of the tap changer current position

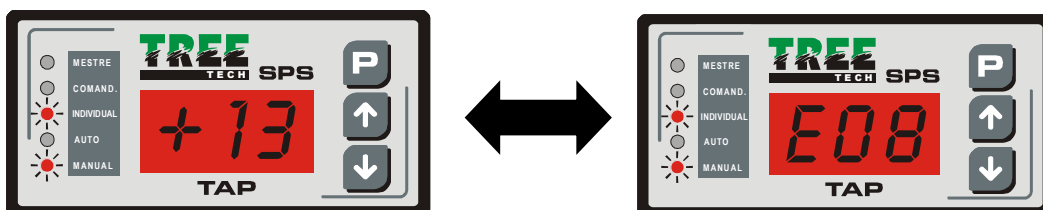
- b) Periodical indication of the tap changer current position and periodical indication of the symbols ↑↑↑ or ↓↓↓, if a tap change is in progress to tap raise or lower respectively. See picture 3.2;



Picture 3.2 – Indication during a change of a position in progress

- c) Periodical indication of the tap changer current position and periodical indication of an error code. The description of the possible error conditions

and of the associated codes can be verified in the item 3.6. See picture 3.3.



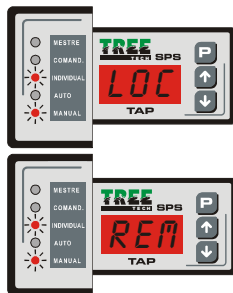
Picture 3.3 – Indication during an error condition occurrence

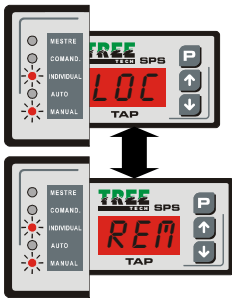


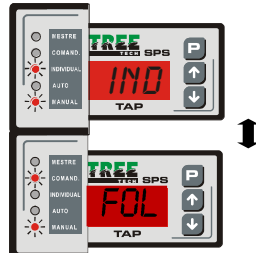
During the operator interventions by the front keyboard, the indications in the display are the following described in the item 3.2.

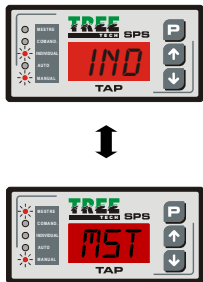

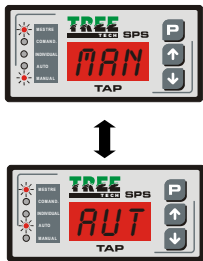

3.2 Local/Remote, Master/Follower/Individual and Manual/Automatic Selections

The Local/Remote, Master/Follower/Individual and Manual/Automatic selections can be operated in local manner, by the SPS front keyboard, as described below.

In cases of single -phase transformers banks, these selections are accomplished using the front of the “Principal” SPS, however it is important to keep in mind that these selections are available to the bank as a whole and not only as the “Principal” phase.

Procedure	Effect	Preview
Press Key moment. ou	It is accessed the first programming menu, with the Local/Remote selection. The current status of this selection is displayed respectively by LOC or REM codes..	




<p>Press ↑ or ↓ keys for a moment.</p>	<p>The selection is changed from Local to Remote or vice versa.</p>	
<p>Press Key P for a moment</p>	<p>If during the previous step, the Remote mode was selected, the SPS exits the programming menu, returning to the condition described in 3.1</p>	
	<p>If during the previous step, the local mode was selected, it is accessed the second programming menu, with Master/Follower/Individual selection. The current status of this selection is displayed respectively by MST, FOL or IND codes.</p>	
<p>Press ↑ or ↓ keys for a moment</p>	<p>The selection Individual is changed to Follower or vice versa if there is another transformer bank selected as Master in the system.</p>	

	<p>The selection Individual is changed to Master or vice versa if there is not another transformer or bank selected as Master in the system.</p>	
<p>Press Key P for a moment</p>	<p>During the Manual/Automatic selection the third programming menu is accessed. The current status of this selection is displayed respectively by MAN or AUT codes.</p>	
<p>Press ↑ or ↓ keys for a moment</p>	<p>The selection is changed from Manual to Automatic or vice versa.</p>	
<p>Press Key P for a moment</p>	<p>The SPS exits the programming menu, returning to the condition described in 3.1</p>	

3.3 Bank/Individual Phase Selection

The Bank/Individual Phase selection is used only during the three-phase banks composed by single-phase units “Secondary 1” and “Secondary 2” steps. This item is not used in three-phase transformers.

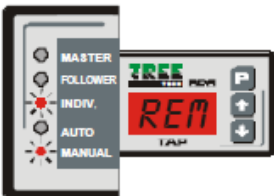
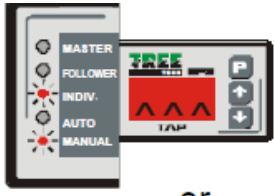
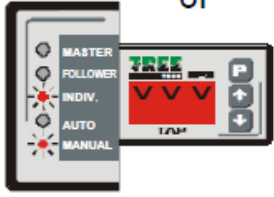
This selection can be can be operated in local manner, by the SPS front keyboard, as described below.

Procedure	Effects	Preview
Press Key P for a moment	It is accessed the programming menu with the Bank/Individual Phase selection. The current status is displayed respectively BAN or MAN codes.	
Press ↑ or ↓ keys for a moment	The Bank Selection is changed to Individual Phase selection or vice versa if the corresponding “Principal” phase is in the Individual and Manual modes.	
	If the corresponding “Principal” phase is not in the in the Individual and Manual modes, this selection keeps in the Bank mode and the Individual Phase selection is not accepted	
Press Key P for a moment	The SPS exits the programming menu, returning to the condition described in 3.1	

3.4 Raise/Lower Tap manual command

The manual command to Raise and Low the position of the on-load tap changer can be operated in local manner, using the ↑ and ↓ keys of the SPS front, as described below. These commands will only be followed if a previous selection of the Local and Manual command modes is done, and if the transformer (or bank) is not in the Follower mode.

In the three-phase bank composed by single-phase units, the manual command to raise or low tap during the “Secondary 1” and “Secondary 2” phases only will be followed if the corresponding SPS have been previously selected in Individual Phase mode. If this selection is in Bank mode, the “Secondary 1” and “Secondary2” phases will only follow simultaneously the raise/lower commands originated in the bank “Principal” phase.

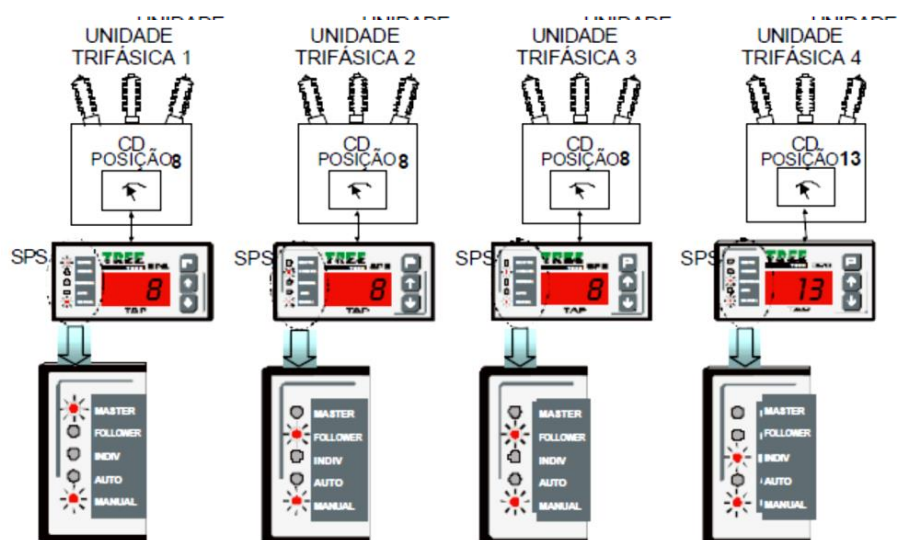
Procedure	Effect	Preview
Press ↑ or ↓ keys for a moment	If the transformer (or bank) is in the Remote mode, the display will show a REM message during 1 second, indicating that the command will not be followed, because the transformer (or bank) is selected in this mode.	
	If the Local and Manual command modes are selected, and if the transformer (or bank) is not in the Follower mode, the corresponding command will be sent to the on-load tap changer, and it will be displayed that the tap change is in progress by the periodical indication of the ↑↑↑ or ↓↓↓ symbols on the display.	 or 
	If the ↑↑↑ or ↓↓↓ symbols are not been periodically indicated yet in the display, it will not be accepted a new command to tap raise or low, because the previous tap change can be still in progress.	

3.5 Examples of Raise/Lower Tap Command

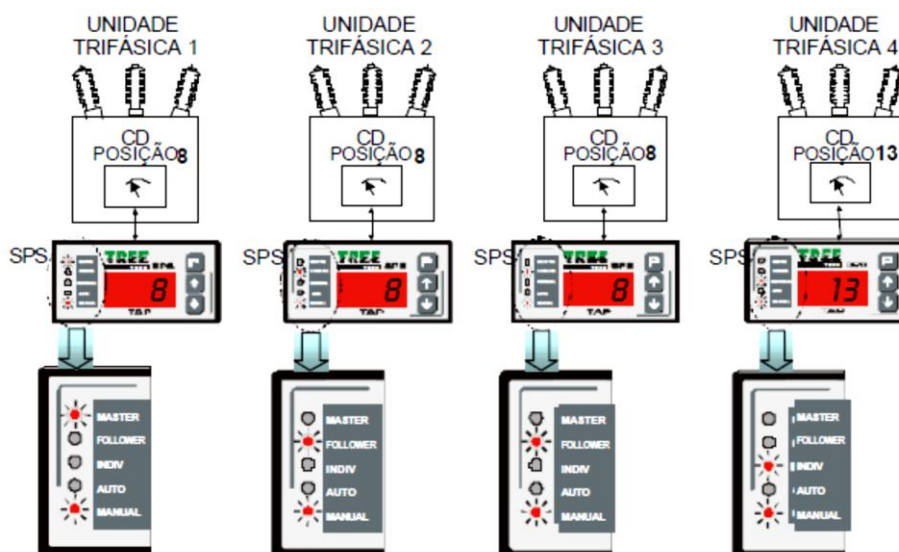
Examples of Raise/Lower tap commands are presented below in several parallelism system situations and configurations.

3.5.1 Three-phase Transformers

- a) One Master transformer, two Followers, one Individual. Raise command done in the Master SPS. See pictures 3.4.a (initial status) and 3.4.b (final status).

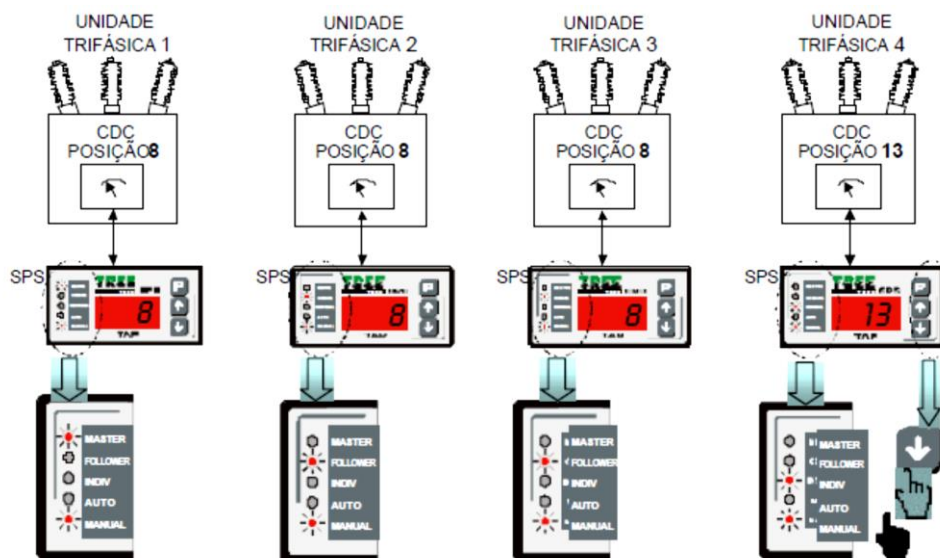


Picture 3.4.a – Example of Raise command – Initial Status (before the command)

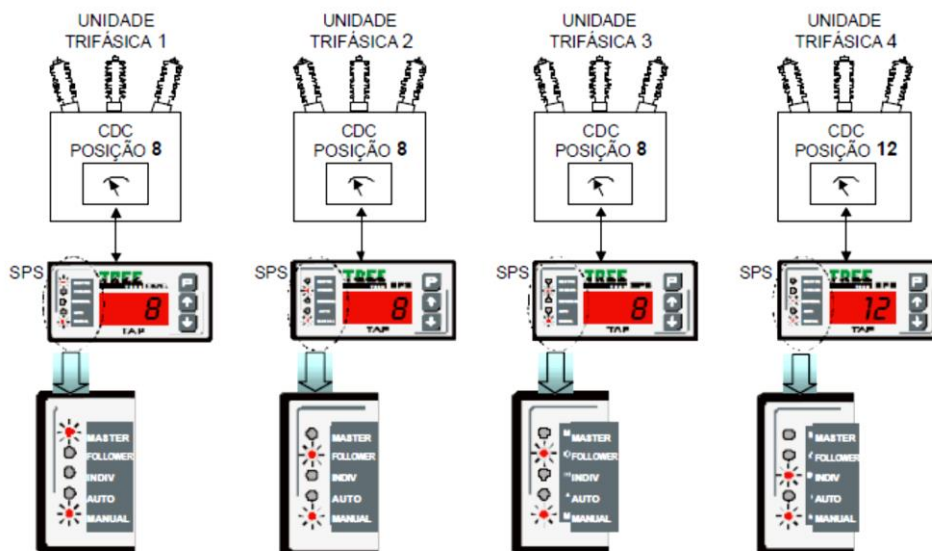


Picture 3.4.b – Example of Raise command – Final Status (after the command)

- b) One Master transformer, two Followers, one Individual. Lower Command done in the Individual SPS. See pictures 3.5.a (initial status) and 3.5.b (final status).



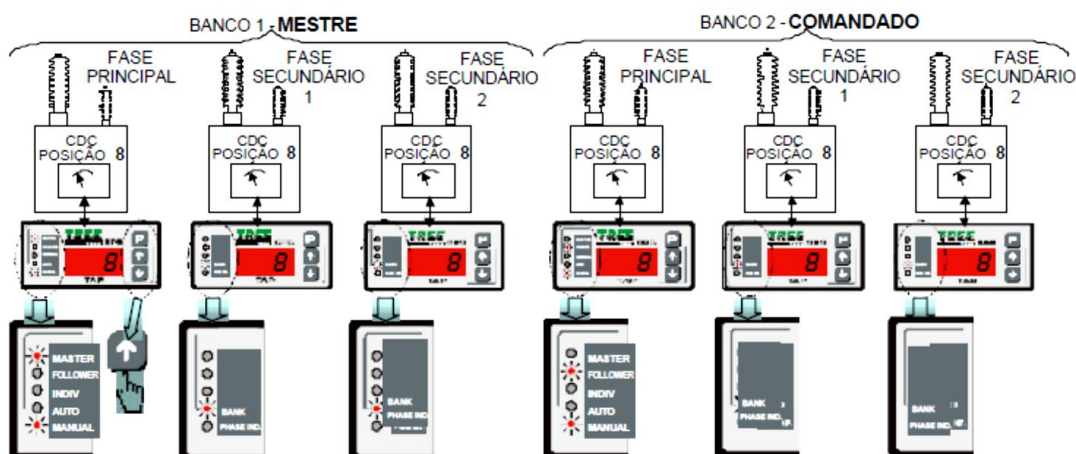
Picture 3.5.a – Example of Lower command – Initial Status (before the command)



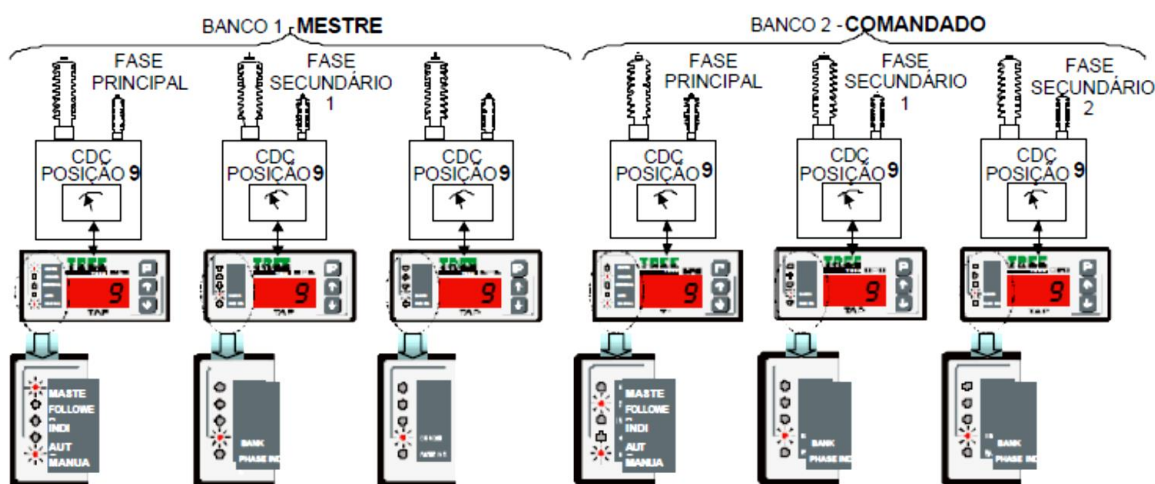
Picture 3.5.b – Example of Lower command – Final Status (after the command)

3.5.2 Single-Phase Transformers Bank

- a) One Master bank, one Follower bank. Raise command done in the Master bank. See pictures 3.6.a (initial status) e 3.6.b (final status).



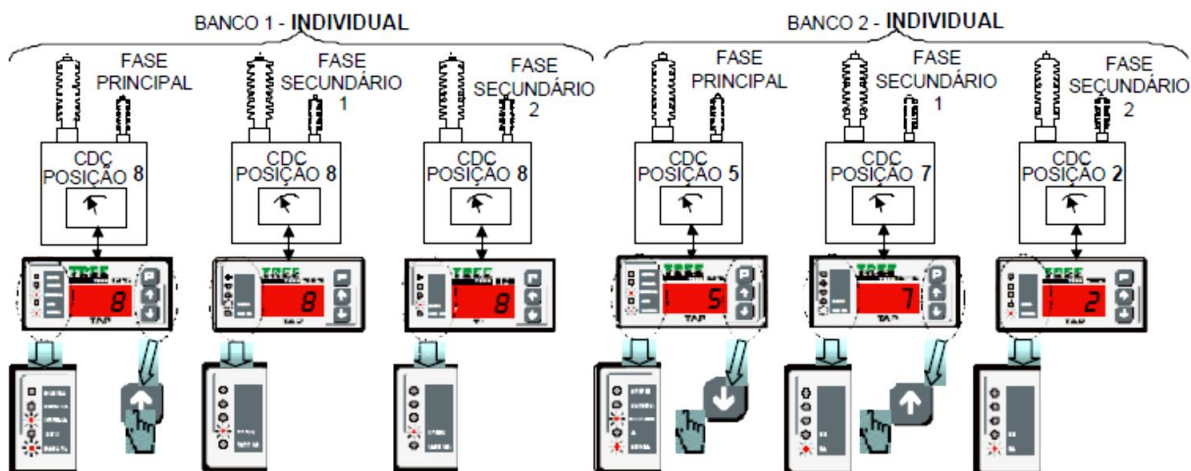
Picture 3.6.a – Example of Raise command – Initial Status (before the command)



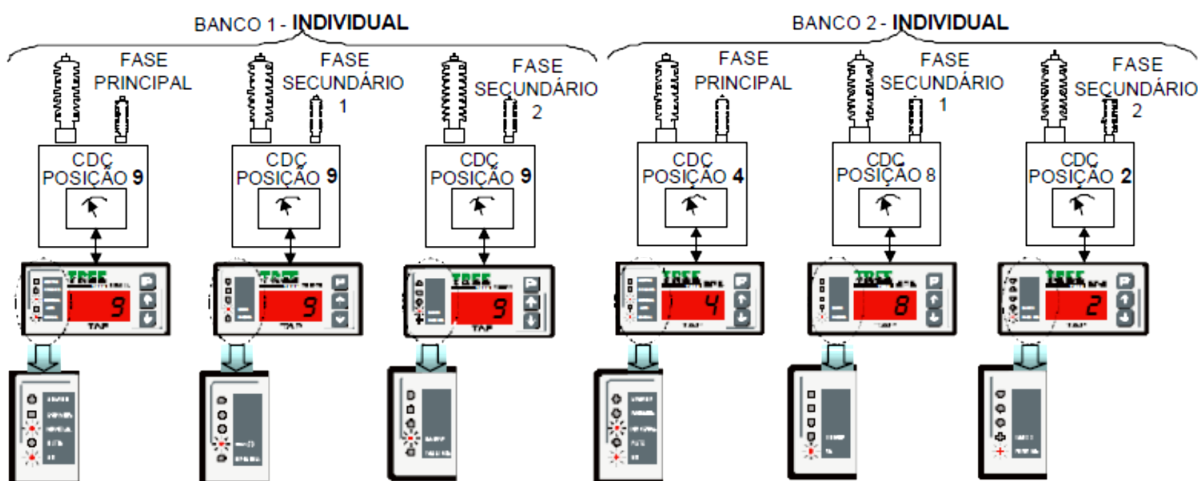
Picture 3.6.b – Example of Raise command – Final Status (after the command)

- b) Bank 1 in Individual, with “Secondary 1” and “Secondary 2” phases in “Bank” mode, raise command done in the “Principal” phase. Bank 2 in Individual, with “Secondary 1” and “Secondary 2” phases in “Individual Phase” mode, lower command done in the “Principal” phase and raise command done in the “Secondary 1” phase. See pictures 3.7.a (initial status) and 3.7.b (final

status).



Picture 3.7.a – Command example - Initial status (before the command raise/lower)



Picture 3.7.b – Command example - Final status (after the command raise/lower)

3.6 Error Conditions Alarms

The several alarm conditions of the SPS are signalized in the front display by the error codes listed below, besides that it allows its remote signaling by output contacts, as described in sub-chapter 5.6. The function of each SPS signaling

contact is programmable, so that a certain error condition will only be signaled by output contact if it has been previously established for one or more output contacts.

All the error indications are automatically restarted, in other words, the indication displayed disappears when the error condition is eliminated, the same occurs with the corresponding signaling contact, which returns to its repose condition.

Code	Error Condition
E01	Synchronism error
E02	COMM-04 and SPS Communication error
E04	Programming error
E05	Simultaneous occurrence of E01 and E04 errors
E08	Tap position reading error
E10	Simultaneous occurrence of E02 and E08 errors
E12	Simultaneous occurrence of E04 and E08 errors

3.6.1 Synchronism Error (E01)

It is caused by a difference in the tap position of tap changers that should be in synchronism. In single-phase transformer banks, there are two types:

- a) Synchronism error among banks – one of the Follower banks is not at the same tap position as the Master bank;
- b) Synchronism error among the phases – the “Secondary 1” and/or “Secondary 2” phases are not at the same tap position as the “Principal” phase of the same bank.

In three-phase transformers, only the first type is applied, in other words, one of the Follower transformers is not at the same tap position as the Master transformer.

Due to the fact that time differences of tap changes can occur among the parallel transformers, the synchronism error just happens after doing a previous timer, adjustable by the user (see sub-chapter 9.1.8).

The synchronism error code (E01) is indicated in the SPS display, which tap position is not in synchronism.

Without putting away another possibilities that can be verified, the possible causes for this error are:

- On-load tap changer defects which can block it to operate a tap change;
- Poor contact or interruption in the tap raise/lower command between the SPS and the charger under load;
- Tap changing operation accomplished in the tap changer command cabinet, without its own SPS have previously been selected in the Individual mode or Individual phase, according to the case.

3.6.2 COMM-04 and SPS Communication Error (E02)

It is caused by a failure in the serial communication that is continuously accomplished among each SPS and the COMM-04 through their RS485 ports. This error can occur by two distinct manners:

- a) The SPS does not receive the communication signals originated by the COMM-04 (or it receives them with errors) during a superior period that is allowed by the SPS (time-out = 5 seconds). In this case, the error code is indicated in the SPS display which did not receive the communication signal;
- b) The COMM-04 does not receive reply (or it receives it with errors) from any of the SPS in three sequent communication tries. In this case, the error code is not indicated in the SPS display, because they are receiving normally the communication signals from the COMM-04. However, the COMM-04 transmits the information of error occurrence via serial, causing the signaling contact interaction, eventually programmed for this function.

Without putting away another possibilities that can be verified, the possible causes for this error are:

- Lack of auxiliary power for one of the SPS or for the COMM;
- Poor contact or interruption in the RS485 serial between the SPS and the COMM;
- The usage of the connection cables which are not the shielded twisted-pair type, letting the serial communication susceptible to electromagnetic interference;
- Lack of grounding of the serial communication cables shield, letting the serial communication susceptible to electromagnetic interference;
- Grounding of the serial communication cable shield in more than one point, causing current circulation through the shield due to ground potential differences;
- Defect of one of the SPS or defect in the COMM.

3.6.3 Programming Error (E04)

The programming conditions listed below are considered invalid, and always it is possible the parallelism system will try to prevent them.

- a) The existence of more than one Master in the parallelism system;
- b) The existence of one or more Followers without a Master in the parallelism system;
- c) The programming of a transformer (or bank) as Follower without it's tap position is equal to the Master's;
- d) The programming of "Secondary 1" or "Secondary 2" phases in bank mode without it's tap position is equal to the "Principal" phase (only for single-phase transformers banks);
- e) The programming of a bank in Automatic mode without the "Secondary 1" and "Secondary 2" phases are in tap position equal to the "Principal" phase (only for single-phase transformers banks).

It will be emitted the programming error alarm if any of these conditions occur or if the attempt of forcing the invalid condition persists for a superior period to the lag programmed by the user (see sub -chapter 9.1.9). The momentary attempt of programming an invalid condition will not generate the programming error notification if this attempt persists during an inferior period to this lag.

Generally, the SPS does not accept the invalid condition that is being attempted to program, and it keeps the previous valid condition. Possible exceptions to this rule are the a) b) items above, for example, if two Master are programmed simultaneously, because the system will not have conditions to verify the previous existence of a Master. Another possibility is the communication fail of any of the SPS, what can generate an invalid programming condition, for example: if the Master SPS communication fails, the Followers SPS can emit the E 04 error due to the existence of a Follower without a Master.

The programming error code (E04) is shown in the SPS display where the invalid condition is present (or where the attempt to program it is).

3.6.4 Tap Position Reading Error (E08)

It is caused by a reading fail of the current tap position of the charger under load, and it is detected by the following reading consistency verifications. For each one of these verifications is applied an error cause code, that is stored for posterior verification by the maintenance department.

- a) Internal Error in the communication between the tap reading microcontroller and the principal microcontroller. This reading error cause is stored as the "C1" code,
- b) Unstable tap position reading, in other words, floating much more fast than what would be possible for the normal operation of the charger under load. This reading error cause is stored as the "C2" code,

- c) Inconsistency in the tap position calculated from the several resistance measurements accomplished in the potentiometric transmitter of the tap changer. This reading error cause is stored as the "C3" code.

Without putting away another possibilities that can be verified, the possible causes for this error are:

- Excessive electromagnetic interference in the measurement cables of the potentiometric position transmitter, due to the usage of non-shielded cables (C2 cause);
- Excessive electromagnetic interference due to the lack of grounding of the measurement cables shield of the potentiometric position transmitter (C2 cause);
- Excessive Electromagnetic interference due to the lack of grounding of the measurement cables shield of the potentiometric position transmitter in more than one point, enabling the current circulation by the shield due to the ground potential differences (C2 cause);
- Poor contact in the cursor of the potentiometric position transmitter or in the connection cables from this one to the SPS (C3 cause);
- Connection cables from the potentiometric position transmitter to the SPS with resistance superior to 8Ω per wire - very reduced size due to the roaming distance (C3 cause);
- Connection cables from the potentiometric position transmitter to the SPS with different sizes or with different lengths in each wire (C3 cause);
- Defect in the SPS tap measurement circuit (C1 cause).

3.7 Blockades due to error conditions

All the error conditions listed above in the 3.6 item cause some blockade level in the parallelism system, as follows:

- Blockade of the SPS that detected (or where occurred) the error;
- Blockade of the SPS Master, if the error occurred in a Follower transformer (or bank), in such manner that do not occur new position changes that would cause a tap difference among the parallel transformers (or that would cause an increasing to a previous existent tap difference);
- Blockade of the "Principal" SPS of an Individual bank, if the error occurred in one of the "Secondary" phases in the bank mode, in such manner that do not occur new position changes that would cause a tap difference between the bank phases (or that would cause an increasing to a previous existent tap difference).

3.8 System Operation during errors presence

An ideal proceeding during any error occurrence is, naturally, detecting and correcting its cause before continue the operation of the parallelism system.

However, when this proceeding is not possible to be done, or when there is no time left to the problem correction, due to the prompt necessity of the system operation, some emergency proceedings can be used, as suggested bellow. It must be taken all cares related to the indicated Special Cautions, to prevent conditions with disconnection chances by the protection acting or even with risk to the transformers integrity.

There are circumstances that must be observed in cases of three-phase transformers and single-phase transformer banks. For this reason the procedures are subdivided into these two cases.

3.8.1 Three-phase Transformers

3.8.1.1 E01 – Synchronism Error

Error condition and its Local	<ul style="list-style-type: none"> • E01 (synchronism error) • Error in only one of the Follower transformers
Contingency Procedure	<ul style="list-style-type: none"> • Select the whole parallelism system for operating in the Manual mode; • Select the transformer where the error occurs as Individual. The Master and the Followers without error will be liberated from blockade, being able to have its tap position manually changed.
Special Cautions	<ul style="list-style-type: none"> • The transformer that presented the error must have its tap position manually changed to follow the tap position of the other units that are operating in parallel, in such manner that the current circulation is prevented; • The unity that presented the error may not reply to the raise/lower commands (this can be the error cause), and in this case it may be necessary to operate it locally, by using the crank; • Do not keep any part of the system in the Automatic mode, because unexpected tap changes could happen that would cause tap difference and current circulation among the transformers.

Error condition and its Local	<ul style="list-style-type: none"> • E01 (synchronism error) • Error in all the Follower transformers • The Master transformer did not perform the tap change
Contingency Procedure	<ul style="list-style-type: none"> • Select the whole parallelism system for operating in the Manual mode; • Select all the transformers as Individual. The transformers that did not present error can already be singly operated. • Optionally, select again the transformers that did not present error as Master and Followers. These transformers are liberated from blockade, being able to have its tap position manually changed.
Special Cautions	<ul style="list-style-type: none"> • The transformer that presented the error must have its tap position manually changed to follow the tap position of the other units that are operating in parallel, in such manner that the current circulation is prevented; • The unity that presented the error may not reply to the raise/lower commands (this can be the error cause), and in this case it may be necessary to operate it locally, by using the crank; • Do not keep any part of the system in the Automatic mode, because unexpected tap changes could happen that would cause tap difference and current circulation among the transformers.

3.8.1.2 E02 – Communication Error

Error condition and its Local	<ul style="list-style-type: none"> • E02 (communication error) • Follower Transformer
Contingency Procedure	<ul style="list-style-type: none"> • Select the whole parallelism system for operating in the Manual mode; • Select all the transformers as Individual. The transformers that did not present error can already be singly operated; • Optionally, select again the transformers that did not present error as Master and Followers. These transformers are liberated from blockade, being able to have its tap position manually changed.
Special Cautions	<ul style="list-style-type: none"> • The transformer that presented the error must have its tap position manually changed to follow the tap position of the other units that are operating in parallel, in such manner that the current circulation is prevented; • If the other transformers keep in the Individual mode, they must be singly operated, in such manner that they can keep the tap conformity and prevent current circulation; • Do not keep any part of the system in the Automatic mode, because unexpected tap changes could happen that would cause tap difference and current circulation among the transformers.

Error condition and its Local	<ul style="list-style-type: none"> • E02 (communication error) • Master Transformer
Contingency Procedure	<ul style="list-style-type: none"> • Select the whole parallelism system for operating in the Manual mode; • Select all the transformers as Individual. The transformers that did not present error can already be singly operated; • Optionally, select again the transformers that did not present error as Master and Followers. These transformers are liberated from blockade, being able to have its tap position manually changed.
Special Cautions	<ul style="list-style-type: none"> • The transformer that presented the error must have its tap position manually changed to follow the tap position of the other units that are operating in parallel, in such manner that the current circulation is prevented; • If the other transformers keep in the Individual mode, they must be singly operated, in such manner that they can keep the tap conformity and prevent current circulation; • Do not keep any part of the system in the Automatic mode, because unexpected tap changes could happen that would cause tap difference and current circulation among the transformers.

Error condition and its Local	<ul style="list-style-type: none"> • E02 (communication error) • Individual Transformer
Contingency Procedure	<ul style="list-style-type: none"> • Select the transformer which presented the error to operate in Manual mode;
Special Cautions	<ul style="list-style-type: none"> • None.

3.8.1.3 E04 – Programming Error

Error condition and its Local	<ul style="list-style-type: none"> E04 (programming error)
Contingency Procedure	<ul style="list-style-type: none"> Verify if the operation is trying to impose to the system an invalid programming condition, as item 3.6.3. Eliminate this imposition, if it exists; Verify if there is communication error (E02) in the SPS of the Master transformer. In this case, eliminate the communication error or perform the operation proceedings for communication error condition.
Special Cautions	<ul style="list-style-type: none"> None.

3.8.1.4 E08 – Tap Reading Error

Error condition and its Local	<ul style="list-style-type: none"> E08 (tap reading error) Follower Transformer
Contingency Procedure	<ul style="list-style-type: none"> Select the whole parallelism system for operating in the Manual mode; Select the transformer that presents error as Individual. Master transformer and Followers transformers without error are liberated from blockade, being able to have its tap position manually changed; The transformer that contains error can only be operated from the on-load tap changer cabinet, as it is not possible to know by the SPS's display what is the real tap position of the tap changer. The transformer that presented the error must have its tap position manually changed to follow the tap position of the other units that are operating in parallel, in such manner that the current circulation is prevented.
Special Cautions	<p>Observe with attention that the transformer which contains the error E08 can only be operated by the tap changer cabinet;</p> <ul style="list-style-type: none"> Do not keep any part of the system in the Automatic mode, because unexpected tap changes could happen that would cause tap difference and current circulation among the transformers.

Error condition and its Local	<ul style="list-style-type: none"> • E08 (tap reading error) • Master Transformer
Contingency Procedure	<ul style="list-style-type: none"> • Select the whole parallelism system for operating in the Manual mode; • Select all the transformers as Individual. The transformers that do not present error can already be singly operated. • Optionally, select again the transformers that did not present error as Master and Followers. These transformers are liberated from blockade, being able to have its tap position manually changed. • The transformer that contains error can only be operated from the on-load tap changer cabinet, as it is not possible to know by the SPS's display what is the real tap position of the tap changer.
Special Cautions	<ul style="list-style-type: none"> • The transformer that presented the error must have its tap position manually changed to follow the tap position of the other units that are operating in parallel, in such manner that the current circulation is prevented. Observe with attention that the transformer which contains the error E08 can only be operated by the tap changer cabinet; • Do not keep any part of the system in the Automatic mode, because unexpected tap changes could happen that would cause tap difference and current circulation among the transformers.

Error condition and its Local	<ul style="list-style-type: none"> • E08 (tap reading error) • Individual Transformer
Contingency Procedure	<ul style="list-style-type: none"> • The transformer that contains error can only be operated from the on-load tap changer, as it is not possible to know by the SPS's display what is the real tap position of the tap changer.
Special Cautions	<ul style="list-style-type: none"> • None.

3.8.2 Three-phase Banks composed by Single -phase Transformers

3.8.2.1 E01 – Synchronism Error

Error condition and its Local	<ul style="list-style-type: none"> • E01 • Banks synchronism error in only one Followerbank
Contingency Procedure	<ul style="list-style-type: none"> • Select the whole parallelism system for operating in the Manual mode; • Select the bank that contains the error as Individual. The Master bank and the Followers banks that do not contain error are liberated from blockade, being able to have its tap position manually changed. • Select Secondary 1 and Secondary 2 phases of the bank that presented error in Individual Phase mode. The three phases can be singly operated by hand.
Special Cautions	<ul style="list-style-type: none"> • The phases of the bank that contains the error must have its tap position manually changed to follow the tap position of the other units that are operating in parallel, in such manner that the current circulation is prevented and the voltage balance among phases is maintained; • The unity that presented the error may not reply to the raise/lower commands (this can be the error cause), and in this case it may be necessary to operate it locally, by using the crank; • Do not keep any part of the system in the Automatic mode, because unexpected tap changes could happen that would cause tap difference and current circulation among the transformers.

Error condition and its Local	<ul style="list-style-type: none"> • E01 • Synchronism error among banks in all Follower banks • Synchronism error among phases in Secondary 1 and Secondary 2 phases of the Masterbank • The Principal phase of the Master bank did not perform the tap change.
Contingency Procedure	<ul style="list-style-type: none"> • Select the whole parallelism system for operating in the Manual mode; • Select all the banks as Individual. The bank that does not present error can already be operated singly in Bank mode. • Optionally, select again the banks that did not present error as Master and Followers. These banks are liberated from blockade, being able to have its tap position manually changed. • Select Secondary 1 and Secondary 2 phases of the bank that presented error in Individual Phase mode. The three phases of this bank can be singly operated by hand.
Special Cautions	<ul style="list-style-type: none"> • The phases of the bank, in Individual Phase mode, must have its tap position manually changed to follow the tap position of the other units that are operating in parallel, in such manner that the current circulation is prevented and the voltage balance among phases is maintained; • One of the units (probably the Principal phase of the bank which was the Master) may not reply to the raise/lower commands (this can be the error cause) and in this case it may be necessary to operate it locally, by using the crank; • Do not keep any part of the system in the Automatic mode, because unexpected tap changes could happen that would cause tap difference and current circulation among the transformers.

Error condition and its Local	<ul style="list-style-type: none"> • E01 • Synchronism error among phases in Secondary 1 and Secondary 2 phases of the Master bank • One of the Secondary phases of the Master bank did not perform the tap change
Contingency Procedure	<ul style="list-style-type: none"> • Select the whole parallelism system for operating in the Manual mode; • Select all the banks as Individual. The banks that do not present error can already be singly operated in Bankmode. • Optionally, select again the banks that did not present error as Master and Followers. These banks are liberated from blockade, being able to have its tap position manually. • Select Secondary 1 and Secondary 2 phases of the bank that presented error in Individual Phase mode. The three phases of this bank can be singly operated by hand.
Special Cautions	<ul style="list-style-type: none"> • The phases of the bank, in Individual Phase mode, must have its tap position manually changed to follow the tap position of the other units that are operating in parallel, in such manner that the current circulation is prevented and the voltage balance among phases is maintained; • The unity that presented the error may not reply to the raise/lower commands (this can be the error cause), and in this case it may be necessary to operate it locally, by using the crank; • Do not keep any part of the system in the Automatic mode, because unexpected tap changes could happen that would cause tap difference and current circulation among the transformers.

Error condition and its Local	<ul style="list-style-type: none"> • E01 • Synchronism error among phases in Secondary 1 and Secondary 2 phases of the bank in Individual mode
Contingency Procedure	<ul style="list-style-type: none"> • Select the bank that presented the error for operating in Manual mode; • Select the Secondary 1 and Secondary 2 phases in Phase Individual mode. The three phases of the bank that presented the error can be singly operated by hand.
Special Cautions	<ul style="list-style-type: none"> • Each phase of the bank that presented the error must have its tap position manually changed, in individual manner, keeping the same tap position to prevent voltage unbalancing in the three-phase system; • The unity that presented the error may not reply to the raise/lower commands (this can be the error cause), and in this case it may be necessary to operate it locally, by using the crank;

3.8.2.2 E02 – Communication Error

Error condition and its Local	<ul style="list-style-type: none"> • E02 (communication error) • Secondary 1 or Secondary 2 phase of the Follower bank.
Contingency Procedure	<ul style="list-style-type: none"> • Select the whole parallelism system for operating in the Manual mode; • Select the bank that presented error as Individual. The Master bank and the Followers banks that do not present error are liberated from blockade, being able to have its tap position manually. • Select Secondary 1 and Secondary 2 phases of the bank that presented error in Individual Phase mode. The three phases can be singly operated by hand.
Special Cautions	<ul style="list-style-type: none"> • The phases of the bank that presented the error must have its tap position manually changed to follow the tap position of the other units that are operating in parallel, in such manner that the current circulation is prevented and the voltage balance among phases is maintained; • Do not keep any part of the system in the Automatic mode, because unexpected tap changes could happen that would cause tap difference and current circulation among the transformers.

Error condition and its Local	<ul style="list-style-type: none"> • E02 (communication error) • Principal phase of the Follower bank
Contingency Procedure	<ul style="list-style-type: none"> • Select the whole parallelism system for operating in the Manual mode; • Select all the banks as Individual. The banks that do not present error can already be singly operated in Bank mode. • Optionally, select again the banks that did not present error as Master and Followers. These banks are liberated from blockade, being able to have its tap position manually changed. • Select Secondary 1 and Secondary 2 phases of the bank that presented error in Individual Phase mode. The three phases can be singly operated by hand.
Special Cautions	<ul style="list-style-type: none"> • The phases of the bank that presented the error must have its tap position manually changed to follow the tap position of the other units that are operating in parallel, in such manner that the current circulation is prevented and the voltage balance among phases is maintained; • If the other banks keep in the Individual mode, they must be singly operated, in such manner that they can keep the tap conformity and prevent current circulation; • Do not keep any part of the system in the Automatic mode, because unexpected tap changes could happen that would cause tap difference and current circulation among the transformers.

Error condition and its Local	<ul style="list-style-type: none"> • E02 (communication error) • Master bank
Contingency Procedure	<ul style="list-style-type: none"> • Select the whole parallelism system for operating in the Manual mode; • Select all the banks as Individual. The banks that do not present error can already be singly operated in Bank mode. • Optionally, select again the banks that did not present error as Master and Followers. These banks are liberated from blockade, being able to have its tap position manually changed. • Select Secondary 1 and Secondary 2 phases of the bank that was the Master in Individual Phase mode. The three phases of this bank can be singly operated by hand.
Special Cautions	<ul style="list-style-type: none"> • The phases of the bank that presented the error must have its tap position manually changed to follow the tap position of the other units that are operating in parallel, in such manner that the current circulation is prevented and the voltage balance among phases is maintained; • Do not keep any part of the system in the Automatic mode, because unexpected tap changes could happen that would cause tap difference and current circulation among the transformers.

Error condition and its Local	<ul style="list-style-type: none"> • E02 (communication error) • Individual bank
Contingency Procedure	<ul style="list-style-type: none"> • Select the bank that presented the error for operating in Manual mode; • Select Secondary 1 and Secondary 2 phases in Individual Phase mode. The three phases of the bank that presented the error can be singly operated by hand.
Special Cautions	<ul style="list-style-type: none"> • Each phase of the bank that presented the error must have its tap position manually changed, in individual manner, keeping the same tap position to prevent voltage unbalancing in the three-phase system;

3.8.2.3 E04 – Programming Error

Error condition and its Local	<ul style="list-style-type: none"> • E04 (programming error)
Contingency Procedure	<ul style="list-style-type: none"> • Verify if the operation is trying to impose to the system an invalid programming condition, as item 3.6.3. Eliminate this imposition, if it exists; • Verify if there is communication error (E02) in the principal SPS of the Master bank. In this case, eliminate the communication error or perform the operation proceedings for communication error condition.
Special Cautions	<ul style="list-style-type: none"> • None.

3.8.2.4 E08 – Tap Reading Error

Error condition and its Local	<ul style="list-style-type: none"> • E08 (tap reading error) • Follower bank
Contingency Procedure	<ul style="list-style-type: none"> • Select the whole parallelism system for operating in the Manual mode; • Select the bank that presented error as Individual. The Master bank and the Followers banks that do not present error are liberated from blockade, being able to have its tap position manually. • Select the Secondary 1 and Secondary 2 phases of the bank that presented the error in Individual Phase mode. The phases that do not present error can be manually operated using the front panel of the SPS, but the phase that contains the error can only be operated from its on-load tap changer cabinet, because it is not possible to know, by the SPS's display, what is the real tap changer position.
Special Cautions	<ul style="list-style-type: none"> • The phases of the bank that presented the error must have its tap position manually changed to follow the tap position of the other units that are operating in parallel, in such manner that the current circulation is prevented and the voltage balance among phases is maintained. Observe with attention that the phase which contains the error E08 can only be operated by its tap changer cabinet; • Do not keep any part of the system in the Automatic mode, because unexpected tap changes could happen that would cause tap difference and current circulation among the transformers.

Error condition and its Local	<ul style="list-style-type: none"> • E08 (tap reading error) • Master bank
Contingency Procedure	<ul style="list-style-type: none"> • Select the whole parallelism system for operating in the Manual mode; • Select all the banks as Individual. The banks that do not present error can already be singly operated in Bank mode. • Optionally, select again the banks that did not present error as Master and Followers. These banks are liberated from blockade, being able to have its tap position manually changed. • Select Secondary 1 and Secondary 2 phases of the bank that was the Master in Individual Phase mode. The phases that do not present error can be manually operated using the front panel of the SPS, but the phase that contains the error can only be operated from its on-load tap changer cabinet, because it is not possible to know, by the SPS's display, what is the real tap changer position.
Special Cautions	<ul style="list-style-type: none"> • The phases of the bank that presented the error must have its tap position manually changed to follow the tap position of the other units that are operating in parallel, in such manner that the current circulation is prevented and the voltage balance among phases is maintained. Observe with attention that the phase which contains the error E08 can only be operated by its tap changer cabinet; • Do not keep any part of the system in the Automatic mode, because unexpected tap changes could happen that would cause tap difference and current circulation among the transformers.

Error condition and its Local	<ul style="list-style-type: none"> • E08 (tap reading error) • Individual bank
Contingency Procedure	<ul style="list-style-type: none"> • Select the bank that presented the error for operating in Manual mode; • Select Secondary 1 and Secondary 2 phases in Individual Phase mode. The phases that do not present error can be manually operated using the front panel of the SPS, but the phase that contains the error can only be operated from its on-load tap changer cabinet, because it is not possible to know, by the SPS's display, what is the real tap changer position.
Special Cautions	<ul style="list-style-type: none"> • Each phase of the bank that presented the error must have its tap position manually changed, in individual manner, keeping the same tap position to prevent voltage unbalancing in the three-phase system. Observe with attention that the phase which contains the error E08 can only be operated by its tap changer cabinet;

Section III – Installation and Project

Index of Subjects

Chapter	Title	Page
4	Topology of the Parallelism System SPS	III – 4
4.1	Topology for three-phase transformers	III – 4
4.2	Topology for single-phase transformers banks	III – 6
5	Inputs and Outputs	III – 9
5.1	Auxiliary power and ground	III – 9
5.2	Tap changer position measurement	III – 9
5.2.1	Connection cables for tap measurement	III – 9
5.2.2	Requirement for the tap position transmitter	III – 11
5.3	Analog output of tap changer position	III – 12
5.4	Raise/Lower Tap output Contacts	III – 13
5.5	Contact inputS for Remote Programming/Command	III – 14
5.5.1	Programming/Command Inputs – Three-phase Transformers or Principal Phase of Single-phase Banks	III – 15
5.5.1.1	Master/Follower/Individual programming Outputs	III – 15
5.5.1.1.1	Local/Remote Programming	III – 15
5.5.1.2	Manual/Automatic programming input	III – 16
5.5.1.3	Raise/Lower Tap command Inputs	III – 17
5.5.2	Programming/Command Inputs – Secondary 1 and Secondary 2 of Single-phase Banks	III – 18
5.5.2.1	Individual Bank/Phase programming Inputs	III – 19
5.5.2.2	Raise/Lower Tap command inputs	III – 19
5.6	output Relays for Signaling	III – 19

Index of Subjects (continues)

5.6.1	Signaling contacts distribution – Three–phase Transformers	III – 21
5.6.2	Signaling contacts distribution – Single–phase Transformers	III – 21
5.7	Serial communication RS485	III – 22
6	Connection schemes	III – 24
6.1	Application with three-phase transformers	III – 24
6.2	Application with single-phase transformers banks	III – 25
6.3	Three-phase transformers parallelism with single-phase transformers banks	III – 25
7	Mechanical Installation	III – 27
7.1	Parallelism Supervisor SPS	III – 27
7.2	Communication Module COMM -04	III – 28

Index of Pictures

Picture	Title	Page
4.1	Topology of SPS application with three-phase transformers	III – 4
4.2	SPS front panel applied to three-phase transformers	III – 5
4.3	Topology of SPS application with single-phase banks	III – 6
4.4	SPS front panel applied to “Principal” phase of each three-phase bank	III – 7
4.5	SPS front panel applied to Secondary 1 and Secondary 2 phases of each three-phase bank	III – 8
5.1	Shield connection of the tap measurement cables	III – 10
5.2	Resistors configuration of the potentiometric transmitter in intermediary positions of the on-load tap changer	III – 12

Index of Pictures (continues)

5.3.a	Manual/Automatic remote programming using a single programming contact	III – 17
5.3.b	Manual/Automatic remote programming using two programming contacts	III – 17
5.4	Contacts connection of Raise/Lower external commands of Automatic and Manual operation devices	III – 18
5.5	SPS signaling contacts with three-phase transformer	III – 21
5.6	SPS signaling contacts with single-phase bank	III – 21
5.7.a	RS485 Ports connection between SPS and COMM -04 for three-phase transformers	III – 22
5.7.b	RS485 Ports connection between SPS and COMM -04 for single- phase transformer banks	III – 23
5.8	Shield connection of the serial communication cables	III – 23
6.1	Connection scheme for a three-phase transformer	III – 24
6.2	Connection scheme for a single-phase bank	III – 26
7.1	SPS principal external dimensions	III – 27
7.2	COMM-04 principal external dimensions	III - 28

4. Topology of the Parallelism System SPS

As a general rule, for each On-Load Tap Changer it is used a unity of the SPS Synchronous Parallelism Supervisor. The serial communication RS485 ports of all the SPS are interconnected, also interconnecting to the COMM Communication Module's RS485 port. It is used a single COMM module for all the SPS interconnected by network; the COMM has the following basic functions:

- Manage the serial communication among the several SPS, ensuring the necessary information distribution for the system operation;
- Allow the serial communication of the parallelism system with an external data acquisition system (supervisor system), without affecting the communication among the SPS due to a failure in the supervisor system.

The SPS topology particularities for application with three-phase transformers and with three-phase banks composed by single-phase units are presented below.

4.1 Topology for three-phase transformers

In the picture 4.1 it can be observed the application of the SPS for three-phase transformers, such as the basic interconnections among the several devices.

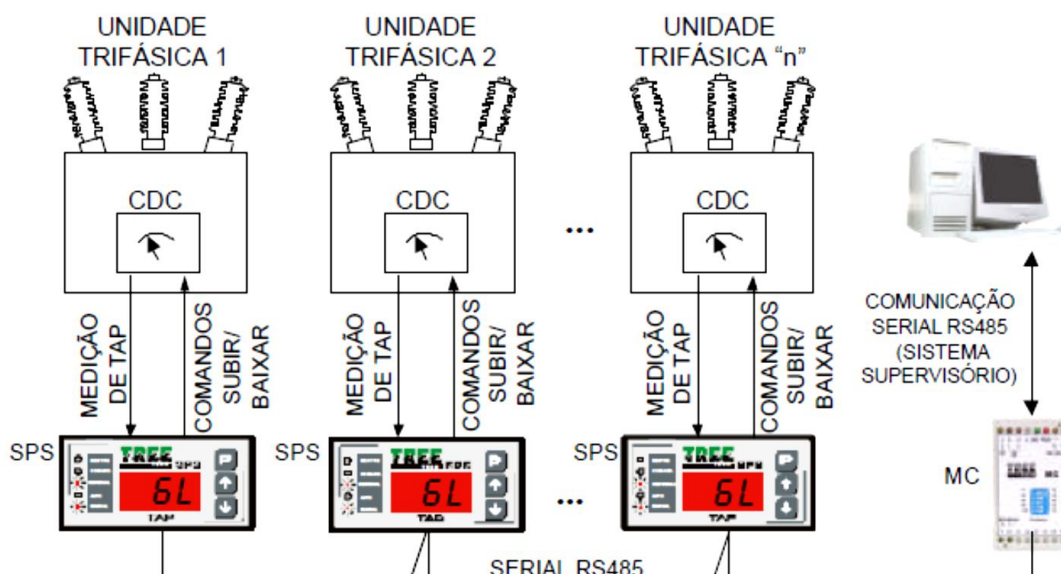


Figure 4.1 – Topology of SPS application with three-phase transformers

In the picture 4.2 it is shown the SPS front panel of each three-phase transformer, composed by:

- 1) Indicator LEDs of the selected parallelism mode: Master, Follower or Individual;
- 2) Indicator LEDs of the selected command mode: Manual or Automatic;
- 3) P, ↑ and ↓ front keys, with the functions:
 - Master/Follower/Individual, Manual/Automatic and Local/Remote selections;
 - Raise/Lower tap position manual commands;
 - Parallelism system configuration.
- 4) Three-digit display for indicating:
 - Current tap position;
 - Position change in progress;
 - Support to the Master/Follower/Individual, Manual/Automatic and Local/Remote selections;
 - Support to the parallelism system configuration;
 - Indication codes for error conditions.

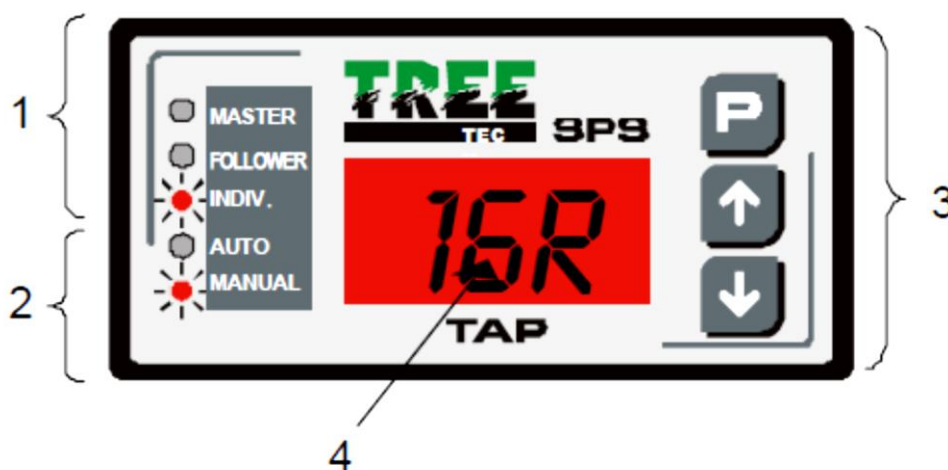


Figure 4.2 – Front panel of SPS applied with three-phase transformers

4.2 Topology for single-phase transformers banks

In the picture 4.3 it can be observed the application of the SPS for three-phase banks composed by single-phase transformers, such as the basic interconnections among the several devices.

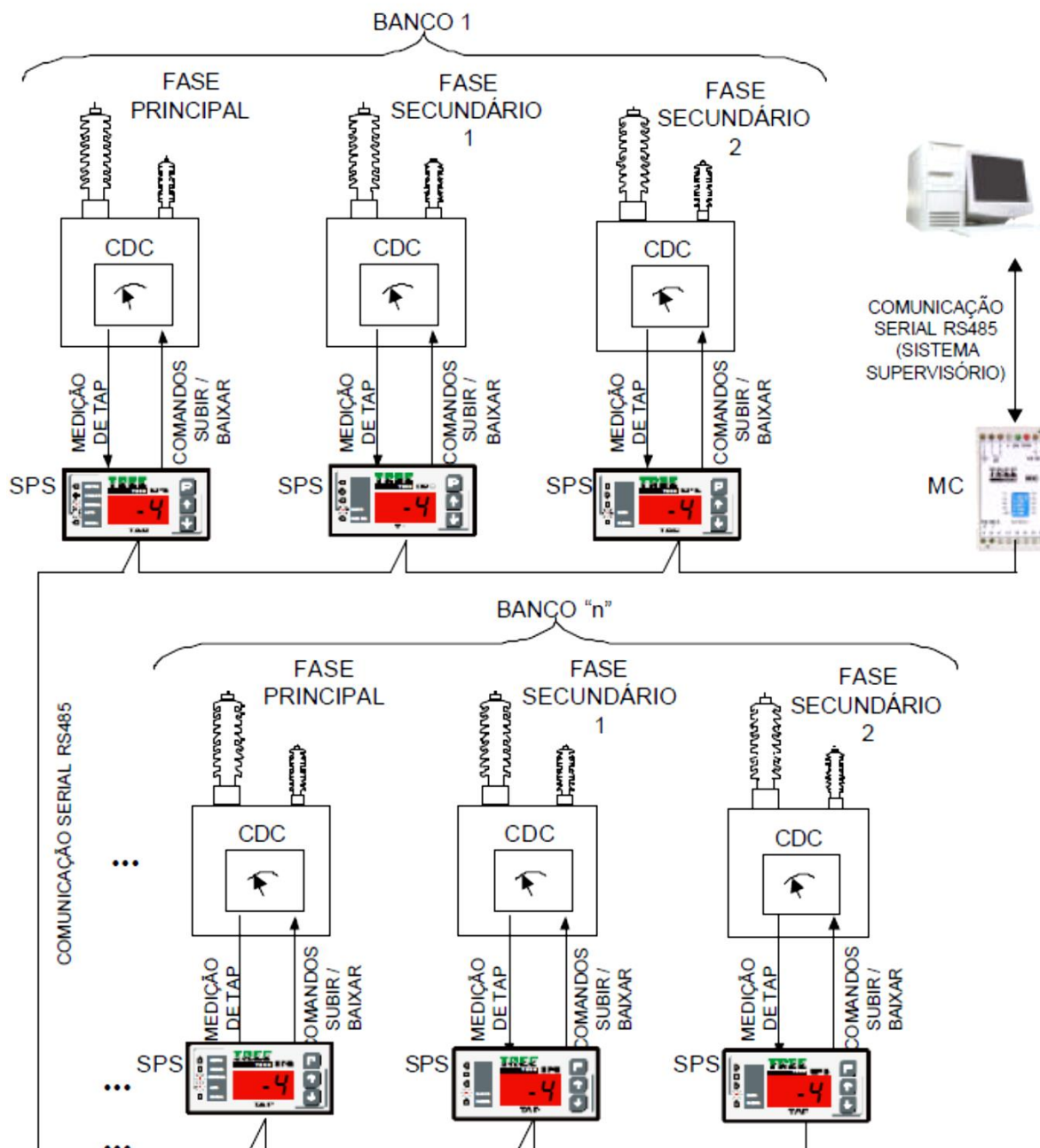


Figure 4.3 – Topology of SPS application with three-phase banks

In the picture 4.4 it is shown the front panel of the "Principal" SPS of each three-phase bank (in the picture 4.3 example, the A phase of each bank), composed by:

- 1) Indicator LEDs of the selected parallelism mode: Master, Follower or Individual;
- 2) Indicator LEDs of the selected command mode for the bank: Manual or Automatic;
- 3) P, ↑ and ↓ front keys, with the functions:
 - Master/Follower/Individual, Manual/Automatic and Local/Remote selections;
 - Raise/Lower tap position manual commands;
 - Parallelism system configuration.
- 4) Three-digit display for indicating :
 - Current tap position;
 - Position change in progress;
 - Support to the Master/Follower/Individual, Manual/Automatic and Local/Remote selections;
 - Support to the parallelism system configuration;
 - Indication codes for error conditions.

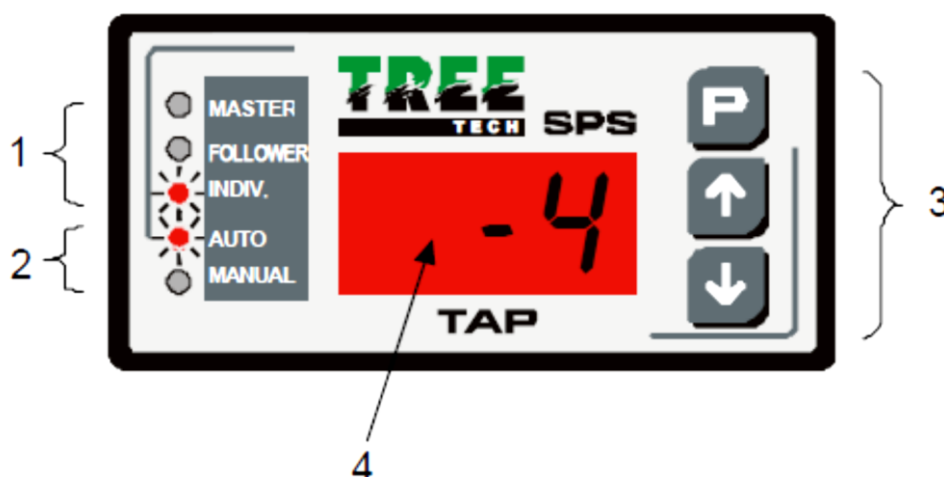


Figure 4.4 – SPS front panel applied to the “Principal” phase of each three-phase bank

In the picture 4.5 it is shown the front panel of the "Secondary 1" and "Secondary 2" SPS of each three-phase bank (in the picture 4.3 example, the B and C phases of each bank), composed by:

- 1) Indicator LEDs of the selected operation mode to the "Secondary 1" or "Secondary 2" phase, "Bank" or "Individual Phase";
- 2) P, ↑ and ↓ front keys, with the functions:
 - Bank/Individual Phase selection;
 - Raise/Lower tap position manual commands (only in "Individual Phase" mode);
 - Parallelism system configuration.
- 3) Three-digit display for indicating:
 - Current tap position;
 - Position change in progress;
 - Support to the Bank/Individual Phase selection;
 - Support to the parallelism system configuration;
 - Indication codes for error conditions.

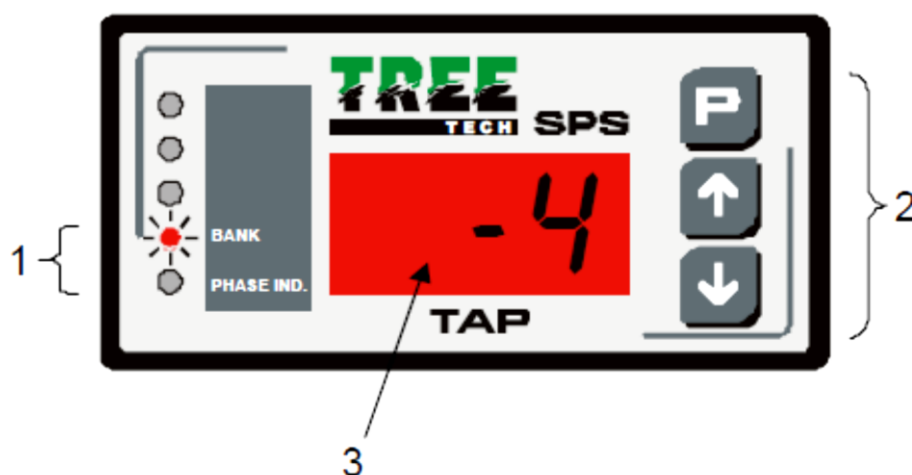


Figure 4.5 – SPS front panel applied to phases “Secondary 1” and “Secondary 2” of each three-phase bank

5. Inputs and Outputs

The following described Inputs and Outputs are available in the SPS. A general vision of all the inputs and outputs can be observed in chapter 6.

5.1 Auxiliary power and Ground

The SPS is capable to operate with auxiliary power in the range from 85 to 265V, in AC or DC, 50 or 60Hz, with consumption lower than 6W. It must be effected the connection of the terminal corresponding to the ground.

- ◆ Power input: terminals 16 and 17;
- ◆ Ground: terminal 15.

5.2 Tap changer position measurement

The SPS performs the on-load tap changer position measurement to verify the position conformity with other units that are operating in parallel, besides that it makes these information available to the user. This measurement is accomplished by an SPS input, specific for connecting a potentiometric position transmitter of the on-load tap changer.

The SPS is provided by an internal microcontroller exclusively dedicated to the necessary calculation for the tap position measurement, verification of its consistency and compensation of the measurement cables resistance.

- ◆ Tap measurement input: terminals 12, 13 and 14 (cursor, start and end, respectively).

5.2.1 Connection cables for tap measurement

The connection of the pontentiometric position transmitter of the on-load tap changer to the SPS is accomplished by three wires: the cursor, the start and the end of the potentiometric transmitter. The three wires must have the same length and size.

For this connection, it must be used shielded cable in the whole course, from the tap changer cabinet to the SPS, with the shield grounded in a single point.

If it is not used a single shielded cable for the whole course, due to intermediary connection binding posts, the shield continuity must be ensured. See picture 5.1. The unshielded stretch cable, due to seam, must be as short as possible.

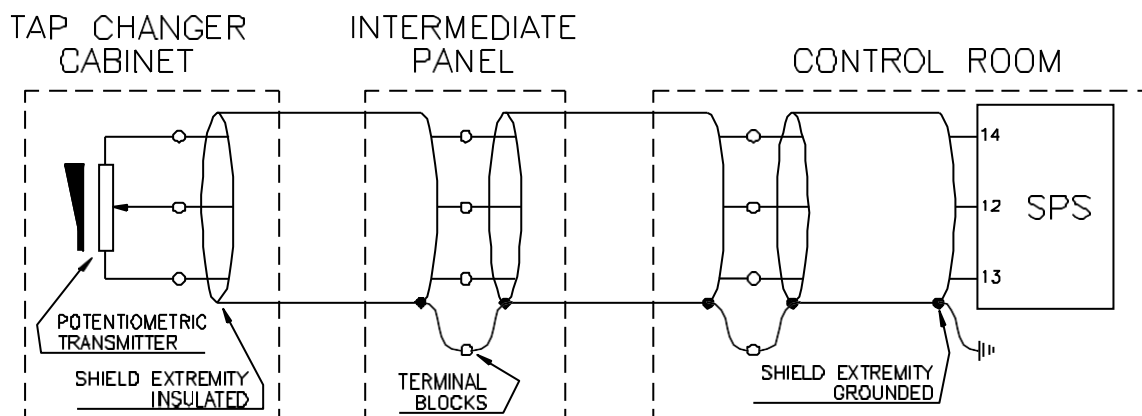


Figure 5.1 – Shield connection of tap measurement cable

The SPS performs the automatic compensation of the connection cables resistance from the pontentiometric transmitter to the SPS, and to such performance, the three wires must have the same length and size, and the maximum acceptable resistance for each wire is 8Ω . Due to this maximum resistance and the size of the cables used, it can be obtained the maximum permitted length for them.

Considering cables with typical resistance of $13,3 \Omega/\text{km}$, $7,98 \Omega/\text{km}$ and $4,95 \Omega/\text{km}$ for the sizes $1,5\text{mm}^2$, $2,5\text{mm}^2$ and 4mm^2 respectively (non tinned cables), the maximum lengths are shown in the following table.

Cables Size	Typical Resistance	Maximum Length
0,5 mm ²	39,0 Ω/km	200 m
0,75 mm ²	26,0 Ω/km	300 m
1 mm ²	19,5 Ω/km	400 m
1,5 mm ²	13,3 Ω/km	600 m
2,5 mm ²	7,98 Ω/km	1000 m
4 mm ²	4,95 Ω/km	1600 m

5.2.2 Requirements for the tap position transmitter

The on-load tap changer position transmitter must be of the potentiometric type, with its resistance changing from zero to the maximum value for the start and finish tap changer positions respectively.

In case of tap changers with "intermediary" positions, namely, transition positions that have the same voltage of other adjacent positions, as shown in the following table, the resistors of the potentiometric crown relative to these positions must be removed and/or short circuited, as shown in the example of the picture 5.2. All the intermediary positions (in the example, 6A, 6 and 6B) will be indicated as tap "6", because they have the same voltage.

Tap Position	Voltage (V)	Current(A)	Resistance Cursor/Initial Position (example for 10φ_i/step)
1	12420	3220,6	0
2	12696	3150,6	10
3	12972	3083,6	20
4	13248	3019,3	30
5	13524	2957,7	40
6A	13800	2898,6	50
6			50
6B			50
7	14076	2841,7	60
8	14352	2787,1	70
9	14628	2734,5	80
10	14904	2683,8	90
11	15180	2635,0	100

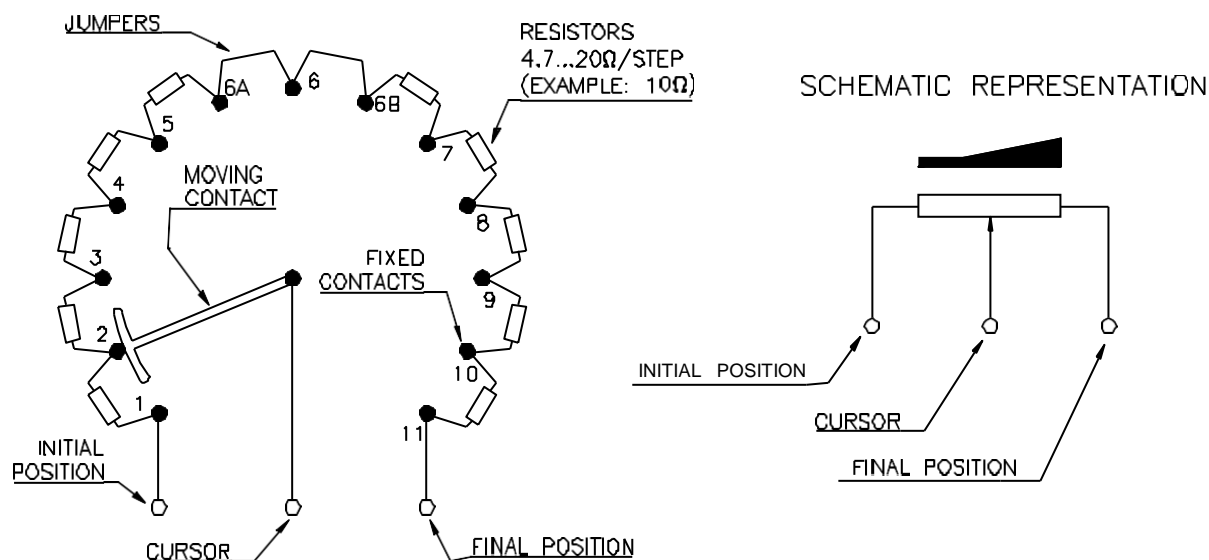


Figure 5.2 – Configuration of potentiometric transmitter resistors at tap changer intermediate positions

The SPS accepts resistance by potentiometric transmitter step (the value of each individual transmitter shown in the picture 5.2) in the range from 4,7 to 20 Ω , and the total resistance of the transmitter from 9,4 to 1000 Ω . The mobile contact (cursor) of the potentiometric transmitter can be "close before open" or "open before close" type, indifferently.

5.3 Analog output of tap changer position

The SPS has an analog output in current loop for remote indication of the tap changer position. The current output value range can be selected using the programming performed in the front of the SPS as shown in one of the following options. The output maximum voltage is 12V, what accepts that be connected the maximum loads indicated by the side of each option:

Output Option	Maximum Load	Output Option	Maximum Load
0...1mA	12000Ω	-1...+1mA	12000Ω
0...5mA	2400 Ω	-5...+5mA	2400 Ω
0...10mA	1200 Ω	-10...+10mA	1200 Ω
0...20mA	600 Ω	-20...+20mA	600 Ω
4...20mA	600 Ω	-	-

The current output will change in line inside the selected range, proportionally to the current tap position. This way, the output value for a given tap position can be calculated by the simple formula as follows:

$$\text{mA output} = \frac{(\text{mA end scale}) - (\text{mA begin of scale})}{(\text{Final Tap}) - (\text{Initial Tap})} \times (\text{Present Tap} - \text{Initial Tap}) + (\text{mA begin of scale})$$

If a Tap Reading Error (E08) occurs, the current output will keep indicating the last read tap position before the Error has occurred.

- ♦ Analog output: terminals 10(-) and 11(+).

5.4 Raise/Lower Tap output contacts

The output contacts for the Raise Tap and Lower Tap commands of the SPS are directly connected to the command circuit of the corresponding on-load tap changer, and generally will act energizing the Raise/Lower counters reels, that energize the activation motor.

All the tap changing commands, originated locally by the front of the SPS, remote by dry contacts or serial connection, are retransmitted to the on-load tap changer by the Raise/Lower Tap output contacts.

These contacts have momentary acting, in such manner that for each tap changing command emitted by the SPS, they will close a single time for about 0,5 second. For this reason, on-load tap changers gifted with intermediary positions, namely, transition positions that have the same voltage of others adjacent positions, as exemplified in the sub-chapter 5.2.2, must have automatic access of the intermediary positions. Still considering the example of the sub-chapter 5.2.2, if the tap changer is at the position 5, and the SPS emits a single Raise Tap command, the on-load tap changer must move from the position 5 to 6a, and right after from 6a to 6, automatically.

The Raise/Lower Tap output contacts can change tap loads until 250Vdc or 250Vac, with maximum power of 70W or 220VA respectively. Their conduction capacity (thermal current) is 2A continuously:

- ◆ Raise/Lower Tap output contacts: terminals 18 (common point), 19 (Raise Tap) and 20 (Lower Tap).

5.5 Contact inputs for Remote Programming/Command

The six inputs for dry contacts of each SPS allow that the programming and the parallelism system commands be remotely performed. The contacts connected to these inputs must be free of any external potential, and they are energized by an internal potential of the SPS, by a common point for all the contacts.

To ensure that a transmitted command be recognized by the SPS, the contacts must keep closed for a minimum time of 0,2 second.

The function of each SPS input will change according to the type of parallel operating transformer, if three-phase or single-phase transformer bank. In this last case, the function of each input will also change according to the position of SPS inside the bank, if Principal or Secondary. Each mentioned possibility is detailed as follows.

5.5.1 Programming/Command inputs - Three-phase transformers or Single-Phase Banks Principal Phase

- ◆ Master/Follower/Individual programming inputs: terminals 1 (master), 2 (follower) and 3 (individual);
- ◆ Manual/Automatic programming input: terminal;
- ◆ Raise/Lower Tap command inputs: terminals 5 (Raise) and 6 (Lower);
- ◆ Common point for all the inputs: terminal 9.

5.5.1.1 Master/Follower/Individual programming inputs

These inputs allow the remote selection of the Master/Follower/Individual operation mode. Commands by pulse and permanent can be used. If it is performed an invalid programming (for an example, trying to select a transformer as Master if there is already another Master selected), the command by pulse is ignored, and the SPS keeps the previous condition; if the invalid command is permanent, it is not obeyed, the SPS keeps the previous condition and it is emitted the Programming Error Alarm (E04) after lapsed the programming alarm timing.

5.5.1.1.1 Local/Remote Programming

The inputs used for Master/Follower/Individual remote programming can also be used for a programming secondary function of the Local/Remote command mode. This command mode is reversed (from Local to Remote or vice versa) every time the contacts connected to the three Master/Follower/individual programming inputs are simultaneously closed, in a momentary way. If the three contacts close and keep closed, there will be an only inversion in the Local/Remote command mode. Additional inversions will be possible only if the contacts open and return to close simultaneously.

5.5.1.2 Manual/Automatic programming input

This input allows the remote selection of the Manual/Automatic command mode. It must be used command by pulse; the command mode is reversed (from Manual to Automatic or vice versa) every time the contact connected to the Manual/Automatic programming input is momentary closed. If this contact close and keep closed, there will be an only inversion in the Manual/Automatic command mode. Additional inversions will be possible only if the contact opens and returns to close.

It is also possible to perform the Manual/Automatic selection using two independent contacts instead of a single contact, being one of them with the Manual function and the other one with the Automatic function. For this proceeding, it must be used the Manual/Automatic reversible auxiliary contact. In case of single-phase transformer banks, this contact is located in the "Principal" SPS of the bank. Comparing to the picture 5.3.a, where it is shown the alternative of a single command contact, and the picture 5.3.b, with the alternative of independent contacts, it can be observed that in both cases, the programming input receives pulses for state inversion, but in the second case the pulse only reaches this input if the contact corresponding to the opposite condition to the current SPS programming is closed. If the contact corresponding to the current SPS condition is closed, this input does not receive the inversion pulse and it is kept in the current condition.

Observe that the Automatic/Manual auxiliary contact of the SPS shown in the picture 5.3.b is used simultaneously in the circuit of the Raise/Lower Tap external command contacts, as described in the sub-chapter 5.5.3.

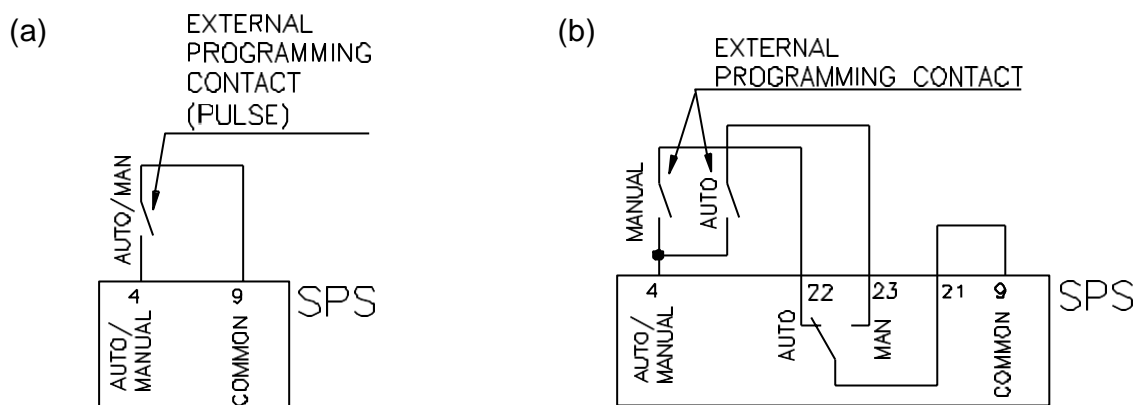


Figure 5.3 – Remote programming Manual/Automatic. (a) Using a single programming contact. (b) Using two programming contacts.

5.5.1.3 Raise/Lower Tap Command inputs

By these inputs, it is possible that Raise/Lower Tap commands be generated by external devices to the SPS. These devices are divided into two categories, Automatic command and Manual command. As an example, we can mention two of the most commonly used, which are the Voltage Regulator Relay for automatic command and the RTU (Remote Terminal Unity) for remote manual command.

Among the four possible combinations for the SPS's Manual/Automatic and Local/Remote command modes, in only one of them the commands received in the Raise/Lower Tap contacts inputs are not obeyed, that it is the Manual and Local combination. For this reason, to avoid that the Automatic and Remote Manual commands be received and followed simultaneously by the SPS, it is used the Manual/Automatic auxiliary contact of the SPS for the interlocking, as shown in the picture 5.4. In the case of single -phase transformer banks, this contact is located in the "Principal" SPS of the bank.

Observe that the Automatic/Manual auxiliary contact of the SPS shown in the picture 5.4 can be used simultaneously in the circuit of Manual/Automatic remote selection, as described in the sub-chapter 5.5.2.

It must be carefully observed the correspondence between the raise/lower tap and raise/lower voltage commands. In some applications, raise tap can mean lower voltage and vice versa. The Raise/Lower inputs of the SPS always refer to the tap position.

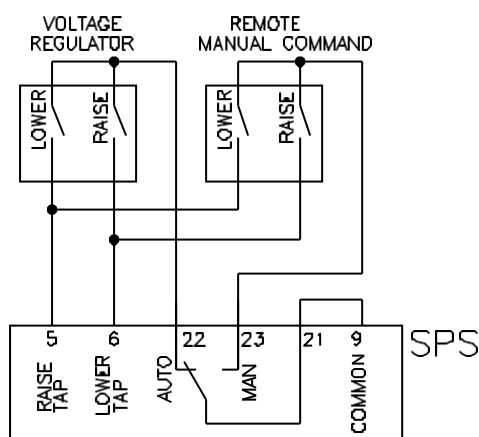


Figure 5.4 – Connection of external command contacts Raise/Lower for Automatic and Manual operation devices.

5.5.2 Programming/Command inputs - Secondary 1 and Secondary 2 Phases of Single-phase banks

- ◆ Bank/Individual Phase programming inputs: terminals 1 (individual phase) and 2 (bank);
- ◆ Raise/Lower tap command inputs: terminals 5 (raise) and 6 (lower);
- ◆ Common point to all the inputs: terminal 9.

5.5.2.1 Bank/Individual Phase programming inputs

These inputs permit the remote selection of the Bank/Phase Individual operation mode. It can be used commands by pulse and permanent. If it is performed an invalid programming (try to select one of the Secondary phases in Bank mode if this phase is not in synchronism with the Principal phase), the command by pulse is ignored, and the SPS keeps the previous condition; but if the invalid command is permanent, it is not obeyed, the SPS keeps the previous condition and it is emitted the Programming Error Alarm (E04) after lapsed the programmed alarm timing. The Programming Error Alarm is also emitted if the two contacts keep simultaneously closed for a superior time of this timing.

5.5.2.2 Raise/Lower Tap command inputs

By these inputs, it is possible that the Raise/Lower tap manual remote commands be generated by external devices to the SPS. These commands will only be obeyed if, in addition to the bank be selected to Remote mode, the Secondary SPS is in Individual Phase mode. In the bank mode, the Secondary SPS will only obey the raise/lower commands originated in the Principal Phase.

5.6 output Relays for Signaling

The SPS is supplied by output contacts for signaling of the operative conditions and/or of alarm that can be present in the parallelism system. Referring to the contacts with programmable function, it can be selected among the options of the following table.

If it is necessary, it is possible to expand the number of signaling contacts of the SPS by an optional external module. See appendix D.

NOTE: NO = Normally Open; NC = Normally Closed

Option	Operation mode	Signaling condition	Condition Location
01	NO	Synchronism error among three-phase transformers or among banks (E01)	In the proper bank or transformer
02	NC		
03	NO	Synchronism error among bank phases (E01) – only for single-phase transformers banks	In the proper bank
04	NC		
05	NO	Communication error between SPS and COMM (E02)	In any point of the system
06	NC		
07	NO	Communication error between SPS and COMM (E02)	In the proper SPS
08	NC		
09	NO	Programming error (E04)	In any point of the system
10	NC		
11	NO	Tap position reading error (E08)	In any point of the system
12	NC		
13	NO	Tap position reading error (E08)	In the proper bank or transformer
14	NC		
15	NO	Correct synchronism and programming	In the proper bank or transformer
16	NC		
17	NO	Three-phase transformer or bank in Master mode	In the proper bank or transformer
18	NC		
19	NO	Three-phase transformer or bank in Follower mode	In the proper bank or transformer
20	NC		
21	NO	Three-phase transformer or bank in Individual mode	In the proper bank or transformer
22	NC		
23	NO	Three-phase transformer or bank in Automatic mode	In the proper bank or transformer
24	NC		
25	NO	Both “Secondary” phases in Bank mode - only for single-phase transformers banks	In the proper bank or transformer
26	NC		
27	NO	Three-phase transformer or bank in Remote mode	In the proper bank or transformer
28	NC		
29	NO	Three-phase transformer or bank in Local mode	In the proper bank or transformer
30	NC		
31	NO	Both “Secondary” phases in Individual Phase mode - only for single-phase transformers banks	In the proper bank
32	NC		
33	NO	Secondary 1 or Secondary 2 SPS in Individual Phase mode - only for single-phase transformers banks	In the proper SPS
34	NC		

5.6.1 Signaling contacts distribution - Three-phase Transformers

In the case of three-phase transformers parallelism, it is used an SPS for each transformer, with the signaling contacts distribution shown in the picture 5.5. One of the contacts has fixed signaling function (command in Manual mode), operating as Normally Open (CO). The other ones have programmable function, as described in the sub-chapters 8.1.10, 8.1.11 and 8.1.12.

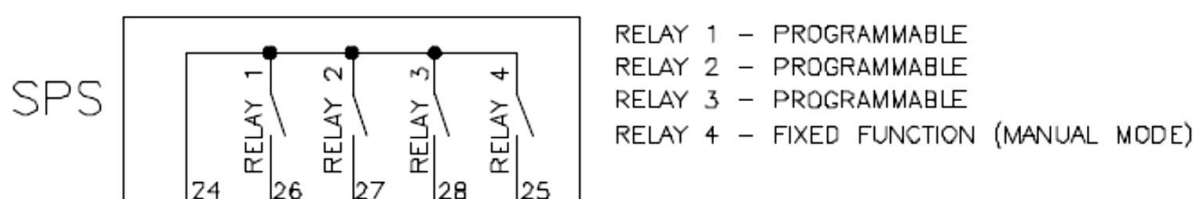


Figure 5.5 – SPS signaling contacts for a three-phase transformer.

5.6.2 Signaling contacts distribution - Single-Phase Transformers

For the parallelism of single-phase transformers banks, it is used an SPS for each phase of the bank, summarizing three SPS for each bank. The signaling contact distribution between the SPS of a bank is shown in the picture 5.6. One of the contacts of the Principal SPS of the bank has fixed signaling function (command in Manual mode), operating as Normally Open (CO). The other ones have programmable function, as described in the sub-chapters 8.1.10, 8.1.11 and 8.1.12. Observe that in the Secondary 1 and Secondary 2 SPS the relays 4 and 5 work simultaneously, in such manner that the selected function for the relay 4 will be reproduced in the relay 5.

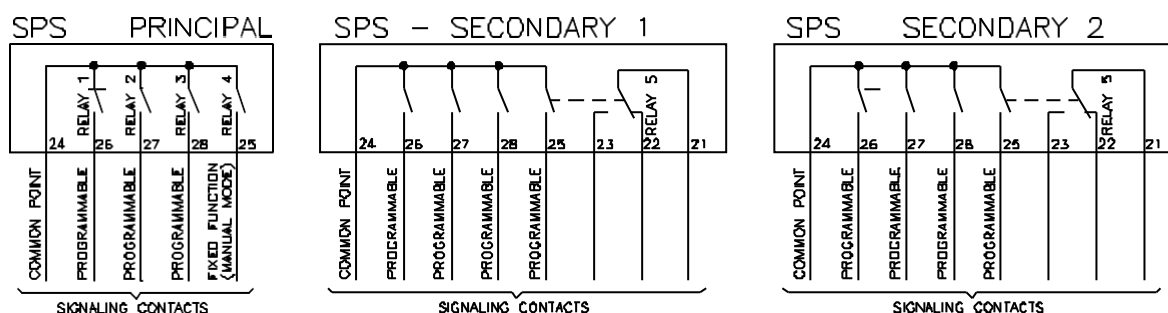


Figure 5.6 – SPS signaling contacts with single-phase banks.

5.7 Serial Communication RS485

Each SPS has a serial communication port RS485 for the communication with the Communication Module COMM -04. By this communication channel, the SPS sends and receives the relevant information to keep the synchronism among transformers in parallel and to supervise all the operative conditions.

It is used a single communication module COMM-04 for all the SPS of a given communication network. This module is supplied by a second port RS485 enable for the user utilization. By this port, can be accessed all the information, selections and commands of any SPS.

The connection of the SPS ports RS485 and of the COMM -04 is shown in the picture

5.7.a for three-phase transformers and in the picture 5.7.b for single-phase transformer banks. It must be used a 120Ω termination resistor in each extreme of the communication network. The cable used must be the shielded twisted-pair type, grounded in a single point.

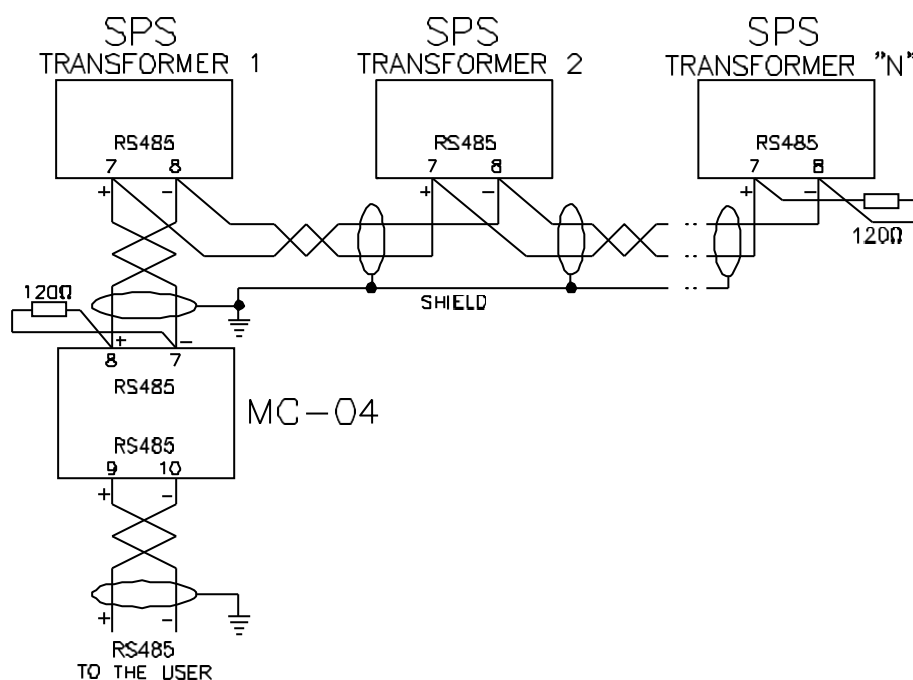


Figure 5.7.a – Connection of RS485 ports between SPS and COMM-04 for three- phase transformers

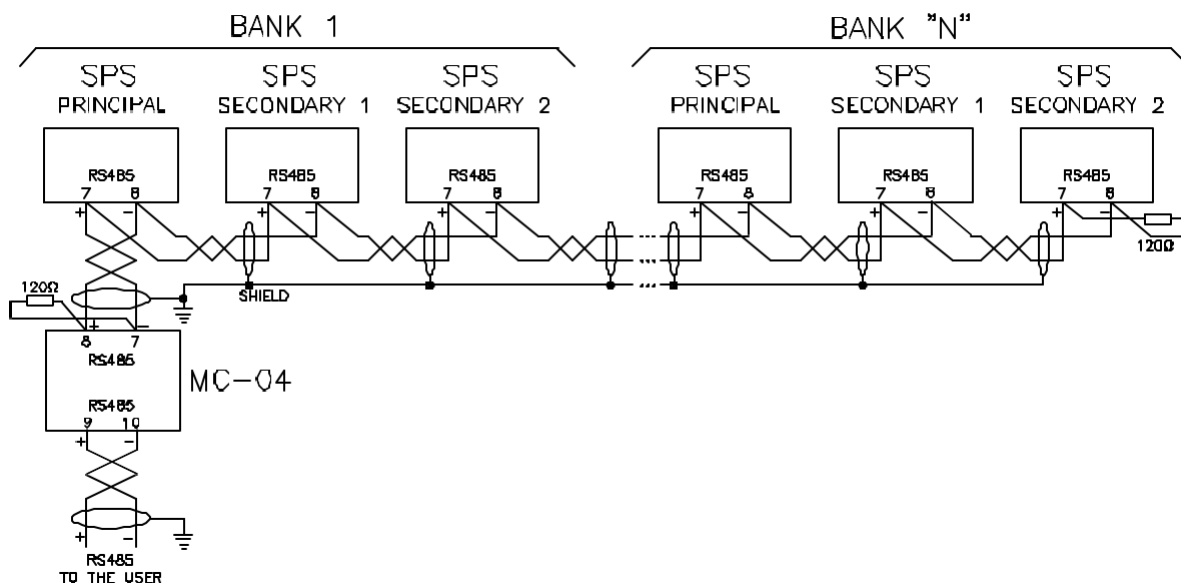


Figure 5.7.b – Connection of RS485 ports between SPS and COMM-04 for single- phase transformers

If it is not used a single shielded twisted-pair cable for the whole course, due to intermediary connection binding posts, it must be ensured the shield continuity, by connecting the shield extremes of the several cables. See picture 5.8 The cable stretch without shield, due to seam, must be as short as possible.

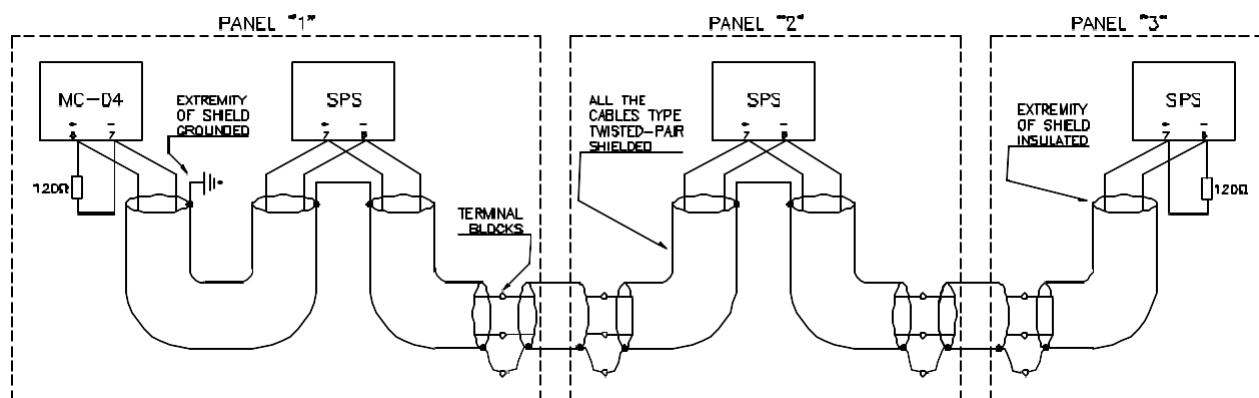


Figure 5.8 – Shield connection of serial communication cables

The maximum distance made by the RS485 serial communication cables, from extreme to extreme, is 1300 meters for the serial that connects the SPS to the COMM - 04 and for the serial from de COMM to the supervisor system (if it is used).

6. Connection schemes

The manner of the SPS connection for application with three-phase transformers and with single-phase transformer banks is basically the same.

Small differences between the two applications are shown in the following sub - chapters.

Chapter 5 shows a more detailed view of the function and of the operation manner of each input/output, here described.

6.1 Application with three-phase transformers

In the picture 6.1 are shown the SPS connections for a three-phase transformer, considering that the connections of the further SPS are identical and are repeated for all the further transformers, being enough to interconnect them by the RS485 serial communication. It is used a single Communication Module COMM -04 for all the SPS.

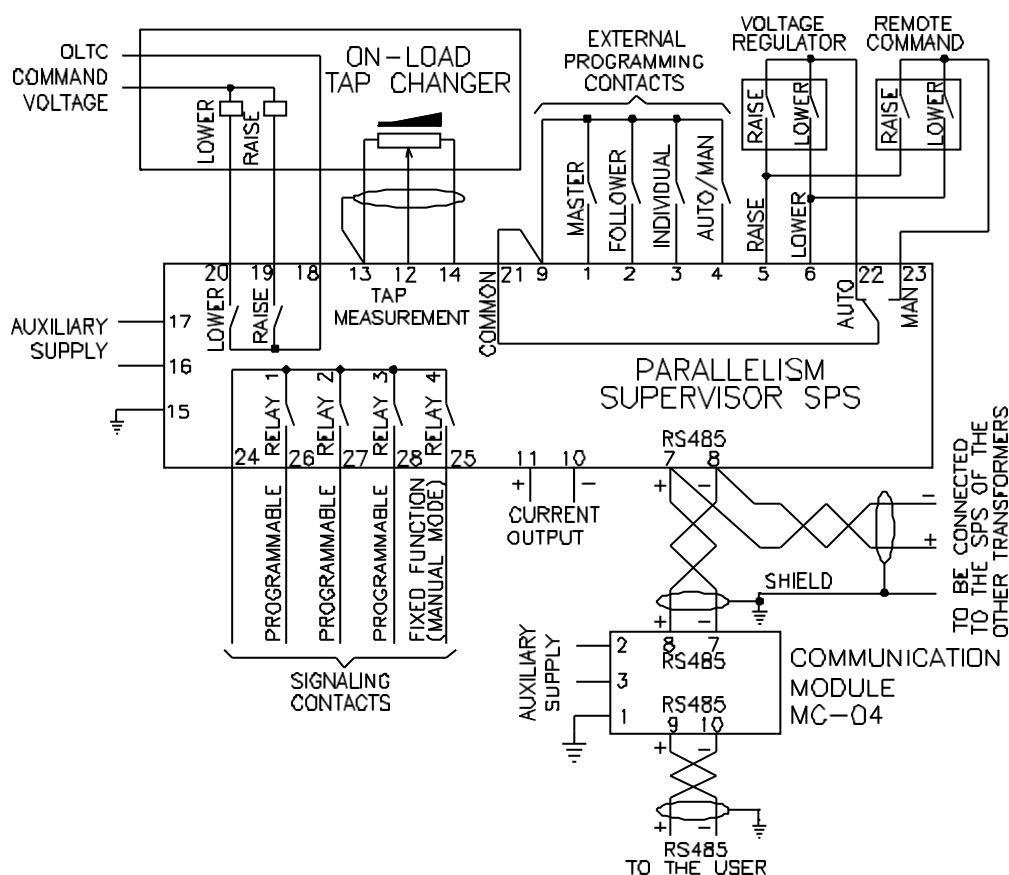


Figura 6.1 – Esquema de Ligação para um transformador Trifásico

6.2 Application with Single -phase Transformers banks

In the picture 6.2 are shown the SPS connections to a single-phase transformers bank, considering that the connections of the further SPS are identical and are repeated for all the further banks, being enough to interconnect them by the RS485 serial communication. It is used a single Communication Module COMM -04 for all the SPS.

6.3 Three-phase Transformers Parallelism with Single-phase Transformers Banks

The operation in parallel of three-phase transformers and of single-phase transformer banks is possible. In this case, it must be followed the corresponding connection scheme for each transformer type, and all the SPS, as much the three-phase as the single-phase transformers, must be interconnected by the RS485 serial communication, with a single communication Module COMM -04 for all of them.

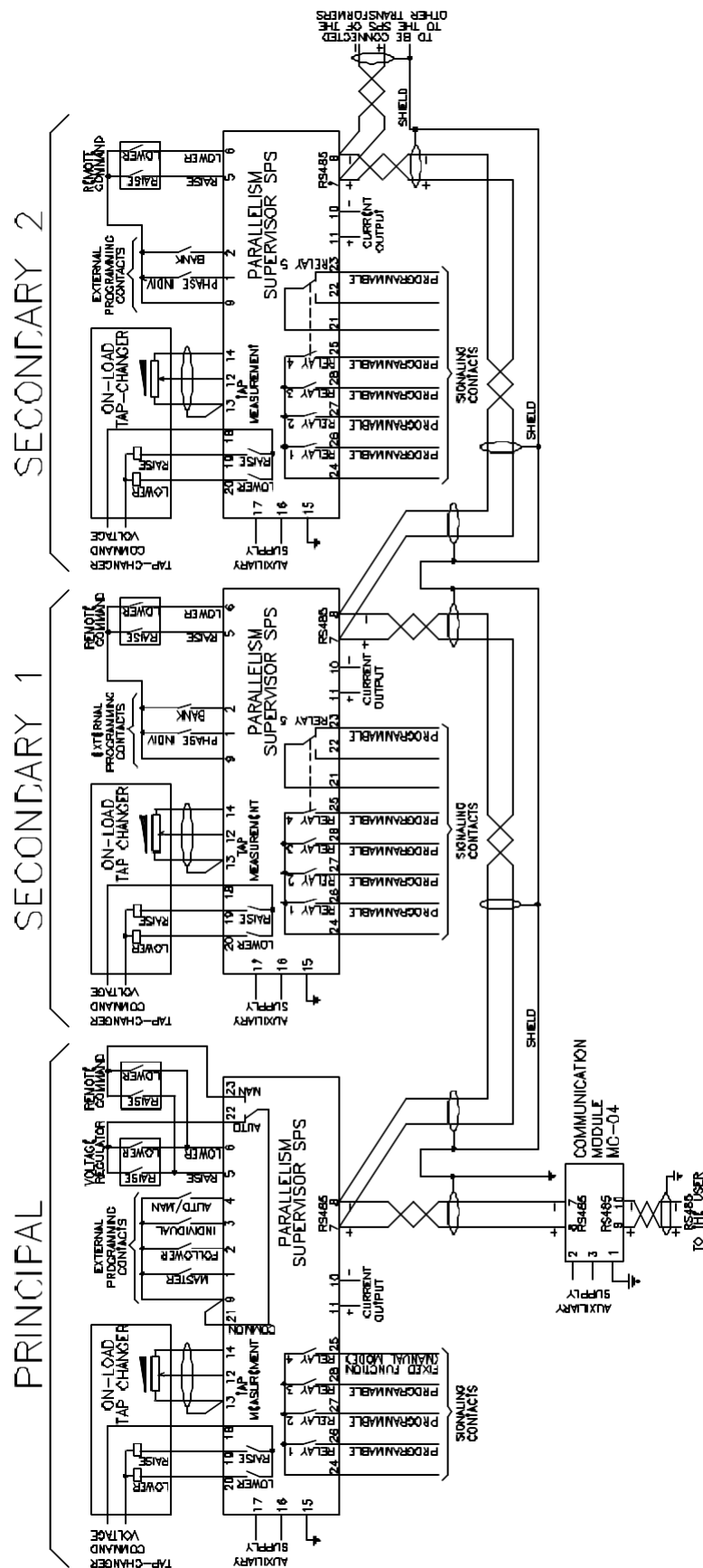


Figura 6.2 – Esquema de Ligação para um Banco Monofásicos

7. Mechanical Installation

The equipment gears of the SPS parallelism system must be installed protected of the intemperate weather, inside the panels or sheltered in building. In any of these cases, there must be an anti-condensation system.

7.1 Parallelism Supervisor SPS

The SPS is appropriate for installation of the built-in type, it can be fixed, for an example, in control cubicle door or front plate. The fixing straps are provided with the SPS. In the picture 7.1 are shown the principal equipment dimensions, and the dimensions of the sheet cutout for its insertion. Special attention must be given to the thickness of the painting layers in the sheet where the indenting is done, because in some cases, when a large thickness painting is used, the lowering of the indenting area can even block the equipment insertion.

The connection terminals are installed in 2 removable connectors in the rear part of the SPS, favoring the connections. It can be used cables from 0,5 to 2,5mm², nude or with terminals of pin (or needle) type.

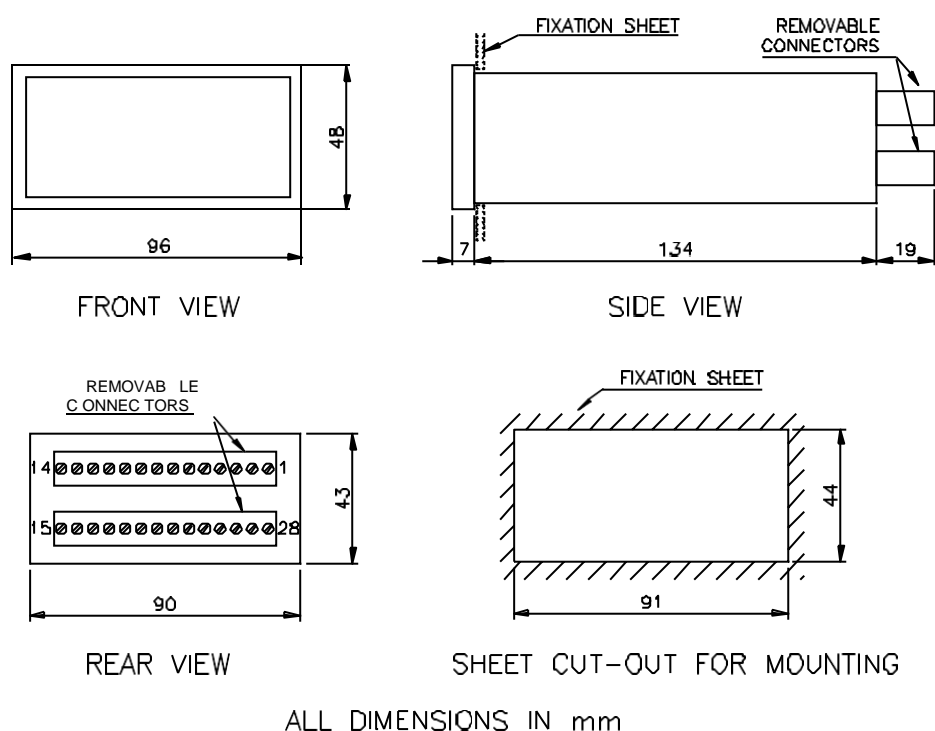


Figura 7.1 – Dimensões externas principais do SPS

7.2 Communication Module COMM-04

The COMM-04 is appropriate to be fixed in pattern rail DIN 35mm, it can be fixed, for an example, in mounting boards inside panels. In the picture 7.2 are shown the principal equipment dimensions.

The connection terminals are installed in the front part of the COMM -04. It can be used cables from 0,5 to 2,5mm², nude or with terminals of pin (or needle) type.

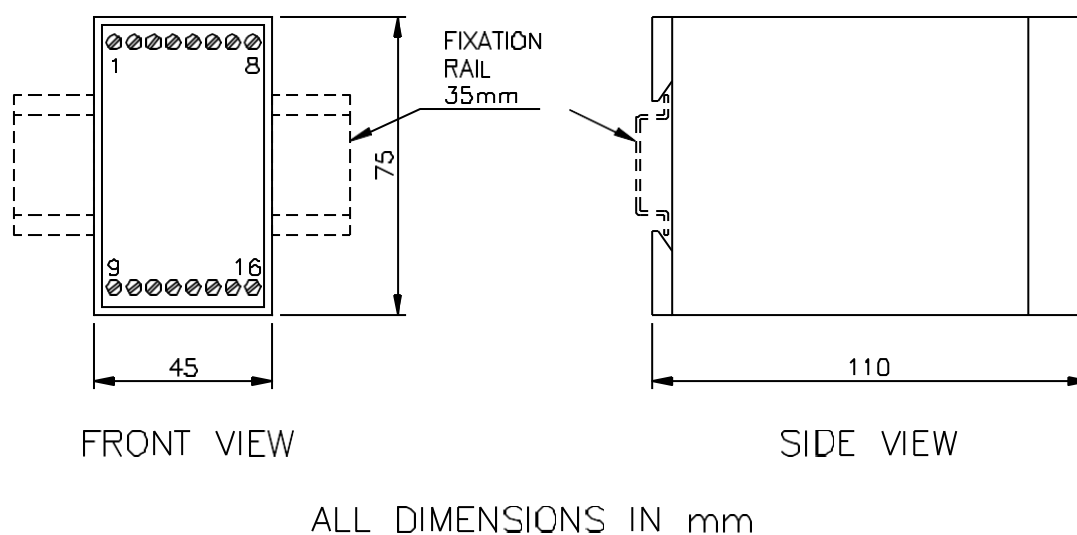


Figura 7.2 – Dimensões externas principais do COMM -04

Section IV – Starting the Operation

Index of Subjects

Chapter	Title	Page
8	Proceeding to start the operation	IV – 3
9	Parameterization	IV – 5
9.1	Parameterization of the Parallelism Supervisor SPS	IV – 5
9.1.1	Parameter MOD	IV – 7
9.1.2	Parameter ADR	IV – 8
9.1.2.1	ADR Programming for Single -phase operation mode	IV – 8
9.1.2.2	ADR Programming for Three-phase operation mode	IV – 9
9.1.2.3	ADR Programming for Three-phase transformers and Single-phase Banks mutual operation	IV – 10
9.1.3	Parameter NOD	IV – 10
9.1.4	Parameter TAP	IV – 11
9.1.5	Parameter IDC	IV – 12
9.1.6	Parameter CNT	IV – 12
9.1.7	Parameter RES	IV – 13
9.1.8	Parameter SNC	IV – 14
9.1.9	Parameter PRG	IV – 15
9.1.10	Parameter RL1	IV – 15
9.1.11	Parameter RL2	IV – 17
9.1.12	Parameter RL3	IV – 17
9.1.13	Parameter RL4	IV – 17
9.1.14	Parameter OCS	IV – 17
9.1.15	Parameter LNG	IV – 18

Index of Subjects (continues)

Chapter	Title	Page
9.2	Parameterization of the Communication Module COMM-04	IV – 18

Index of Pictures

Picture	Title	Page
9.1	Individual resistors (step resistance) of the on-load tap changer potentiometric transmitter	IV – 13
9.2	Dip-Switches for adjustment of the COMM-04 address	IV – 19

8. Proceeding to start the operation

As soon as the equipment installation according to the Section III of this manual is done, the starting the operation must follows the following basic steps.

- Disable the OLTCs commands (example: turn off the motors switches or select the OLTC for Local command) before energizing the SPS. During this period, the commands that maybe necessary for the tap change must be performed in the proper tap changer cabinet;
- Check the correction of the electric connections (e.g.: by continuity tests);
- Energize the SPS and the COMMs-04 with the power voltage of 85 ~ 265Vcc/Vca;
- Perform the whole SPS parameterization, according to the instructions in the sup-chapter 9;
- Put all the SPS in Local, Individual and Manual command modes (see sub - chapter 3.2);
- In single-phase transformers bank, select Secondary 1 and Secondary 2 phases of the bank in Individual Phase mode (see sub-chapter 3.3);
- If there is no error indications (see sub-chapter 3.6), enable the tap changers remote command, allowing the command by the SPS;
- Command manually each OLTC by the corresponding SPS, passing by all the tap positions. Observe if there is no inversion between the raise and lower tap signaling, and also observe if the tap indication is correct in all the positions and if there is no occurrence of tap reading errors(E08);
- Settle manually all the tap changers, putting all of them at the same tap position;
- Select one of the transformers or banks as Master and select, one by one, the further transformers or banks as Followers;
- Command manually the Master, raising or lowering the position by the front keyboard (see sub-chapter 3.4 and 3.5) and verify if all the Followers follows it;

- Simulate, in a possible manner, the several error conditions (see sub-chapter 3.6), verifying the error indications in the display, and verifying the operation of the programmed signaling contacts;
- Simulate, in a possible manner, the several operative conditions (for example: master, follower, manual, automatic etc.), verifying the operation of the programmed signaling contacts;
- Select the final configuration of the operation wanted, in other words, which transformers or banks must be Master, Follower or Individual, which is the command wanted, if Manual or Automatic and if Local or Remote.

9. Parameterization

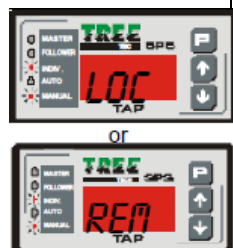
To ensure the correct operation of the parallelism system, several parameters must be settled in the SPS, which will provide the equipment the necessary information for its operation. Its front keyboard can perform the adjustments, with the display assistance, or by the serial communication port available to the user in the communication module COMM-04 (see sub-chapter 5.7).





The proceeding used to perform the SPS parameterization via front keyboard is indicated in the following sub-chapter 8.1. The parameterization proceeding of the communication module COMM-04, turning viable the usage of the serial communication port available to the user, is described in the sub-chapter 8.2.

9.1 Parameterization of the Parallelism Supervisor SPS

The proceeding to access the several adjustment parameters of the SPS is presented below. Observe that, to access the parameterization, it is primarily necessary to enter in the programming menu.

Forward, in the sub-chapters 8.1.1 to 8.1.12, is the description of each parameter, and all the advises for their selection.

Procedimento	Efeito	Visualização
Press P Key for a moment	<p>The password for accessing the SPS programming menu is requested.</p> <p>The Value that appears in the menu (by default 165) is the password recovery password. For this value the password is 0 (zero).</p> <p>Press up and down until you reach the correct password. The default password is 0 (zero)</p>	

Press P Key for a moment	It is accessed the first programming menu, with the Local/Remote selection. The current condition of this selection is shown in the display by the initials LOC or REM, respectively.	 OR 
Press P Key again, keeping it pressed for around 3 seconds	It is accessed the first parameter for adjustment, indicated in the display by the initial MOD (SPS operation mode)	
Press ↑ or ↓ key for a moment	It is indicated in the display the current value of the parameter MOD	

All SPS are provided with the default access password 0 (zero). After the first access the user can customize the password in the configuration menu of the equipment.

In case of lost or forgotten new password set, Treotech can assist in recovery if the number shown on the screen is informed when SPS requests the password.

To recover your password or obtain technical assistance for SPS or any other Treotech product, please contact us at the address below:

Treotech Sistemas Digitais Ltda - Technical Assistance

Rua José Alvim, 100 - Rooms 03 and 04 - Downtown

Atibaia - Sao Paulo - Brazil

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Procedure	Effect	Preview
Press ↑ ou ↓ keys for a moment	The value of the parameter MOD is changed	 
Press P key for a moment	It is accessed the next parameter for adjustment, indicated in the display by the initial ADR (SPS's address in the serial communication).	
Press ↑ ou ↓ keys for a moment	It is indicated in the display the current value of the parameter ADR	
Press ↑ ou ↓ keys for a moment	The value of the parameter ADR is changed	 
Press P key for a moment	Repeating these 3 steps, all the further SPS parameters can be accessed and edited. <ul style="list-style-type: none"> - NOD (number of three-phase sets in parallel) - TAP (total number of taps of the OLTC) - IDC (tap indication type) - CNT (central tap of the OLTC) - RES (Step resistance of potentiometric transmitter – Only for SPS) - SNC (timing for synchronism) - PRG (time of invalid programming alarm) - RL1...RL4 (signaling relays 1...4 functions) - PSS (Set the standard equipment password) - OCS (mA output current) - LNG (interface language for operation) 	
Press ↑ ou ↓ keys for a moment		
Press ↑ ou ↓ keys for a moment		 
Press P key for a moment		

9.1.1 Parameter MOD

It is the SPS Operation Mode, selected among the following options:

Parameter MOD	Description
0	Do not perform parallelism
1	Perform single -phase bank parallelism
2	Perform three-phase transformer parallelism

- Option 0 (do not perform parallelism)

The option 0 allows the SPS to operate singly, without interchanging information with the Communication Module or with others SPS. In this case, the Master/Follower/Individual selection keeps disabled, because the transformer will always operate in Individual mode.

This option can be used, for example, when there is only one three-phase transformer in the substation, however there is a future enlargement forecast with transformers parallel operation. The first transformer can already be equipped with an SPS, being prepared to the future parallelism, however it will initially operate singly. Under this condition it is not necessary using the communication module COMM-04. The SPS will not emit the alarm for communication error (E02).

- Option 1 (perform parallelism of single-phase bank)

The option 1 must be selected if the SPS is associated to one of the single-phase transformers of a bank. When this option is selected, the SPS assumes the “Principal” or “Secondary” function in the bank, according to the selection performed in the parameter ADR (address in the serial communication), explained forward in sub-chapter 8.1.2.

- Option 2 (perform parallelism in three-phase transformer)

The option 2 must be selected if the SPS is associated to a three-phase transformer.

9.1.2 Parameter ADR

It is the SPS Address in the serial communication with the communication module COMM-04. As general rule, each SPS connected to the same communication network (in other words, the same module COMM-04) must have a single address, without repetition.

The address accepted by the SPS in the parameterization will vary according to the Operation Mode previously selected (see sub-chapter 8.1.1), if Three-phase or Single-phase, as following detailed.

9.1.2.1 Programming ADR for Single -phase operation mode

If the single-phase operation mode was selected (MOD=1), the SPS allows programming of any value for the parameter ADR, in the range of 1 to 18, what grants a total of 6 transformers banks operating in parallel.

In this operation mode, the programmed value for the address adjustments to which bank the SPS belongs, and it adjusts the function assumed by it in the single-phase bank, if "Principal", "Secondary 1" or "Secondary 2", according the following table (See sub-chapter 2.1 to get a better understanding of the Principal and Secondary functions).

The address numbering must necessarily be started by bank 1, and continued to the following bank addresses, if they exist. For example, if there are 3 banks, it must necessarily be programmed the addresses from 1 to 9. It must not be programmed, for example, the addresses from 4 to 12.

The incorrect addresses programming will cause the Communication Error alarm (E02).

Parameter ADR	Bank that the SPS belongs to	SPS Function in the bank
1	Bank 1	Secondary 2
2		Secondary 1
3		Principal
4	Bank 2	Secondary 2
5		Secondary 1
6		Principal
7	Bank 3	Secondary 2
8		Secondary 1
9		Principal
10	Bank 4	Secondary 2
11		Secondary 1
12		Principal
13	Bank 5	Secondary 2
14		Secondary 1
15		Principal
16	Bank 6	Secondary 2
17		Secondary 1
18		Principal

9.1.2.2 Programming ADR for Three-phase operation mode

If the three-phase operation mode was selected (MOD=2), the SPS only allows programming of values multiple of 3 for the parameter ADR, in the range of 3 to 18, what grants a total of 6 three-phase transformers operating in parallel. Following a similar philosophy to the single-phase operation mode shown above, the further values (1, 2, 4, 5, ..., 16, 17) are not accepted by the SPS, considering that a single three-phase transformer includes three single-phase transformers.

The addresses numbering must necessarily be started by transformer 1, and continued to the following transformer addresses, if they exist. For example, if there are 3 three-phase transformers, it must necessarily be programmed the addresses of 3, 6 and 9. It must not be programmed, for example, the addresses of 6, 9 and 12.

The incorrect addresses programming will cause the Communication Error alarm (E02).

Parameter ADR	Three-phase transformer that the SPS belongs to
3	Transformer 1
6	Transformer 2
9	Transformer 3
12	Transformer 4
15	Transformer 5
18	Transformer 6

9.1.2.3 Programming ADR for Three-phase transformers and Single-phase Banks mutual operation

The philosophy used for the distribution of the SPS addresses in the three-phase and single-phase operation modes allows the parallel operation of three-phase transformers and single-phase banks. For each transformer type, it must be followed the corresponding instructions, as described in the sub-chapters 8.1.2.1 and 8.1.2.2.

An example of addresses programming for operation of a single-phase bank and two three-phase transformers is presented in the following table. The example above is not the only one that can be applied, this way, any three-phase transformers and single-phase bank combination can be used.

Parameter ADR	Three-phase transformer that the SPS belongs to
3	Three-phase transformer 1
6	Three-phase transformer 2
7	Single-phase bank 3
8	
9	

9.1.3 Parameter NOD

It is the total number of “three-phase sets” operating in parallel, with the SPS connected to the same serial communication network. Each three-phase transformer is considered as a three-phase set, the same occurs with each single-phase transformers bank (3 single-phase transformers). For example, if there is a

single-phase bank and two three-phase transformers operating in parallel, the parameter NOD will be programmed as 3.

The parameter NOD is programmed only in the SPS whose address (parameter ADR) has been selected as 3. In the further SPS the parameter NOD will not be requested.

Adjustment range: 1 to 6.

9.1.4 Parameter TAP

It is the total number of on-load tap changer positions. In cases of tap changers with “intermediary” positions, in other words, transition positions that have the same voltage than other adjacent positions, as exemplified in the following table, the parameter TAP value must not include the intermediary positions, because these positions (in the examples: 6A, 6 and 6B) will be indicated as tap “6”, as they have the same voltage. In this example, the parameter TAP is programmed as 11.

Tap position	Voltage (V)	Current (A)
1	12420	3220,6
2	12696	3150,6
3	12972	3083,6
4	13248	3019,3
5	13524	2957,7
6A	13800	2898,6
6		
6B		
7	14076	2841,7
8	14352	2787,1
9	14628	2734,5
10	14904	2683,8
11	15180	2635,0

Adjustment range: 2 to 50.

9.1.5 Parameter IDC

It is the tap indication type adopted for presentation in the SPS display, that generally follows the same indication type used in the proper on-load tap changer. There are four indication options, shown in the following table.

Parameter IDC	Description	Example 1	Example 2
0	Bilateral numerical	-8 ... 0 ... +8	-12 ... 0 ... +20
1	Inverted bilateral numerical	+8 ... 0 ... -8	+12 ... 0 ... -20
2	Alphanumerical	8L ... N ... 8R	12L ... N ... 20R
3	Inverted alphanumerical	8R ... N ... 8L	12R ... N ... 20L
4	Simple numerical	1 ... 17	1 ... 33

In the example 1, it is presented a tap changer with a total tap number equal 17 (TAP=17), with the neuter position (0 and N) centralized in the Bilateral numerical and Alphanumerical indications. The example 2 presents a tap changer with a total of 33 taps, with the neuter position decentralized in the Bilateral numerical and Alphanumerical indications.

9.1.6 Parameter CNT

It is the position, counted from the beginning of the measurement range, where the on-load “neuter” tap changer is found. This parameter will have practical effects only when the Bilateral numerical and Alphanumerical indication types are selected (see sub-chapter 8.1.5), because it allows that the tap changer positions with raise and lower ranges of asymmetric voltage be indicated.

The following table exemplifies the effect caused by this parameter in the tap indication for a 33-position tap changer and Bilateral numerical and Inverted alphanumerical indication types.

Parameter CNT	Bilateral numerical Example	Inverted alphanumerical Example
15	-14 ... 0 ... +18	14R ... N ... 18L
16	-15 ... 0 ... +17	15R ... N ... 17L
17	-16 ... 0 ... +16	16R ... N ... 16L
18	-17 ... 0 ... +15	17R ... N ... 15L
19	-18 ... 0 ... +14	18R ... N ... 14L

Adjustment range: 2 to 50.

9.1.7 Parameter RES

It is the resistance by step of the on-load tap changer potentiometric transmitter (in other words, each individual resistor value, shown in the picture 9.1).

Adjustment range: 4.7 to 20Ω.

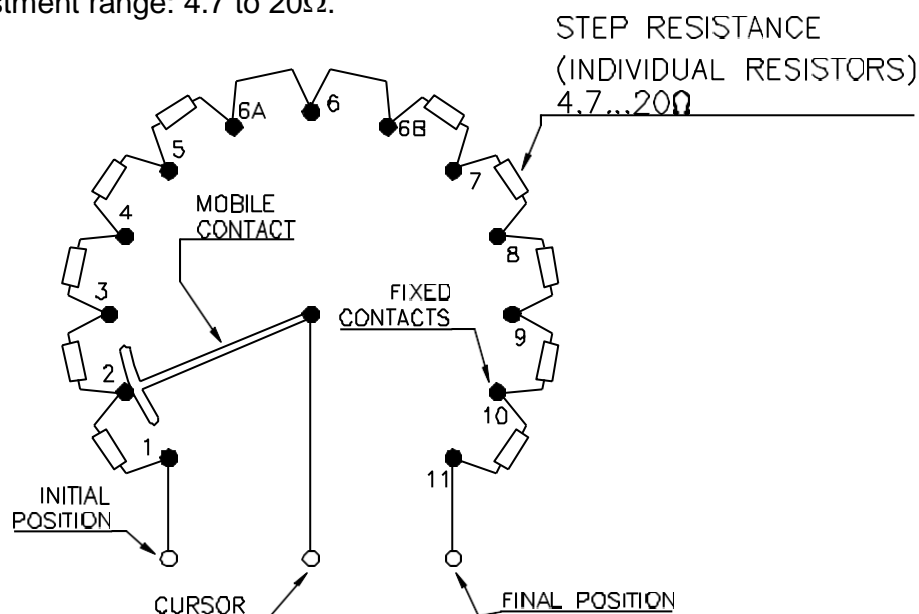


Figure 9.1 –Individual resistors (step resistance) of OLTC potentiometric position transmitter

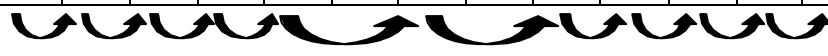
9.1.8 Parameter SNC

The parameter SNC (synchronism time) is associated to the period of time that the on-load tap changer takes to perform a complete tap change. The time adjusted for this parameter is used by the SPS for the following:

- Timing for synchronism error alarm (E01) – for example, if there is tap divergence of the Follower transformer related to the Master, the SPS will only emit the synchronism error alarm after elapsed the time adjusted in SNC. It prevents the emission of false alarms, due to the timing difference of tap change that can exist among the tap changers.
- Delay for successive tap changes – if several successive tap changes are necessary, the SPS Master will only accept a new command after elapsed the SNC time in all parallel tap changers. It prevents that a new tap change be performed before all the tap changers have concluded the previous tap change,

what could provoke a synchronism error. During the SNC time counting, after the emission of a tap change command, the SPS indicates in its display that the tap change is in progress presented by the symbols ^^^ or vvv (raising or lowering tap changer, respectively).

Due to these functions performed by the SPS, based on the parameter SCN, its adjustment must be superior, with a 2-second minimum, than the longest time that the tap changer takes to tap change. In the case of transformers with intermediary tap, the longest change time is located in the tap change that demands to pass by intermediary positions. Consider the following example, which the time to perform only one tap change is 5 second:

Tap changer position	1	2	3	4	5	6A	6	6B	7	8	9	10	11
Tap changer time (s)													
	5	5	5	5	10			10		5	5	5	5

As it can be observed, the change from position 5 to 6 and from 6 to 7 demands to pass by the intermediary positions 6A and 6B, respectively. Thus, the longest change time is, as a matter of fact, 10 seconds, and not 5, as initially thought. This way, the parameter SNC adjustment must be the longest tap change time (10s) plus the minimum delay (2s), totaling the ideal 12-second adjustment.

It is allowed adjustments longest than the one described above, however they present an inconvenience that can unnecessarily turn the successive tap changes very slow.

Adjustment: 1 to 100 seconds.

9.1.9 Parameter PRG

The PRG parameter is a timing for the invalid programming alarm emission. The programming conditions considered invalid are detailed in sub-chapter 3.6.3.

This timing objective is preventing the unnecessary alarm emission due to a temporary invalid condition, as an example, if the operator decides to invert the Master and Follower selections of the SPS. During this process, the condition of

two Masters or Followers without a Master can exist.

Adjustment range: 2 to 25 seconds.

9.1.10 Parameter RL1

It is the signaling function selected for the output relay 1. The output contacts distribution among the SPS for instances of three-phase transformers and single-phase banks parallelism is detailed in sub-chapter 5.6.

The signaling functions available for programming are listed in the following table, which one is also valid for signaling relays 2, 3 and 4.

NOTE: NO = Normally Open; NC = Normally Closed

Parameter RL1, RL2, RL3 or RL4	Operation mode	Signaling Condition	Condition's local occurrence
01	NO	Synchronism error among three-phase transformers or among banks (E01)	In the proper bank or transformer
02	NC		
03	NO	Synchronism error among phases of the bank (E01) – only for single-phase transformers banks	In the proper bank
04	NC		
05	NO	Communication error between SPS and COMM (E02)	In any point of the system
06	NC		
07	NO	Communication error between SPS and COMM (E02)	In the proper SPS
08	NC		
09	NO	Programming error (E04)	In any point of the system
10	NC		
11	NO	Tap position reading error (E08)	In any point of the system
12	NC		
13	NO	Tap position reading error (E08)	In the proper bank or transformer
14	NC		
15	NO	Correct synchronism and programming	In the proper bank or transformer
16	NC		
17	NO	Three-phase transformer or bank in Master mode	In the proper bank or transformer
18	NC		
19	NO	Three-phase transformer or bank in Follower mode	In the proper bank or transformer
20	NC		
21	NO	Three-phase transformer or bank in Individual mode	In the proper bank or transformer
22	NC		
23	NO	Three-phase transformer or bank in Automatic mode	In the proper bank or transformer
24	NC		
25	NO	Both “ Secondary” phases in Bank mode - only for single-phase transformers banks	In the proper bank
26	NC		
27	NO	Three-phase transformer or bank in Remote mode	In the proper bank or transformer
28	NC		
29	NO	Three-phase transformer or bank in Local mode	In the proper bank or transformer
30	NC		
31	NO	Both “ Secondary” phases in Individual Phase mode - only for single-phase transformers banks	In the proper bank
32	NC		
33	NO	Secondary 1 or Secondary 2 SPS in Phase Individual mode – only for single-phase transformers banks	In the proper SPS
34	NC		

9.1.11 Parameter RL2

It is the signaling function selected for the output relay 2, similar to the one shown in chapter 9.1.10 for relay 1, including the signaling functions available for programming.

9.1.12 Parameter RL3

It is the signaling function selected for the output relay 3, similar to the one shown in chapter 9.1.10 for relay 1, including the signaling functions available for programming.

9.1.13 Parameter RL4

It is the signaling function selected for the output relay 4, similar to the one shown in chapter 9.1.10 for relay 1, including the signaling functions available for programming.

However, it is important to observe that the output relay 4 does not have programmable signaling function in all instances. In the three-phase operation mode, acting as Principal of single-phase bank, the relay 4 has a “Manual Command” fixed signaling function, Normally Open. See sub-chapters 5.6.1 and 5.6.2. In these cases, the SPS will not request the parameter RL4 programming.

9.1.14 Parameter PSS

Set new password for access to programming menus.

Setting range: 0 to 999 in steps of 1

The default password is 0 (zero).

9.1.15 Parameter OCS

It is the selection of the value range of current in loop analog output of the SPS, for remote indication of the on-load tap changer position. The sub-chapter 5.3 presents details of the operation mode of the current output.

The options shown in the following table are available:

Parameter OCS	output Range	Parameter OCS	output Range
1	0...1mA	2	-1...+1mA
3	0...5mA	4	-5...+5mA
5	0...10mA	6	-10...+10mA
7	0...20mA	8	-20...+20mA
9	4...20mA	-	-

9.1.16 Parameter LNG

It is the interface language selection for the SPS operation. All the description initials for operating in the sub-chapter 3 are shown in English language. If another interface language is selected, the initials will be changed (see SPS Technical Manual in the corresponding language).

The following interface languages are available:

Parameter LNG	Interface Language
1	Portuguese
2	English
3	Spanish

9.2 Parameterization of the Communication Module COMM-04

The Communication Module does not request any special adjustment for the parallelism system operation. However, when the serial communication port RS485

is used, available for connection to a supervisor system (see sub-chapter 5.7), it is necessary to parameter this port address for the communication with protocol Modbus RTU.

The address adjustment of the COMM-04 is completely independent of the programmed addresses in the SPS. It must be observed that the address adjusted in the COMM-04 is single in the external communication network to which it is connected to (it does not regard to the communication network of the SPS, which is independent), without address repetition with other equipment gears that may be connected to the same serial communication.

The address adjustment of the COMM-04 is performed by the dip-switches located in its front part, as can be observed in picture 9.2. The following table indicates the dip-switch position to get the wanted address.

Address	Dip-switch Position					Address	Dip Switch Position				
	5	4	3	2	1		5	4	3	2	1
0	■	■	■	■	■	16	□	■	■	■	■
1	■	■	■	■	□	17	□	■	■	■	□
2	■	■	■	□	■	18	□	■	■	□	■
3	■	■	□	■	□	19	□	■	□	■	□
4	■	■	□	■	■	20	□	■	□	■	■
5	■	■	□	■	□	21	□	■	□	□	■
6	■	■	□	□	■	22	□	■	□	□	■
7	■	■	□	□	□	23	□	■	□	□	□
8	■	□	■	■	■	24	□	□	■	■	■
9	■	□	■	■	□	25	□	□	■	□	□
10	■	□	■	□	■	26	□	□	■	□	■
11	■	□	■	□	□	27	□	□	■	□	□
12	■	□	□	■	■	28	□	□	□	■	■
13	■	□	□	■	□	29	□	□	□	■	□
14	■	□	□	□	■	30	□	□	□	□	■
15	■	□	□	□	□	31	□	□	□	□	□

LEGEND: ■ ON □ OFF



Figure 9.2 – Dip-Switches for address adjust of COMM -04

Section V – Troubleshooting

Index of subjects

Chapter	Title	Page
10	Troubleshooting	V – 2
10.1	Master/Follower/Individual, Manual/Automatic and Bank/Individual Phase Selections	V – 2
10.2	Raise/Lower tap commands	V – 4
10.3	Local and remote indication of tap position and signaling contacts	V - 5
10.4	Error indication E01	V – 6
10.5	Error indication E02	V – 8
10.6	Error indication E04	V – 10
10.7	Error indication E08	V – 10
10.8	Indication of error combinations E10 and E12	V – 11

10. Troubleshooting

If difficulties or trouble appears in the operation the SPS parallelism system, we suggest you to consult the possible causes and simple solutions presented below. If these informations are not sufficient to solve the difficulties, please get in contact with Treetech's technical assistance or its authorized agent.

10.1 Master/Follower/Individual, Manual/Automatic and Bank/Individual Phase Selections

- The SPS does not allow to select the Follower condition

Probable Causes	Possible Solutions
There is not another transformer or bank selected as Master in the communication network	First, select a transformer or bank as Master, and then select the Follower
There is a failure in the serial communication (E02) in the SPS Master	Fix the communication failure - see specific item in this sub-chapter
The transformer or bank that should be set as Follower has not the same tap position of the Master	Equalize the tap position of the transformer that will operate as Follower with the Master's position

- The SPS does not allow to exit the Master selection

Probable Causes	Possible Solutions
There is at least 1 transformer or bank that is in the Follower condition	First, select the Follower transformer or bank as Individual, allowing the Master to be also selected as Individual

- The SPS does not allow to select the Automatic condition

Probable Causes	Possible Solutions
In case of single-phase transformers banks, the Secondary 1 and Secondary 2 phases are not in synchronism (same tap position) with the Principal phase	Equalize the tap positions of the Secondary 1 and Secondary 2 with the Principal Phase

- The Secondary 1 and Secondary 2 SPS do not allow to select the Bank condition to (only for single-phase banks)

Probable Causes	Possible Solutions
The Secondary 1 and Secondary 2 phases are not in synchronism (same tap position) with the Principal phase	Equalize the Secondary 1 and Secondary 2 tap position with the Principal phase
There is a failure in the serial communication (E02) in the Principal SPS of the bank	Fix the communication failure - see specific item in this sub-chapter

- The SPS does not allow to select the Individual Phase condition (only for single-phase banks)

Probable Causes	Possible Solutions
The bank is not in Individual and Manual modes	First, select the bank as Individual and Manual, allowing the Secondary ones to be selected in the Individual Phase mode

- The SPS does not allow the Master/Follower/individual, Manual/Automatic and Bank/Individual Phase selections to be performed in its front panel

Probable Causes	Possible Solutions
The SPS is in Remote operation mode, therefore, it only follows the selections performed via dry contacts or via serial communication	Select the SPS for Local mode (see sub-chapter 3.2)

- The SPS does not allow the Master/Follower/Individual, Manual/Automatic and Bank/individual Phase selections to be performed via dry contacts or via serial communication

Probable Causes	Possible Solutions
The SPS is in Local operation mode, therefore, it only follows the selections performed in its front panel	Select the SPS for Remote mode (see sub-chapter 3.2)

10.2 Raise/Lower tap commands

- The SPS does not follow the Raise and Lower tap commands performed in its front panel

Probable Causes	Possible Solutions
The SPS is in Remote operation mode, therefore, it only follows the selections performed via dry contacts or via serial communication	Select the SPS for Local mode (see sub-chapter 3.2)
The SPS is in Follower mode, therefore, it only follows the Raise/Lower tap commands emitted by the Master	Perform the Raise/Lower tap commands in the Master SPS, or change the Follower SPS for Individual (see sub-chapter 3.2)
The SPS is in the Automatic mode, therefore, it only follows the commands generated by the voltage regulator relay (or similar device)	Select the SPS for Manual mode (see sub-chapter 3.2)
In case of Secondary 1 and Secondary 2 SPS of single-phase banks, these are in Bank mode, therefore, they only follow the raise/lower tap commands emitted by the Principal SPS of the Bank	Select the Secondary 1 and Secondary 2 SPS for operate in Individual Phase mode (see sub-chapter 3.3). To allow this selection, the bank must be in Individual and Manual mode.
The on-load tap changer is in Local mode or it is turned off, or there is no power/command supply, or any charging switch is turned off	Verify the on-load tap changer, the power/command circuit charging switches and the auxiliary power.

- The SPS does not follow the Raise and Lower tap commands performed via dry contacts or via serial communication

Probable Causes	Possible Solutions
The SPS is in Local operation mode, therefore, it only follows the selections performed in its front panel	Select the SPS for Remote mode (see sub-chapter 3.2)
The SPS is in the Follower mode, therefore, it only follows the Raise/Lower tap commands emitted by the Master	Perform the Raise/Lower tap commands in the SPS Master, or change the SPS Follower as Individual (see sub-chapter 3.2)
The SPS is in the Automatic mode, therefore, it only follows the commands generated by the voltage regulator relay (or similar device)	Select the SPS for Manual mode (see sub-chapter 3.2)
In case of Secondary 1 and Secondary 2 SPS of single-phase banks, these are in the Bank mode, therefore, they only follow the raise/lower tap commands emitted by the Principal SPS of the Bank	Select the Secondary 1 and Secondary 2 SPS to operate in Individual Phase mode (see sub-chapter 3.3). To allow this selection, the bank must be in Individual and Manual mode
The on-load tap changer is in the Local mode or it is turned off, or there is no power/command supply, or any charging switch is turned off	Verify the on-load tap changer, the power/command circuit charging switches and the auxiliary power.

10.3 Tap position Local and Remote indications and Signaling contacts

- The indication of the tap position in the front panel of the SPS does not correspond to the real position of the tap changer

Probable Causes	Possible Solutions
It was not selected the correct option of SPS tap indication type	Select the indication type corresponding to your tap changer according to the instructions described in the sub-chapter 9.1.5
It was not selected the correct "neuter" tap position option of the tap changer, related to indication of bilateral numerical (-/+) or alphanumerical (L/R) type.	Select the "neuter" tap position of the tap changer according to the instructions described in the sub-chapter 9.1.6

- The on-load tap changer has bilateral numerical (-/+) or alphanumerical (L/R) tap indication, and the tap position indication in the front of the SPS is inverted in relation to the real position

Probable Causes	Possible Solutions
It was not selected the correct option of tap indication type of the SPS	Select the indication type corresponding to your tap changer according to the instructions described in the sub-chapter 9.1.5

- The SPS's current output mA for remote indication of tap position does not correspond to the expected value

Probable Causes	Possible Solutions
It was not selected the correct option of the SPS's output current range	Select the wanted output current range according to the instructions described in the sub-chapter 9.1.14
The calculation of the expected value for the current output is mistaken	See the calculation formula of the expected value for the current output in the sub-chapter 5.3

- The SPS's signaling contacts do not close (or open) in the expected condition

Probable Causes	Possible Solutions
The correct options for the signaling functions of the SPS's programmable contacts were not selected	Select the wanted signaling functions for the SPS's programmable contacts according to the instructions described in the sub-chapters 9.1.10 to 9.1.13
One (or more) SPS in the network has an error communication (E02), blocking the information of the condition that must be signaled be rightly received and distributed	Fix communication failure - see specific item in this sub-chapter

10.4 Error indication E01

- E01 – Synchronism error in only one of the Follower transformers or banks

Probable Causes	Possible Solutions
The Follower on-load tap changer is in Local mode or it is turned off	Select the on-load tap changer command as remote
There is no power or command supply for the Follower tap changer	Retrieve the auxiliary power
The power/command charging switches of the Follower tap changer are turned off	Turn on the power/command circuit charger switches again
The cables that carry the SPS's raise/lower tap commands to the on-load tap changer are blocked or have poor contact	Fix the raise/lower tap commands cables connections between the SPS and the on-load tap changer
The timing for synchronism error alarm is minor than the necessary.	Adjust the timing parameter for synchronism error alarm according to the recommendations described in sub-chapter 9.1.8
The Follower on-load tap changer does not perform the automatic transition among the intermediary positions	Enable the command circuit of the on-load tap changer to transit automatically among the intermediary positions
It was performed a local command of tap change in the proper cabinet of the on-load tap changer, without the corresponding SPS has been previously selected as Individual	Select the corresponding SPS as Individual, allowing the local commands of the tap changer without error occurrence E01
	Perform the tap change operations only in the SPS Master. The Followers tap changes will automatically occur
	Perform the local tap change in the tap changer's cabinet only after the Master performs an identical tap change

- E01 – Synchronism error in all the Follower transformers or banks (and also in the Secondary 1 and Secondary 2 phases of the Master bank, in case of single-phase banks)

Probable Causes	Possible Solutions
The Master on-load tap changer (or the Principal phase of the Master Bank, in case of single-phase banks) is in Local mode or it is turned off	Select the on-load tap changer command as Remote
There is no power or command supply for the Master tap changer (or for the Principal phase of the Master bank, in case of single-phase banks)	Retrieve the auxiliary power
The power/command charging switches of the Master Tap changer (or of the Principal phase of the Master bank, in case of single-phase banks) are turned off	Turn on the power/command circuit charger switches again
The Master on-load tap changer (or the Principal phase of the Master Bank, in case of single-phase banks) does not perform the automatic transition among the intermediary positions	Enable the command circuit of the on-load tap changer to transit automatically among the intermediary positions
The cables that carry the raise/lower tap commands from the Master SPS (or the Principal phase of the Master bank, in case of single-phase banks) to the on-load tap changer are blocked or have poor contact	Fix the raise/lower tap commands cables connections between the SPS and the on-load tap changer
The timing for synchronism error alarm is minor than the necessary in all the Follower SPS	Adjust the timing parameter for synchronism error alarm according to the recommendations described in sub-chapter 9.1.8
It was performed a local command of tap change in the proper cabinet of the on-load tap changer, without the corresponding SPS has been previously selected as Individual	Select another SPS as Master, and the SPS that presented the error as Individual, allowing the local commands of the tap changer without the error occurrence E01
	Perform the tap change operations only in the SPS Master.
	Perform the local tap change in the cabinets of all the tap changers in parallel

- E01 – Synchronism error in the Secondary 1 and Secondary 2 phases of the Master/Individual bank (only in case of single-phase banks)

Probable Causes	Possible Solutions
The on-load tap changer of the Secondary 1 or 2 phase of the Master/Individual bank is operating in Local mode or it is turned off	Select the on-load tap changer as remote
There is no power or command supply for the Secondary 1 or 2 phase of the Master/Individual bank	Retrieve the auxiliary power
The power/command charging switches of the Secondary 1 or 2 phase of the Master/Individual bank are turned off	Turn on the power/command circuit charger switches again
The cables that carry the raise/lower tap commands from the Secondary 1 or 2 SPS to the on-load tap changer are blocked or have poor contact	Fix the raise/lower tap commands cables connections between the SPS and the on-load tap changer
The timing for synchronism error alarm is minor than the necessary	Adjust the timing parameter for synchronism error alarm according to the recommendations described in sub-chapter 9.1.8
The Secondary 1 or 2 phase on-load tap changer of the Master/Individual bank does not perform the automatic transition among the intermediary positions	Enable the command circuit of the on-load tap changer to transit automatically among the intermediary positions
It was performed a local command of tap change in the proper cabinet of the on-load tap changer, without the corresponding SPS ha been previously selected as Individual Phase	Select the corresponding SPS as Individual Phase, allowing the Local commands of the tap changer to be performed without the error occurrence E01
	Perform the tap change operations only in the Principal SPS of the Master bank. The tap changes of the Secondary 1 and 2 will occur automatically
	Perform the local tap change in the cabinet of the tap changer only after the Principal of the Master bank has performed an identical tap change

10.5 Error Indication E02

- E02 – Communication error in only one of the SPS

Probable Causes	Possible Solutions
Poor contact in the cables' connection from the serial communication RS485 to the SPS that presents the error E02	Improve the cable connection of the serial communication
SPS's upper rear connector is not rightly inserted	Push the upper rear connector until it inserts perfectly to the SPS
Incorrect adjustment of the ADR and/or NOD parameters	Adjust the ADR and/or NOD parameters according to the instructions described in the sub-chapters 9.1.2 and 9.1.3

- E02 – Communication error in all the SPS of the network simultaneously

Probable Causes	Possible Solutions
Poor contact or interruption in the cables connection from the serial communication RS485 to the communication module COMM- 04	Improve the cable connections from the serial communication to the COMM-04
Incorrect adjustment of the ADR and/or NOD parameters	Adjust the ADR and/or NOD parameters according to the instructions described in the sub-chapters 9.1.2 and 9.1.3
Lack of auxiliary power to the communication module COMM-04	Retrieve the auxiliary power to the communication module
Defective communication module COMM-04	Replace the communication module COMM-04 by a reserve unity

- E02 – Signaling contact of the communication error condition set, however none of the SPS presents the indication E02 in it's display

Probable Causes	Possible Solutions
Incorrect adjustment of the ADR and/or NOD parameters	Adjust the ADR and/or NOD parameters according to the instructions described in the sub-chapters 9.1.2 and 9.1.3
Lack of auxiliary power for one or more SPS in the network	Retrieve the auxiliary power to the SPS(s)
One or more SPS in the network is defected (completely out, even though supplied)	Replace the defected SPS by a reserve unity

- E02 – Sporadic and random indication of communication error E02 in several SPS of the network, simultaneously or not

Probable Causes	Possible Solutions
Poor contact in the cables connection from the Serial communication RS485 to the communication module COMM-04	Improve the cable connection from the serial communication to the COMM-04
Serial communication cables are not shielded twisted-pairtype	Replace the cables of the serial communication by shielded twisted-pair, according to the instructions described in the sub-chapter 5.7
Shield of the serial communication cables is grounded in more than one point or it is not grounded	Ground the shield of the serial communication cables in a single point, according to the instructions described in the sub-chapter 5.7

10.6 Error indication E04

- E04 – Programming error

Probable Causes	Possible Solutions
Programming attempt of invalid condition for a longer period than the adjusted timing	Program only valid conditions, according to the sub-chapter 3.6.3
	Increase the alarm timing E04, if the invalid programming condition is only temporary
Communication error in the Master SPS (or in the Principal phase of the Master bank)	Correct the communication error E02; see specific item in this sub-chapter
Simultaneous programming changes in two or more SPS were performed, what allows to force an invalid condition that commonly would not be accepted by the SPS (for an example, 2 Masters)	Correct the invalid programming condition, according to the sub-chapters 3.2 and 3.6.3

10.7 Error Indication E08

- E08 – Tap position reading error

To easy the tap reading error diagnostic, it is convenient to consult in the SPS the cause of the reading error and the tap position that it was at the moment of the error occurrence. Follow the following proceeding:

- Press momentarily the key P;
- Press simultaneously the keys P and ↑. It will be shown in the display the cause code of the last reading error occurred, C1, C2 or C3;
- Press momentarily the key P. It will be shown in the display the tap position that was the tap changer at the moment the error occurred.

Having the cause code of the reading error, verify the probable causes and possible solutions in the table below.

Code	Probable Causes	Possible Solutions
C1	Internal defect in the SPS (communication failure between microcontrollers)	Replace the defected SPS by a reserve unity
C2	Connection cables of the potentiometric transmitter are not shielded type	Replace the connection cables from the potentiometric transmitter to the SPS by shielded cables, according to instructions described in the sub-chapter 5.2.1
	Shield of the connection cables from the potentiometric transmitter to the SPS are grounded in more than one point or are not grounded, or without of shield continuity along the course.	Ground the connection cables shield from the transmitter to the SPS in a single point, and keep the shield continuity, according to the instructions described in sub-chapter 5.2.1
	Poor contact in the potentiometric position transmitter cursor or in the connection cables from it to the SPS	Fix the poor contact in the cables or in the potentiometric transmitter cursor
C3	Connection cables from the potentiometric transmitter to the SPS with resistance higher than 8 ohms by wire – very reduced size in function of the traveled distance	Replace the connection cables from the potentiometric transmitter to the SPS by cables with an adequate size, according to the instructions described in the sub-chapter 5.2.1
	Connection cables from the potentiometric transmitter to the SPS with different sizes or lengths in each wire	Replace the connection cables from the potentiometric transmitter to the SPS by shielded cables with identical sizes in the 3 wires, according to instructions described in the sub-chapter 5.2.1
	Poor contact in the potentiometric position transmitter cursor or in the connection cables from it to the SPS	Fix the poor contact in the cables or in the potentiometric transmitter cursor
	Error in the adjustment of the TAP and/or RES parameters of the SPS	Correct the adjustment of the TAP and/or RES parameters according to the instructions described in the sub-chapters 9.1.4 and 9.1.7
	The potentiometric transmitter has step resistors installed in the intermediary positions of the tap changer	Remove the resistors from the intermediary positions of the tap changer, replacing them by jumpers, according to the instructions described in the sub-chapter 5.2.2
	The step resistors of the potentiometric transmitter have tolerance higher than 1% of its nominal value	Replace the step resistors of the potentiometric transmitter by other of better precision or equal to 1%

10.8 Indication of error combinations E10 e E12

- E10 – Simultaneous occurrence of errors E02 and E08 – consult the sub-chapters 10.5 and 10.7
- E12 – Simultaneous occurrence of errors E04 and E08 – consult the sub-chapters 10.6 and 10.7

Section VI – Appendix

Index

Appendix	Title	Page
A	Technical Data	VI – 2
A.1	Synchronous Parallelism Supervisor SPS	VI – 2
A.2	Communication Module COMM-04	VI – 2
B	Type tests	VI – 3
C	Order Specification	VI – 4
C.1	Synchronous Parallelism Supervisor SPS	VI – 4
C.2	Communication Module COMM-04	VI – 4
D	Optional Accessories	VI – 5
D.1	Expansion of Signaling Contacts	VI – 5
D.2	Transmitter of Potentiometric Position of Magnetic type	VI – 5
E	Registers Map	VI – 6
E.1	General Information	VI – 6
E.2	Registers available in <i>buffer</i> in the COMM-04 (reading only)	VI – 6
E.3	Registers unavailable in <i>buffer</i> in the COMM -04 (reading and writing)	VI – 9

Appendix A – Technical Data

A.1 Synchronous Parallelism System SPS

Power Voltage:	85 to 265 Vdc/Vac 50/60Hz
Consumption:	< 5 W
Operation Temperature:	-10 a +70 °C
Protection Degree:	IP 40
Fixation:	Built-in panel
Tap Measurement input:	Potentiometric, 3 wires
Number of Taps of the OLTC:	2 to 50
Total resistance of the potentiometric transmitter:	9,4 to 1000Ω
Resistance by step of the potentiometric transmitter:	4,7 to 20Ω
Analog Output Options and Maximum Load:	0 ... 1 mA - 12000Ω
	0 ... 5 mA - 2400Ω
	0 ... 10 mA - 1200Ω
	0 ... 20 mA - 600Ω
	4 ... 20mA - 600Ω
	0,5% of the scale ending
Maximum error of the Analog Output:	Potential free
output Contacts:	70 W / 250 VA
Maximum Potency de Chaveamento:	250 Vdc/Vac
Maximum Voltage de Chaveamento:	2,0 A
Maximum Current of Conduction:	1 (one) RS485 for connection to the
Serial communication portal:	COMM-04 Modbus RTU (<i>slave</i>)
Communication Protocol with the COMM-04:	Maximum 6 (six)
Three-phase banks or transformers in parallel:	

A.2 Communication Module COMM-04

Power Voltage:	85 to 265 Vdc/Vac 50/60Hz
Consumption:	< 5 W
Operation Temperature:	-10 a +70 °C
Protection Degree:	IP 40
Fixation:	Mounting in Rail 35mm
Serial communication ports:	2 (two) RS485 for connection to the SPS and to the System
Communication Protocol with the SPS:	supervisor
Communication Protocol with the Supervisor System:	Modbus RTU (<i>master</i>)
	Modbus RTU (<i>slave</i>)

Appendix B –Type Tests

Parallelism Supervisor SPS and Communication Module COMM -04

Surges and transients (IEC 60255-6)

Peak value 1 ^o cycle:	2,5 kV
Frequency:	1,1 MHz
Time:	2 s
Repetition Rate:	400 (surges/s)
Declining a 50%:	5 cycles

Impulse (IEC 60255-5)

Wave form:	1,2/50 µs
Amplitude:	5 kV
Number of pulses:	3 negative e 3 positive with break of 5 seconds among pulses.
Energy:	0,5J

Applied Voltage (IEC 60255-5)

Tolerable voltage nominal to the industrial frequency:	2,0 kVrms, 60 Hz, for 1 minute between circuits and mounting panel.
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Electromagnetic Susceptibility (IEC 61000-4-3)

Severity Level:	3
Frequency:	20 to 2000MHz
Field intensity:	10 V/m

Electrostatic Discharges (IEC 61000-4-2)

Air mode:	10 discharges level 3 (8kV)
Contact mode:	10 discharges level 3 (8kV)

Prompt Electric Transients (IEC 61000-4-4)

Severity Level:	4
Test in the Power input:	4kV
Test in the inputs/outputs:	2kV

Climatic Assay(IEC 60068-2-14)

Temperature Range:	-10 a +70°C
Test timing:	6 hours

Appendix C – Specification for Order

C.1 Synchronous Parallelism System SPS

The SPS was schemed to allow a universal application, exempting specific data information during the equipment purchase. The following selections contribute for its universal application. These selections are performed in the firmware (internal software) of the SPS by its front panel (see sub-chapter 8.1):

- Transformer type: three-phase or single-phase;
- Number of tap changer positions: from 2 to 50;
- Tap indication type: simple numerical, bilateral numerical or alphanumeric, with direct or inverted indication and with “neuter” tap that can be selected;
- Resistance by step of the potentiometric transmitter: from 4,7 to 20 ohms;
- Maximum tap change time of the tap changer: from 1 to 100 seconds;
- Current output for tap remote 0-1, 0-5, 0-10, 0-20 or 4-20mA, with bipolar output option (-/+);
- Interface language for operation: Portuguese, English or Spanish.

Thus, during the SPS purchase it is not necessary to inform none of the data above described, because the user parameterizes the device according to its use.

Specify the required equipment:

- SPS: (potentiometric type tap input);

C.2 Communication Module COMM-04

The Communication Module is a general application device that is also used with another Treetech devices further than the SPS. What distinguishes the COMM application is its internal software.

The code “04” indicates the COMM application with the SPS, lacking only to specify its texts language, as seen below.

COMM – 04

Version

Language

Being:

- Version: 04 = SPS firmware V1.1
- Language: 1 = Portuguese
2 = English
3 = Spanish

Example : COMM – 041 - Version = For SPS V1.1; Language = Portuguese

Appendix D – Optional Accessories

D.1 Signaling Contacts Expansion

If it is necessary, it is possible to expand the number of signaling contacts of the parallelism system using the Data and Control Acquisition Module in its special version named by its initials MD3-SP2.

The expansion of the signaling contacts can be especially useful when the SPS is used with three-phase transformer, because in this case only 4 signaling contacts are available per three-phase unity.

The MD3-SP2 module has 8 output contacts Normally Open grouped in 2 4-contact sets. Each set of contacts attends to one three-phase transformer or to one bank, in such manner that each MD3-SP2 module attends up to 2 transformers or banks. Each 4-contact set has the following fixed signaling functions: Master, Follower, Individual and Remote.

Detailed information can be found in the specific MD3-SP2 documentation.

D.2 Potentiometric Position Transmitter of Magnetic type

The majority of the recent on-load tap changers, and some of the antique ones, is supplied in the factory by potentiometric position transmitter or dry contacts that allow the creation of the transmitter by means of the adequate step resistors installation.

However, in case of tap changers that do not have any of these alternatives, Treetech can provide potentiometric position transmitters magnetically operated, without mechanical contacts, what makes its installation easy in antique equipment already in operation.

Contact us regarding to this equipment supply and to get its installation services.



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