INSTRUMENTOS PARA TESTES ELÉTRICOS

Test Tutorial

Equipment Type: Protection Relay

Brand: ABB

Model: REL650

Function: 25 or RSYN – Synchronism Check

Tool Used: CE-6006; CE-6707; CE-6710; CE-7012 or CE-7024

Objective: Test when two systems can connect, respecting voltage, frequency and angle limits, that is, if they are in synchronism.

Version control:

Version	Descriptions	Date	Author	Reviewer
1.0	Initial Version	17/01/2022	M.R.C.	M.P.S

Summary

Statement of responsibility

The information contained in this tutorial is constantly verified. However, differences in description cannot be completely excluded; in this way, CONPROVE disclaims any responsibility for errors or omissions contained in the information transmitted.

Suggestions for improvement of this material are welcome, just user contacts us by email suporte@conprove.com.br.

The tutorial contains knowledge gained from the resources and technical data at the time was writing. Therefore, CONPROVE reserves the right to make changes to this document without prior notice.

This document is intended as a guide only; the manual of the equipment under tested must always be consulted.

ATTENTION!

The equipment generates high current and voltage values during its operation.
Improper use of the equipment can result in material and physical damage.

Only suitably qualified people must handle the instrument. It should be noted that the user must have satisfactory training in maintenance procedures a good knowledge of the equipment under tested and also be aware of safety standards and regulations.

Copyright

Sequence for testing the ABB REL650 relay in the Synchronism software

1. Relay connection to CE-6006

Appendix A-1 shows the relay terminal designations.

1.1 *Auxiliary Source*

Connect the positive (red terminal) of the Vdc Aux. Source to pin 3 on the relay terminal X410 and the negative (black terminal) of the Vdc Aux. Source to pin 1 on the relay terminal X410.

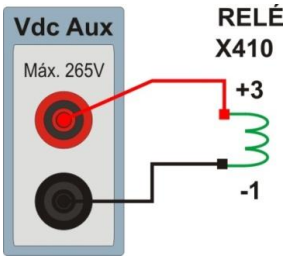

Figure 1

1.2 *Voltage Coils*

To establish the connection of the voltage coils, connect channels V1, V2 and V3 with pins 1, 3 and 5 of the relay terminal X102 and the common ones to pins 2, 4 and 6. If these last three points are short-circuited, connect all common to that point. To establish the connection of the second system, connect channel V4 to pin A7 of the relay terminal and connect its common to pin A8 of the relay terminal.

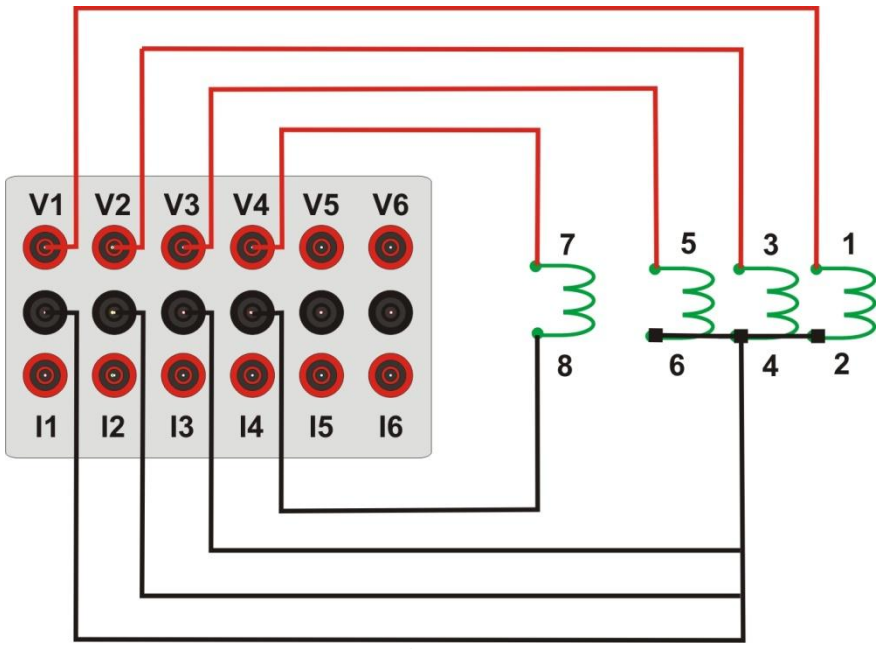

Figure 2

1.3 *Binary Inputs*

Connect CE-6006 binary input to X307 relay slot binary output.

- BI1 to pin 07 and its common to pin 08.

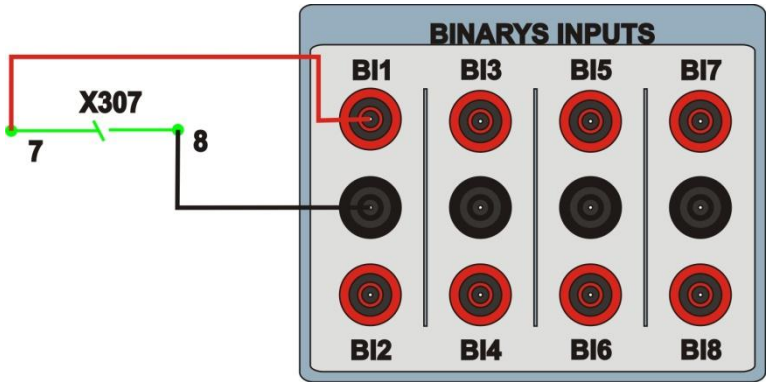

Figure 3

2. REL650 Relay Configuration

Connect an Ethernet cable from the notebook with the relay. Then open ***PCM600*** by double clicking on the software icon.

Figure 4

Note: In this tutorial it is considered that there is no configuration in the relay, so all parameterization will be inserted in the relay.

2.1 *Creating a new file*

First, a new project must be included. Click on the *"File"* option and then *"New Project ..."*

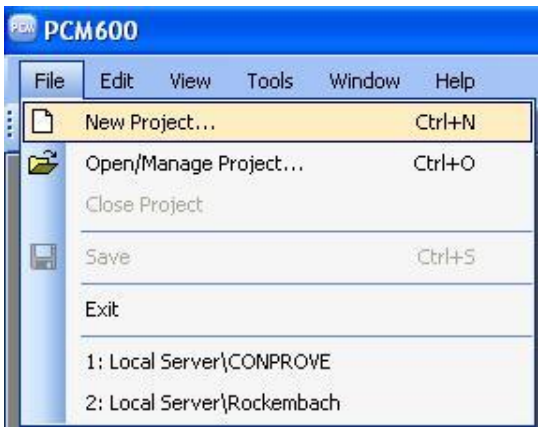

Figure 5

Choose a name for the project, in this case *"25"* was used and then click on *"Create"*.

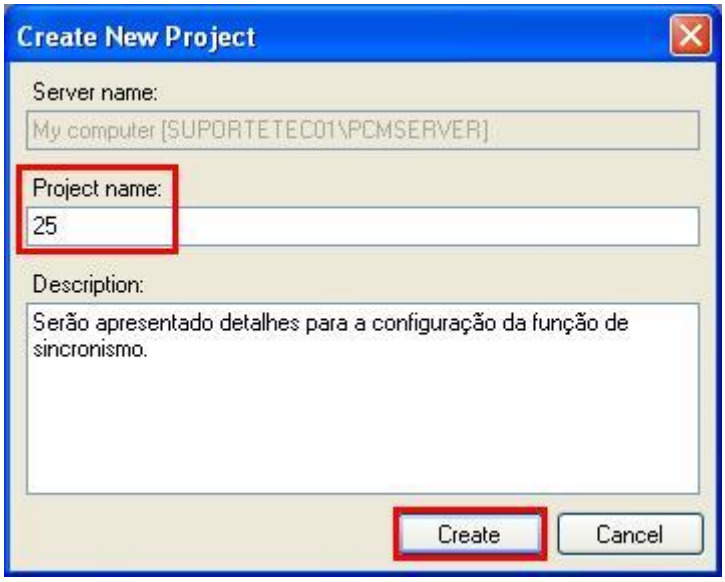

Figure 6

Right-click on the created plant and insert a substation.

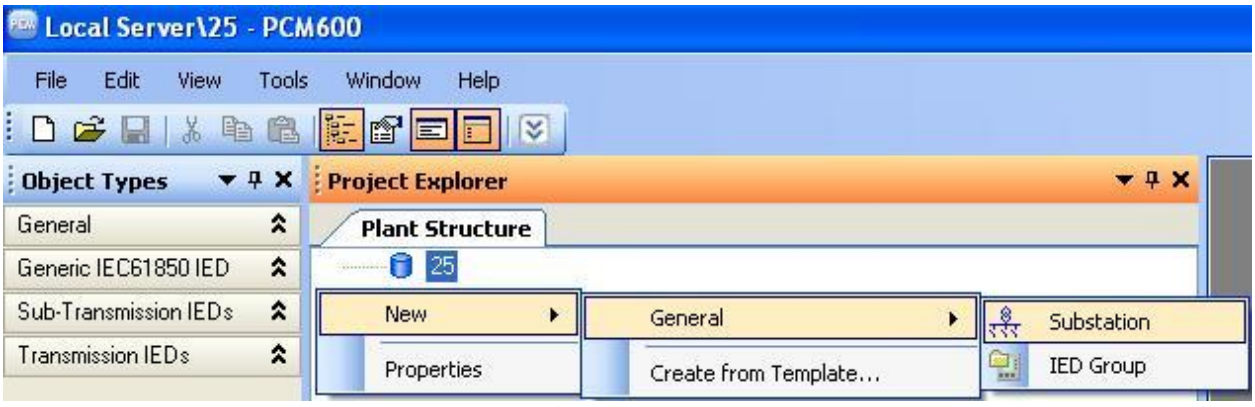

Figure 7

Within the substation created, enter the voltage level according to the following figure:

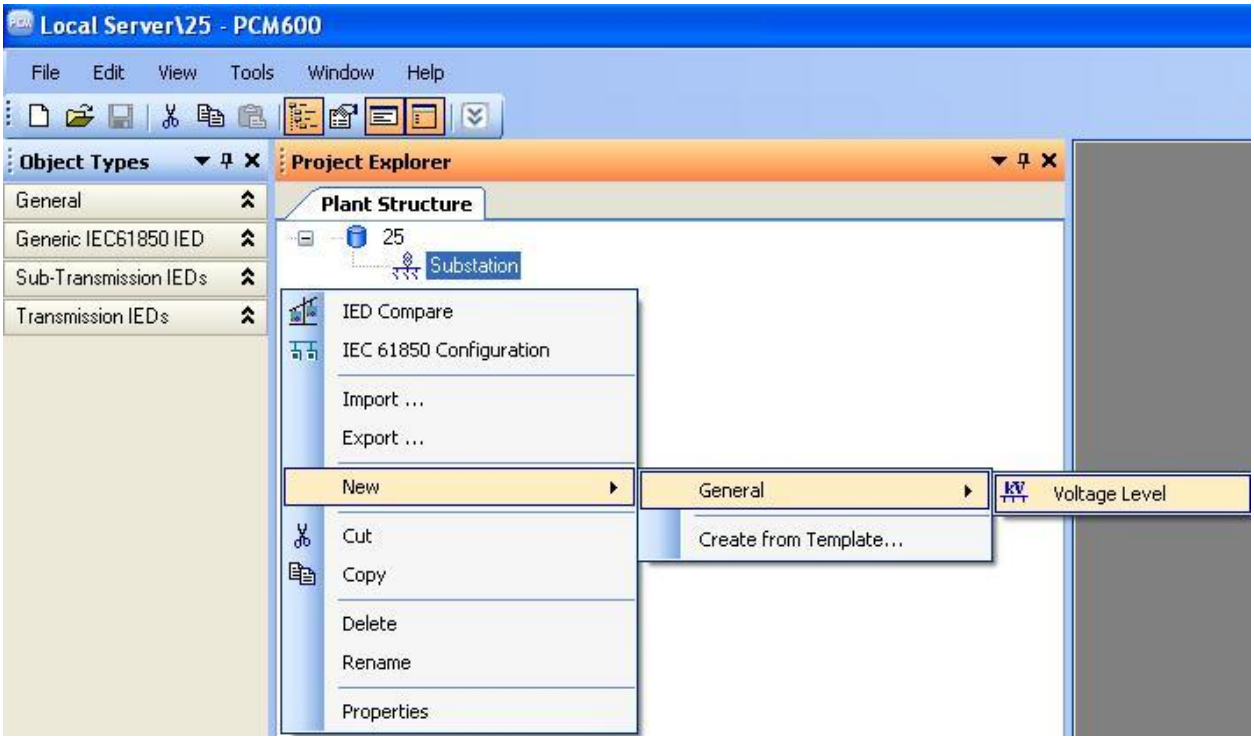

Figure 8

Within the voltage level a bay must be inserted.

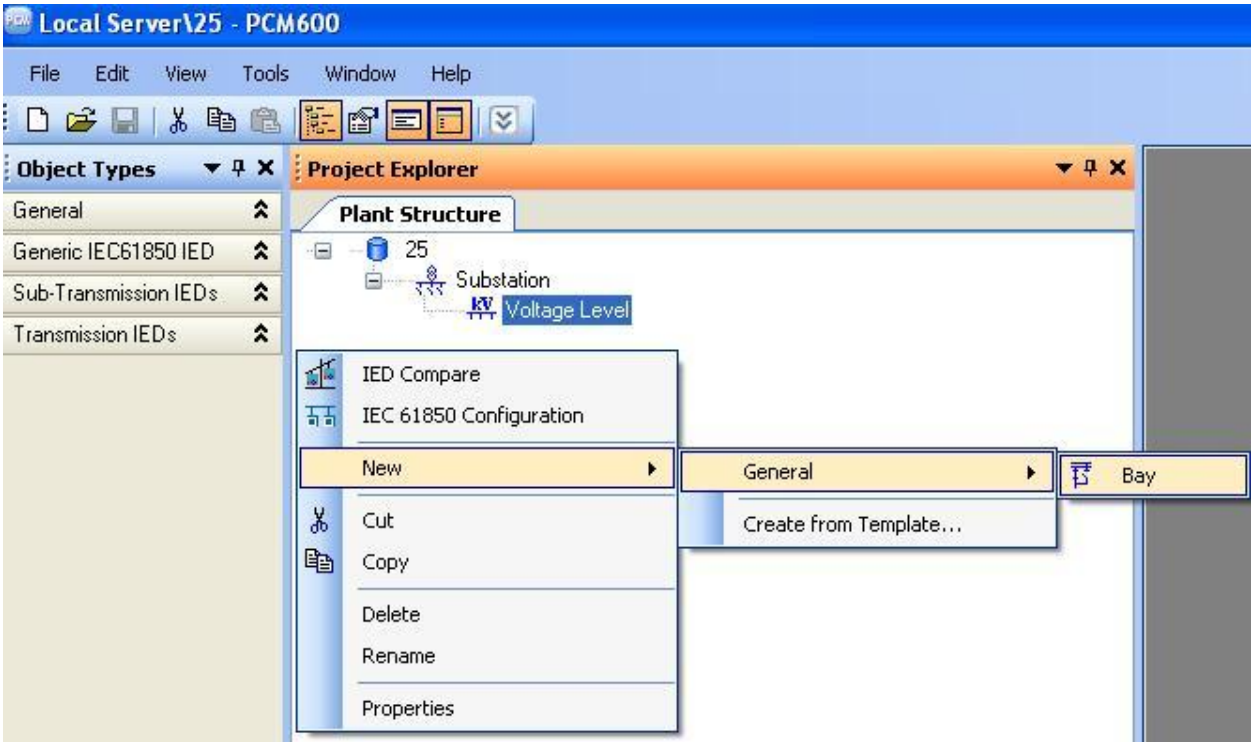

Figure 9

The REL650 relay is inserted inside the bay.

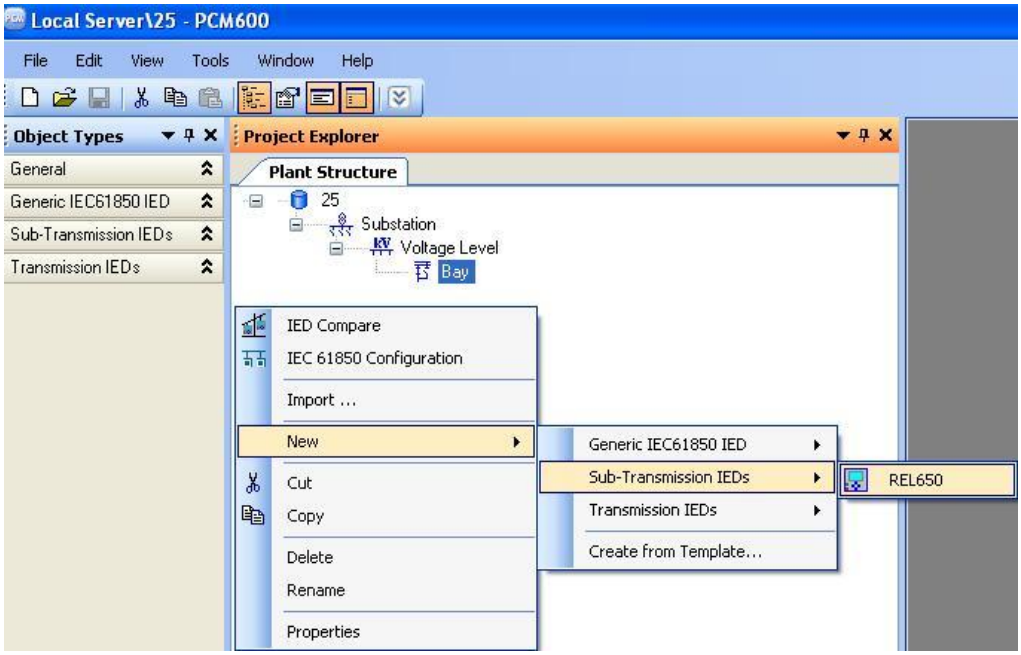

Figure 10

2.2 *Setting up communication*

Choose the option *"Online Configuration"* and click on *"Next >"*.

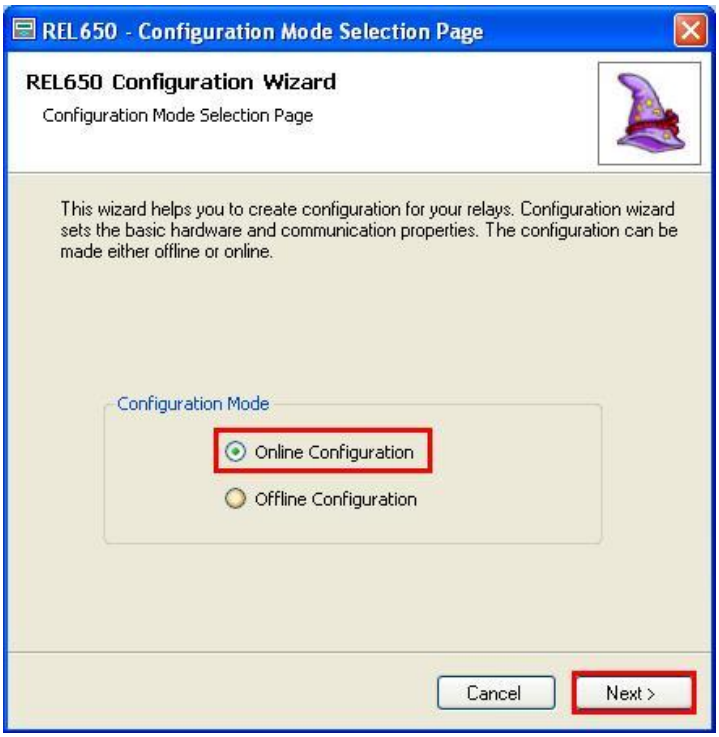

Figure 11

Choose the *"Next >"* option again.

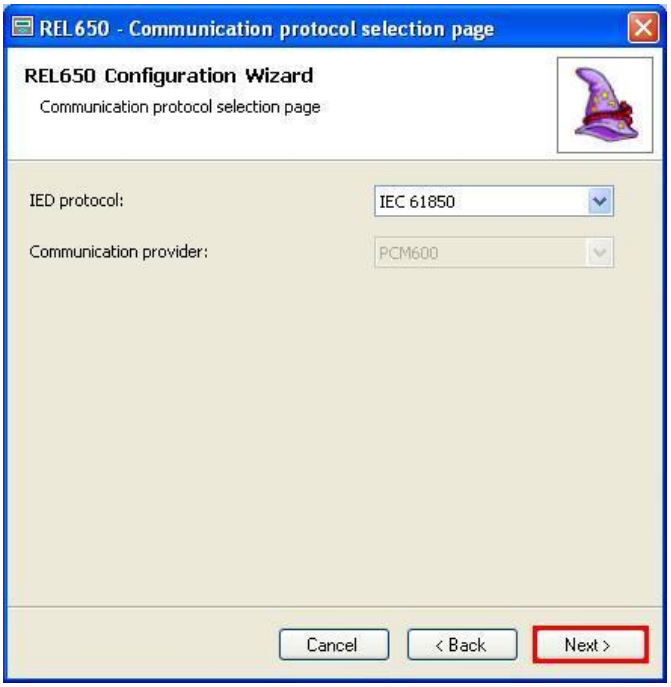

Figure 12

On the next screen, the user chooses between two options *"LAN1"* or *"Front Port"*, then he must see in the relay which IP is configured. To do this, go to *"Settings > General settings > Communication > Ethernet configuration"* and view the desired IP. Adjust this value in PCM and in this tutorial the option *"Front Port"* was chosen.

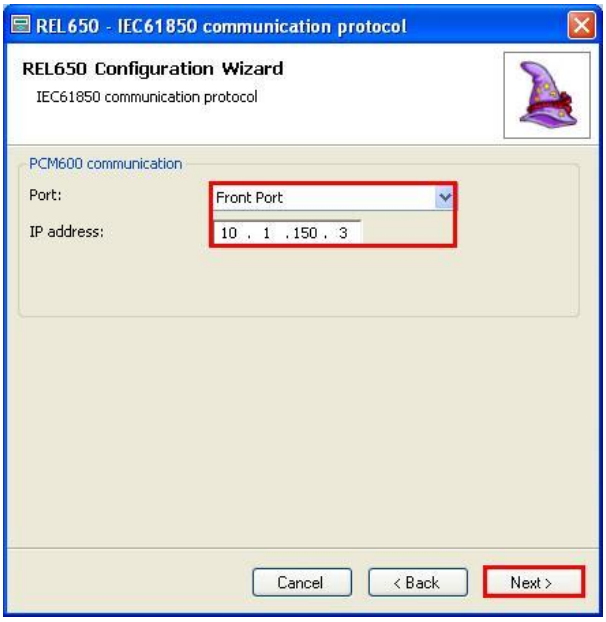

Figure 13

Then click on *"Next >"* and on the next screen on *"Scan"*.

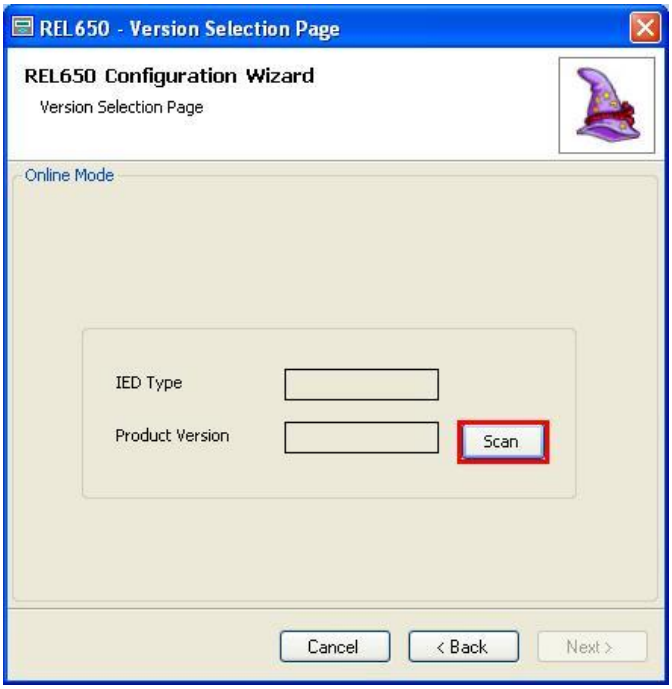

Figure 14

If the settings are correct, the software identifies the relay model and its version as shown in the following screen.

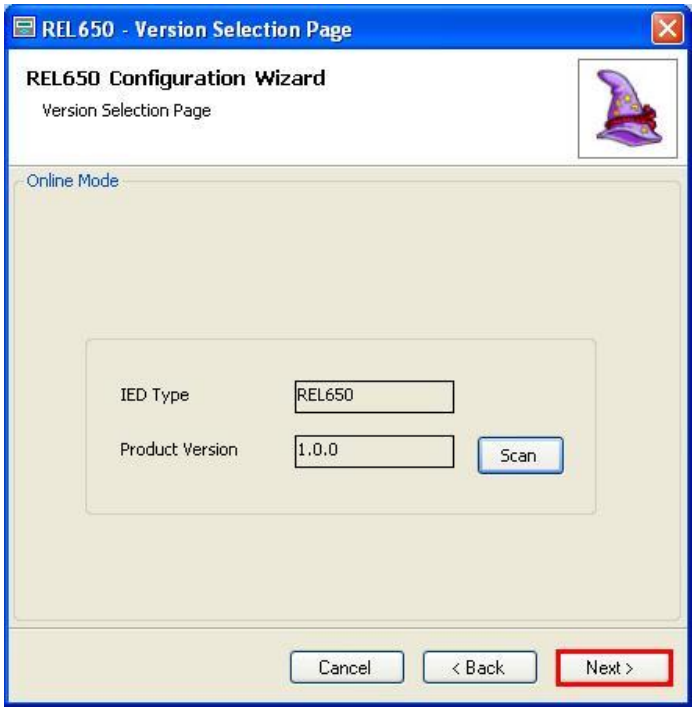

Figure 15

On the next screen, the relay identifies the type of housing and display.

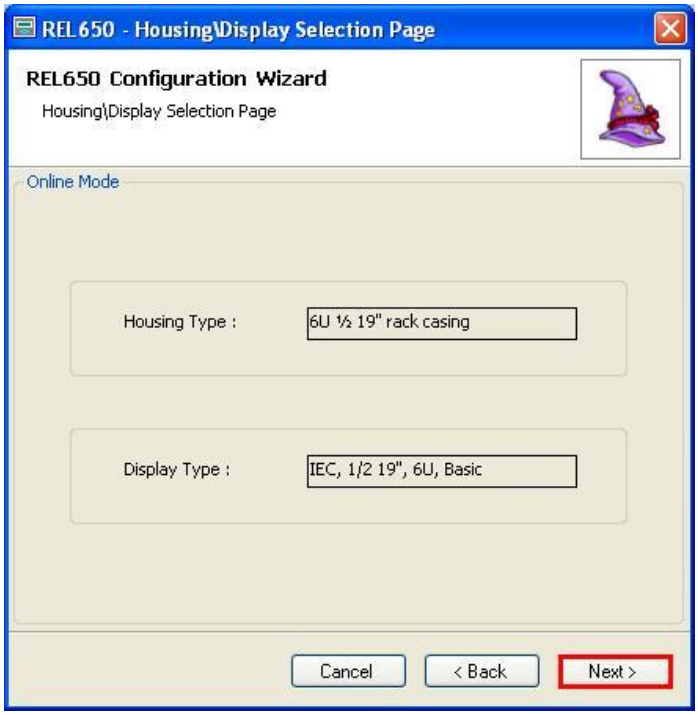

Figure 16

Finally, the complete relay information.

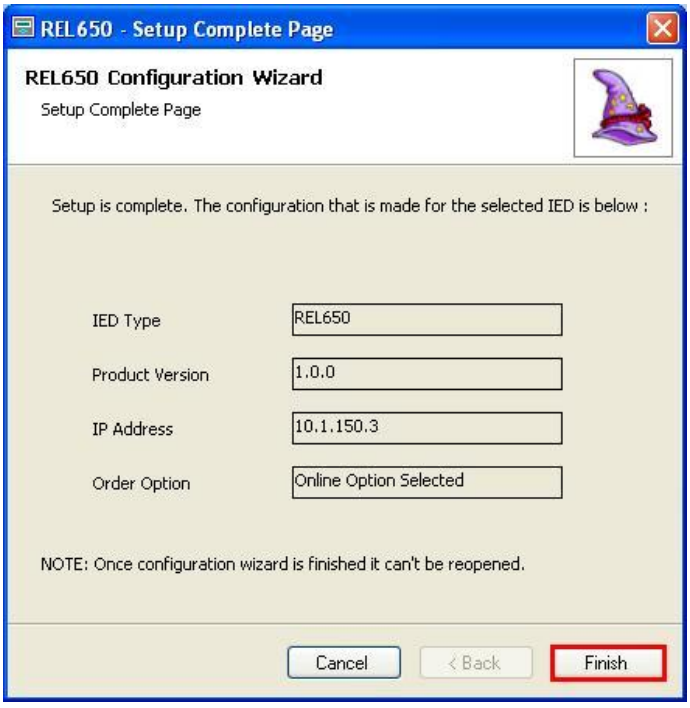

Figure 17

2.3 *TRM_2*

Click on the *"+"* signs near to *"IED Configuration"* and *"HW Configuration"*. Within the last option the relay shows all slots that are inserted in the relay. Right click on the *"TRM_2"* option and select *"Parameter Setting"*.

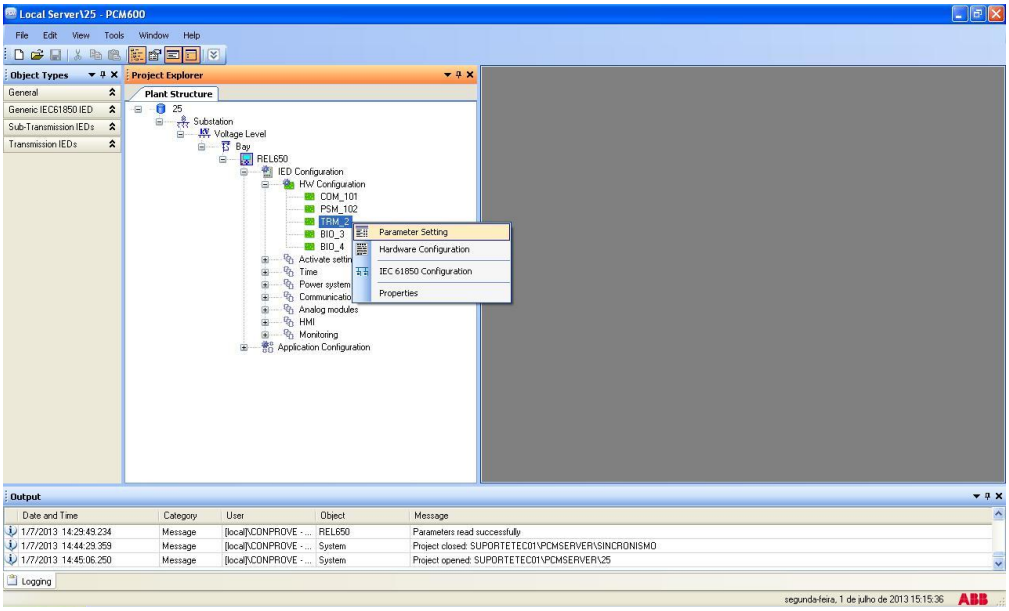

Figure 18

In this window, the current and voltage transformation relationships must be configured. In this case, only channels 6, 7, 8, and 9 will be configured since the protection to be analyzed is the synchronism.

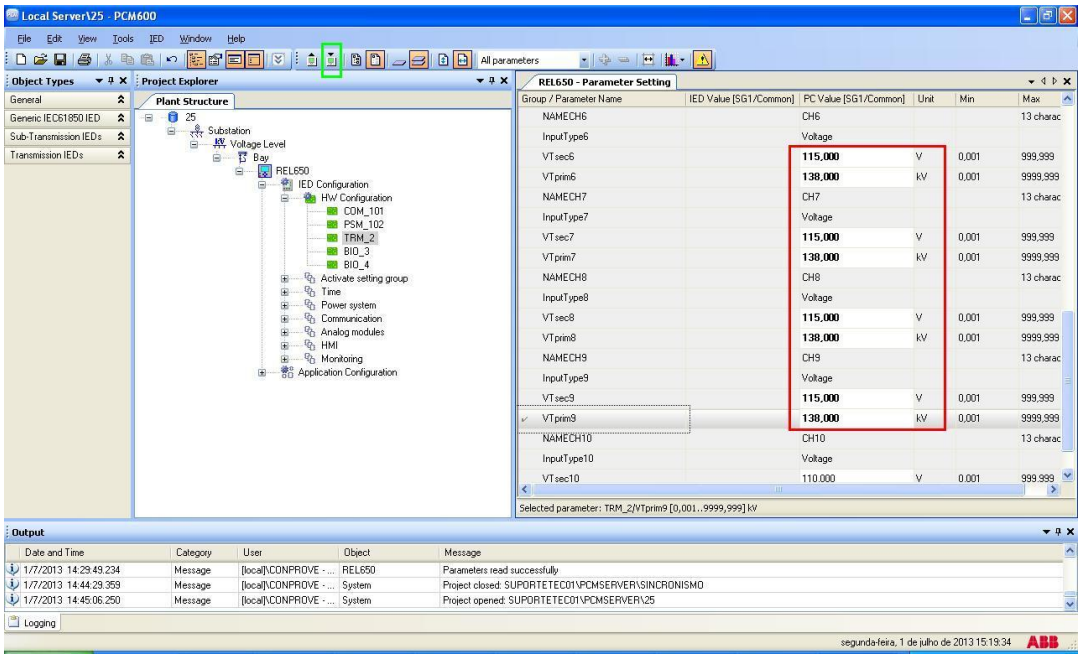

Figure 19

In the icon highlighted in green in the previous figure, the changes are sent to the relay. There are three shipping options:

1. Submit only a specific value;
2. Submit all changes made within a setting group.
3. Send all parameterized settings within the group.

In this case, only the settings that have been changed are sent.

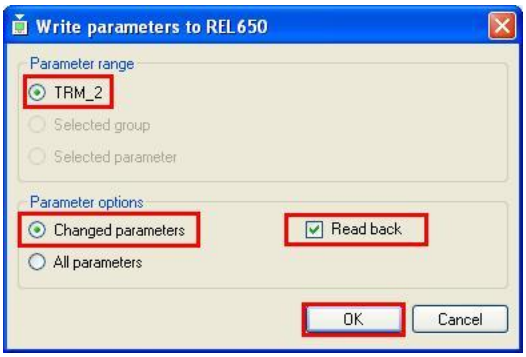

Figure 20

Note: Whenever the user makes a change in any setting group, this procedure must be repeated.

2.4 *SETGRPS: 1*

Click the *"+"* sign near to *"Activate setting group"* and then *"SETGRPS: 1"* and make sure that group one is active.

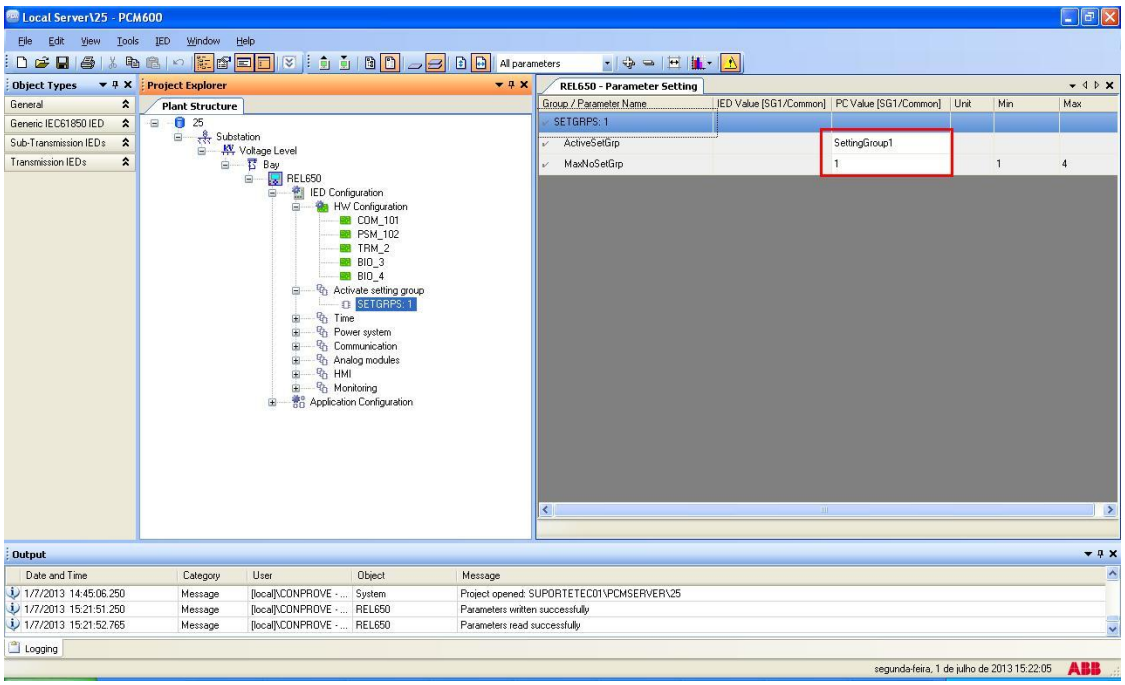

Figure 21

2.5 *PRIMVAL: 1*

Click on the *"+"* signs near to *"Power System"* and *"Primary values"* and select the *"PRIMVAL: 1"* option. In this group, the frequency and phase sequence values are adjusted. Send the settings to the relay if there is any change.

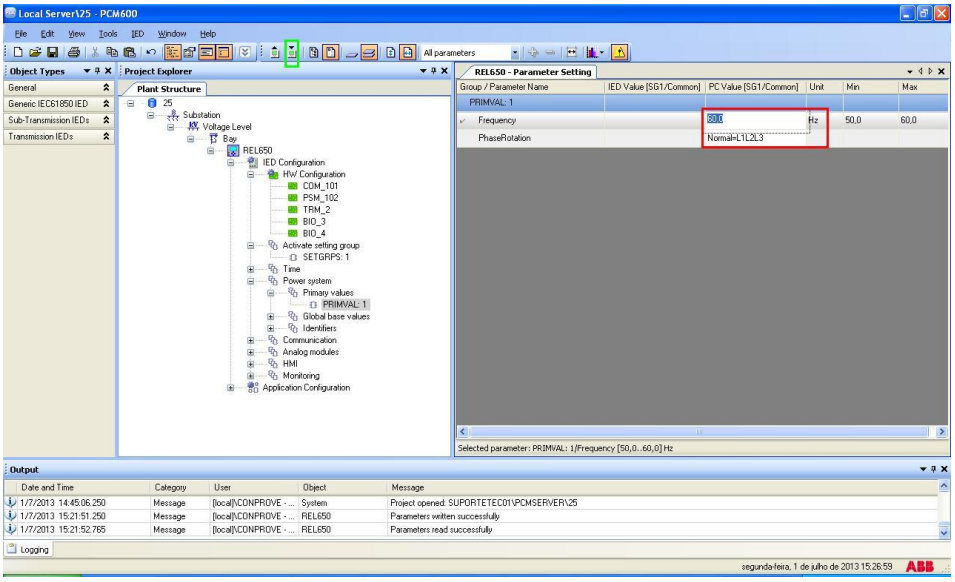

Figure 22

2.6 *GBASVAL: 1*

Click the *"+"* sign next to *"Global base values"* and then *"GBASVAL: 1"* and adjust the base voltage value. The other base value groups will not be used.

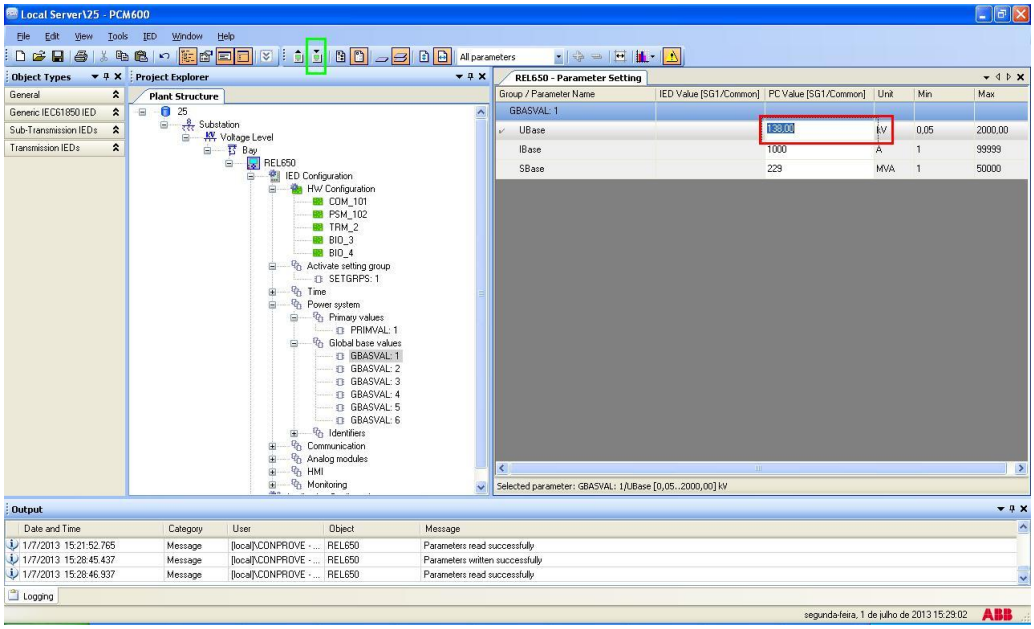

Figure 23

2.7 *AISVBAS: 1*

Click on the *"+"* signs beside *"Analog modules"* > *"Reference channel service values"*,select the option *"AISVBAS: 1"* and set channel 6 as the reference channel, which is equivalent to the A-phase voltage.

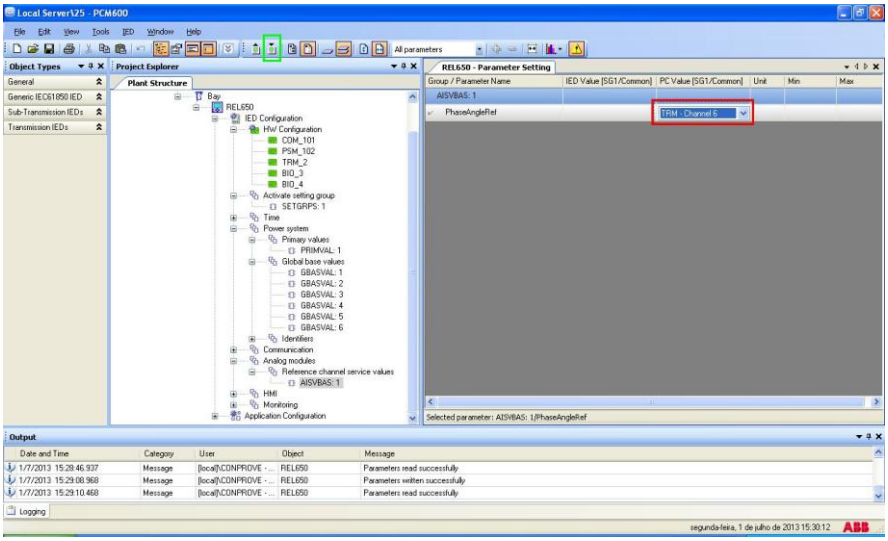

Figure 24

2.8 *Application Configuration*

Select the *"Application Configuration"* option, right click and choose *"Application Configuration"* again. In this field, the protection logic blocks must be entered.

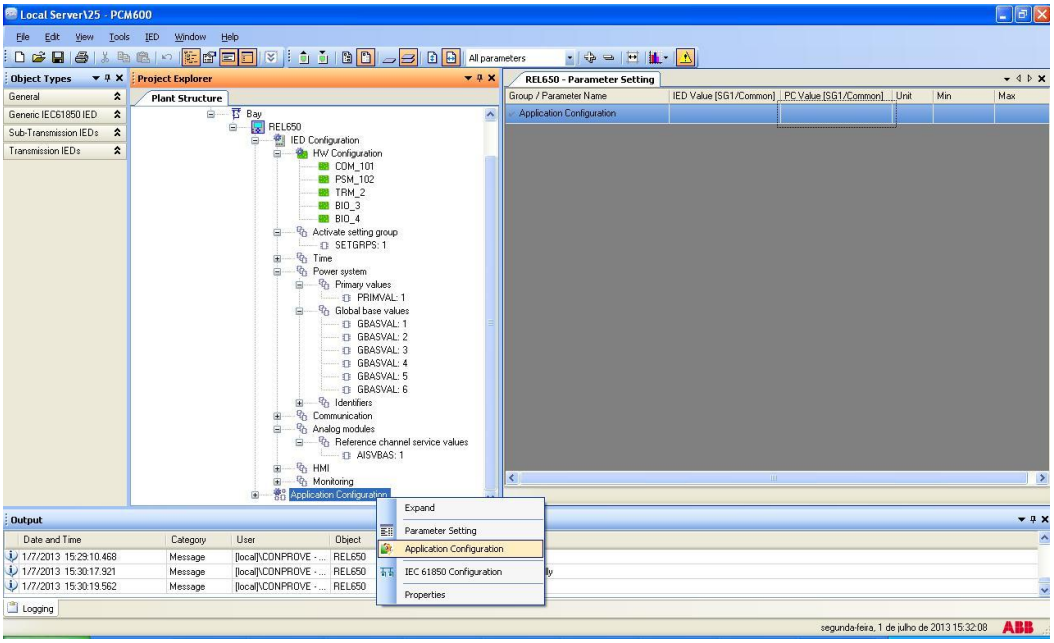

Figure 25

On the screen that opens, right click and then choose the option *"Insert FunctionBlock"*.

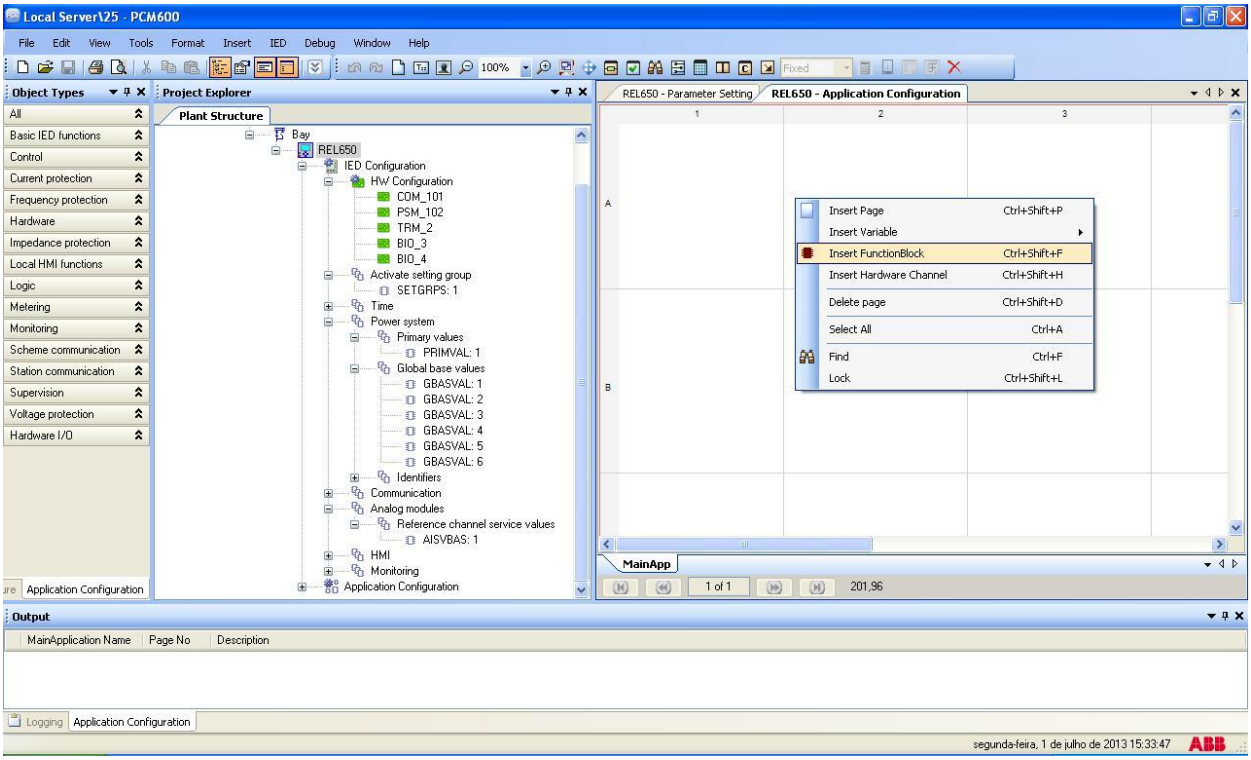

Figure 26

2.9 *SMAI_20_2 (Voltage Lines)*

Click on the *"+"* sign near to *"Basic IED functions"* and insert the *"SMAI_20_2"* block that will be responsible for the line voltage channels. To understand the perfect functioning of the different blocks, consult the REL650 manual.

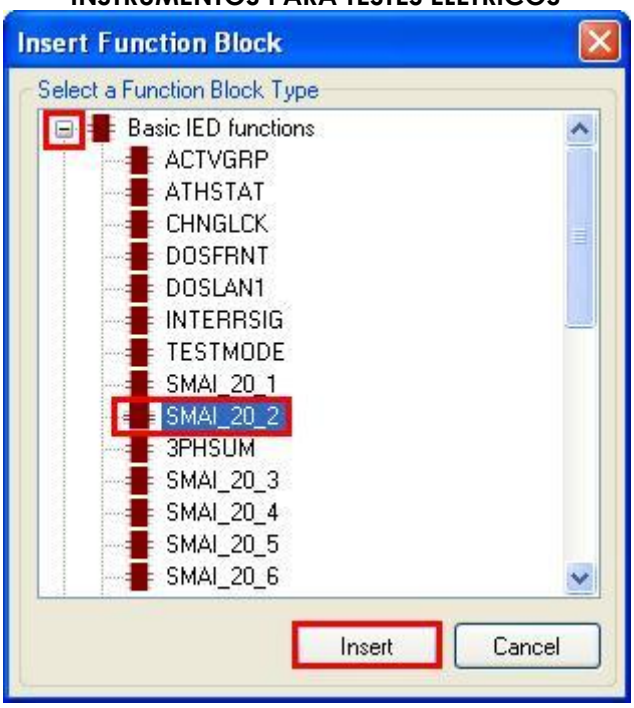

Figure 27

On the next screen, set the *"Cycle Time"* to 20.

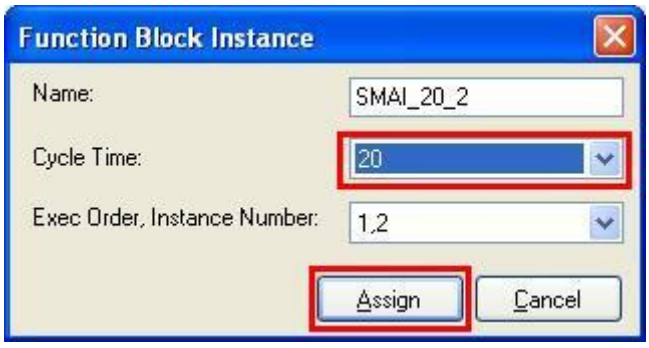

Figure 28

The next step is to route the function block's channel input with its physical channel. To do this right click outside the block and choose the following option.

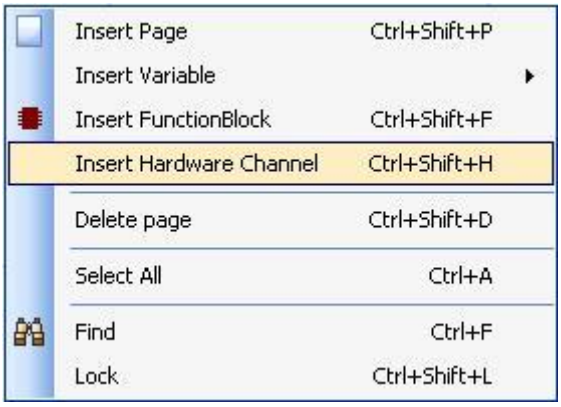

Figure 29

Choose the *"Analog Input"* option and click on *"Insert"*.

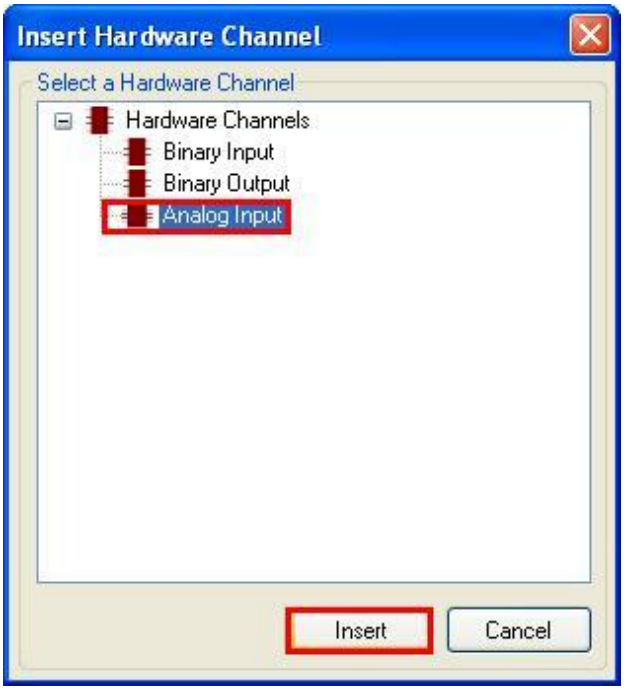

Figure 30

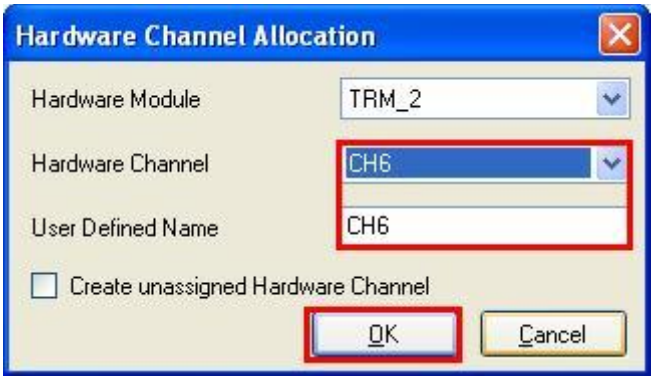

Figure 31

Repeat the procedure of the 3 previous figures changing the *"Hardware Channel Allocation"* option to CH7 and CH8. Then make the connections with the block.

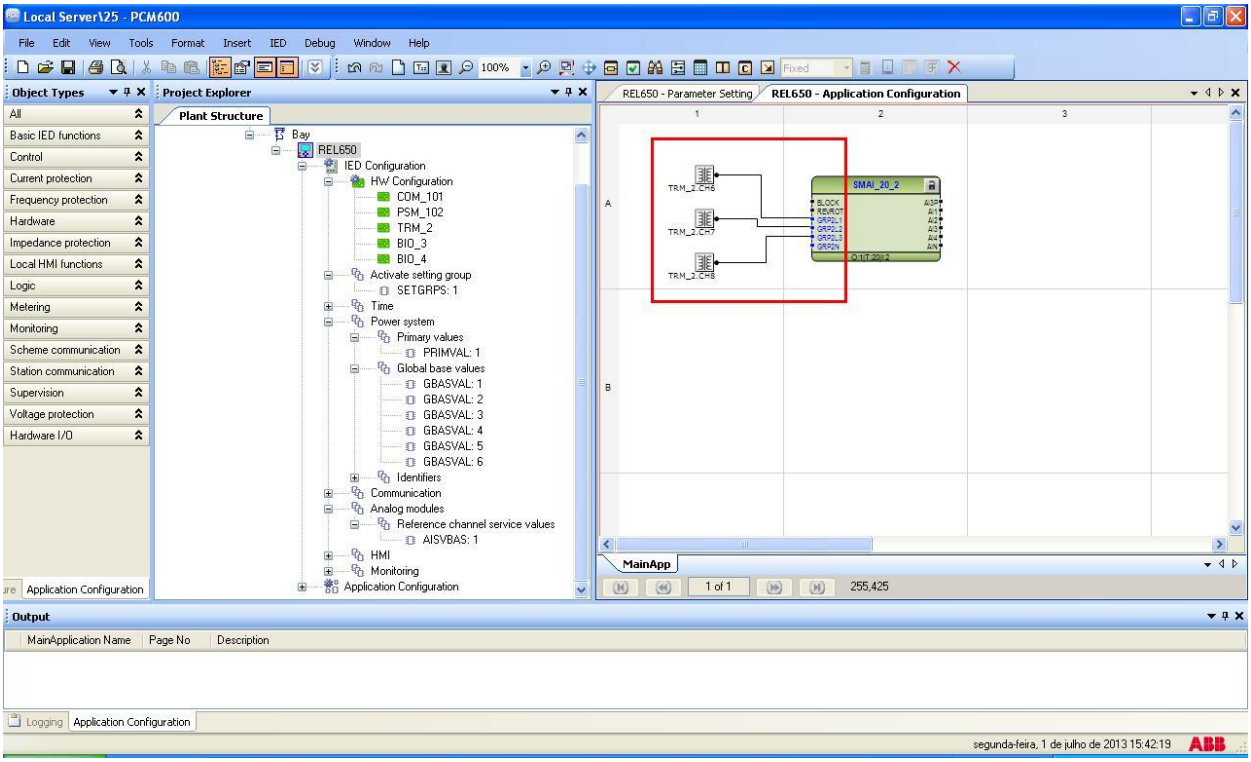

Figure 32

Assign an output variable to the *"AI3P"* option. Right-click and choose *"Insert Variable > Output"*.

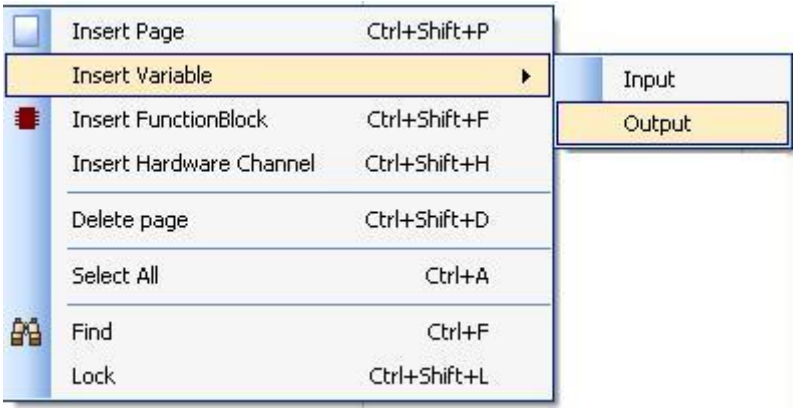

Figure 33

Choose a name for this variable, in this case, *"Tensão_Linha"* and connect it with the output *"AI3P"*.

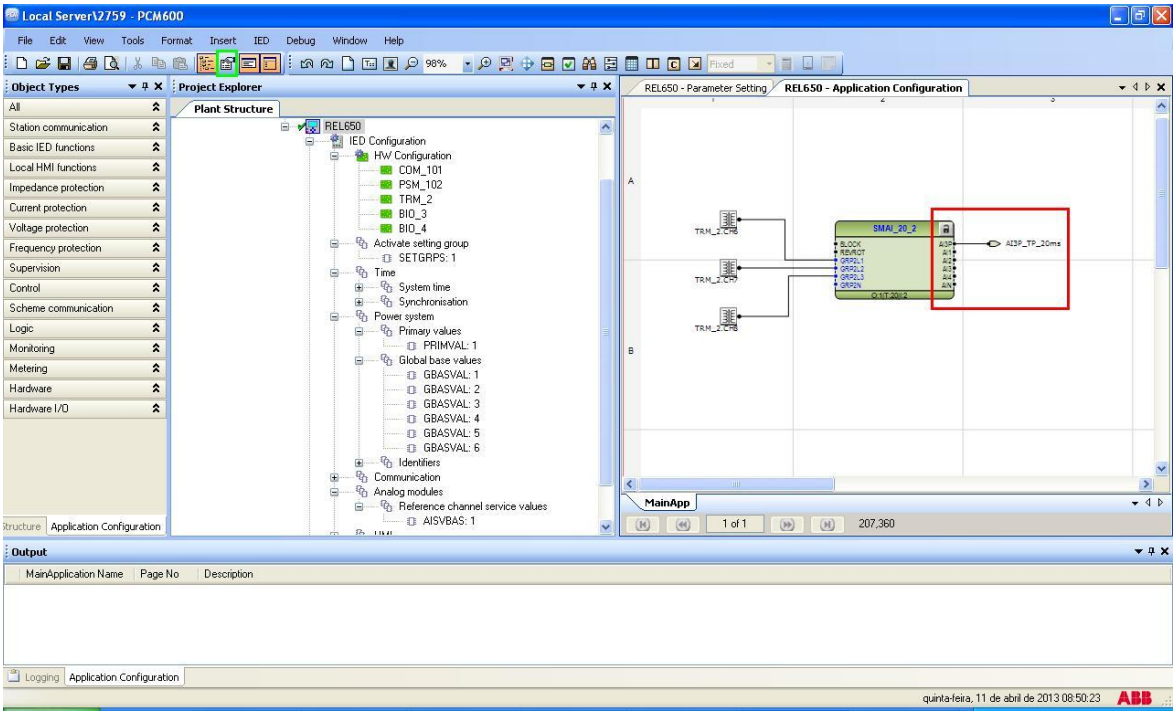

Figure 34

2.10 *SMAI_20_3 (Voltage Bus)*

Repeat the procedure in item *"2.9"* and insert the block *"SMAI_20_3"* which will be responsible for the bus voltage channels.

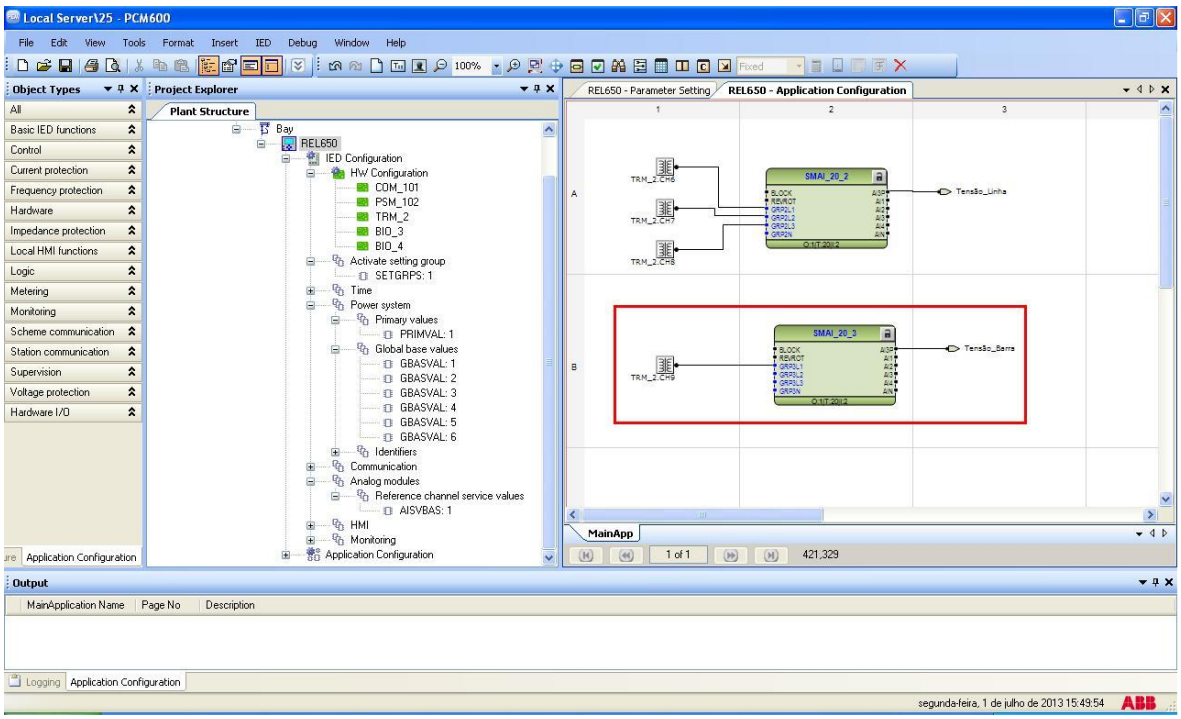

Figure 35

Clicking on the icon highlighted in green and on the *"MainApp"* tab changes the name of the tab to *"CANAIS_TENSÃO"*, for example.

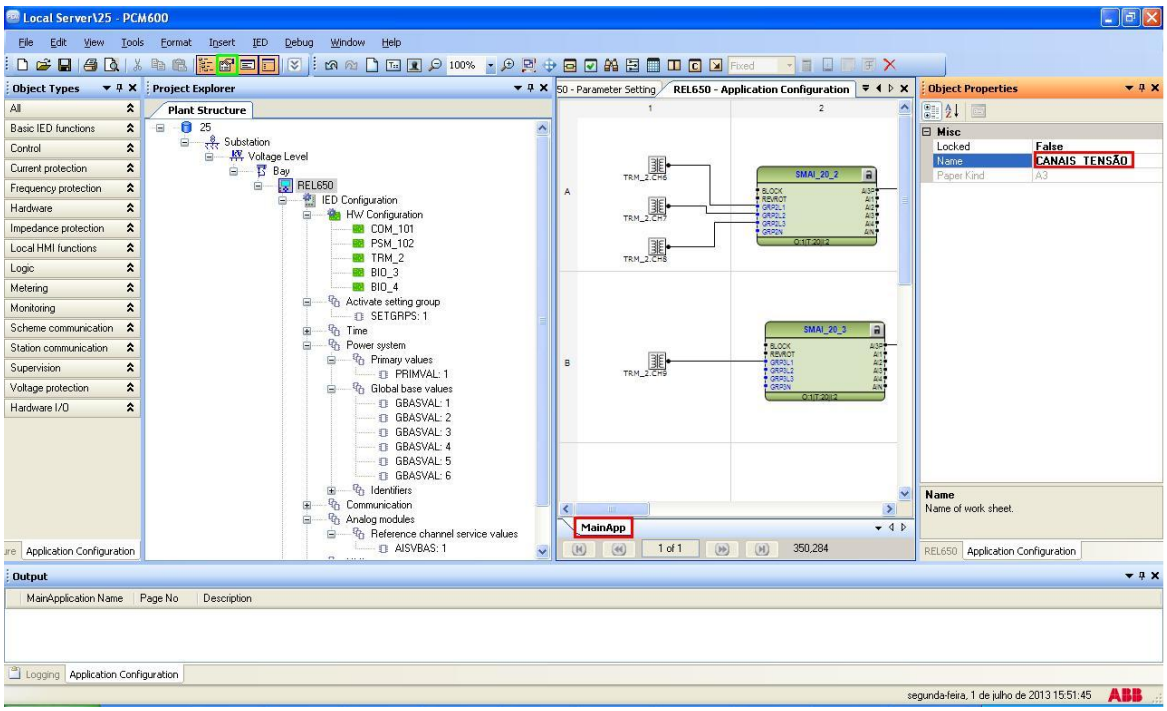

Figure 36

Close the *"Object Properties"* window and insert a new tab to create the fixed signals block.

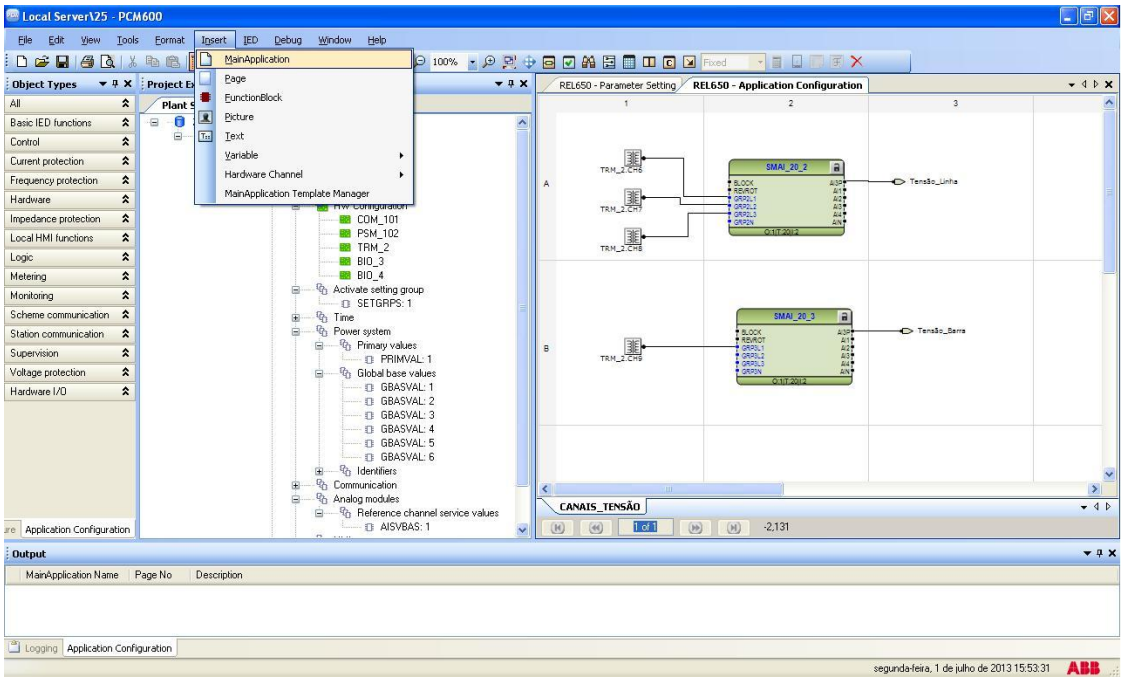

Figure 37

2.11 *FXDSIGN (Fixed Signals)*

Right-click on the new tab, choose the *"Insert Function Block"* option, click on the *"+"* sign near to "Logic" and finally choose the *"FXDSIGN"* block. In this block, the names of the variables for the logic level 1 state and for the off signals group are assigned.

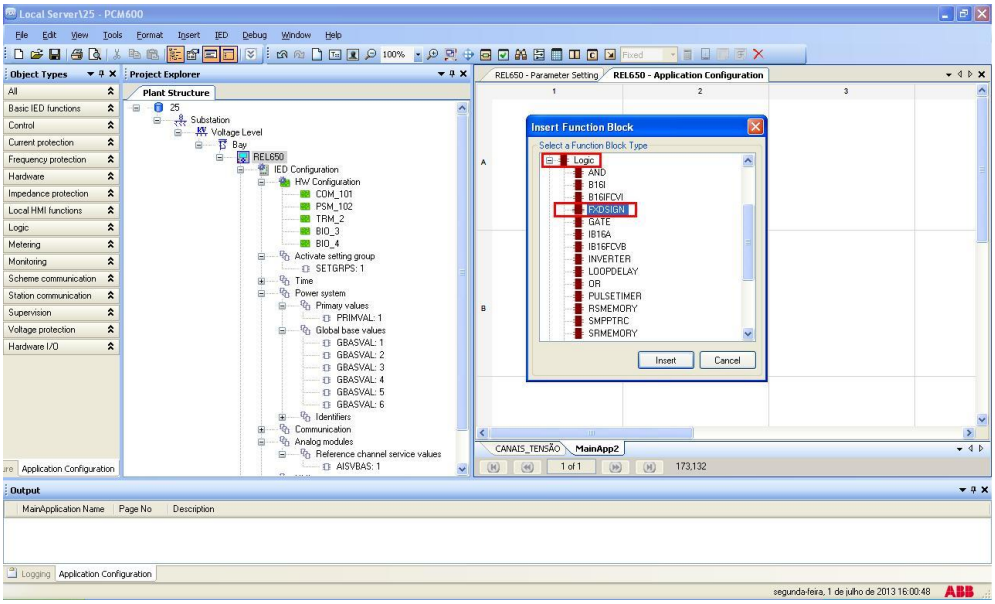

Figure 38

Click on *"Assign"* in the next figure (didn't show) and assign two output variables one *"TRUE"* for logic level 1 and *"GRP_OFF"* for signal group off. These signals are needed for the next synchronization block.

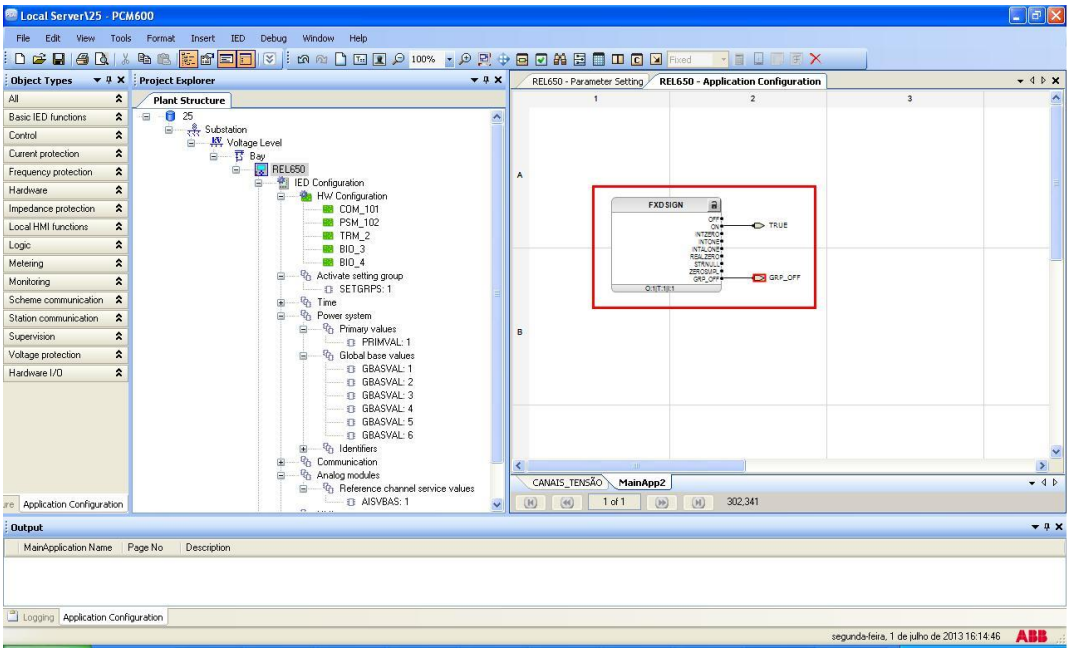

Figure 39

Change the name of the tab to *"SINAIS_FIXOS"*.

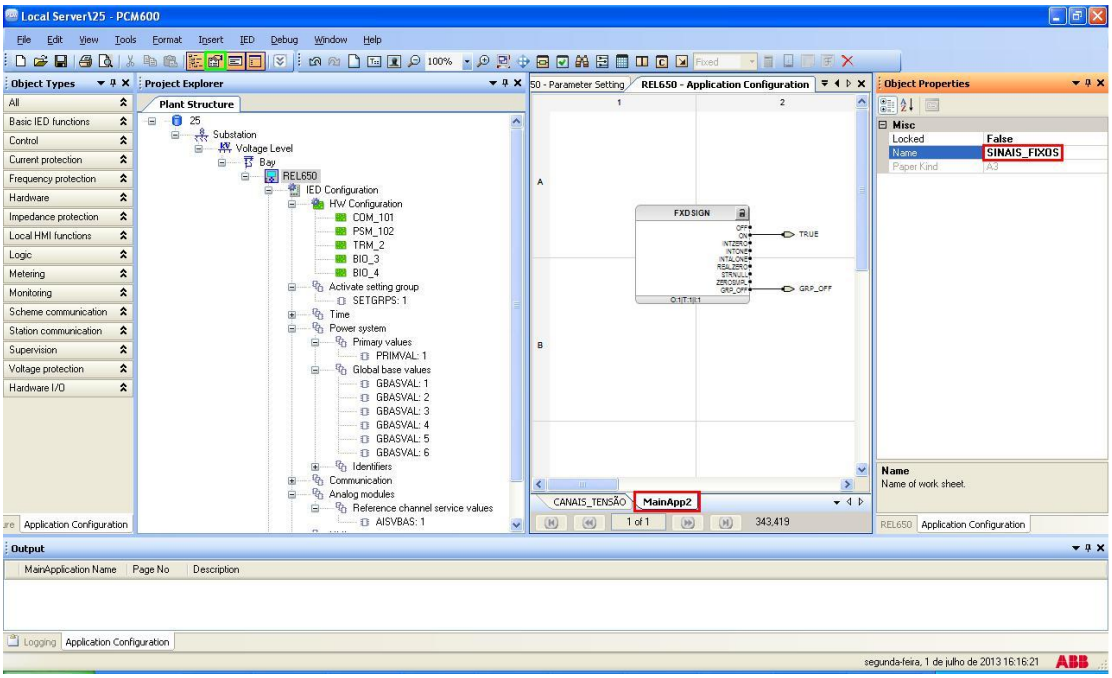

Figure 40

Close the *"Object Properties"* window and insert a new tab to create the sync function block.

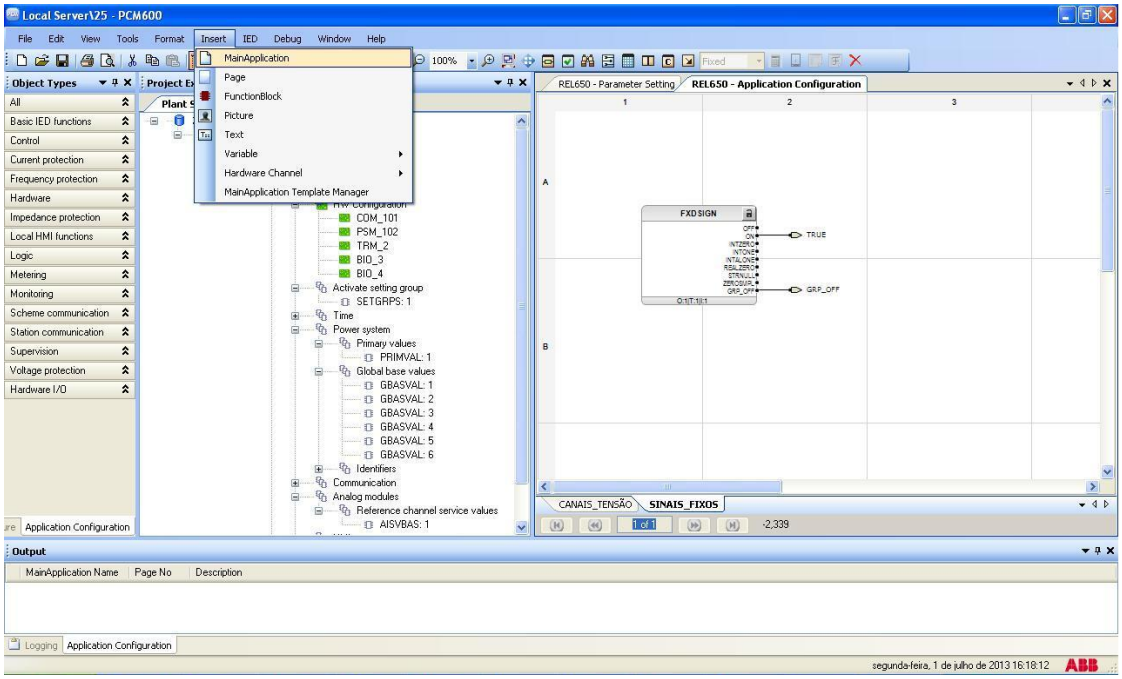

Figure 41

2.12 *SESRSYN (Synchronism)*

Right-click on the new tab, choose the *"Insert Function Block"* option, click on the *"+"* sign near to *"Control"* and finally choose the *"SESRSYN"* block. On the next screen (didn't show) click on *"Assign"*.

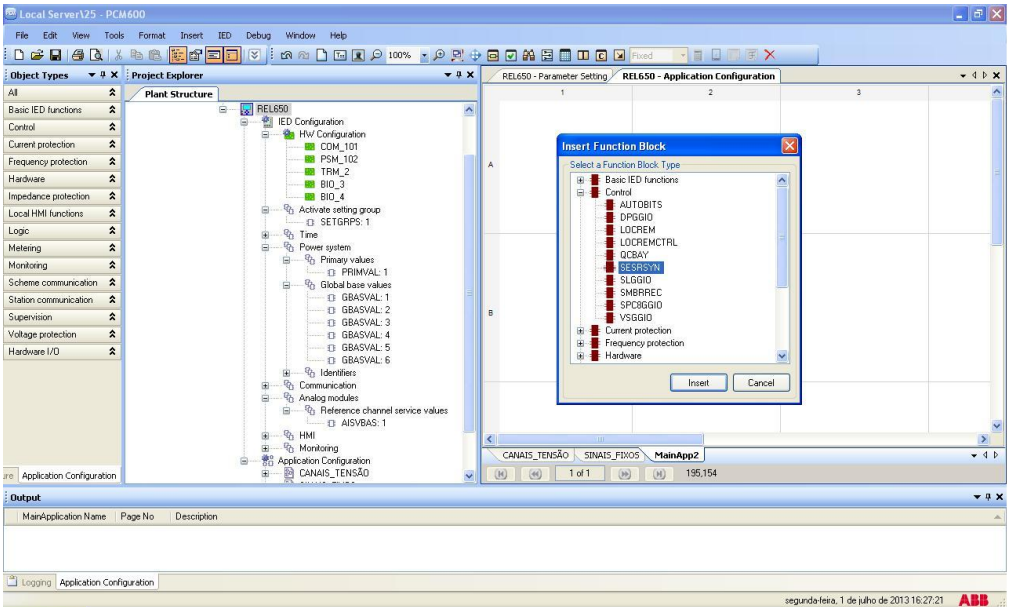

Figure 42

Enter four input variables and one output variable and use the following nomenclature.

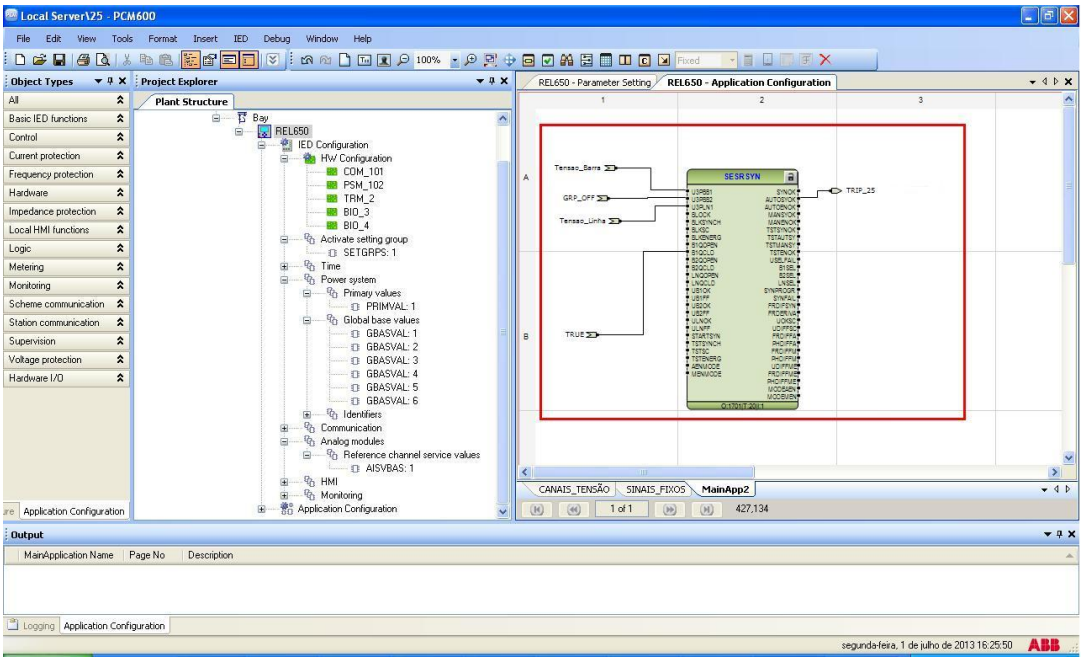

Figure 43

Change the name of the tab to *"SINCRONISMO"*.

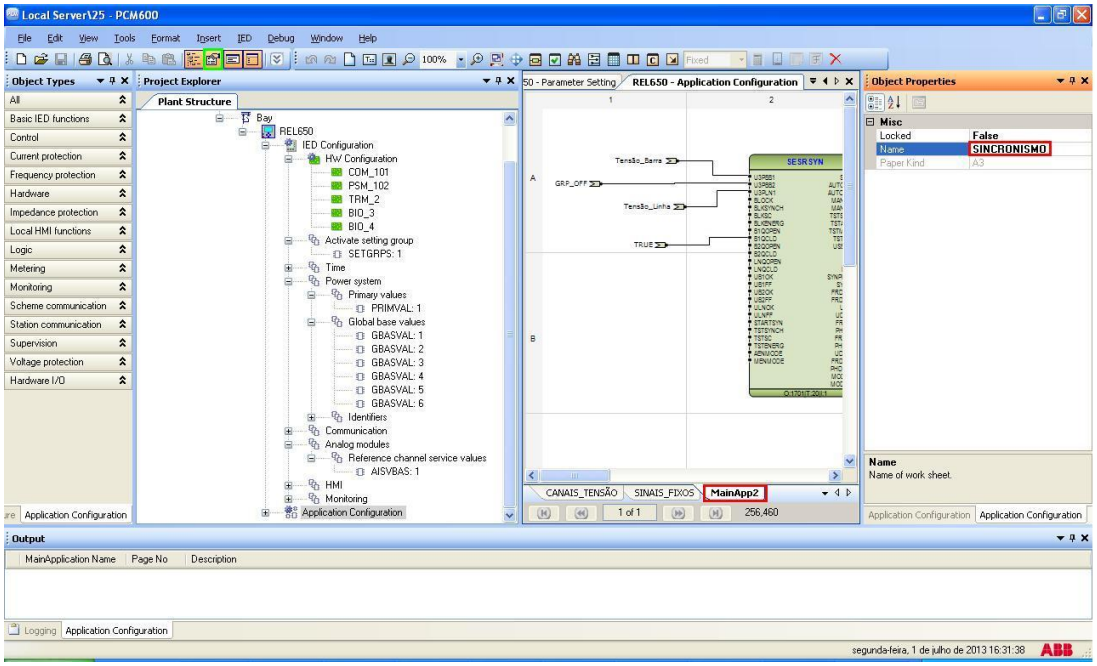

Figure 44

2.13 *Binary Outputs*

The last block to be created is the one for the binary outputs. So create a new tab as shown below.

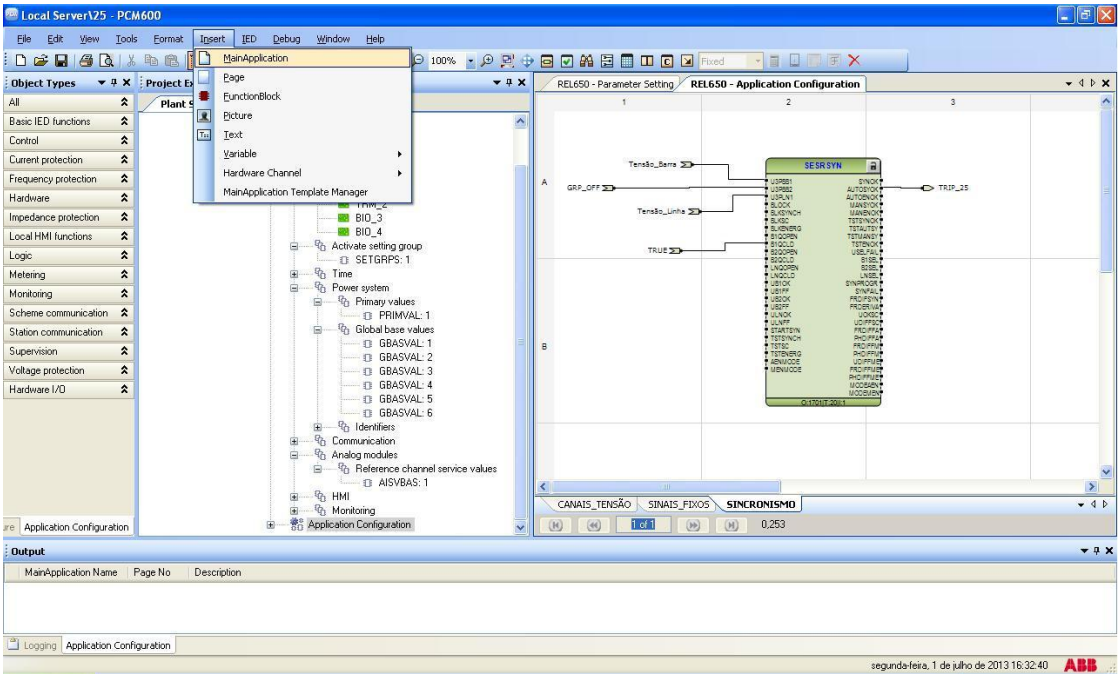

Figure 45

Right-click inside the new tab and choose *"Insert Hardware Channel"*, then *"Binary Output"* and *"Insert"*.

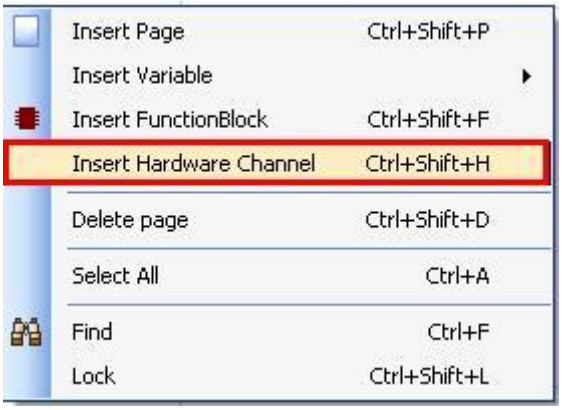

Figure 46

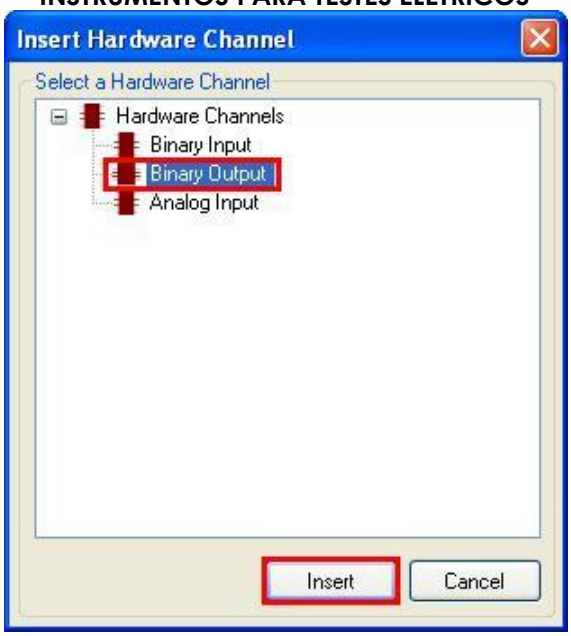

Figure 47

The next step is to choose the channel module *"PSM_102"* and the binary output (BO4).

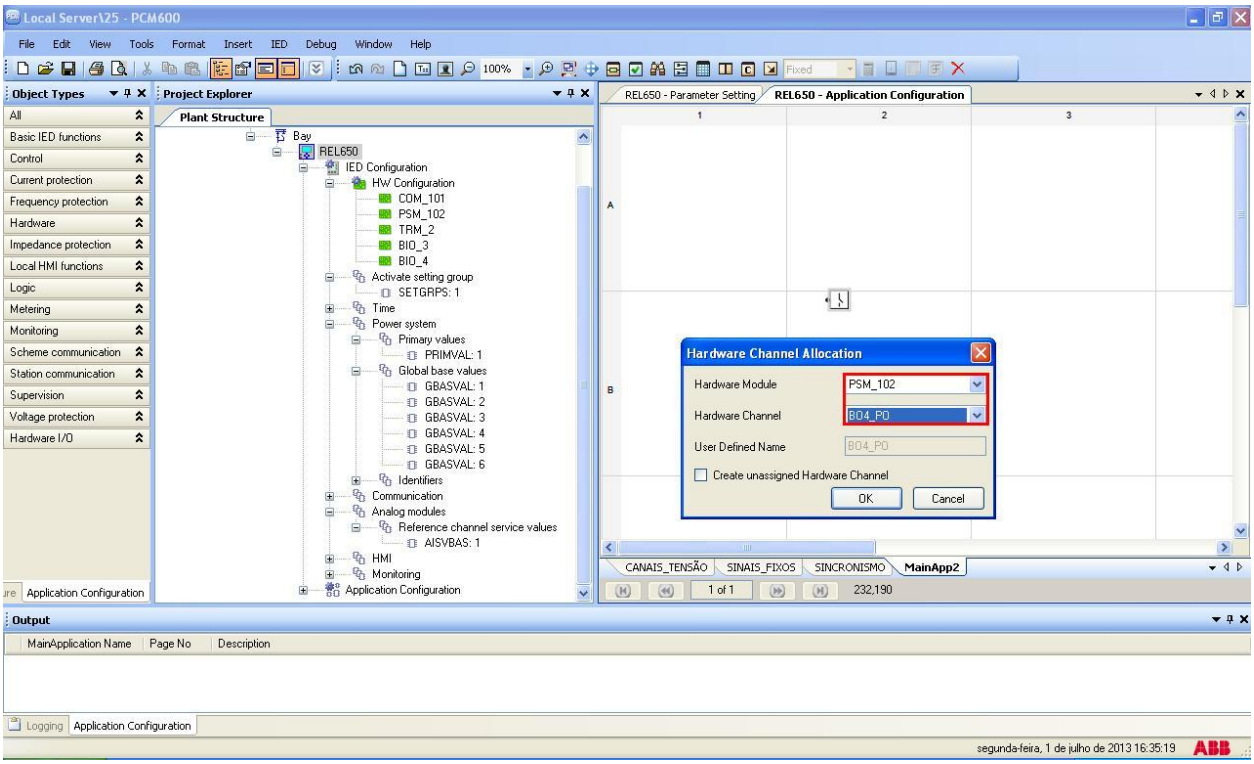

Figure 48

Create an input variable using the name *"TRIP_25"*. Change the name of the tab to *"BINARY_OUTPUTS"*.

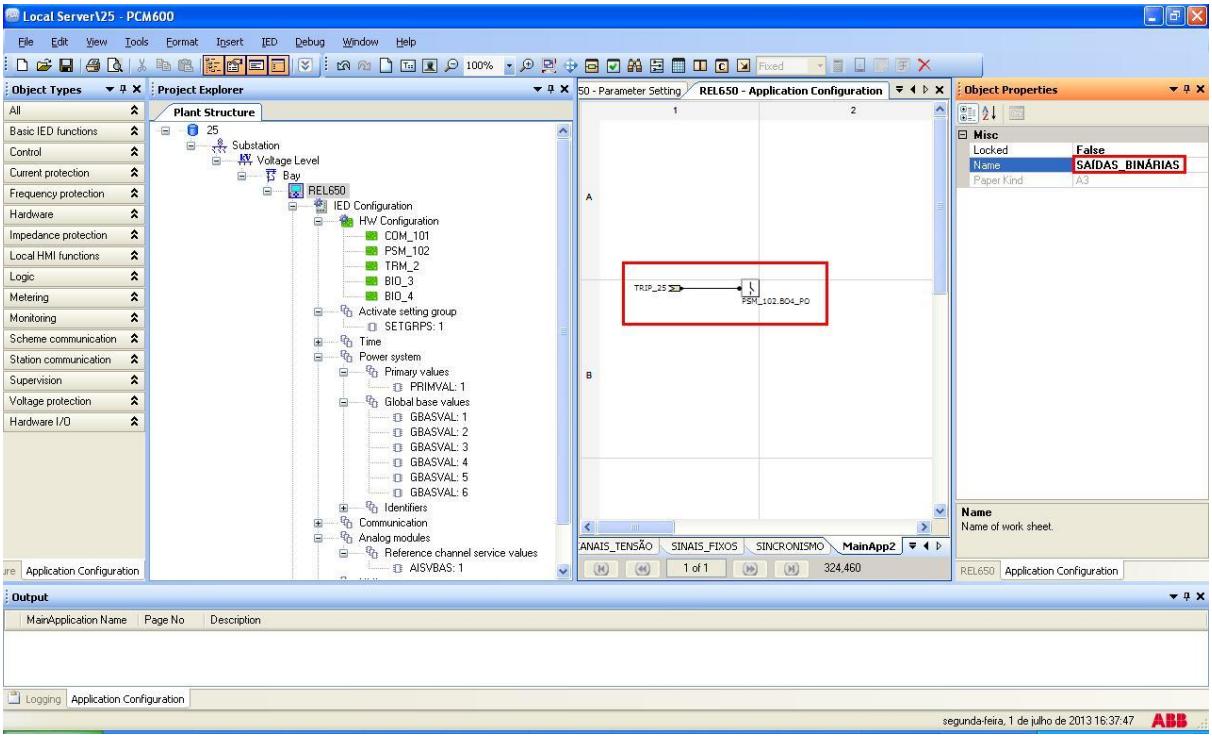

Figure 49

Click on the icon highlighted in green in the following figure to validate the configuration then click on *"OK"* and save the configuration.

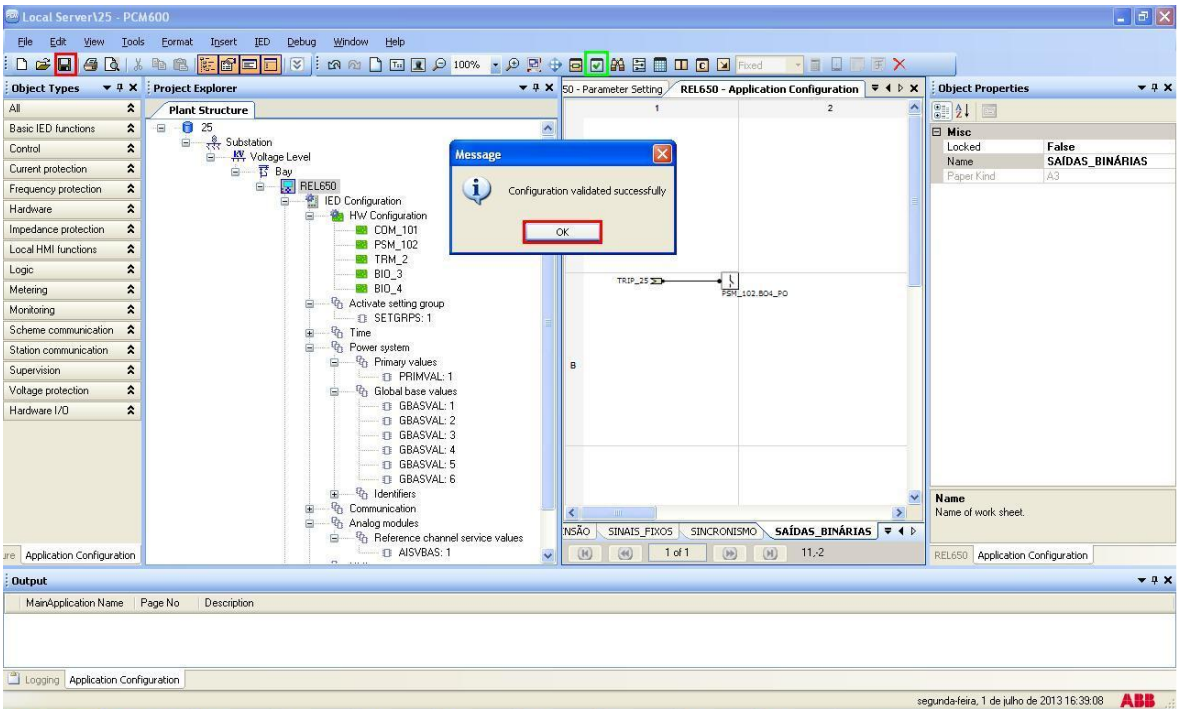

Figure 50

3. Parameterization of the ABB REL650 relay

3.1 *REL 650 Parameter Setting*

Choose the top tab *"REL 650 Parameter Setting"* and click on the *"+"* signs near to *"Application Configuration > SINCRONISMO > Control"* and finally *"SESRSYN:1"*.

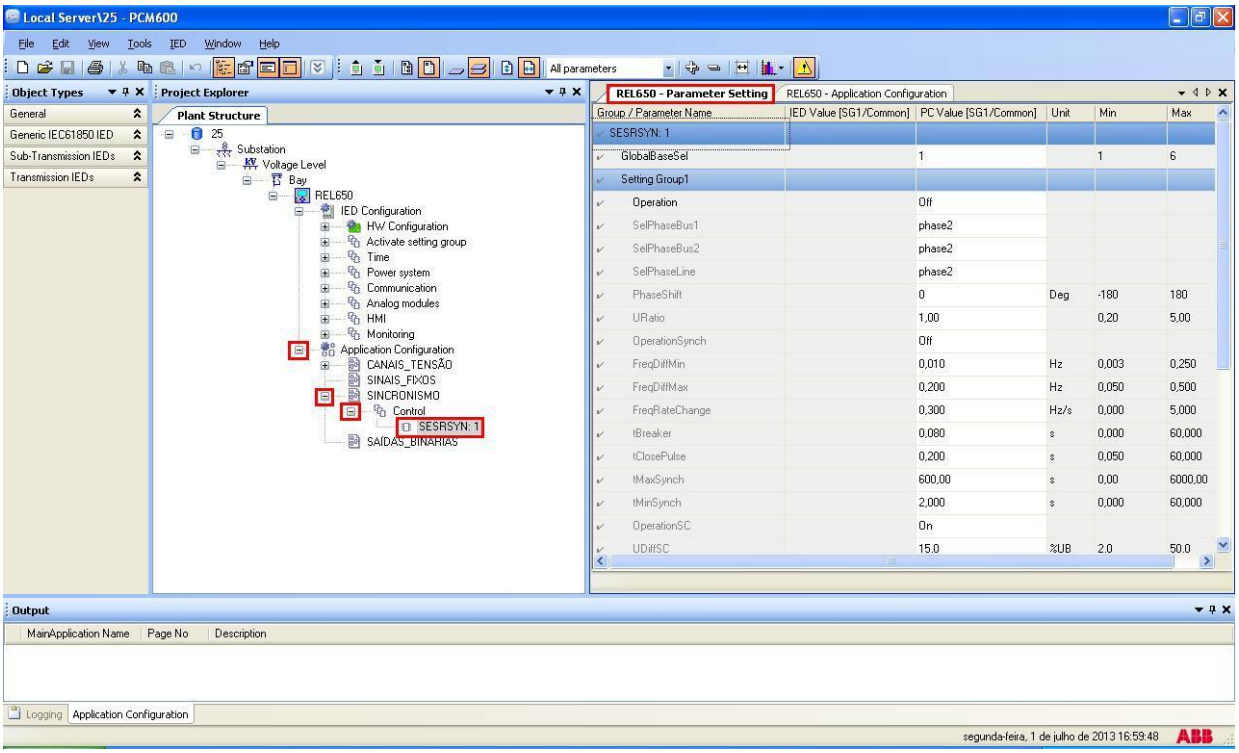

Figure 51

Activate the function and make the following adjustments:

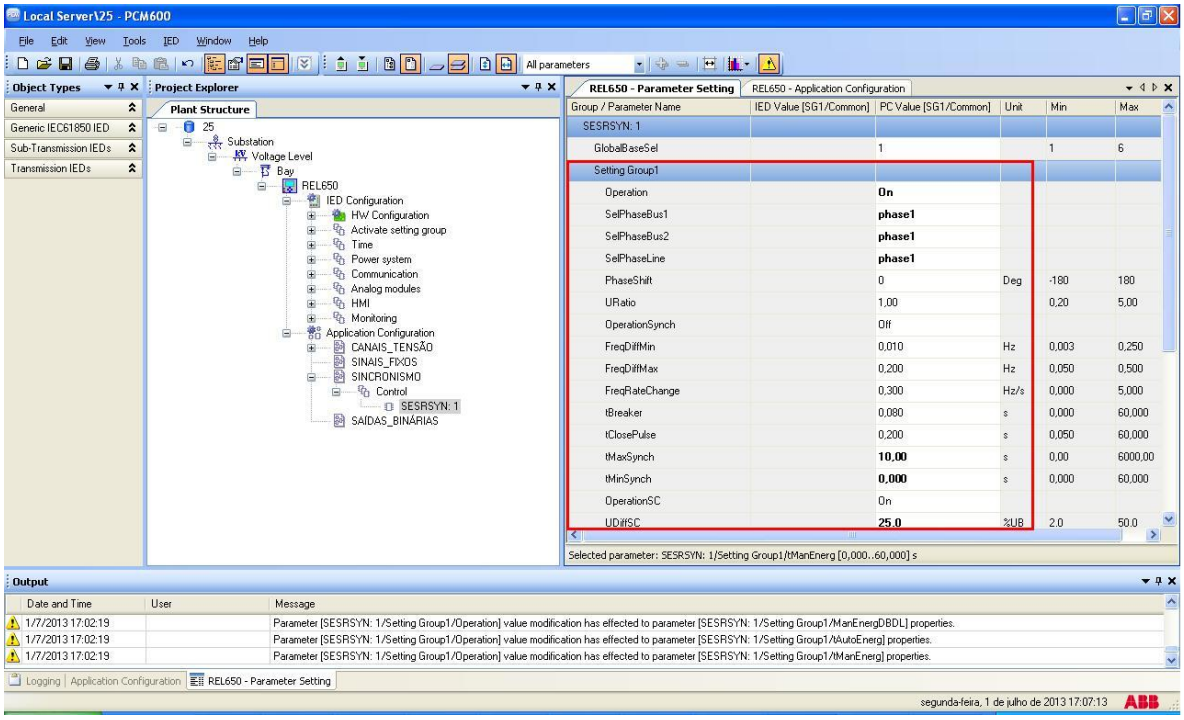

Figure 52

Click on the highlighted button in the figure below to save the adjustments after performing the parameterizations.

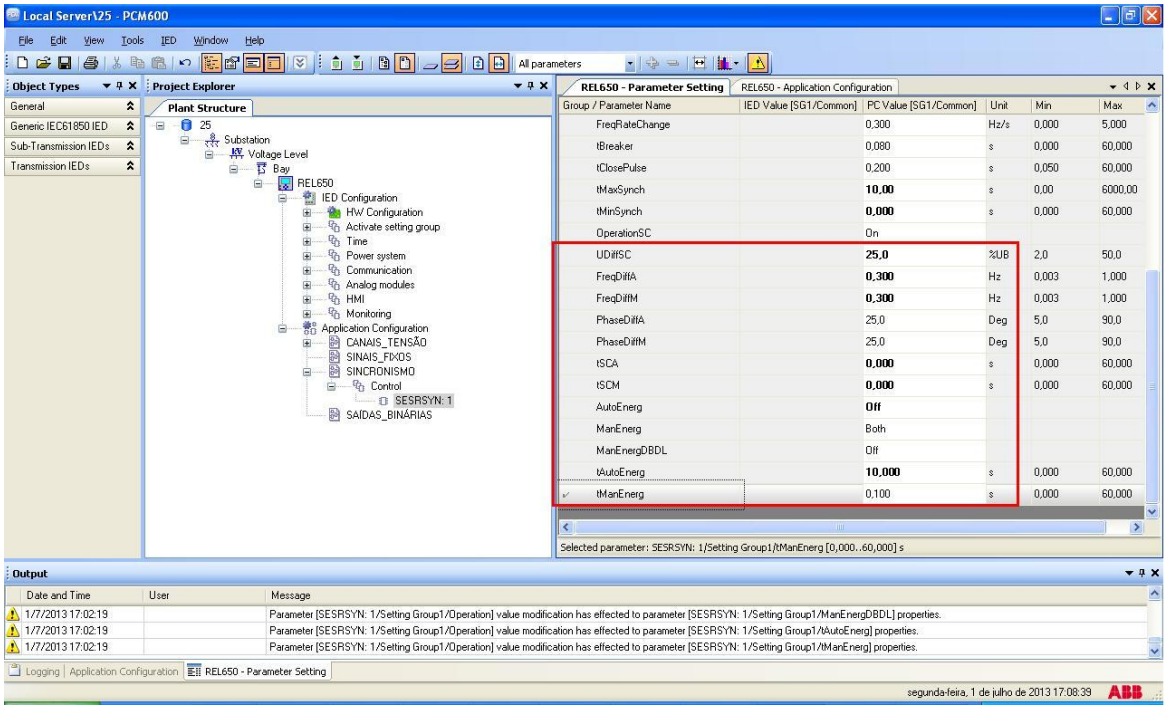

Figure 53

Right-click on the relay icon and submit the changes. In the following message click on *"Yes"*.

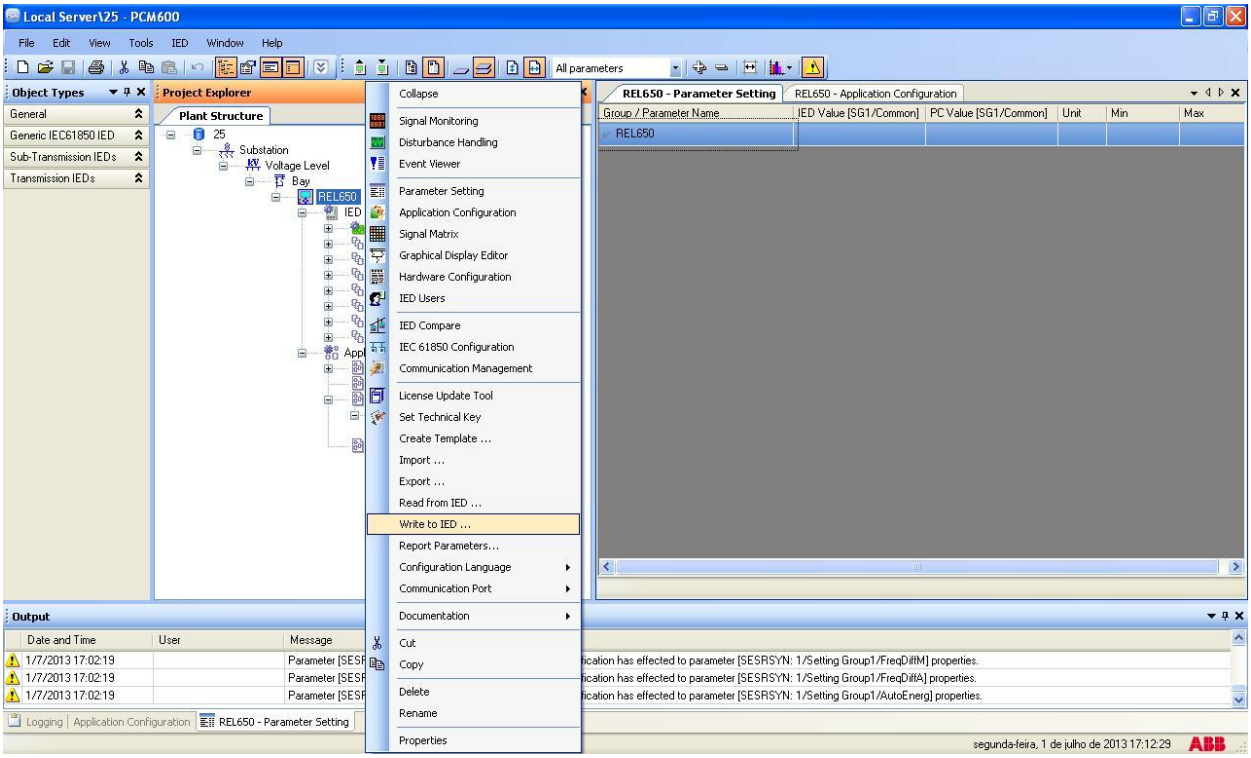

Figure 54

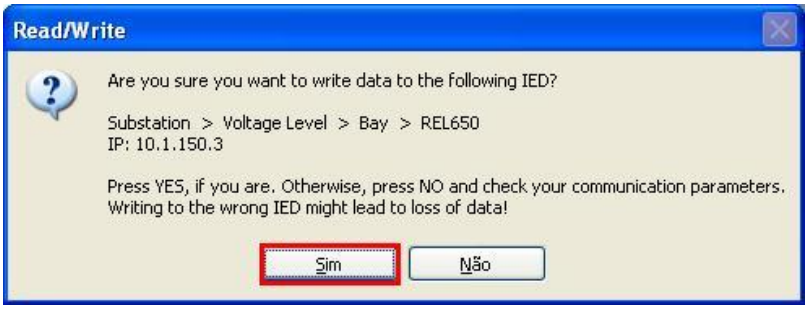

Figure 55

4. Synchronism software adjustment

4.1 *Opening the software*

Open the Conprove Test Center (CTC) software, shown in the figure below.

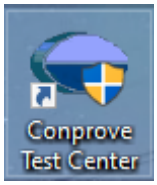

Figure 56

Click on the Synchronism software icon.

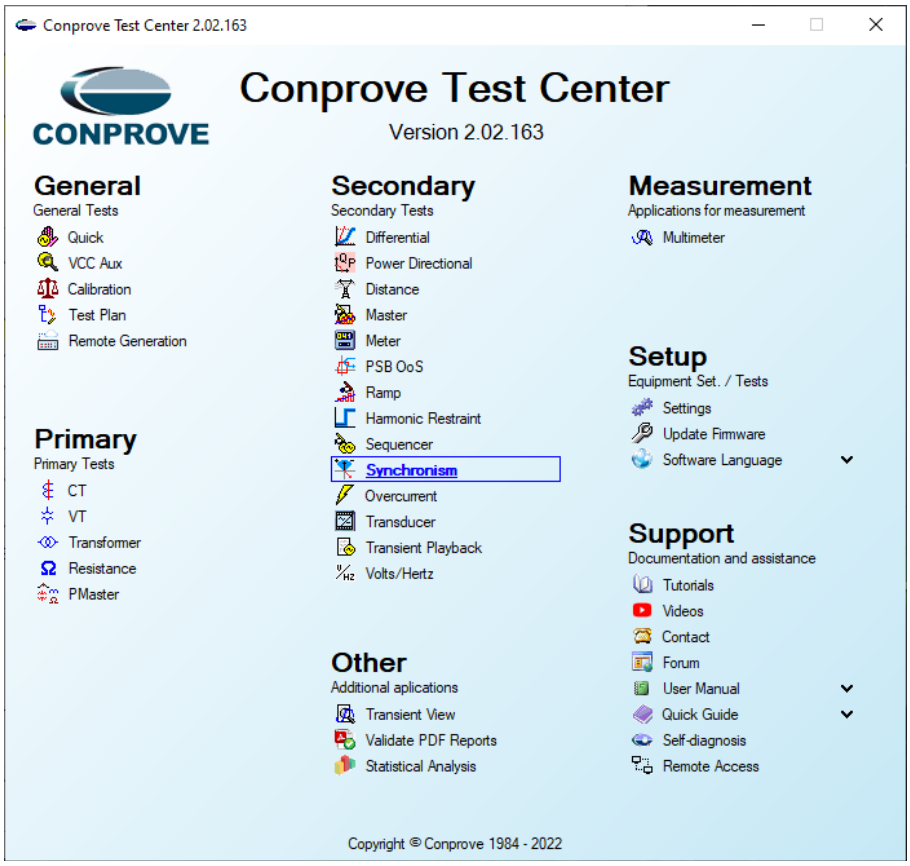

Figure 57

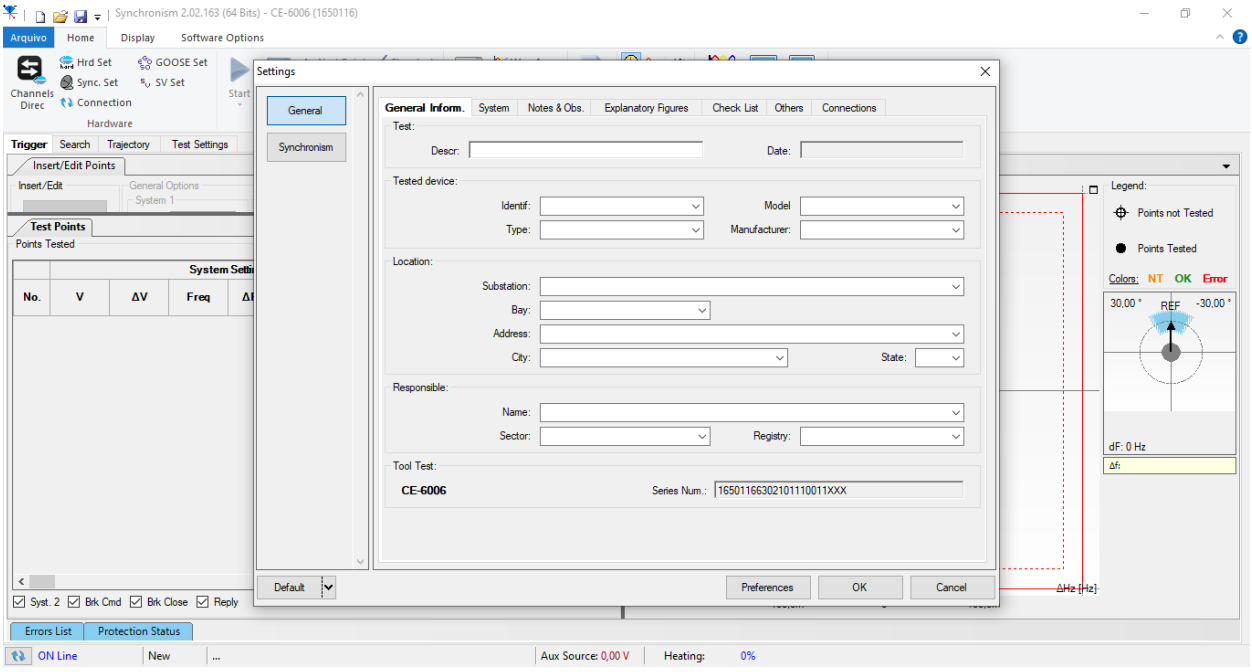

Figure 58

4.2 *Configuring the Settings*

When opening the software the *"Settings"* screen will open automatically (provided that the option *"Open Settings when Start"* found in the *"Software Options"* menu is selected). Otherwise, click directly on the *"Settings"* icon.

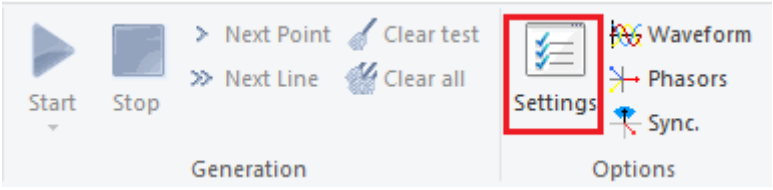

Figure 59

Inside the *"Settings"* screen, fill in the *"General Inform."* with details of the tested device, installation location and the person responsible. This makes reporting easier, as this tab will be the first to be shown.

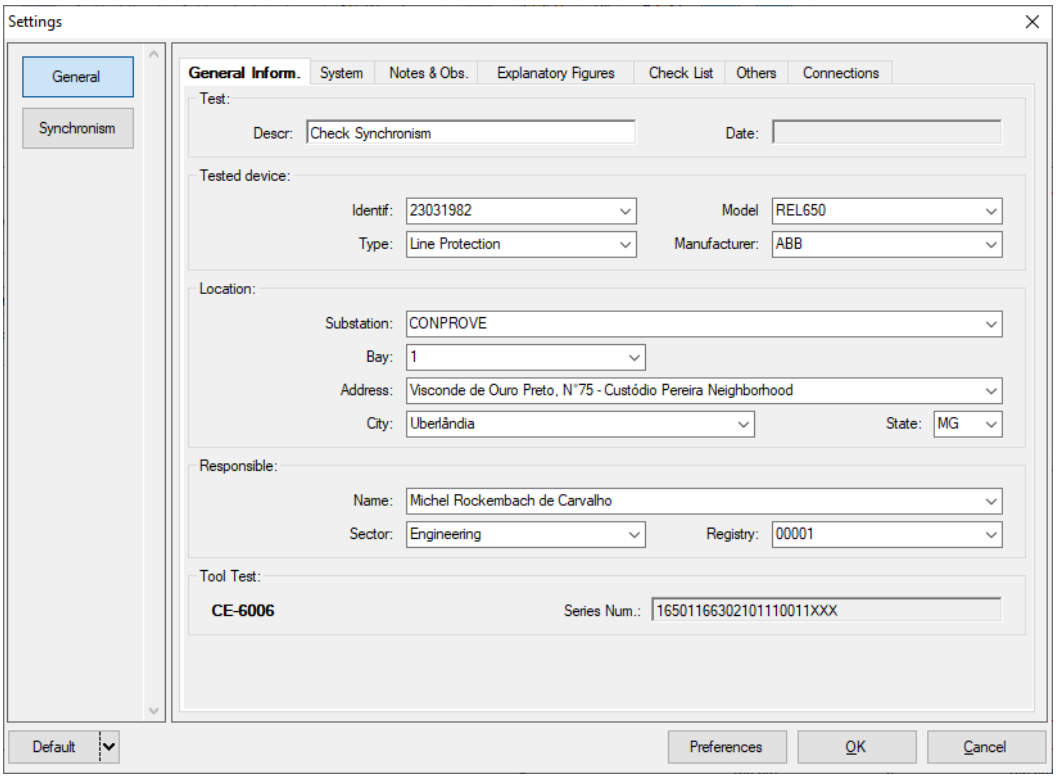

Figure 60

4.3 *System*

In the following screen, within the Nominal sub tab, the frequency values, phase sequence, primary and secondary voltages, primary and secondary currents, transformation ratios of VTs and CTs are configured. There are also two sub-tabs *"Impedance"* and *"Source"* whose data are not relevant for this test.

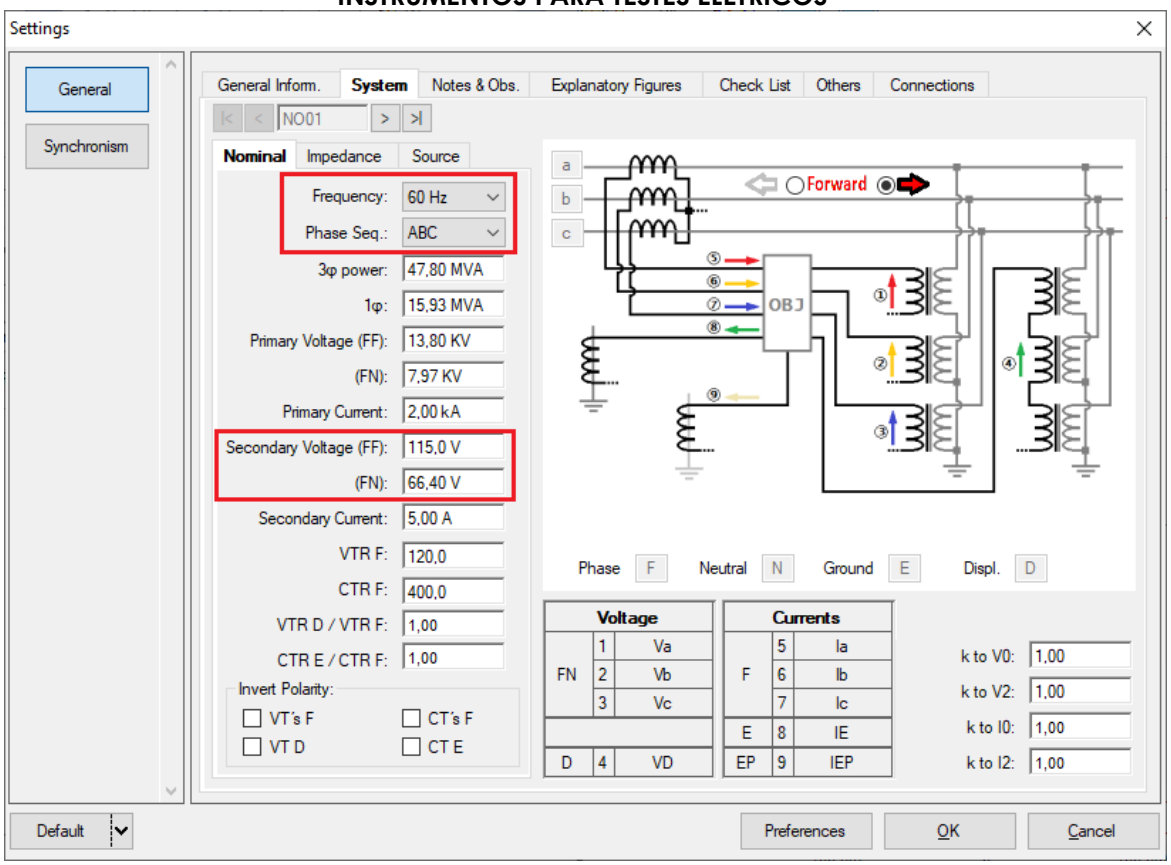

Figure 61

There are other tabs where the user can enter *"Notes & Obs., Explanatory Figures,"* can create a *"Check List"* of the procedures for carrying out the test and even create a diagram with all the schematic of the connections between the test set and the test equipment.

5. Channel Targeting and Hardware Configurations

Click on the icon illustrated below.

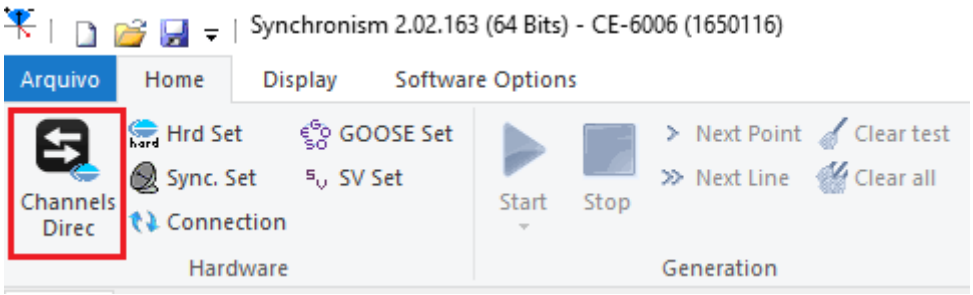

Figure 62

Then click on the highlighted icon to configure the hardware.

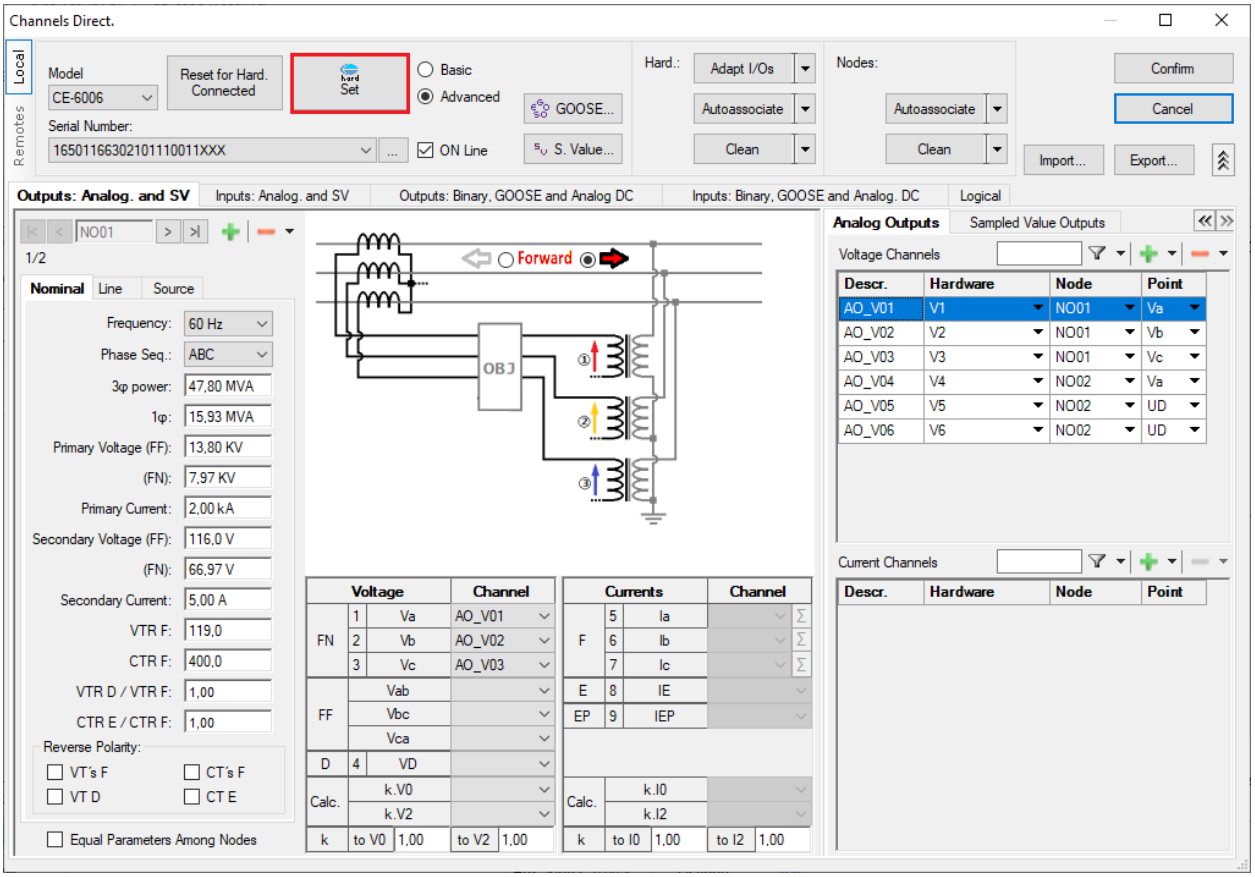

Figure 63

Choose channel configuration, adjust auxiliary source and stop method of binary inputs. Finally, click on *"OK"*.

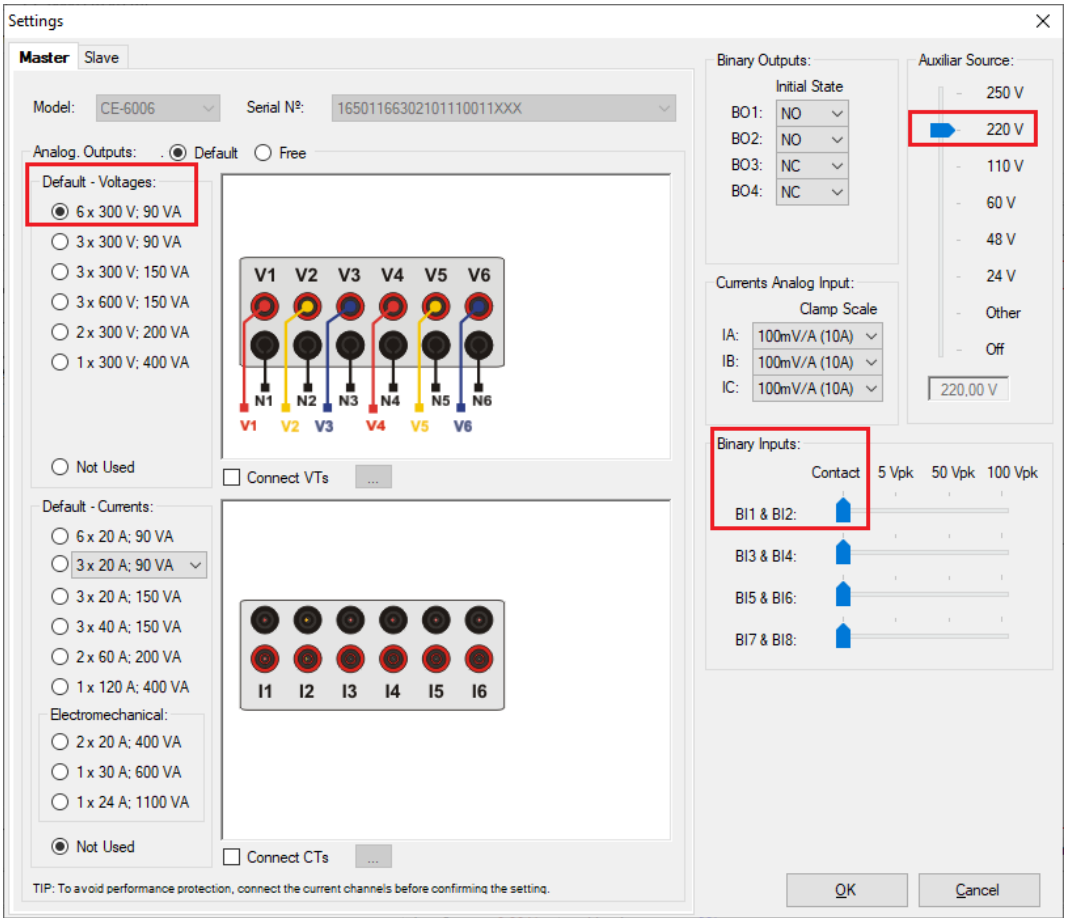

Figure 64

On the next screen choose *"Basic"* and on the next window (didn't show) choose *"YES"*, finally click on *"Confirm"*.

Figure 65

6. Synchronism Adjustments

6.1 *Synchronism > Systems Screen*

Click again on the *"Settings"* icon and then *"Synchronism > Systems"*. In this tab, the data of system 1 must be inserted, specifying its composition: Single-phase, Three-phase FN or Three-phase FF. The reference voltage must be adjusted, and depending on the case, it is necessary to compensate for the phase shift inserted by the transformer.

For system 2, it must be configured similarly to system 1 regarding its composition and reference voltage. In this same screen, the primary and secondary voltage values are adjusted, in addition to the primary and secondary currents. For the circuit breaker, the time value for its effective closing must be entered. There is also the *"Equal Levels of System 1"* field, which when selected, equals the voltages of system 2 to system 1.

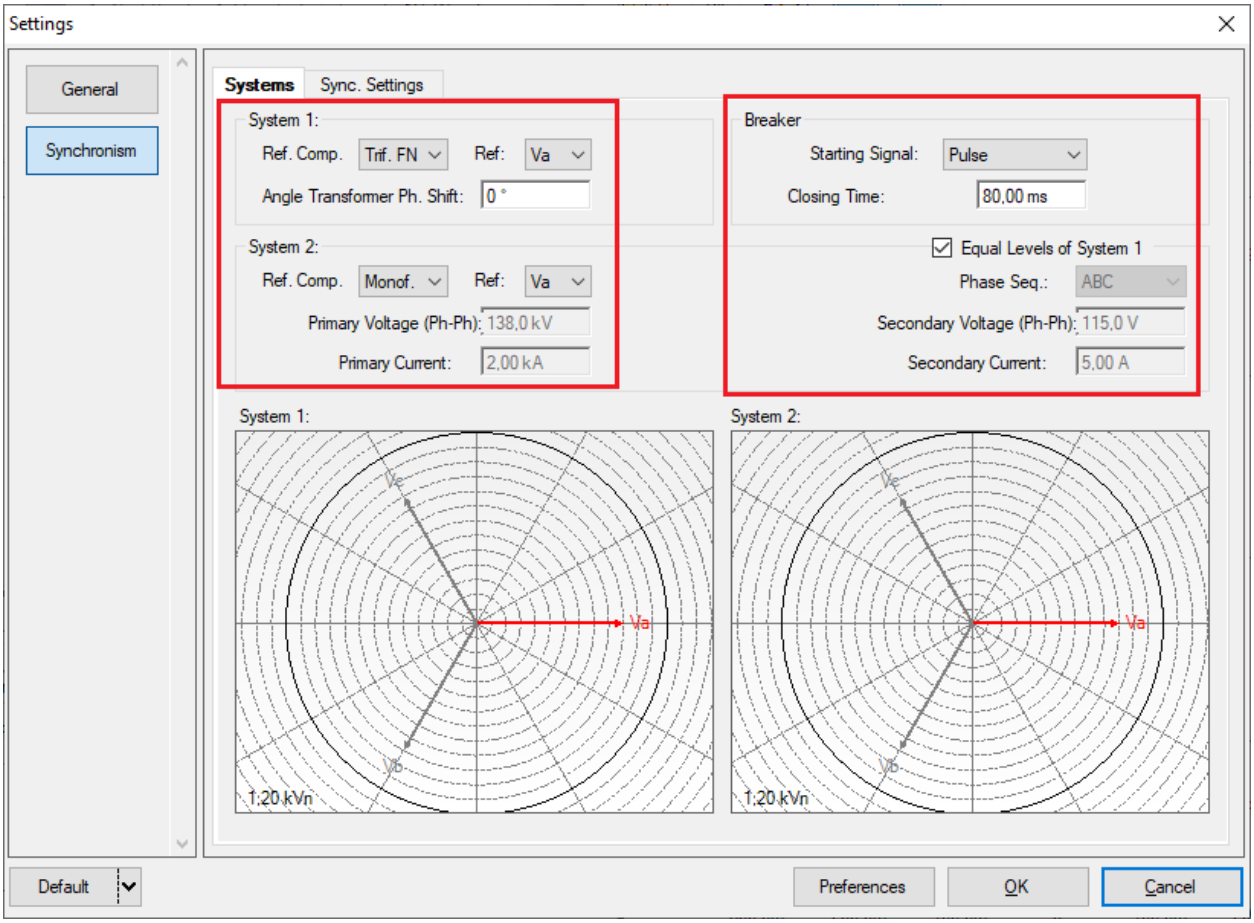

Figure 66

6.2 *Synchronism > Sync. Settings*

This screen stipulates the differences in voltage, frequency and the maximum tolerable angle for synchronism to occur. The maximum and minimum permitted voltage and frequency values are also adjusted so that synchronism occurs. These values are adjusted in percentage referring to the nominal values of the system 1. Also set the maximum time for synchronism to occur (adopted 10.0s) and the relative and absolute tolerances for voltage, frequency, time and the absolute tolerance for the angle. Tolerances are adjusted according to the values in Appendix A.

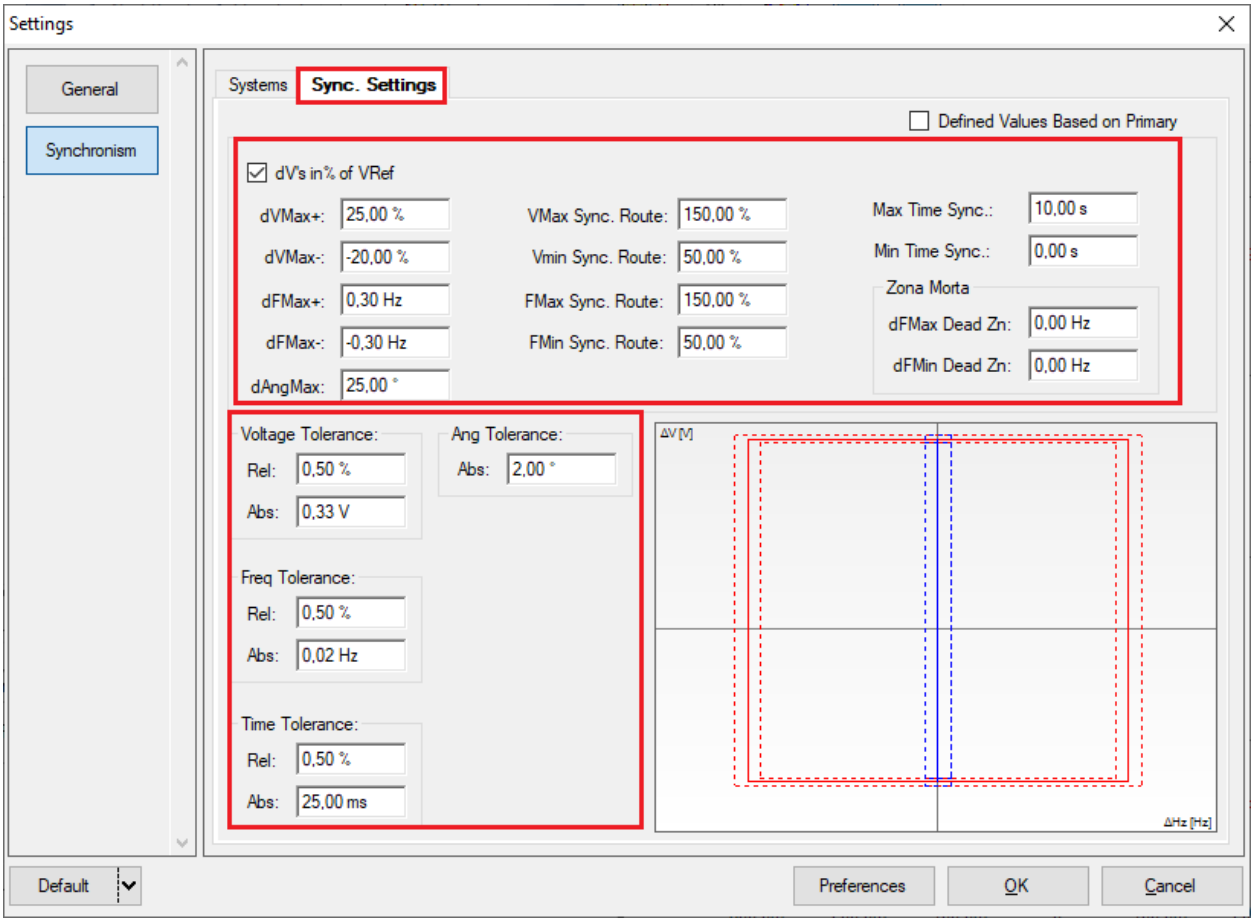

Figure 67

NOTE: Although the voltage difference is 25% of the nominal, the relay only synchronizes with at least 80% of the voltage value. Therefore, the upper deviation is worth 25% and the lower deviation is 20%.

7. Test Settings

On the *"Test Settings"* tab, the voltage generation channels and the stopwatch interface must be correctly directed. The binary input responsible for the synchronization function is BI01. Check the options *"Enable Pre-Simulation 1", "Enable Post-Simulation"* both in *"Nominal - Not Sync."* for 100ms and 200ms.

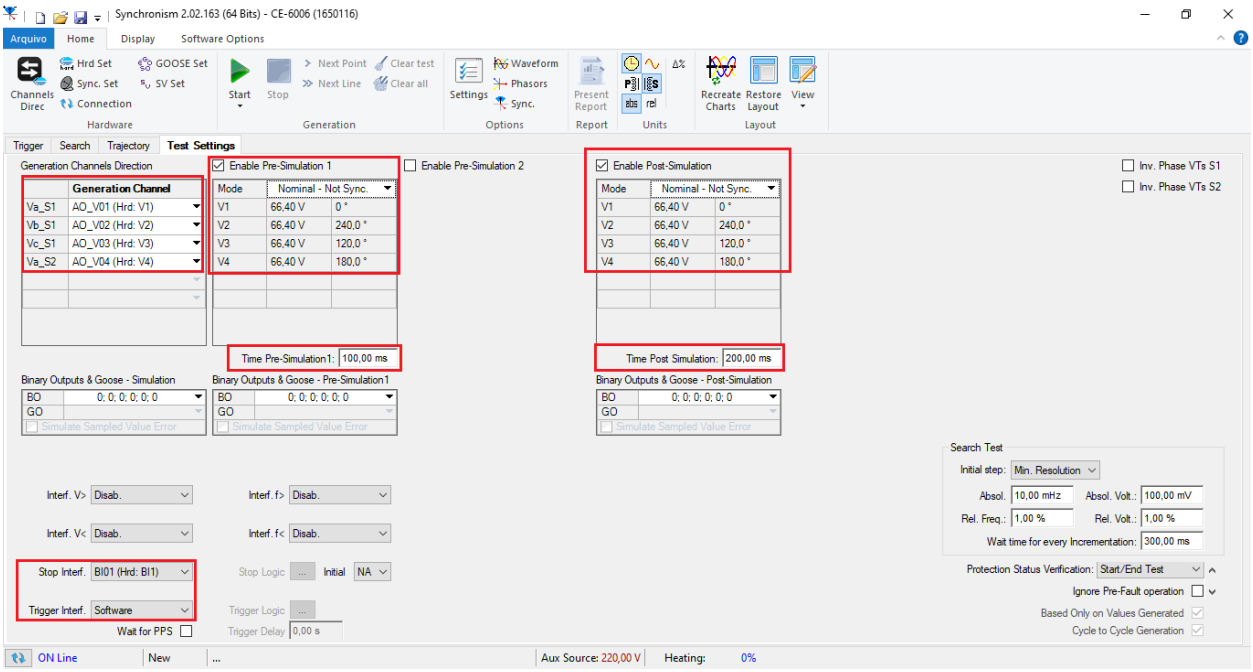

Figure 68

8. Trigger Test

In the trigger test, points inside and outside the synchronism zone are verified. The points represent the difference in voltage and frequency with respect to system 1. You can also specify an angle difference for the two systems. To insert the points click on *"New Point"* and choose a point directly on the graph and then on the item *"Confirm"*. Another option is to choose the voltage, frequency and angle difference values by writing these values in their respective fields. The last option would be to click on the *"Sequence"* option and choose an angle step so that several points are automatically created on the edges of the sync zone. The nominal values of voltage and frequency of system 1 must be adjusted. The figure below illustrates this situation.

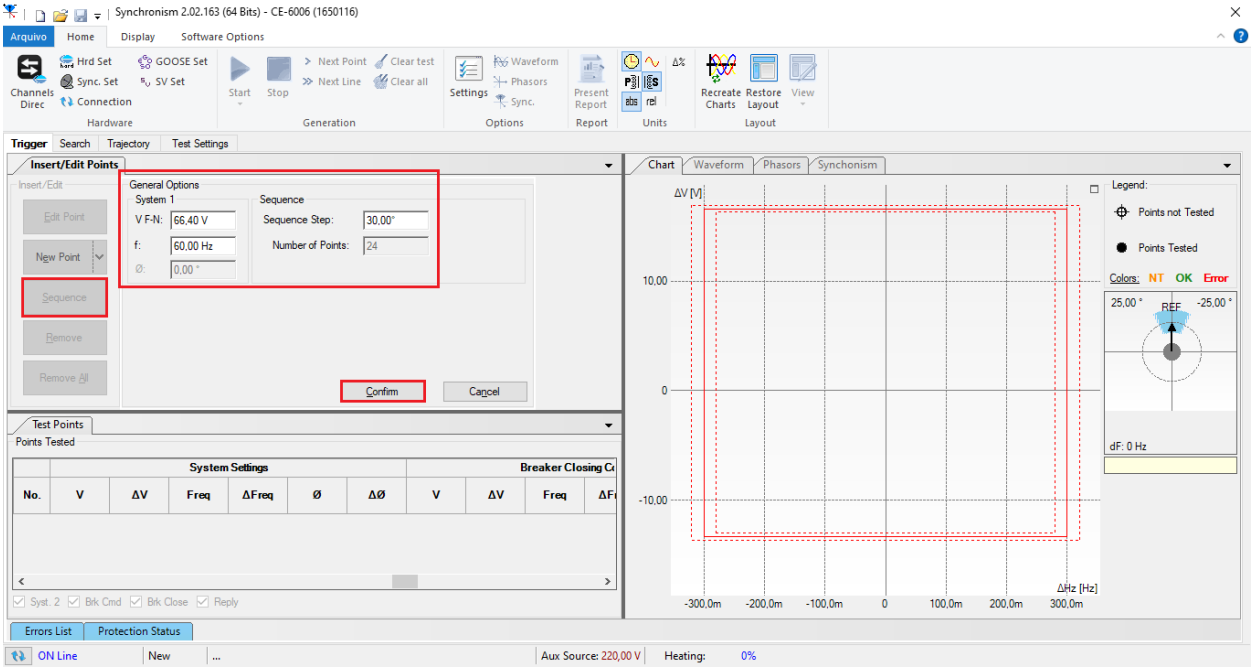

Figure 69

Choosing the sequence with a step of 30.00°, phase-neutral voltage of 66.40 volts, frequency of 60.00Hz and clicking on the button *"Confirm"* the following points are create:

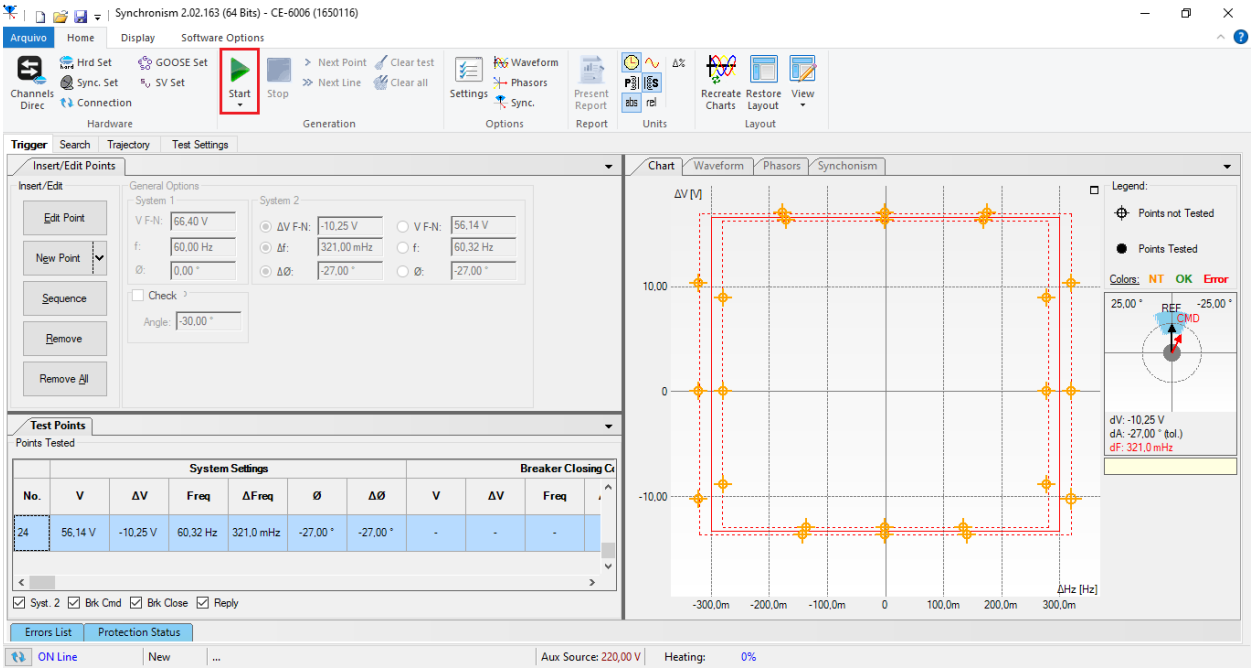

Figure 70

The next step is to start the generation through the *"Start"* button or the shortcut *"Alt + G"*. The figure below shows the final test result.

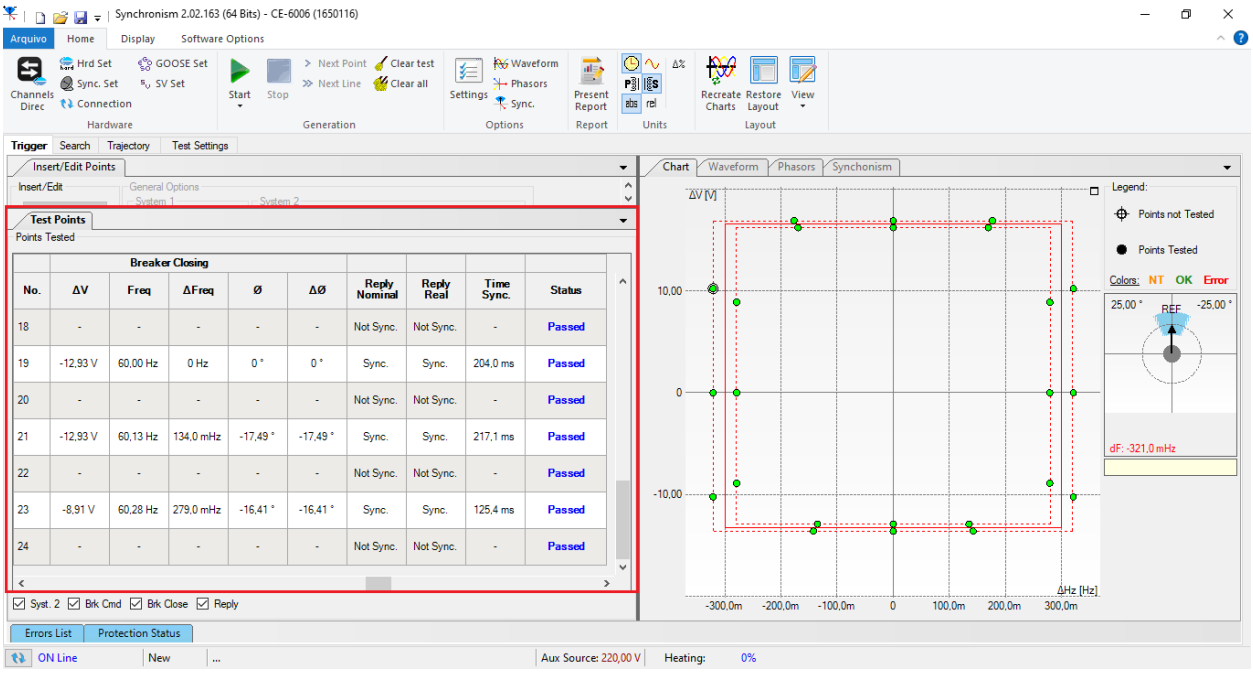

Figure 71

9. Trajectory Test

This test has the same objective as the *"Trigger Test"*, finding the moment of synchronism, however the big difference is that the voltage and current values of system 2 vary over time. Differently from what happens in the *"Trigger Test"* where these values are fixed. To perform the test, use the *"Sequence"* option with the step equal to 30.0° reaching the following screen.

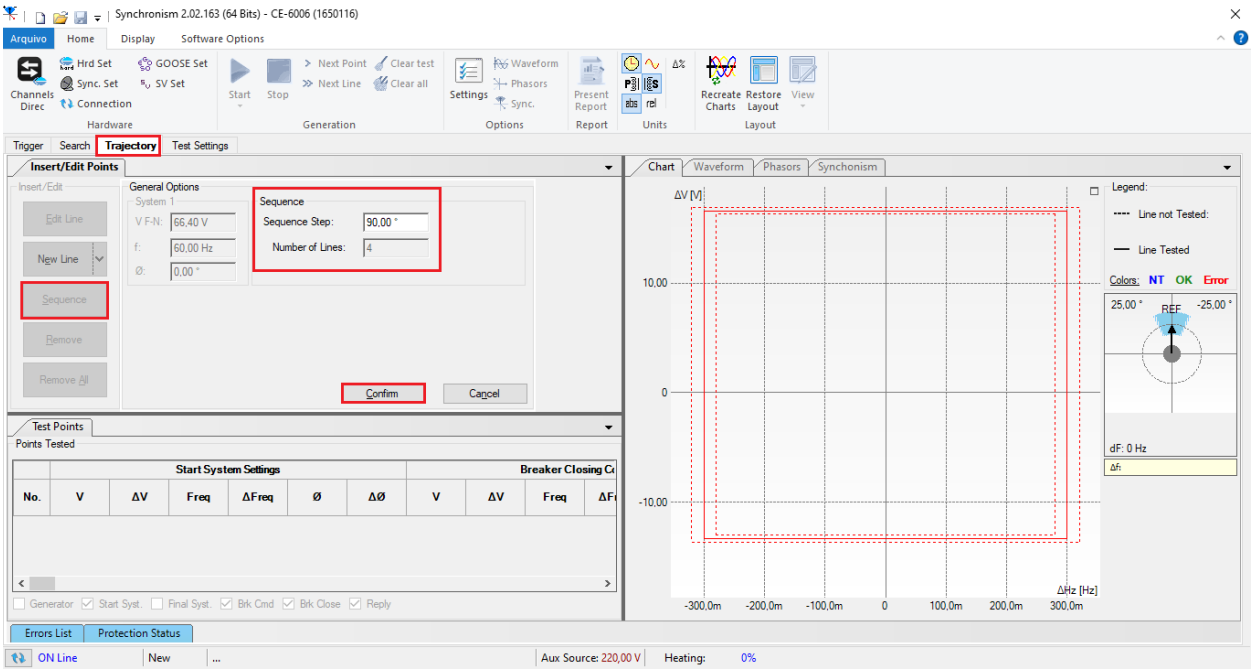

Figure 72

Clicking the *"Confirm"* button automatically creates the lines shown below:

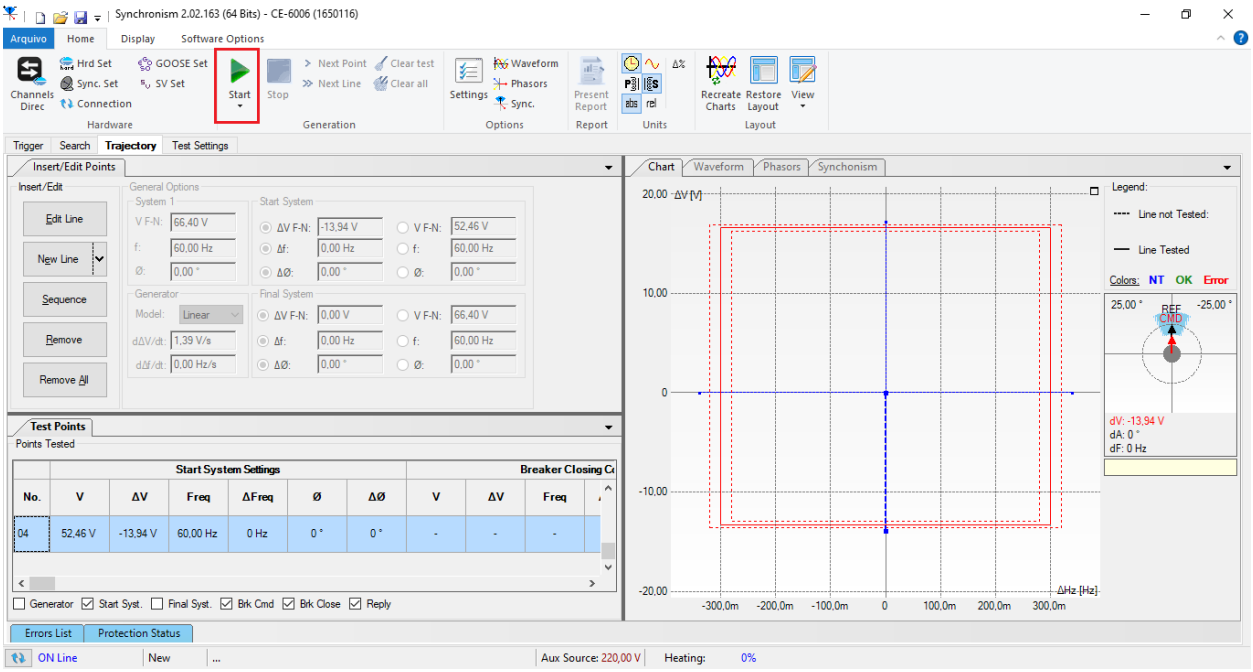

Figure 73

The next step is to start the generation through the *"Start"* button or the shortcut *"Alt + G"*. The figure below shows the final test result.

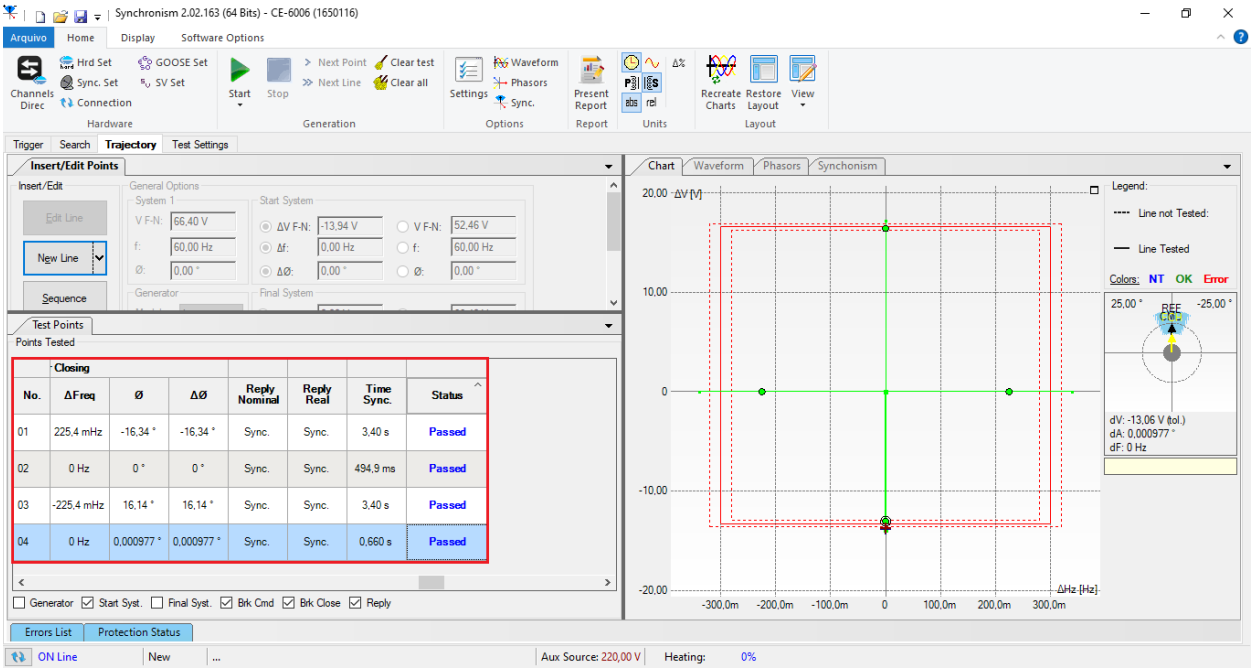

Figure 74

10. Report

After finishing the test, click on the *"Present Report"* icon in the previous figure or through the command *"Ctrl +R"* to call the report pre-configuration screen. Choose the desired language as well as the options that should be part of the report.

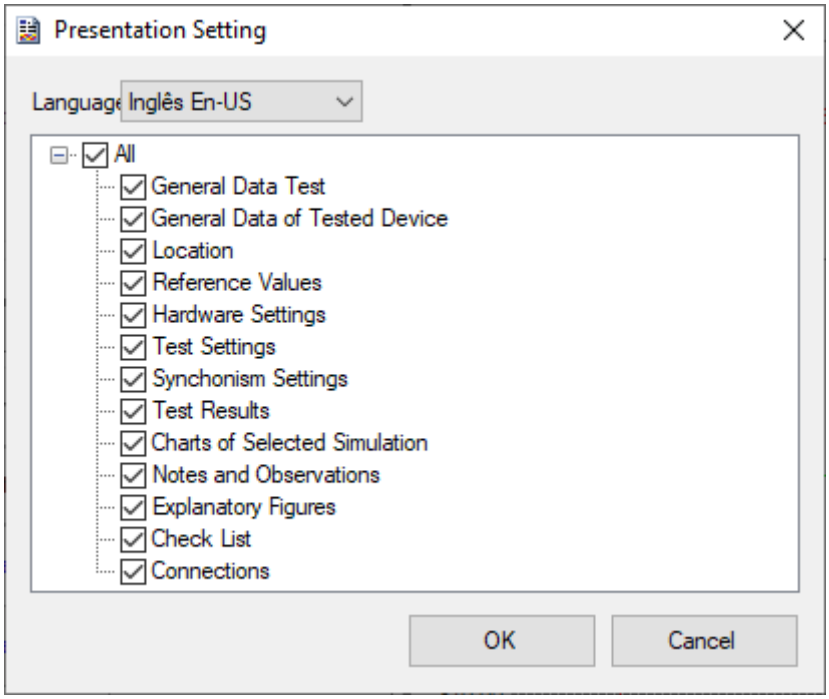

Figure 75

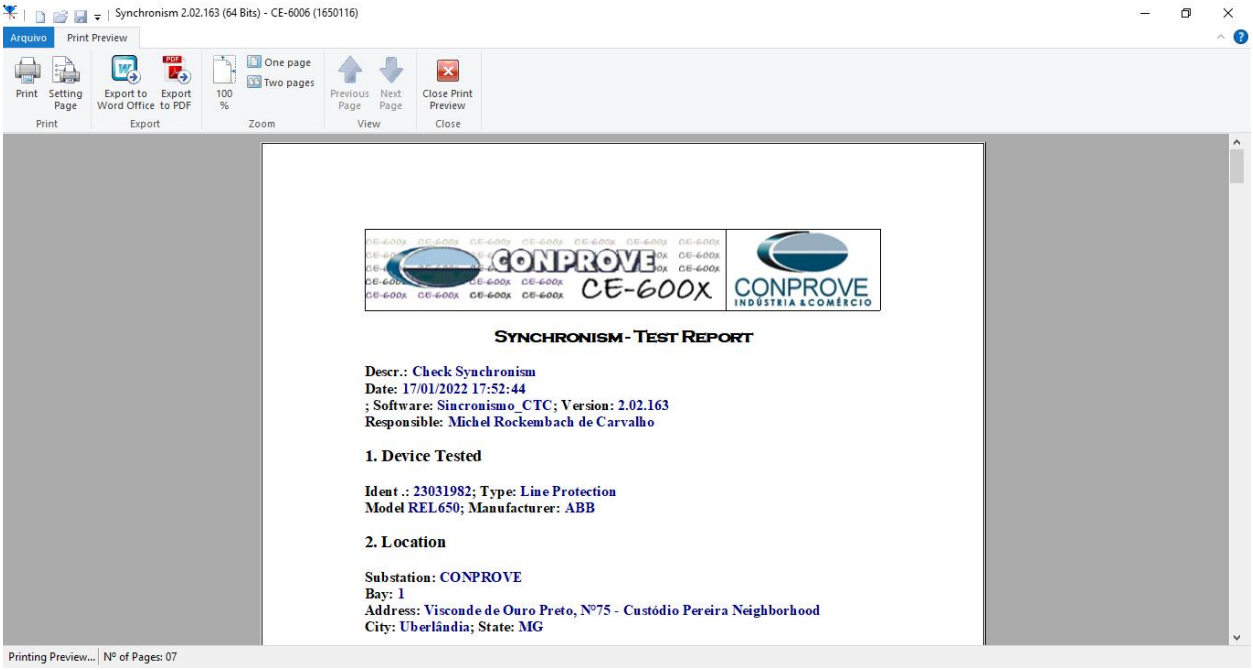

Figure 76

APPENDIX A

A.1 Terminal Designations

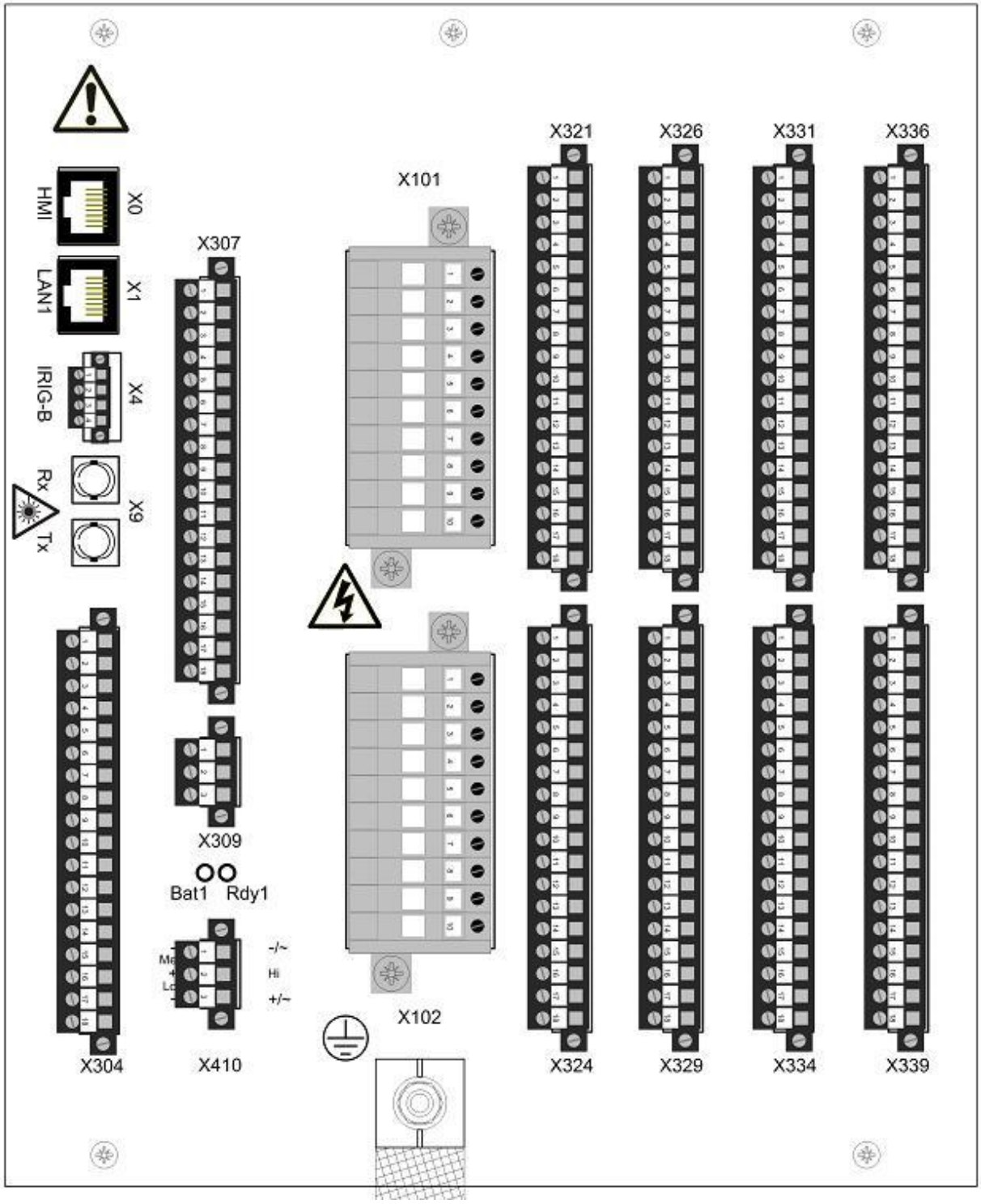

Figure 77

Table 527: Auxiliary voltage supply of 110...250 V DC or 100...240 V AC

Case	Terminal	Description
6U half 19"	X410-1	- Input
	X410–3	+ Input

Table 526: Analog input modules

Terminal	TRM 6I + 4U	TRM 8I + 2U	TRM 4I + 1I + 5U	AIM 6I + 4U	AIM 4I + 1I + 5U
X101-1, 2	1/5A	1/5A	1/5A	1/5A	1/5A
X101-3, 4	1/5A	1/5A	1/5A	1/5A	1/5A
X101-5, 6	1/5A	1/5A	1/5A	1/5A	1/5A
X101-7, 8	1/5A	1/5A	1/5A	1/5A	1/5A
X101-9, 10	1/5A	1/5A	0.1/0.5A	1/5A	0.1/0.5A
X102-1, 2	1/5A	1/5A	100/220V	1/5A	100/220V
X102-3, 4	100/220V	1/5A	100/220V	100/220V	100/220V
X102-5, 6	100/220V	1/5A	100/220V	100/220V	100/220V
X102-7, 8	100/220V	100/220V	100/220V	100/220V	100/220V
X102-9, 10	100/220V	100/220V	100/220V	100/220V	100/220V

Terminal	Description	PCM600 info	
		Hardware module instance	Hardware channel
X307-5 X307-6	- +	PSM_102	BO3_PO_TCS
X307-7 X307-8	Power output 4, normally open	PSM_102	BO4_PO
X307-9 X307-10	Power output 5, normally open	PSM_102	BO5_PO
X307-11 X307-12	Power output 6, normally open	PSM_102	BO6_PO

Table 539: Output contacts X307, 6U half 19"

Terminal	Description	PCM600 info	
		Hardware module instance	Hardware channel
X307-13 X307-14	Signal output 1, normally open	PSM_102	BO7_SO
X307-15 X307-16	Signal output 2, normally open	PSM_102	BO8_SO
X307-17 X307-18	Signal output 3, normally open	PSM_102	BO9_SO

A.2 Technical Data

Technical data

Table 223: SESRSYN technical data

Function	Range or value	Accuracy
Phase shift, φ_{line} - φ_{bus}	(-180 to 180) degrees	-
Voltage ratio, U_{bus}/U_{line}	0.2 to 5.0	-
Frequency difference limit between bus and line	(0.003-1.000) Hz	± 2.0 mHz
Phase angle difference limit between bus and line	(5.0-90.0) degrees	± 2.0 degrees
Voltage difference limit between bus and line		± 0.5% of U_r
Time delay output for synchrocheck	(0.000-60.000) s	± 0.5% ± 25 ms
Time delay for energizing check	(0.000-60.000) s	± 0.5% ± 25 ms
Closing time for the circuit breaker	(0.000-60.000) s	± 0.5% ± 25 ms

APPENDIX B

Equivalence of software parameters and the relay under test.

Table 1

Software Sincronismo		ABB REL 650 Relay	
Parameter	**Figure**	**Parameter**	**Figure**
Secondary Voltage (FF) System 1	61	VT sec6	19
System 2 Ref	66	VT sec9	19
Secondary Voltage (Ph-Ph)System 2	66	URatio* Nominal VABC	52
dVMax+	67	UDIffA	53
dVMax-	67	-20% (Appendix C)	--
dFMax+	67	FreqDiffA	53
dFMax-	67	FreqDiffA (negative signal)	53
dAngMax	67	PhaseDiffA	53

APPENDIX C