INSTRUMENTOS PARA TESTES ELÉTRICOS

Test Tutorial

Equipment Type: Protection Relay

Brand: ABB

Model: REL650

Functions: 21 or PDIS – Distance

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

Objective: Search Test of Zones with Quadrilateral Characteristics

Version Control:

Version	Descriptions	Date	Author	Reviewer
1.0	Initial Version	30/03/2022	M.R.C.	G.C.D.P.

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 via email suporte@conprove.com.br.

The tutorial contains knowledge gained from the resources and technical data at the time it was written. 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 test 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 test and also be aware of safety standards and regulations.

Copyright

Sequence for testing the REL650 relay in the Distance 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 of the relay terminal X410.

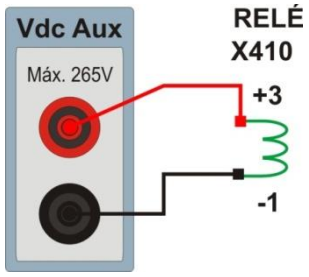

Figure 1

1.2 *Current and Voltage Coils*

To establish the connection of the voltage coils, connect channels V1, V2 and V3 to pins 1, 3 and 5 of terminal X102 of the relay and those common 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 current coils, connect channels I4, I5 and I6 to pins 1, 3 and 5 of terminal X101 of the relay, short circuit pins 2, 4 and 6, connect pin 6 to 7 and turn on the common from current channels to pin 8.

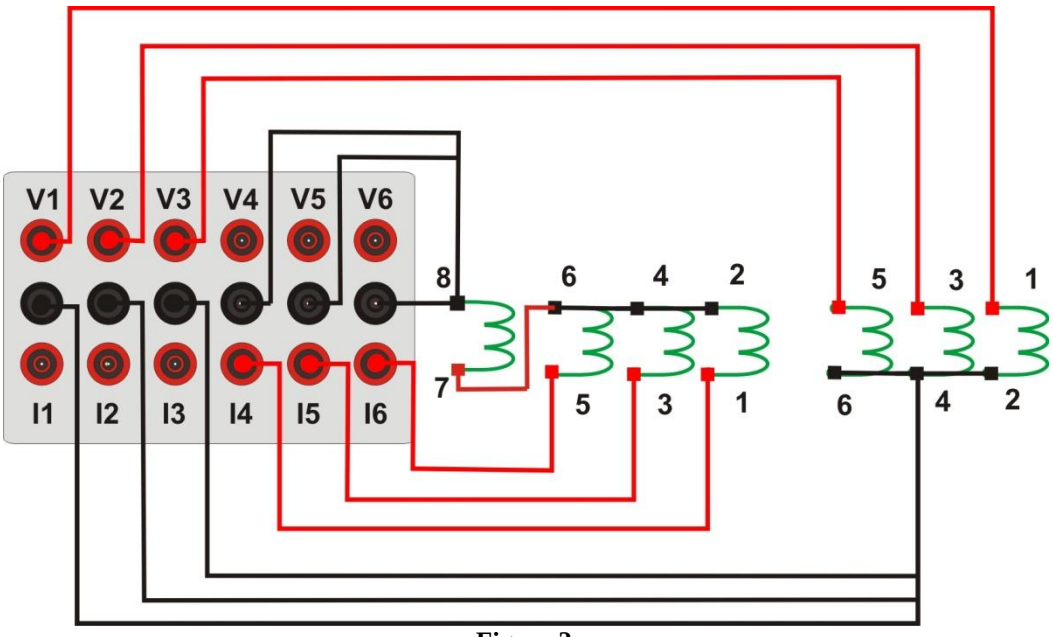

Figure 2

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.

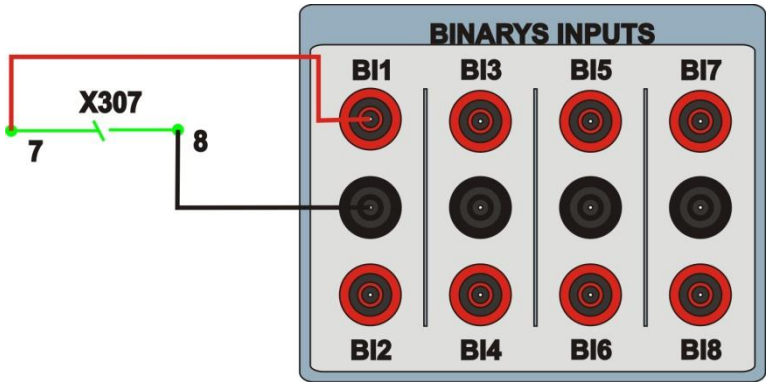

Figure 3

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 ..."*.

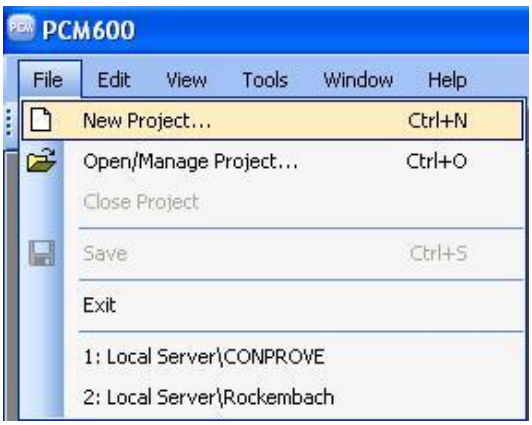

Figure 5

Choose a name for the project, in this case *"21"* was used and then click on *"Create"*.

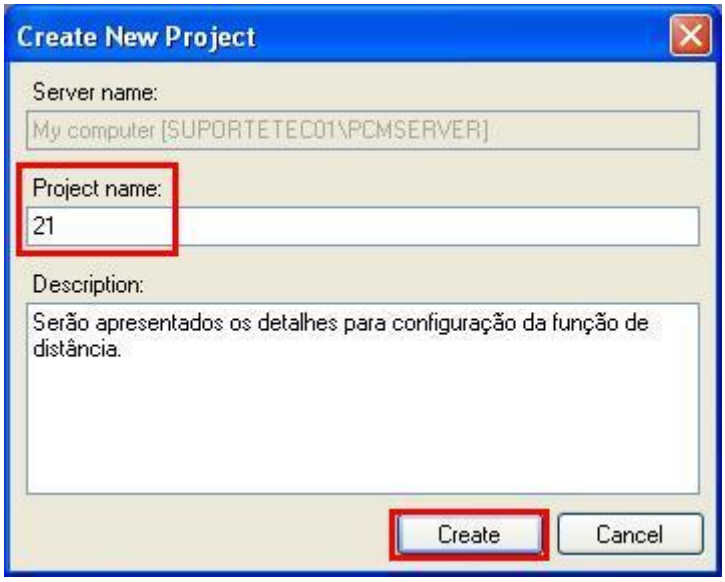

Figure 6

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

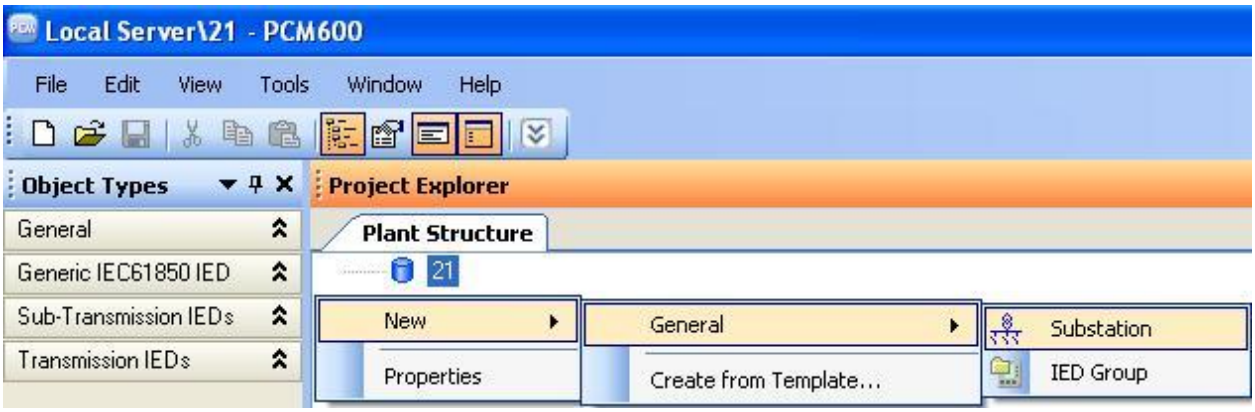

Figure 7

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

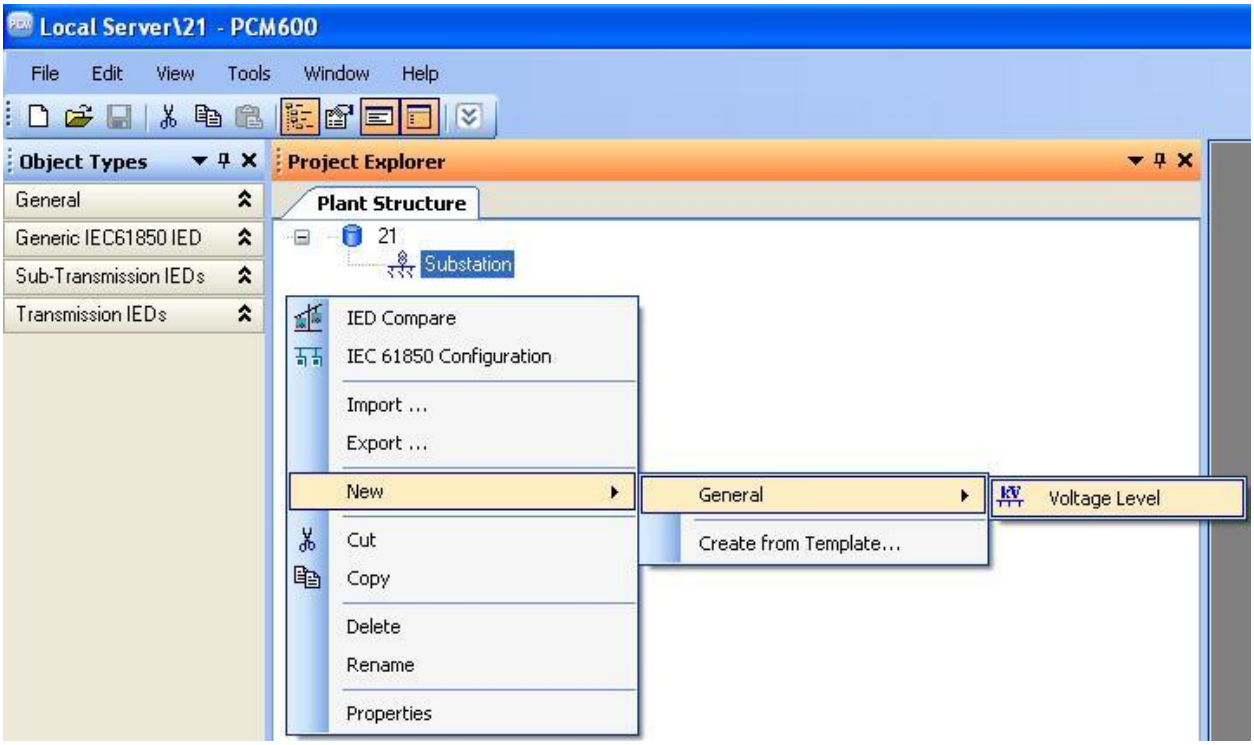

Figure 8

Within the voltage level a bay must be inserted.

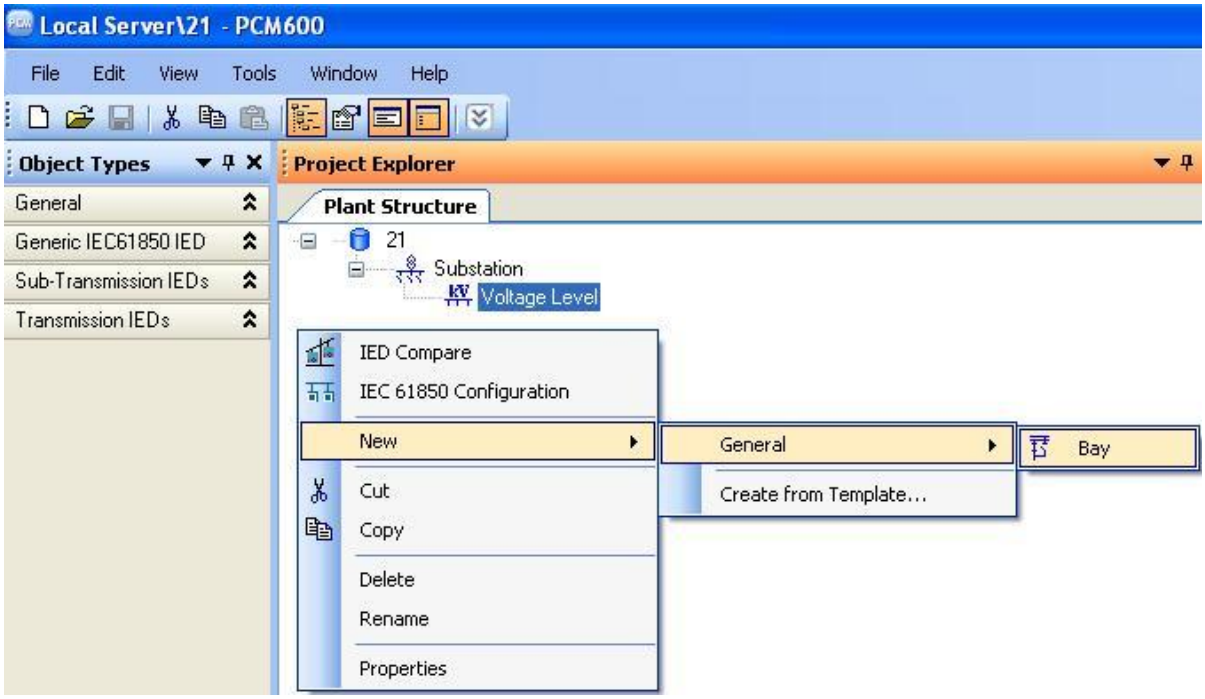

Figure 9

The REL650 relay is inserted inside the bay.

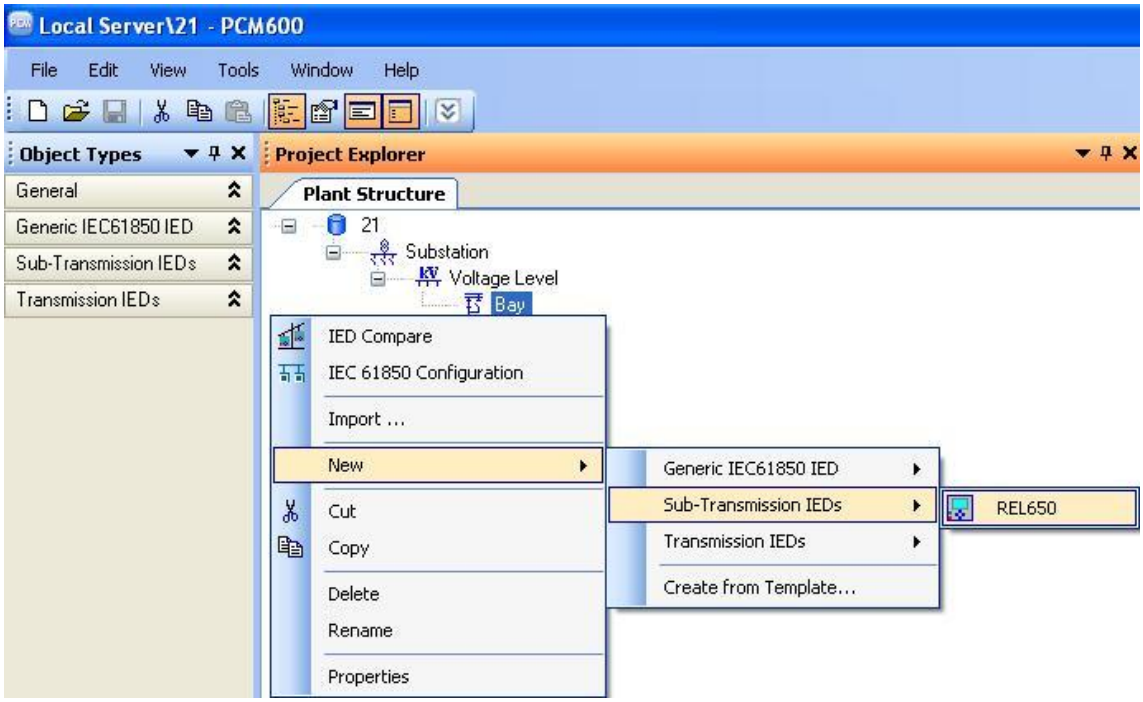

Figure 10

2.2 *Setting up communication*

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

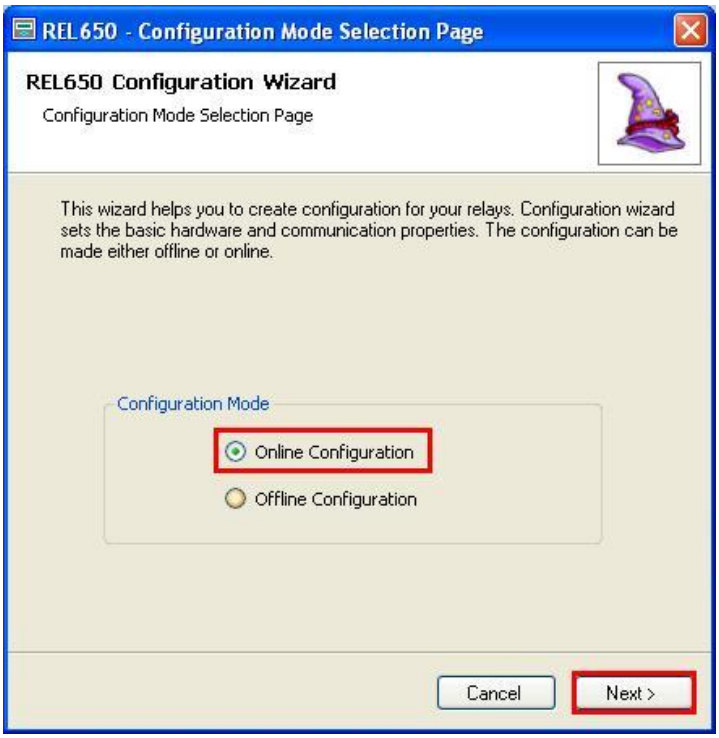

Figure 11

Choose the *"Next >"* option again.

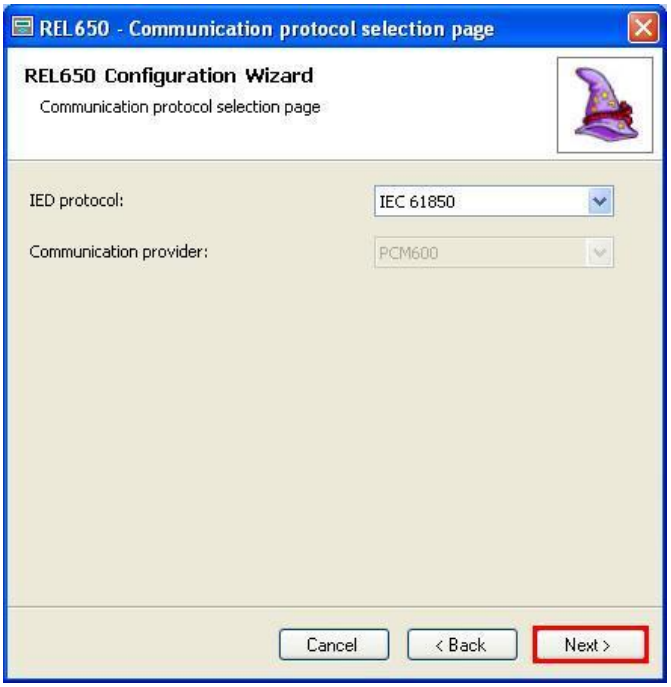

Figure 12

On the next screen, the user chooses between two options *"LAN1"* or *"Front Port"*, then you 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.

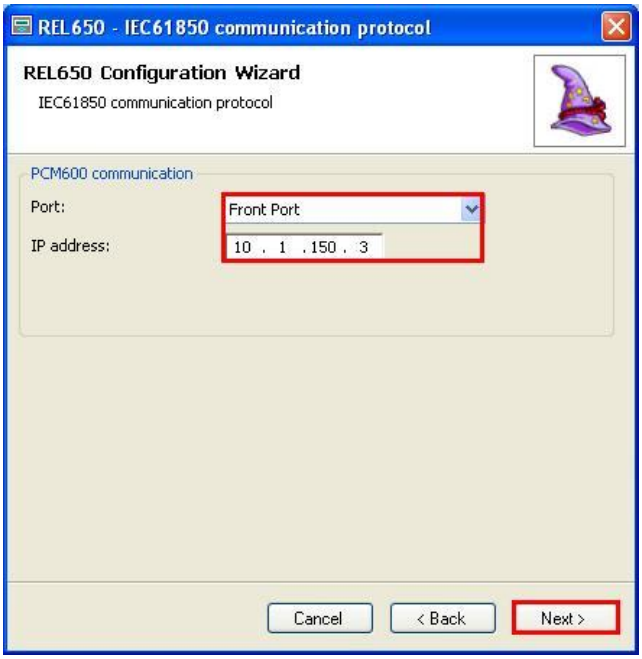

Figure 13

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

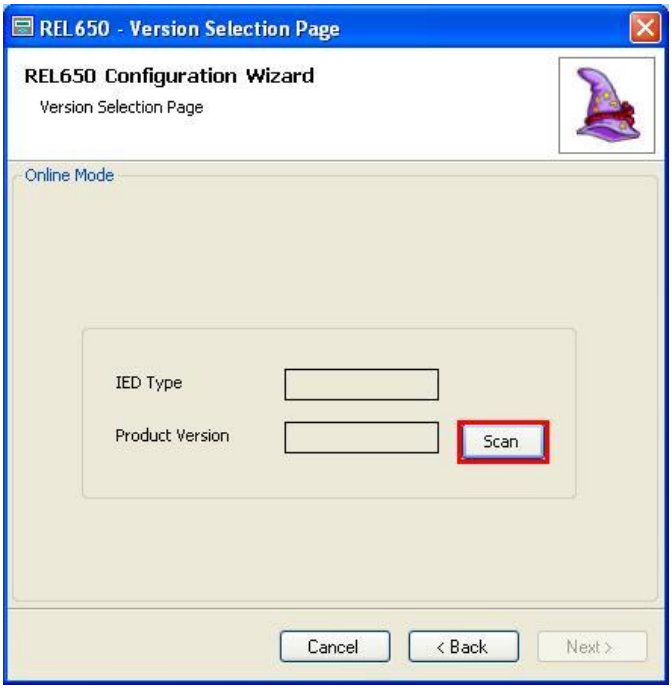

Figure 14

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

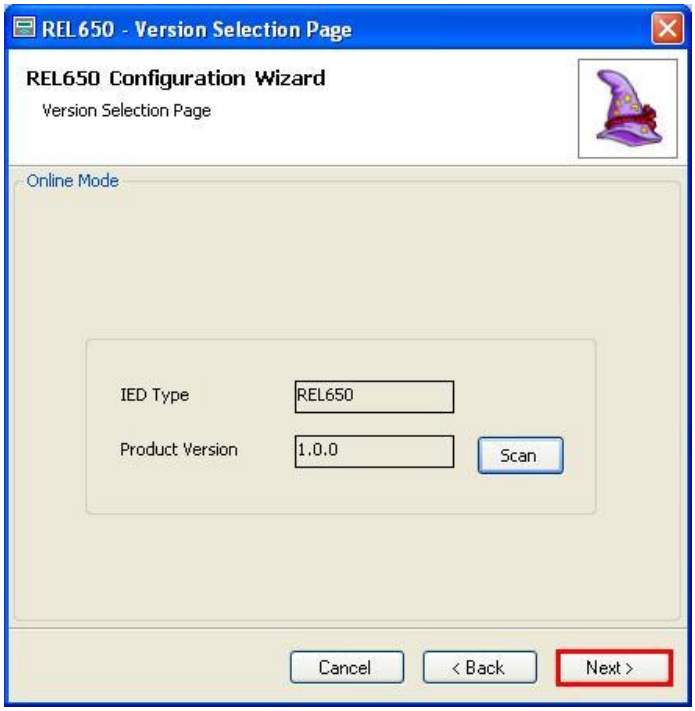

Figure 15

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

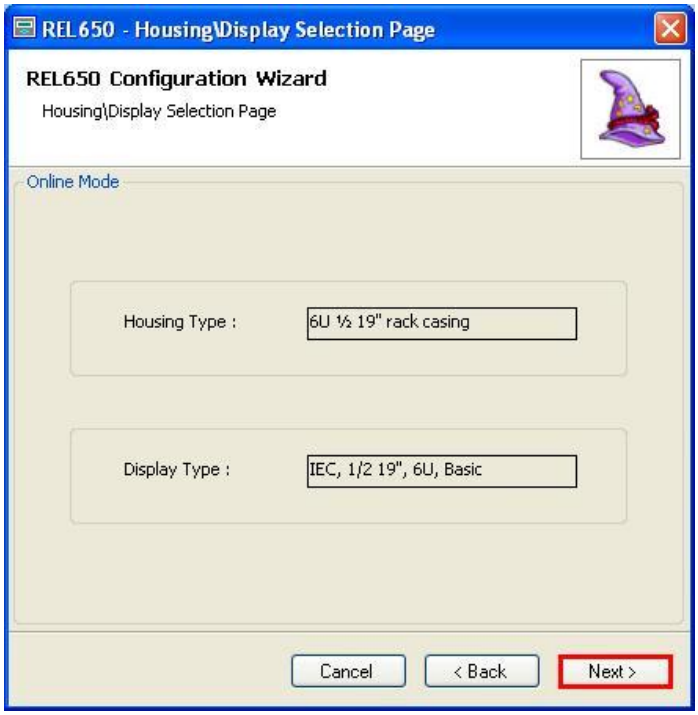

Figure 16

Finally, the complete relay information.

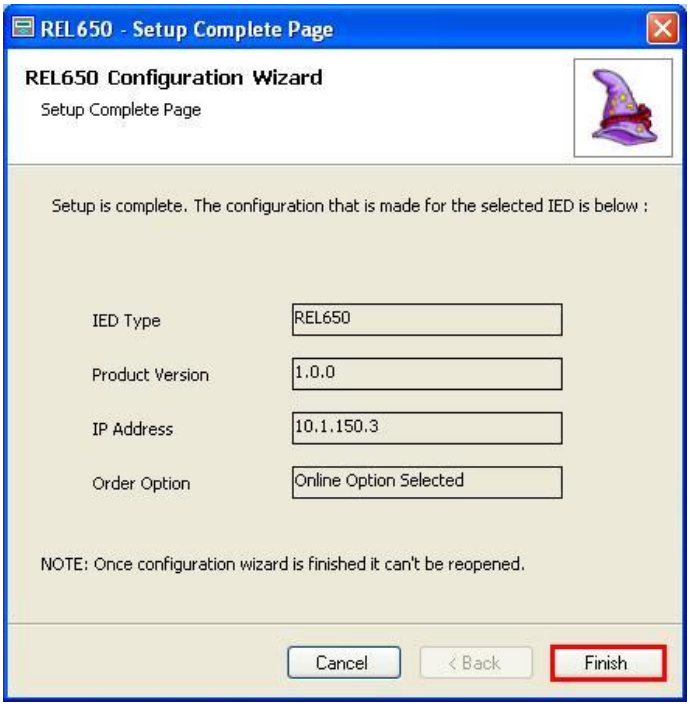

Figure 17

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"*.

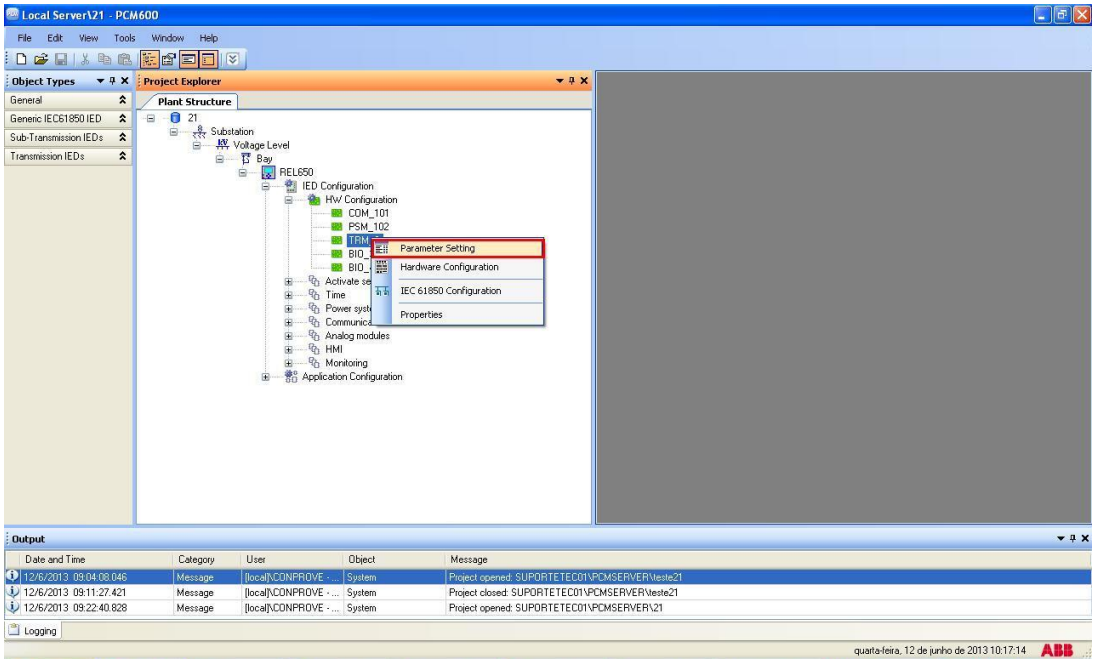

Figure 18

In this window, the relations of current and voltage transformations must be configured. For current use the first 4 channels and for voltage use channels 6 to 8.

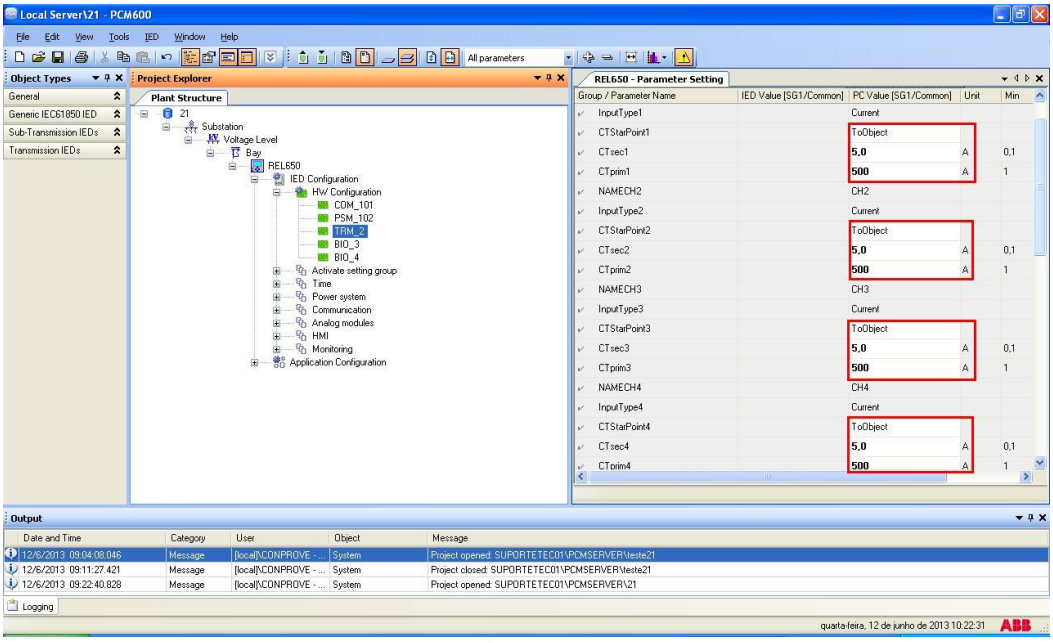

Figure 19

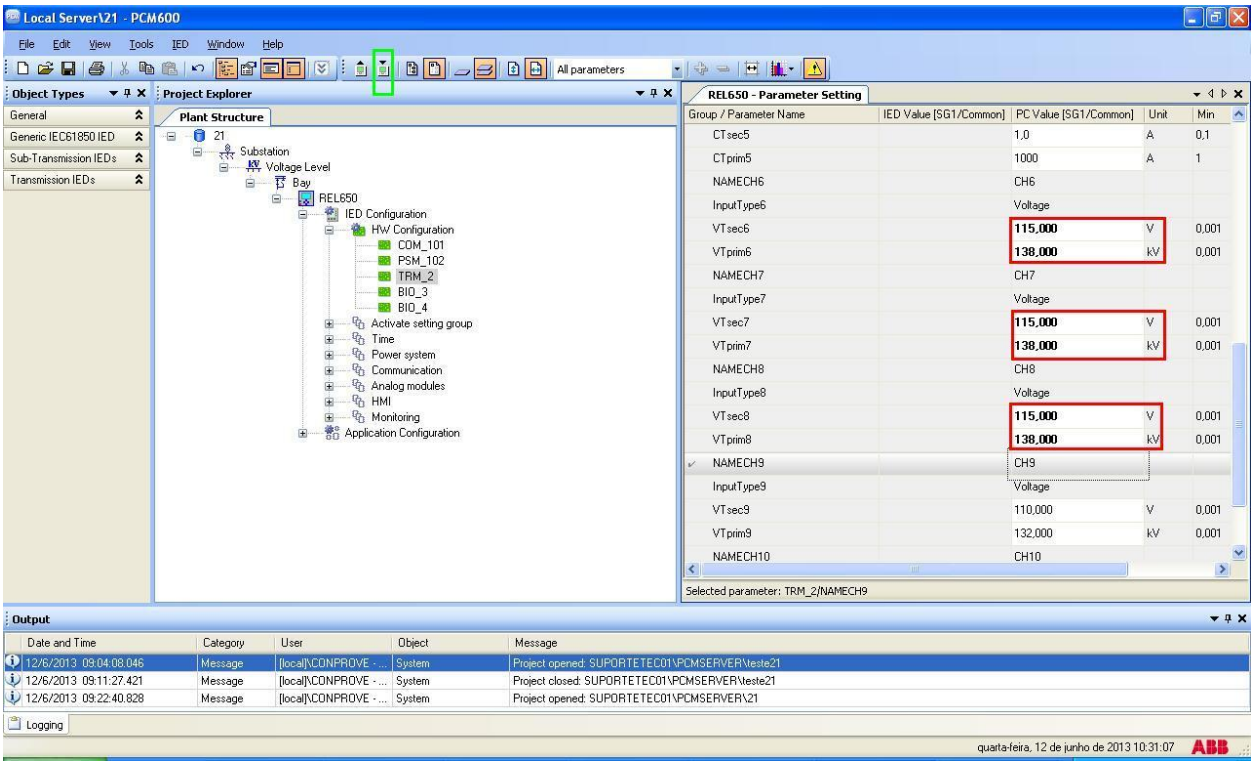

Figure 20

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 21

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.

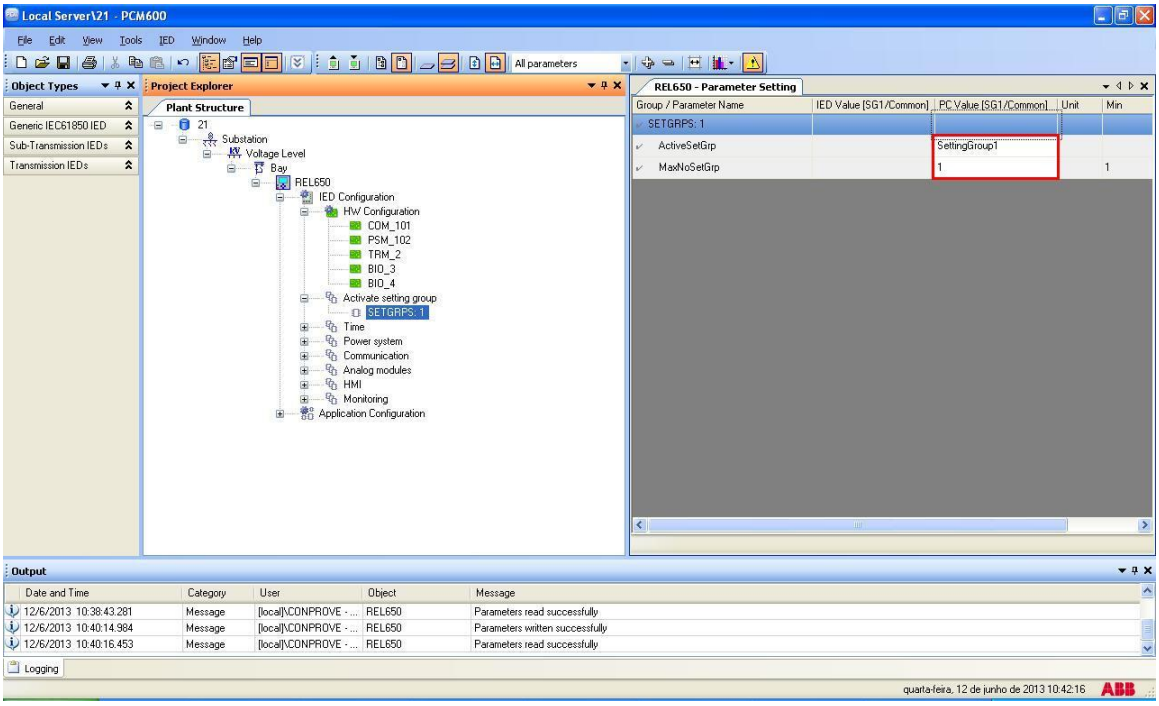

Figure 22

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.

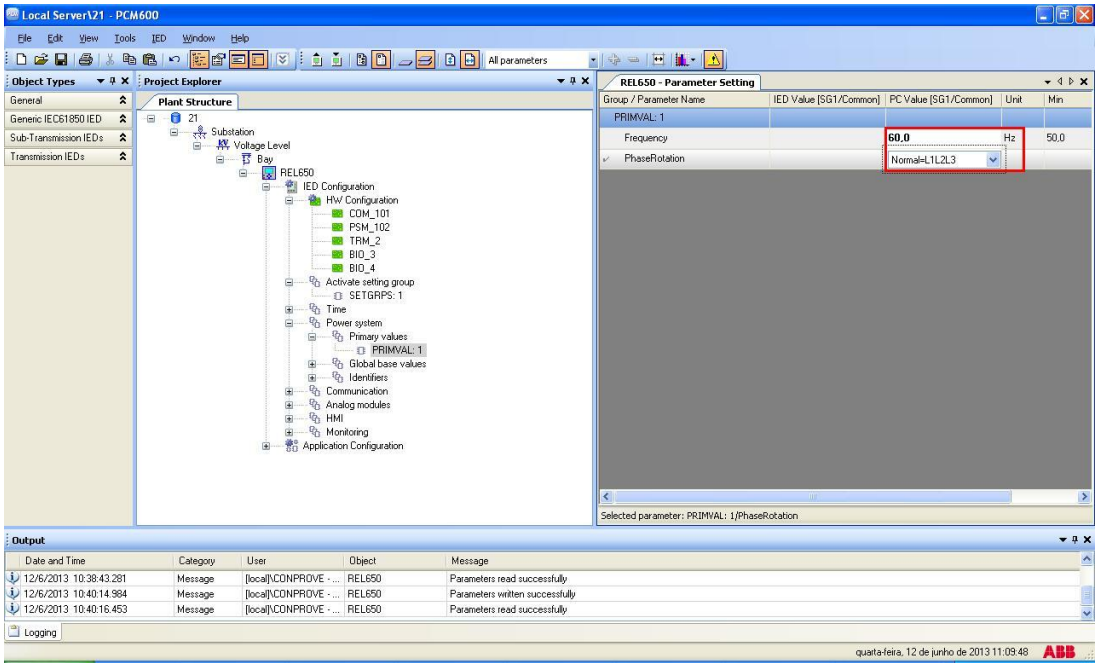

Figure 23

2.6 *GBASVAL: 1*

Click the *"+"* sign near to *"Global base values"* and then *"GBASVAL: 1"* and adjust the base voltage, current and power values. The other groups of base values will not be used.

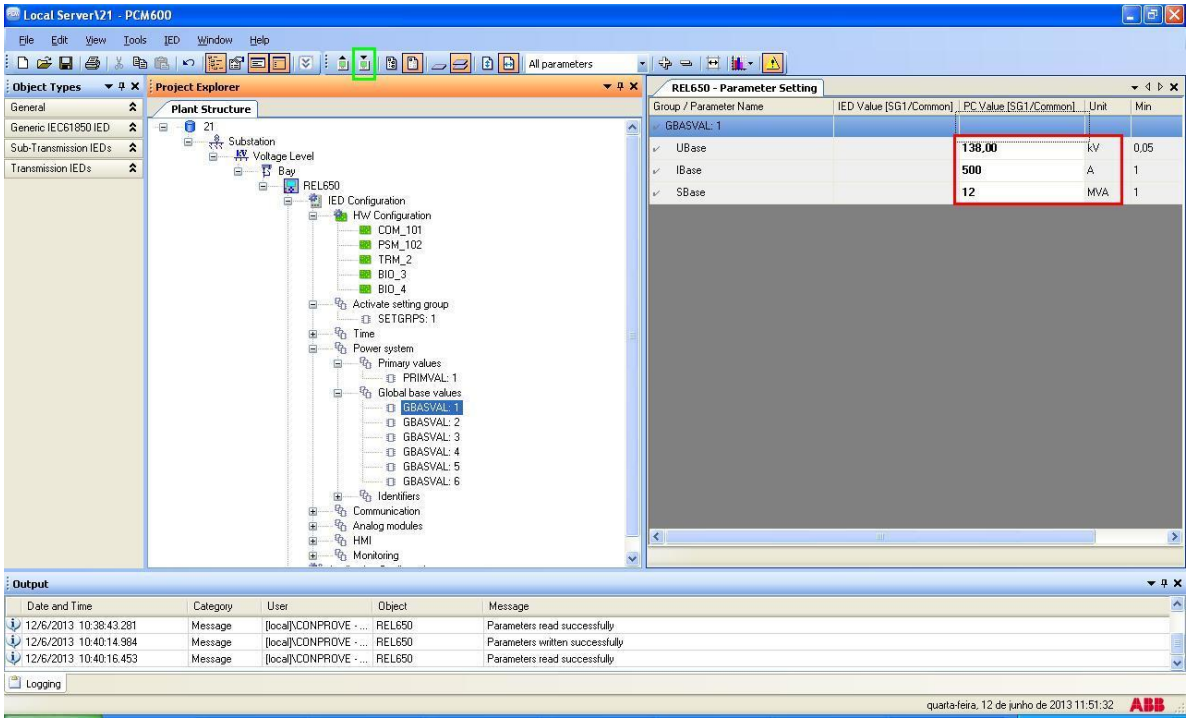

Figure 24

2.7 *AISVBAS: 1*

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

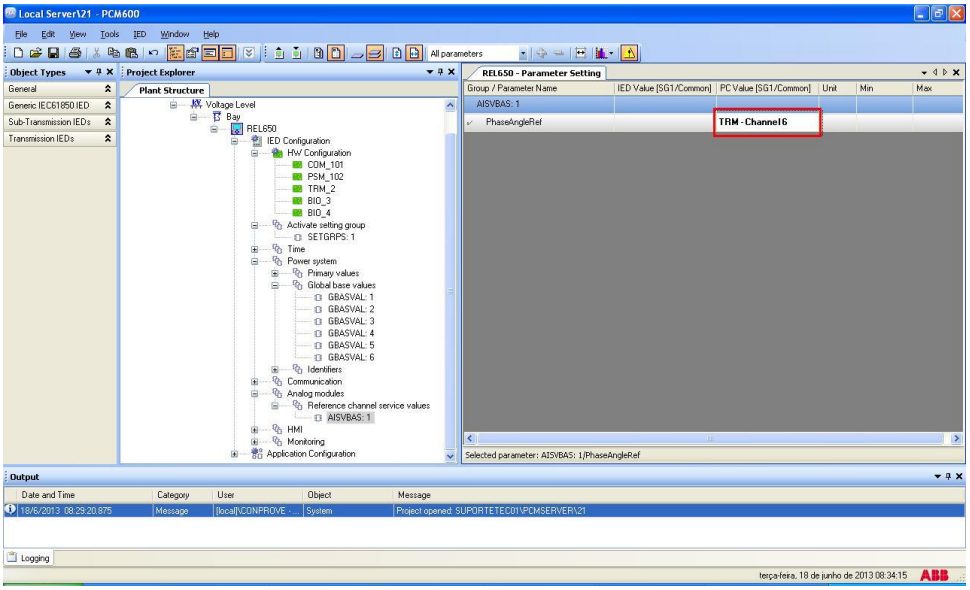

Figure 25

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.

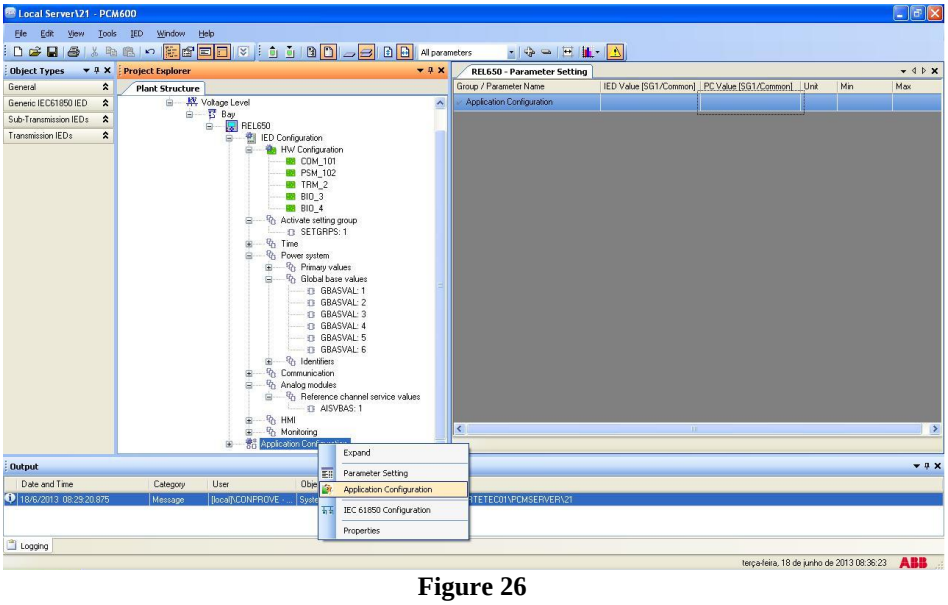

Figure 26

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

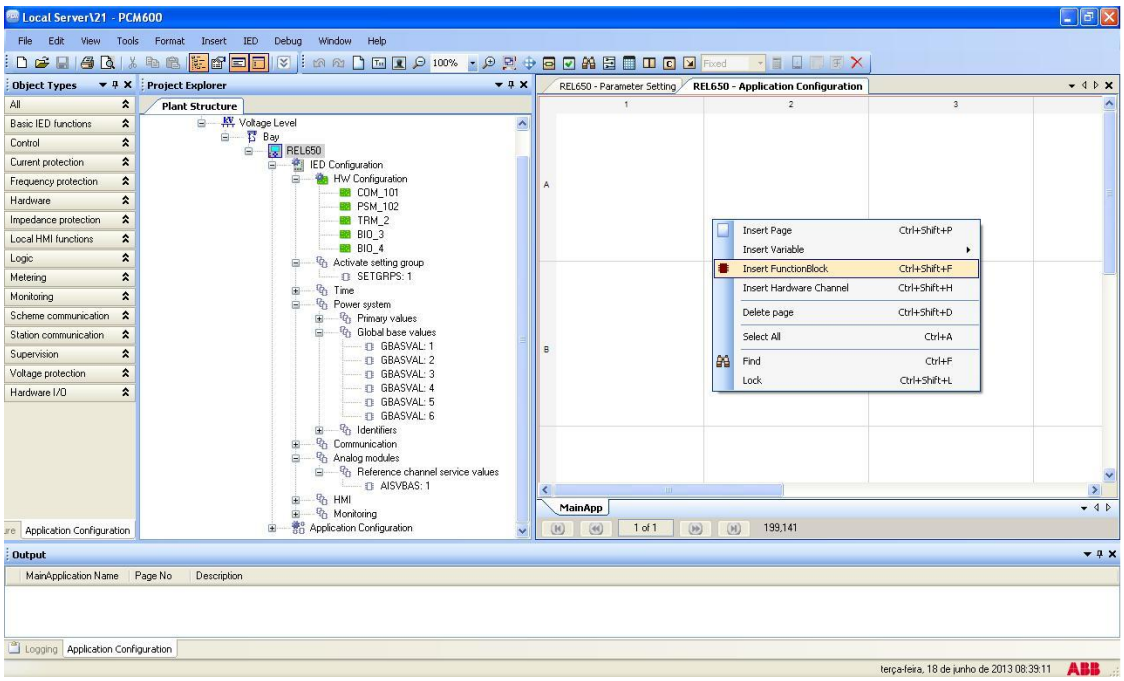

Figure 27

2.9 *SMAI_20_1 (Currents)*

Click on the *"+"* sign near to *"Basic IED functions"* and insert the *"SMAI_20_1"* block that will be responsible for the current channels . To understand the perfect functioning of the different blocks, consult the REL650 manual.

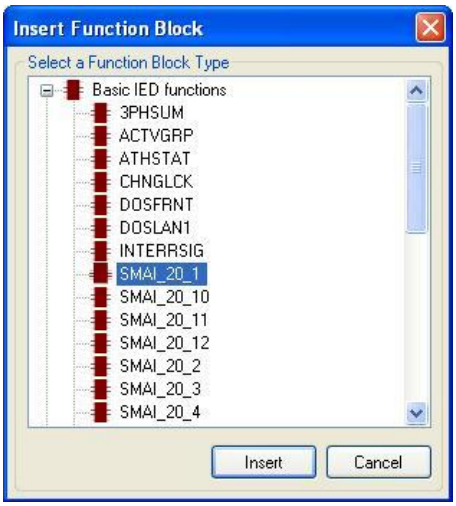

Figure 28

On the next screen set the *"Cycle Time"* to 5.

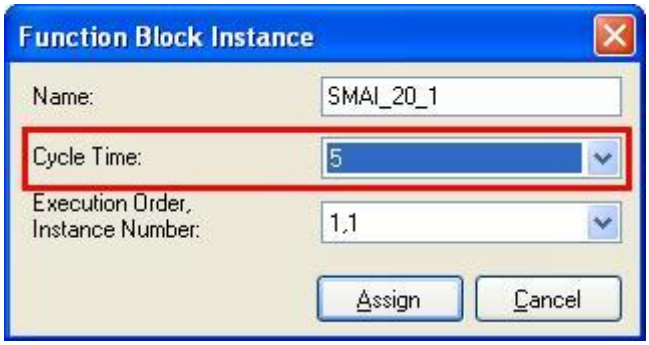

Figure 29

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.

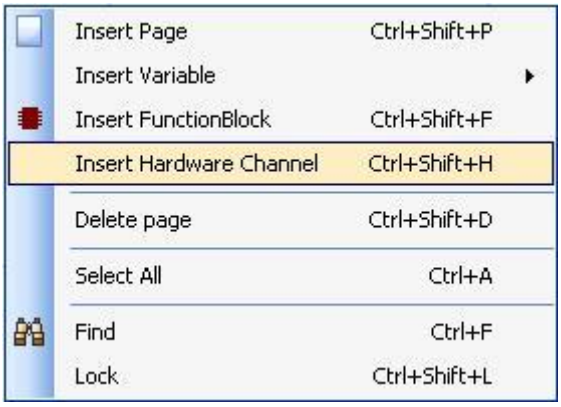

Figure 30

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

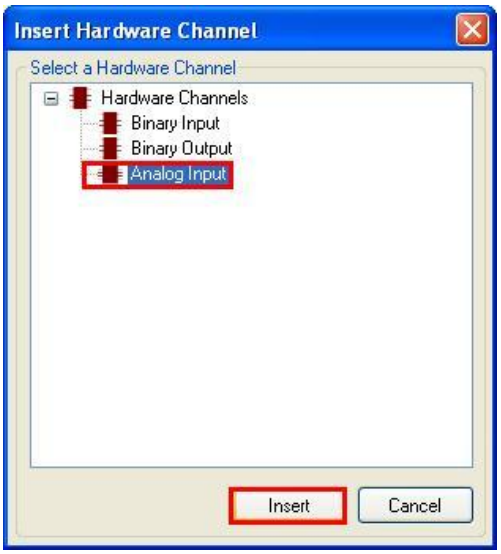

Figure 31

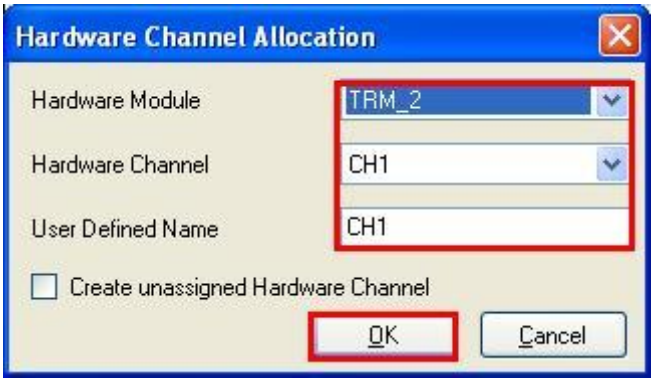

Figure 32

Repeat the procedure of the previous 3 figures only changing the option of *"Hardware Channel"* to CH2, CH3 and CH4. Then make the links with the blocks.

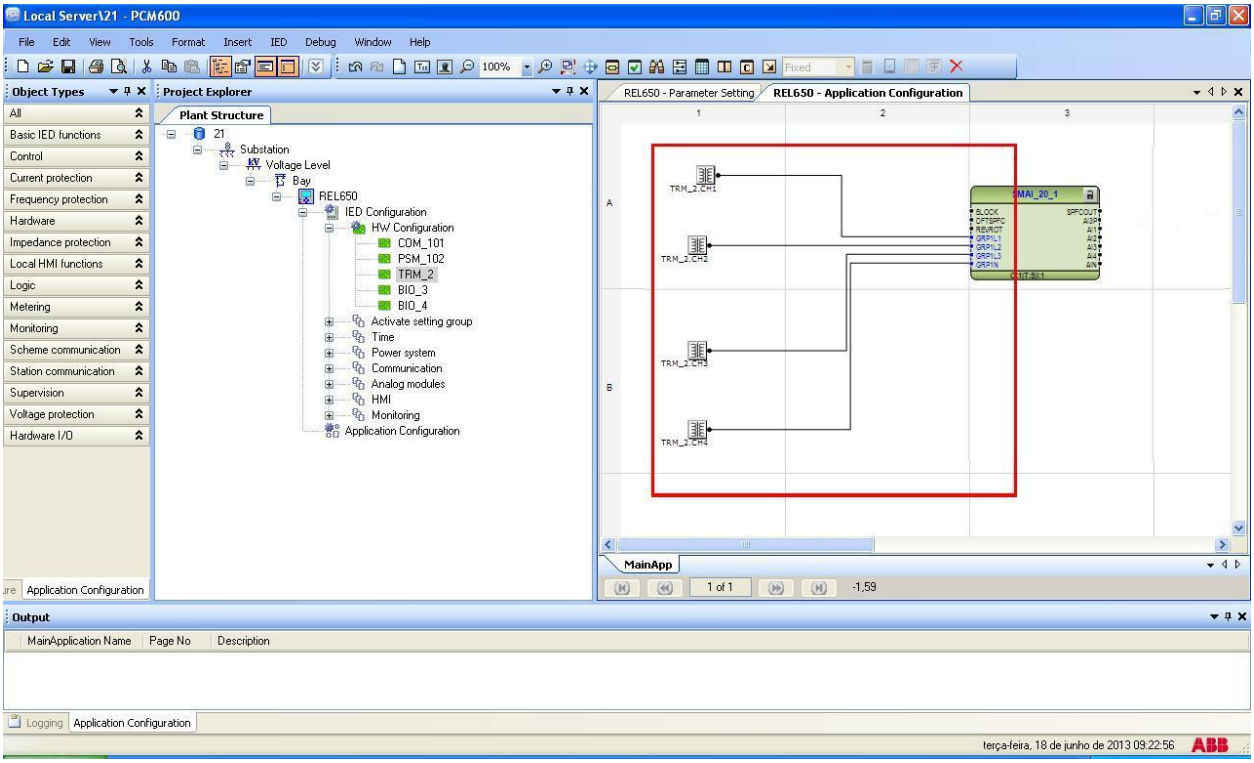

Figure 33

Assign an output to the *"AI3P"* option of each block. Right click and choose *"Insert Variable > Output"*.

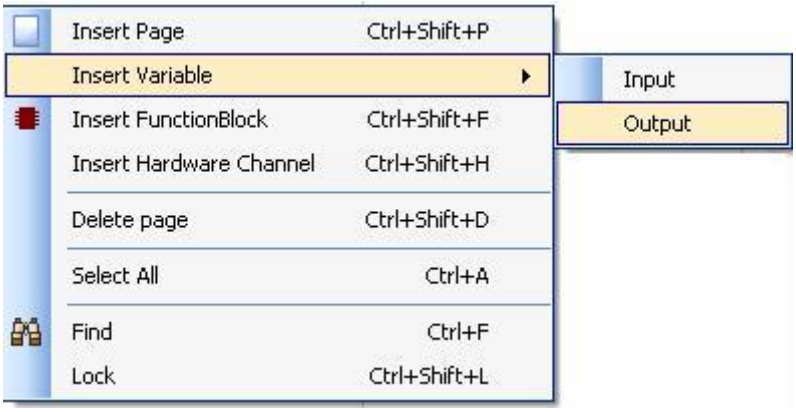

Figure 34

Choose a name for these variables, in this case, *"AI3P_TC_05ms"* for the first block and *"AI3P_TC_20ms"* for the second block and connect with the AI3P outputs of each block.

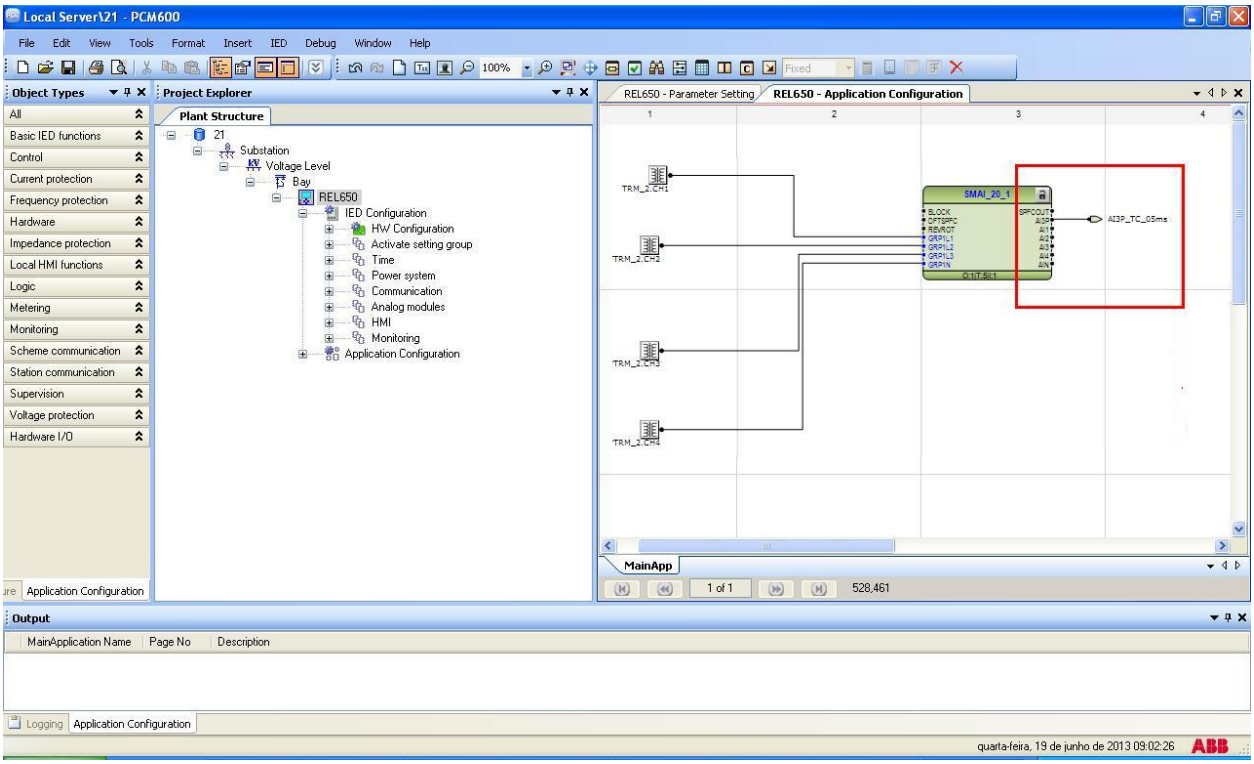

Figure 35

Clicking on the *"MainApp"* tab enables you to change the name of the tab. For example, change to *"CANAIS_CORRENTE"* as shown in Figure 36.

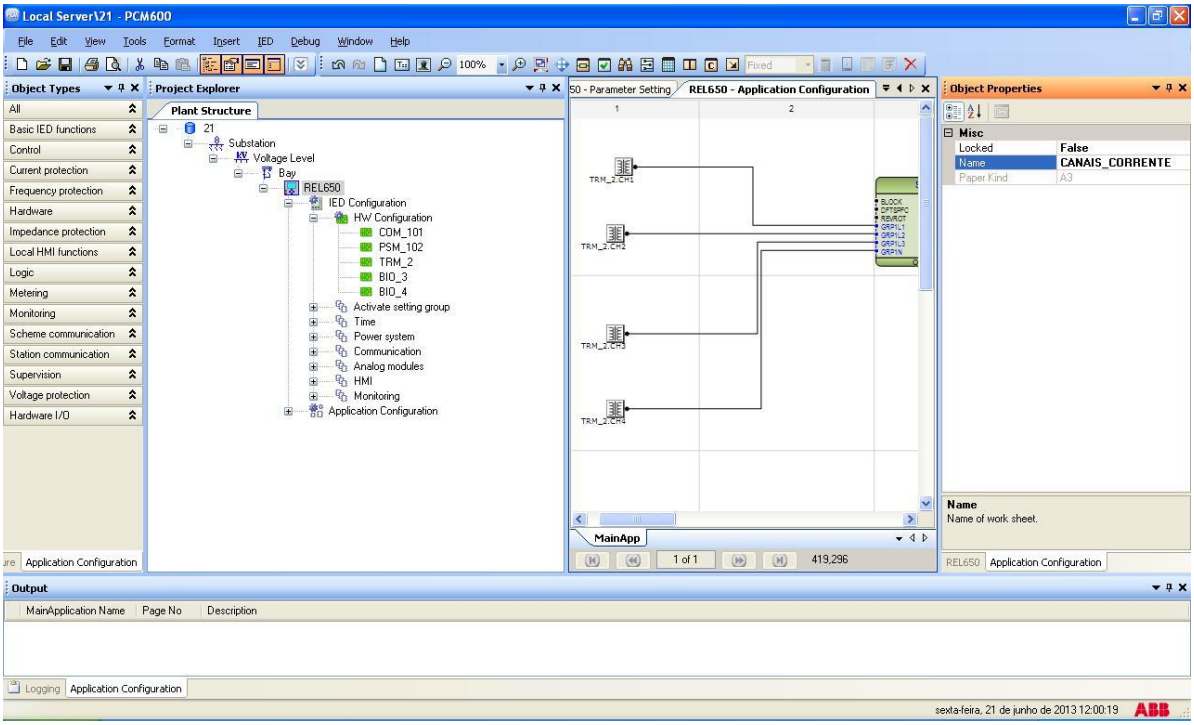

Figure 36

Close the *"Object Properties"* window that was opened in the last Figure and then click *"Insert > MainApplication"*.

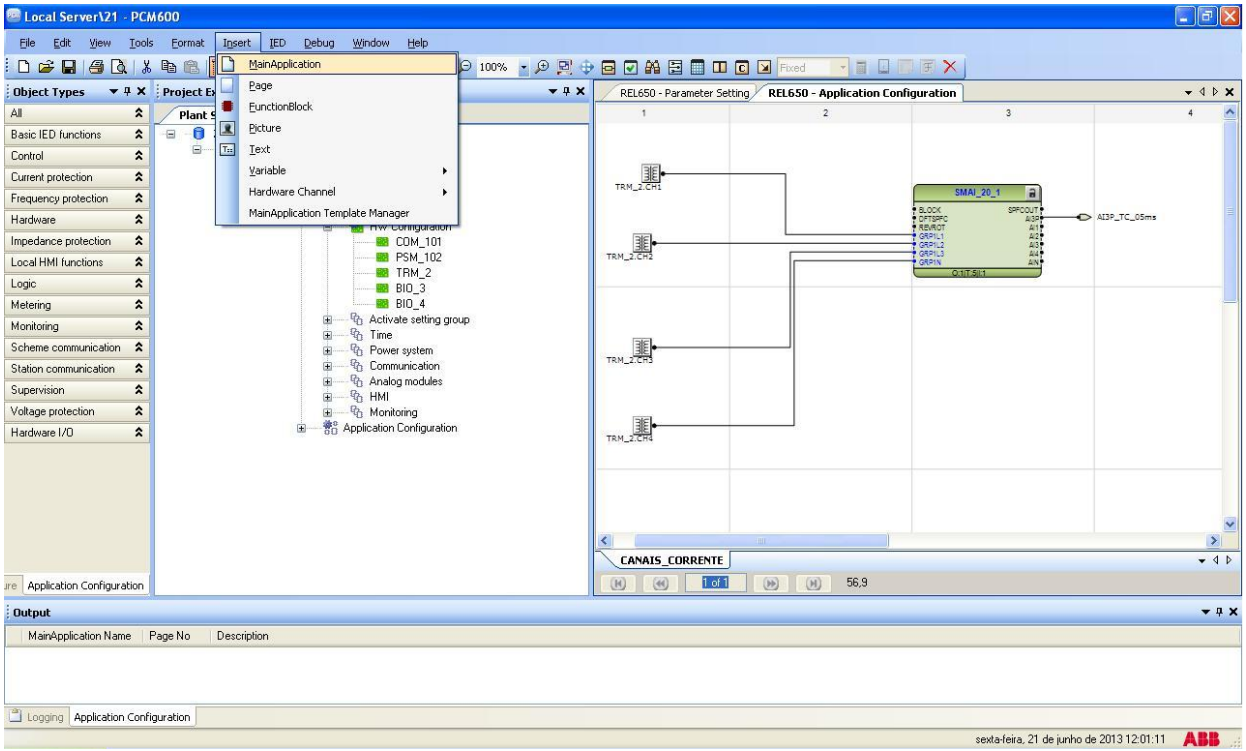

Figure 37

2.10 *SMAI_20_2 (Voltages)*

In the new tab, the block responsible for the voltage channels is configured. Repeat the procedure from figures 27 to 36 changing the used block to *"SMAI_20_2"*, the measurement channels CH6, CH7 and CH8 and the output variable to *"AI3P_TP_05ms"*.

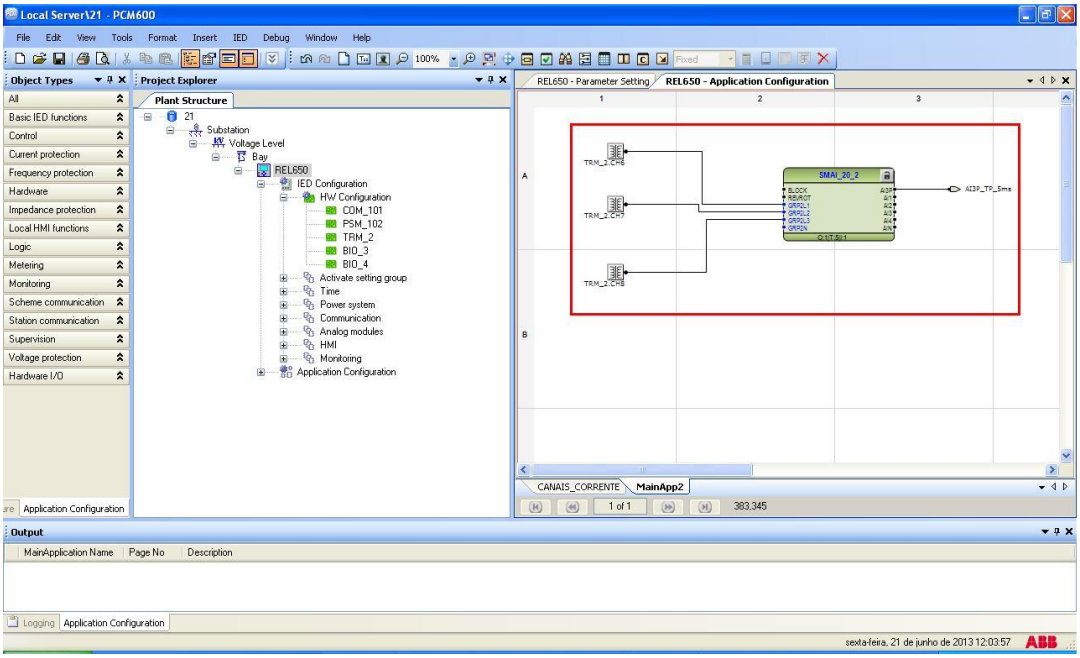

Figure 38

Click on the icon highlighted in green, click on the *"MainApp2"* tab and change the name of the tab to *"CANAIS_TENSÃO"*.

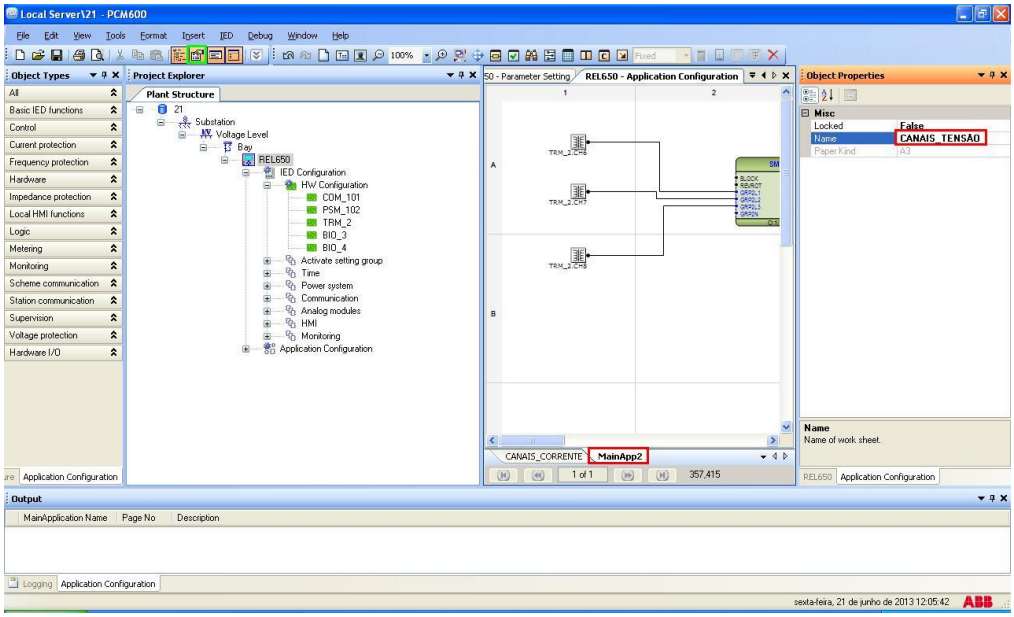

Figure 39

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

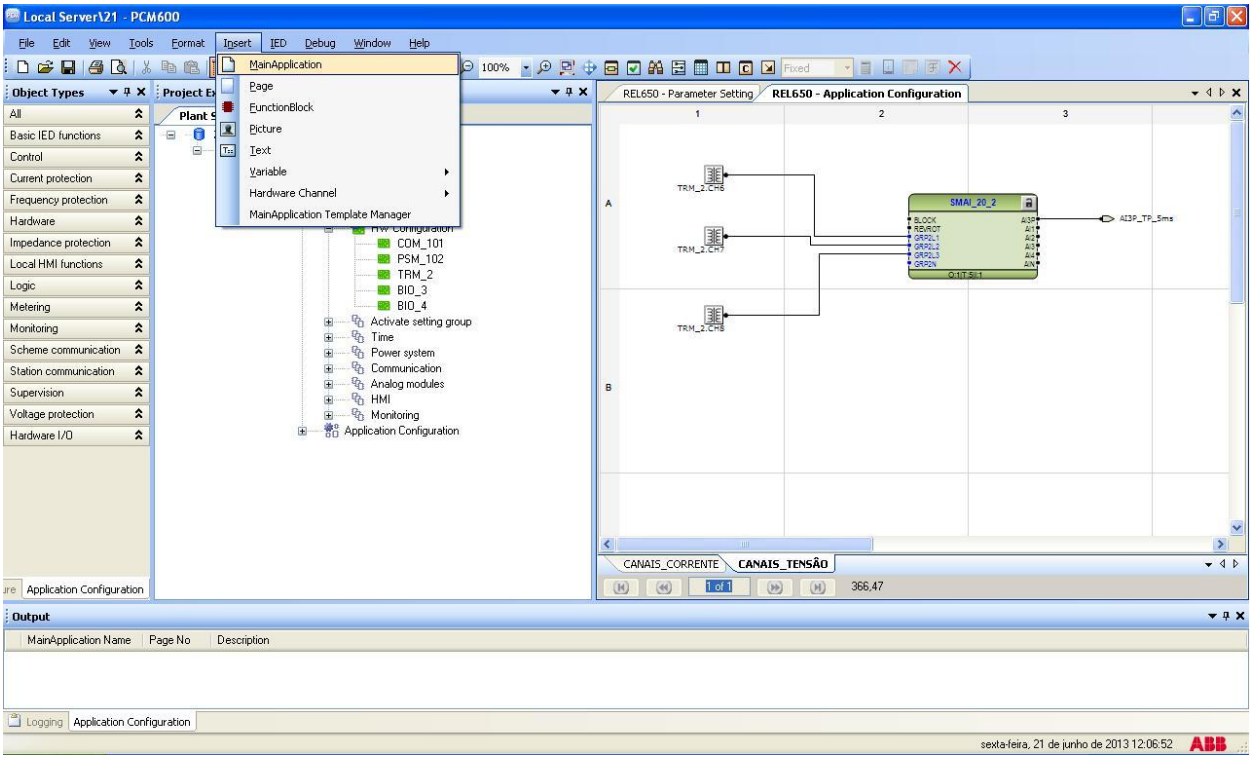

Figure 40

2.11 *ZQDPDIS (Quadrilateral Distance)*

Right-click on the new tab, choose *"Insert Function Block"*, click on the *"+"* sign near to *"Impedance protection"* and finally choose the *"ZQDPDIS"* block.

Figure 41

Clique em *"Assign"* na janela seguinte (não mostrada). Para se utilizar todo o potencial da função de distância devem-se utilizar mais três blocos conjuntamente com o bloco *"ZQDPDIS"*.

2.12 *ZDNRDIR (Directionality of the distance function)*

Right-click on the tab, choose *"Insert Function Block"*, click on the *"+"* sign near to *"Impedance protection"* and finally choose the *"ZDNRDIR"* block. This block determines if the zone characteristics are forward (forward), reverse (reverse) or without directionality (offset).

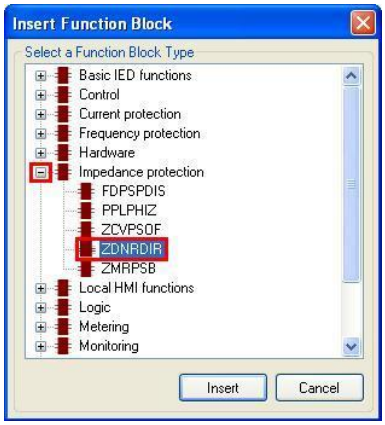

Figure 42

Click *"Assign"* in the next window (not shown).

2.13 *FDPSPDIS (Phase selector with load compensation)*

Right-click on the tab, choose *"Insert Function Block"*, click on the *"+"* sign near to *"Impedance protection"* and finally choose the *"FDPSPDIS"* block. This block determines in which phase the fault occurs and alsoallows load compensation.

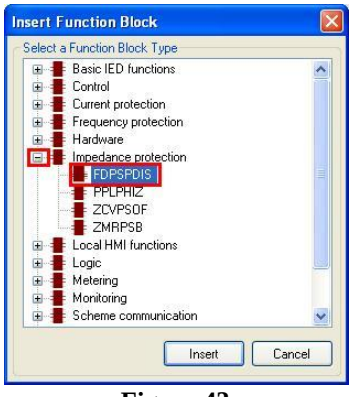

Figure 43

Click *"Assign"* in the next window (not shown).

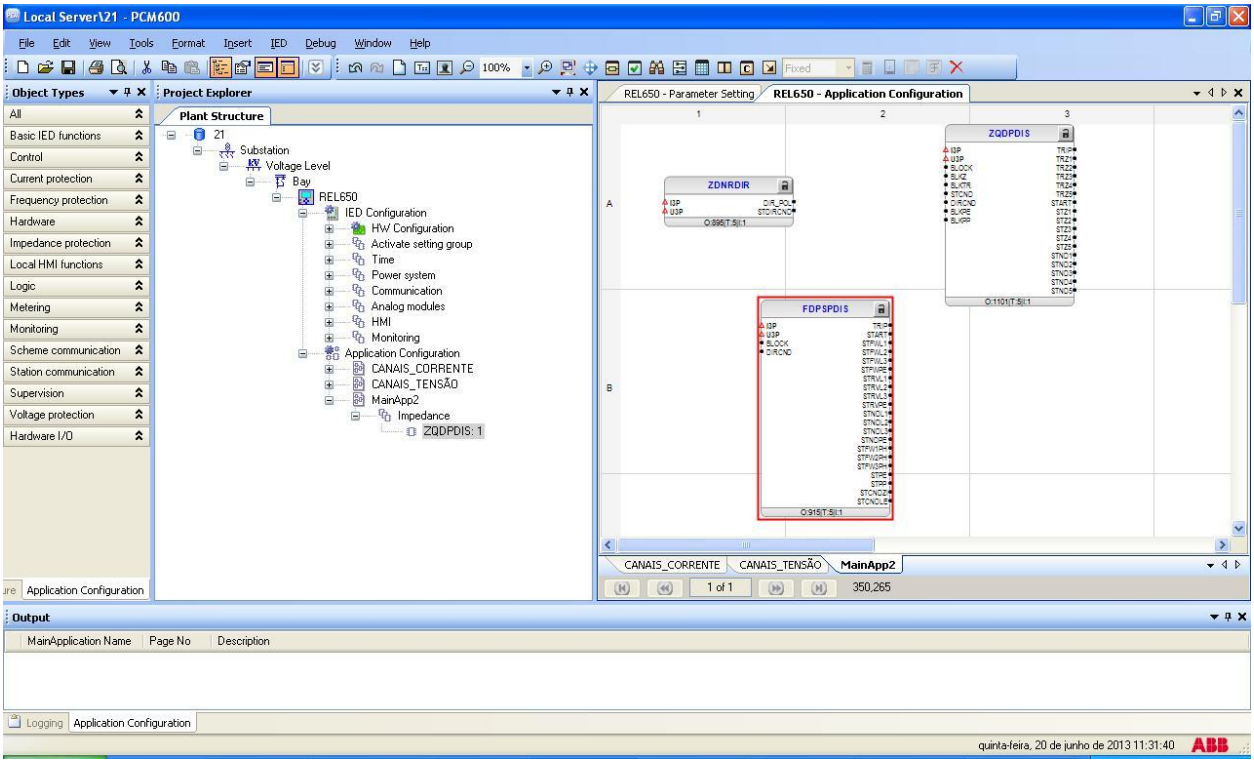

Figure 44

Click the right button and choose *"Insert Variable > Input"* to insert two input variables of current and voltage with 5ms cycle. Use the same name given in figures 36 and 39. Connect with the voltage and current inputs of each block.

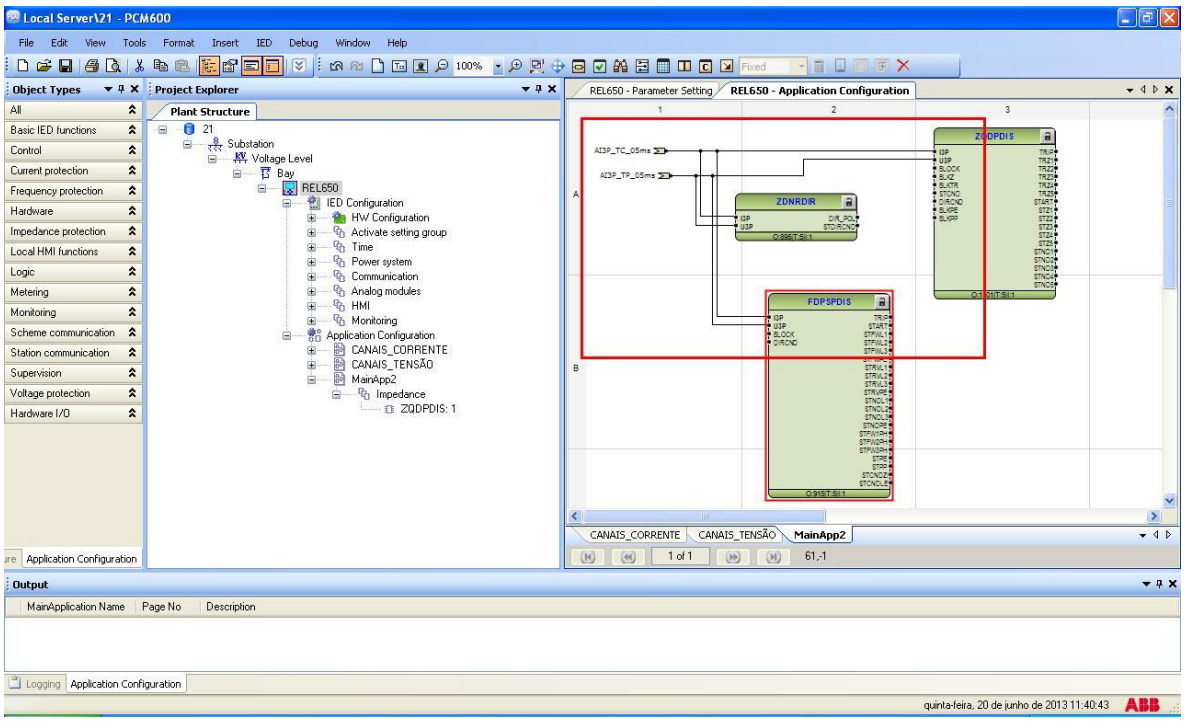

Figure 45

Connect the *"STDIRCND"* output of the *"ZDNRDIR"* block to the *"DIRCND"* inputs of the *"FDPSPDIS"* and *"ZQDPDIS"* blocks. Then connect the *"STCNDZI"* output of the *"FDPSPIDS"* block to the *"STCND"* input of the *"ZQDPIS"* block. Finally create an output variable and connect it to the trip of the *"ZQDPIS"* block. The name of this variable can be *"TRIP_21"*.

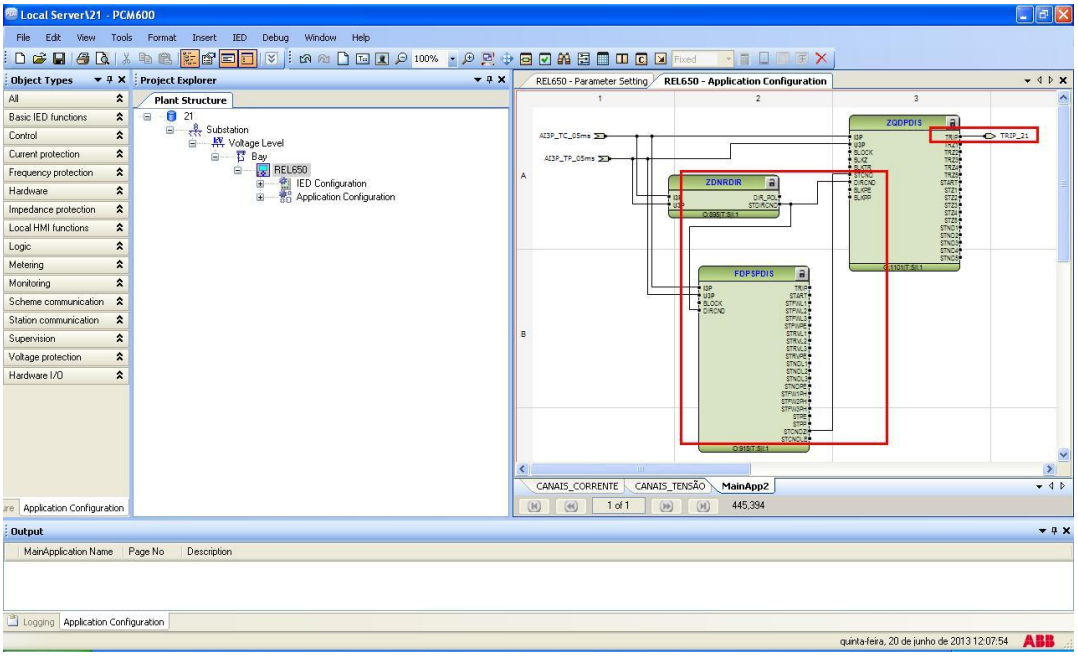

Figure 46

Change the tab name to *"DISTANCIA"*.

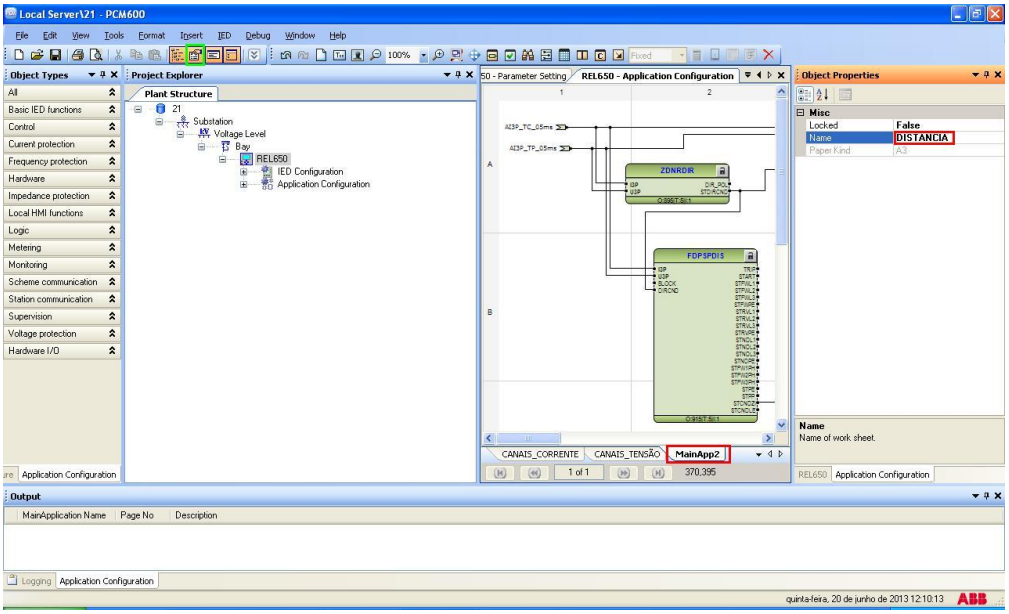

Figure 47

2.14 *Binary Outputs*

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

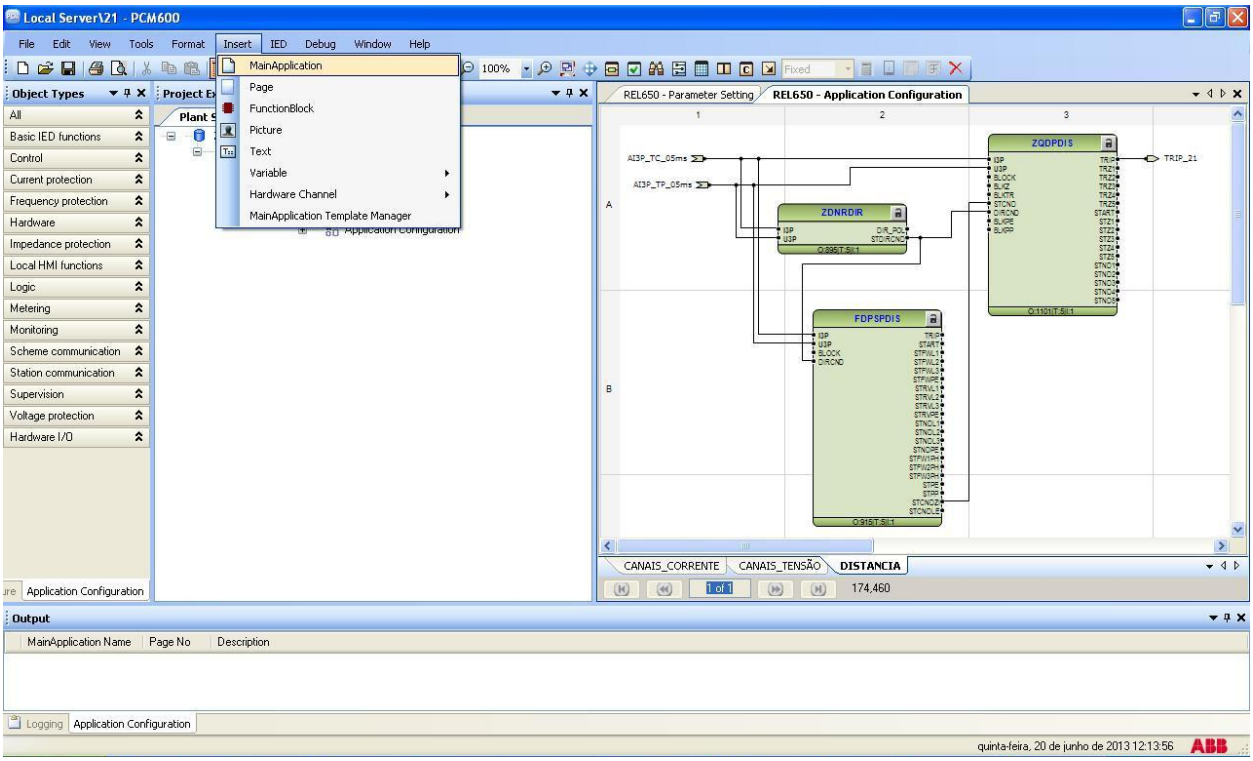

Figure 48

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

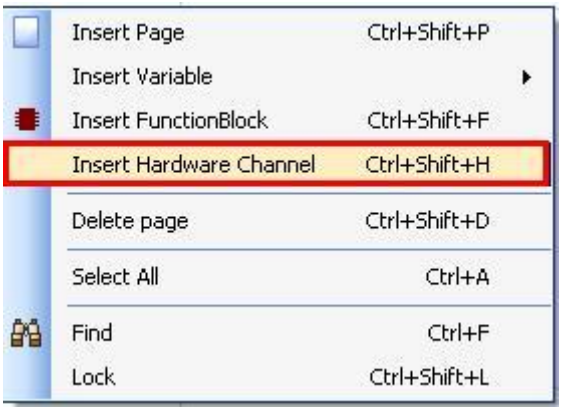

Figure 49

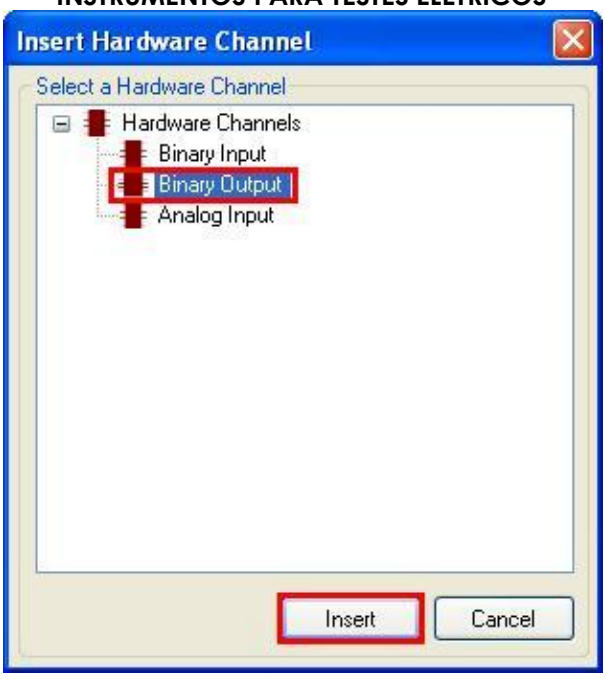

Figure 50

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

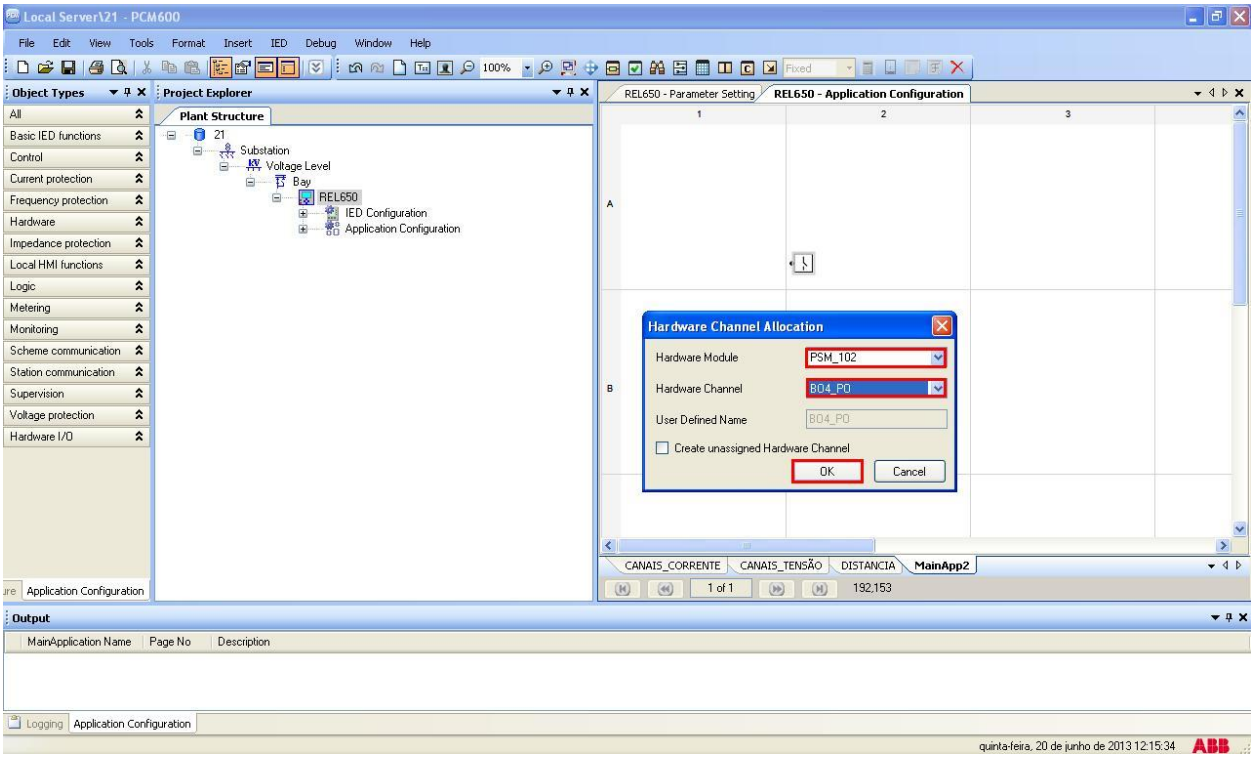

Figure 51

Create an input variable using the same name as the distance block output variable and associate the binary output. Change the name of the tab to *"SAÍDAS_BINÁRIAS"*.

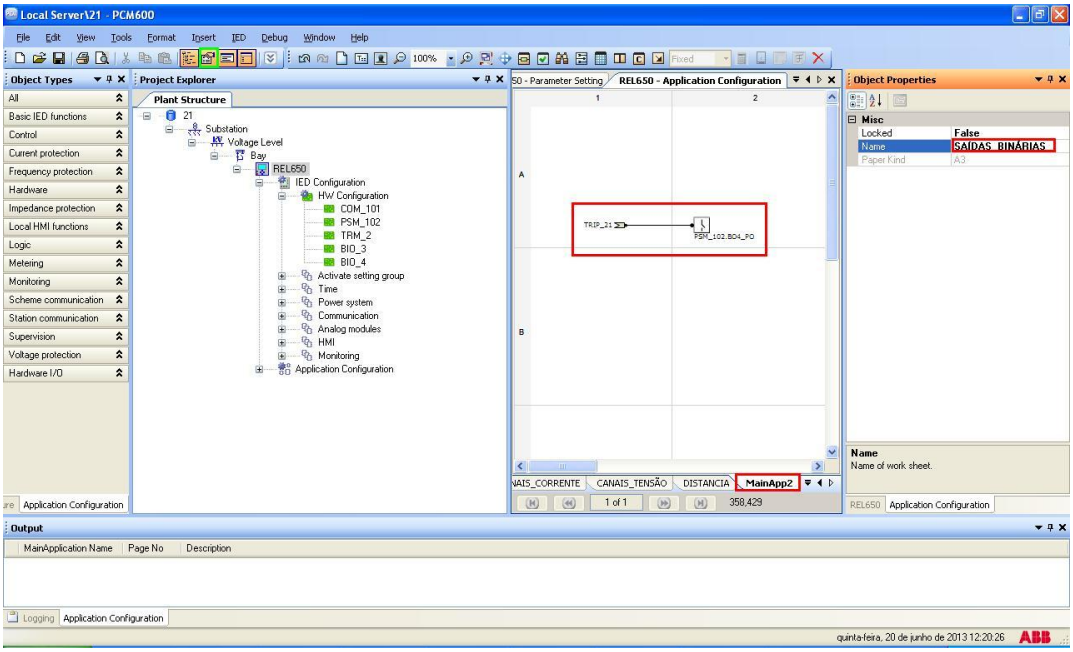

Figure 52

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

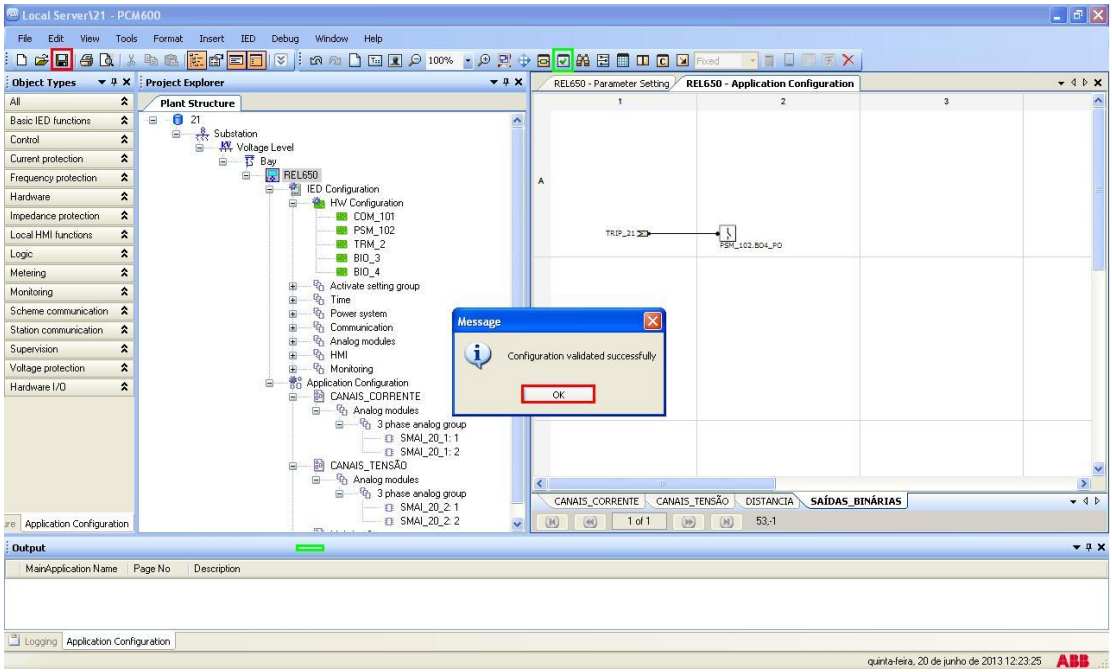

Figure 53

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 beside *"Application Configuration > DISTANCIA > Impedance"* and finally *"ZQDPDIS : 1"*.

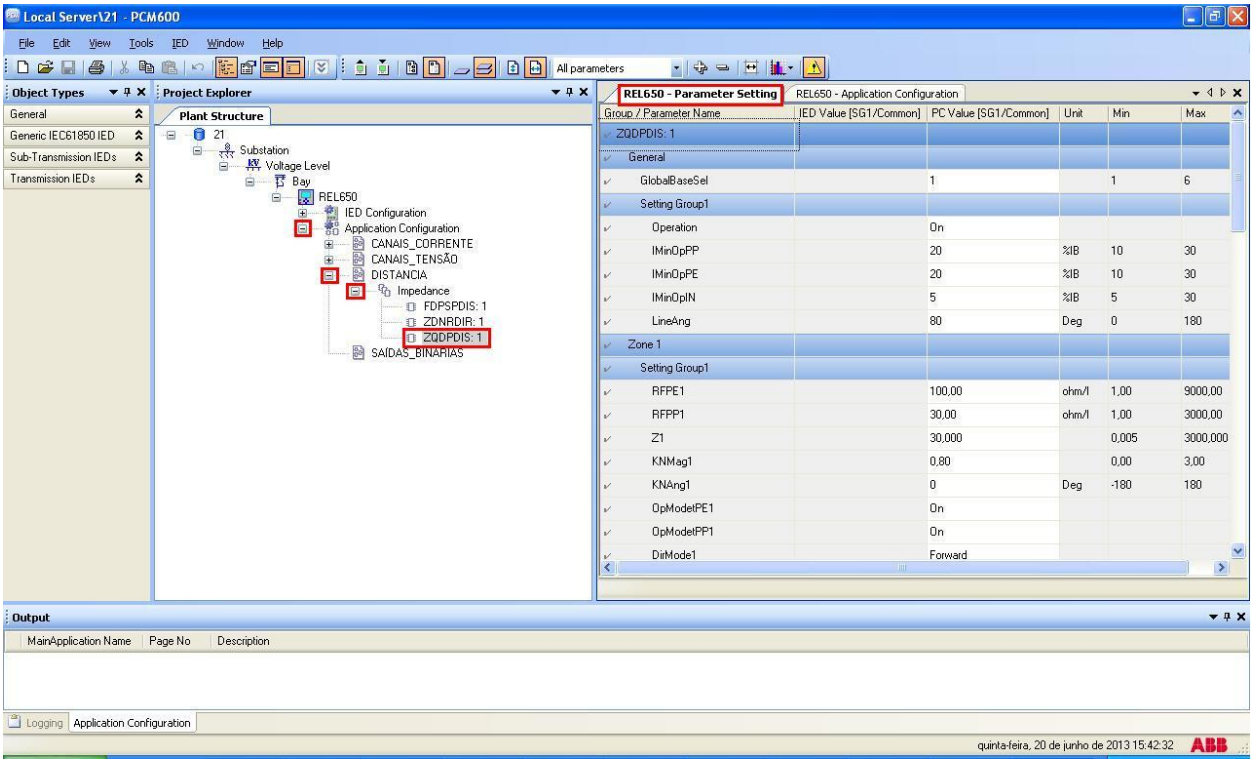

Figure 54

The relay allows up to 5 protection zones to be parameterized, but for simplicity in this tutorial only 3 zones will be active. The first two will have the forward directionality *"Forward"* and the third backward directionality *"Reverse"*. For the first zone make the following adjustments:

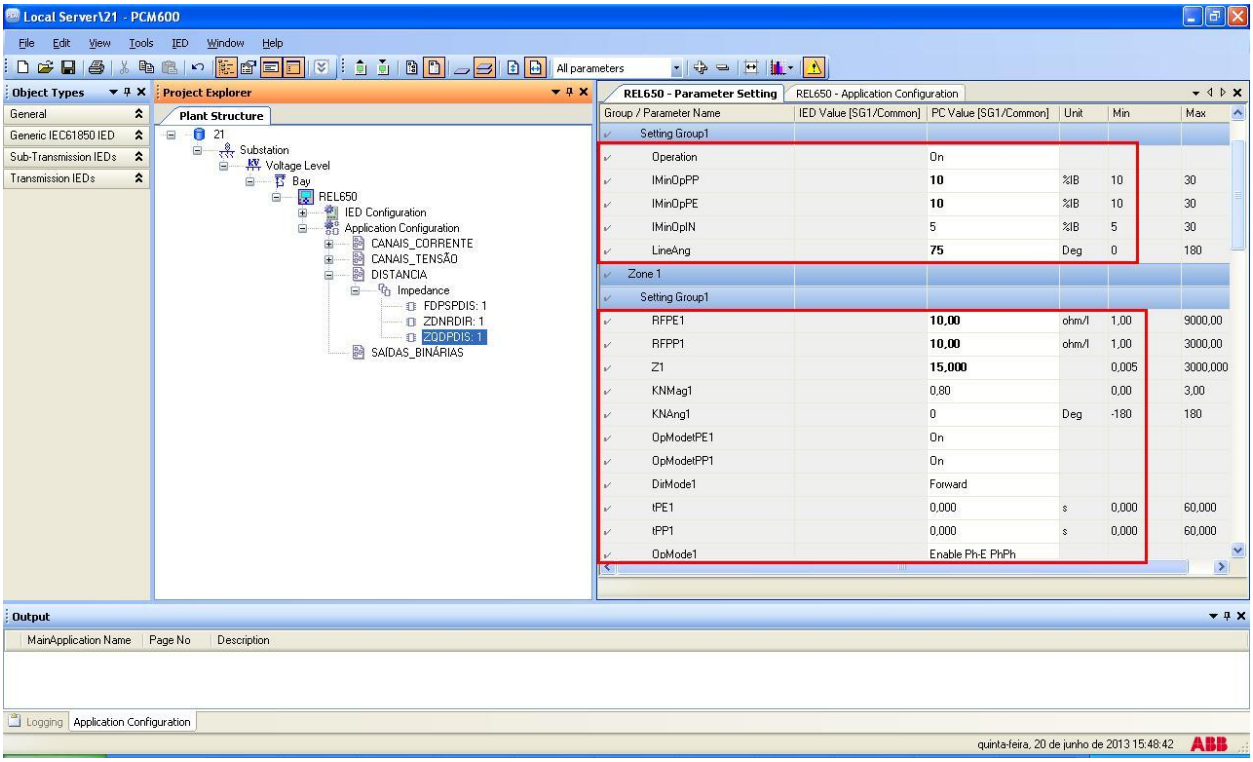

Figure 55

Now the adjustments for the second zone.

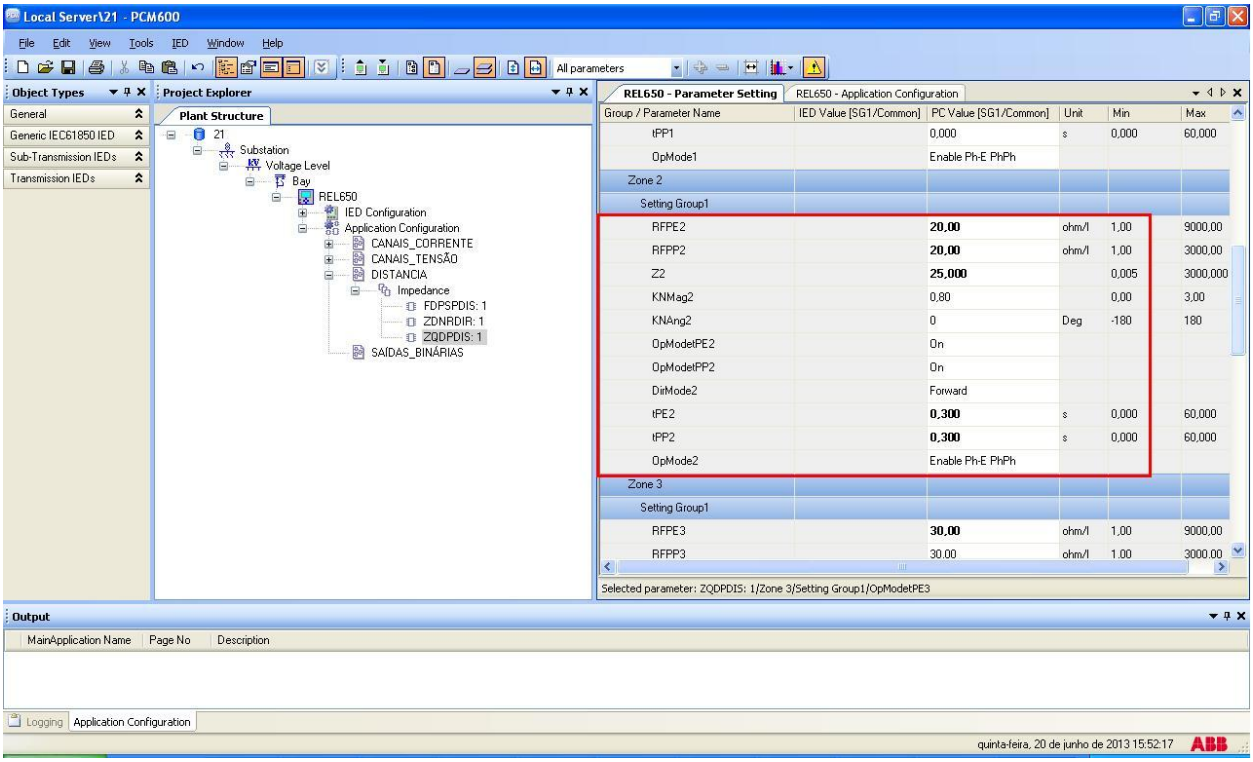

Figure 56

Finally, parameterize the third zone.

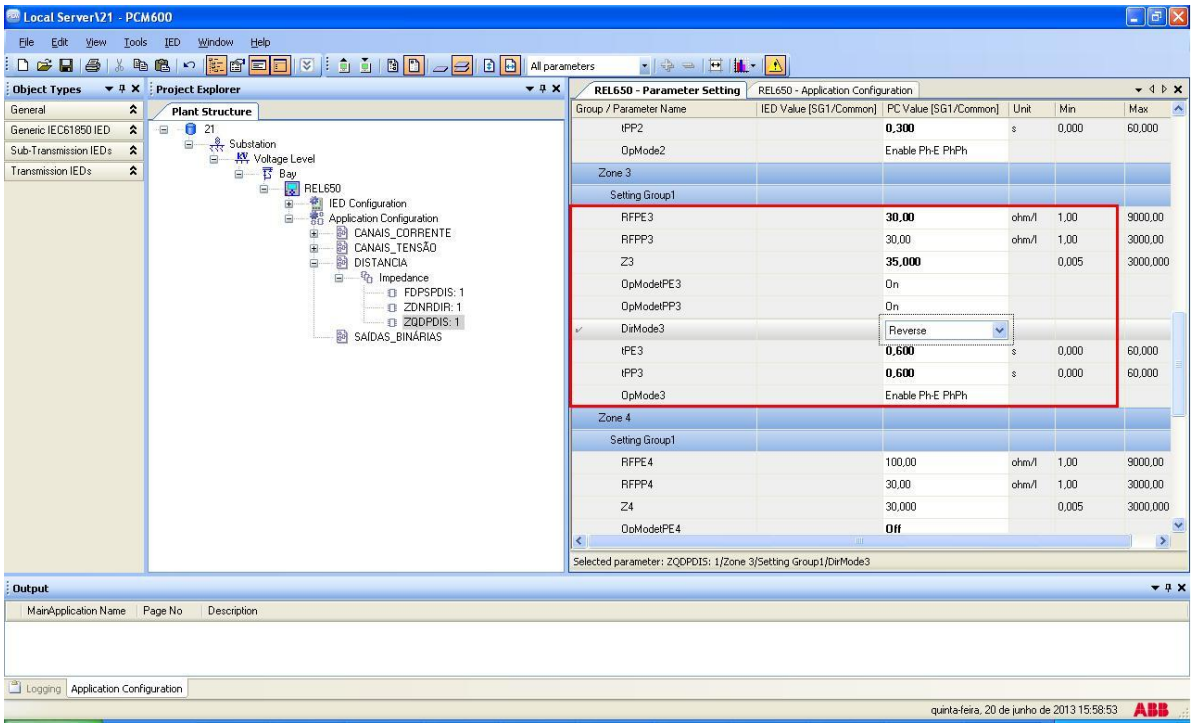

Figure 57

To disable zones 4 and 5 make the following settings.

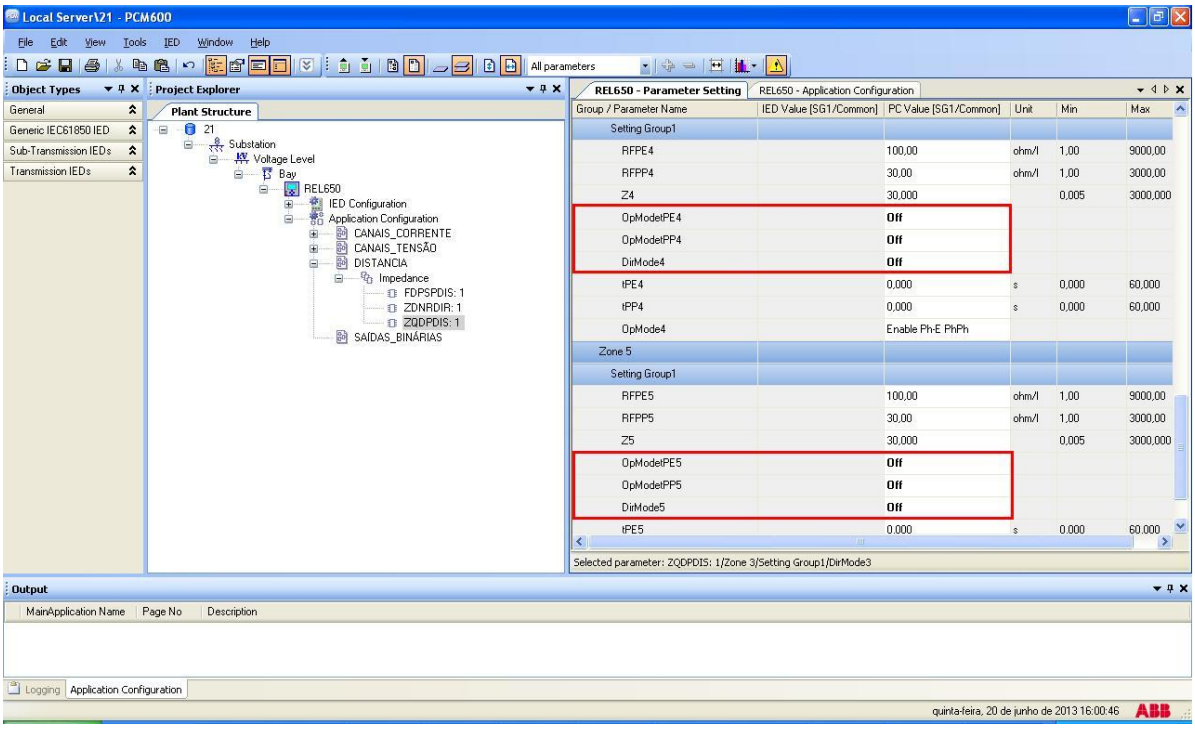

Figure 58

The next step is to parameterize the directionality limits: click on the option *"ZNRDIR: 1"* and make the following adjustments:

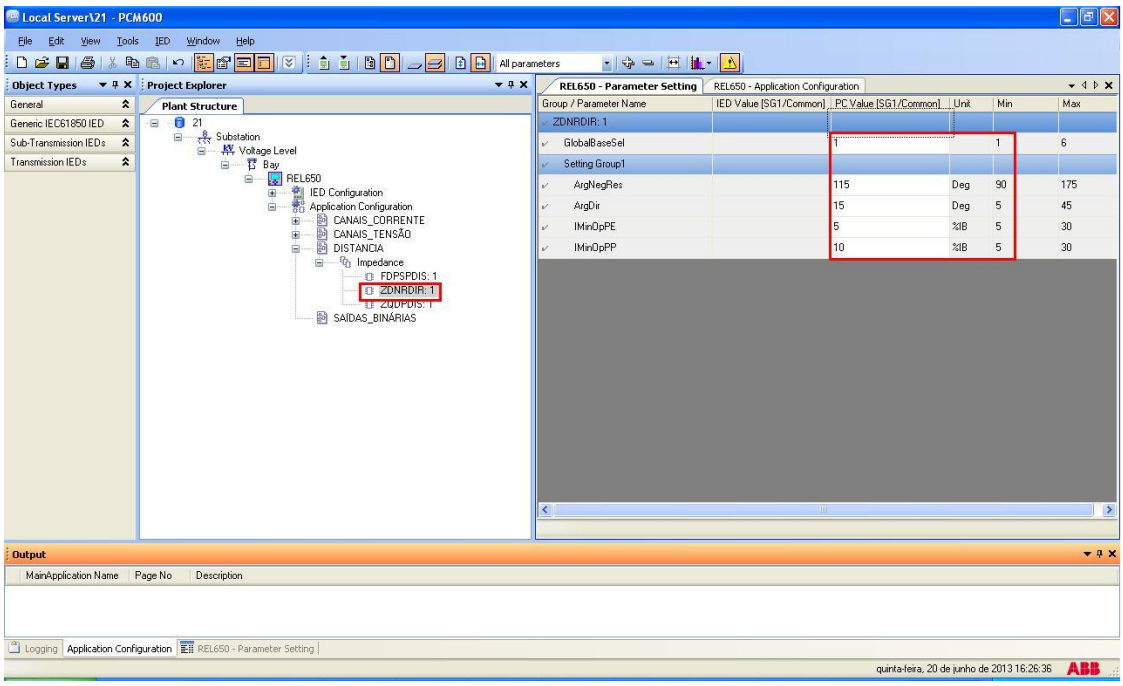

Figure 59

The last parameterization is the phase selector and load compensator. Select the option *"FDPSPDIS: 1"* and perform the following settings.

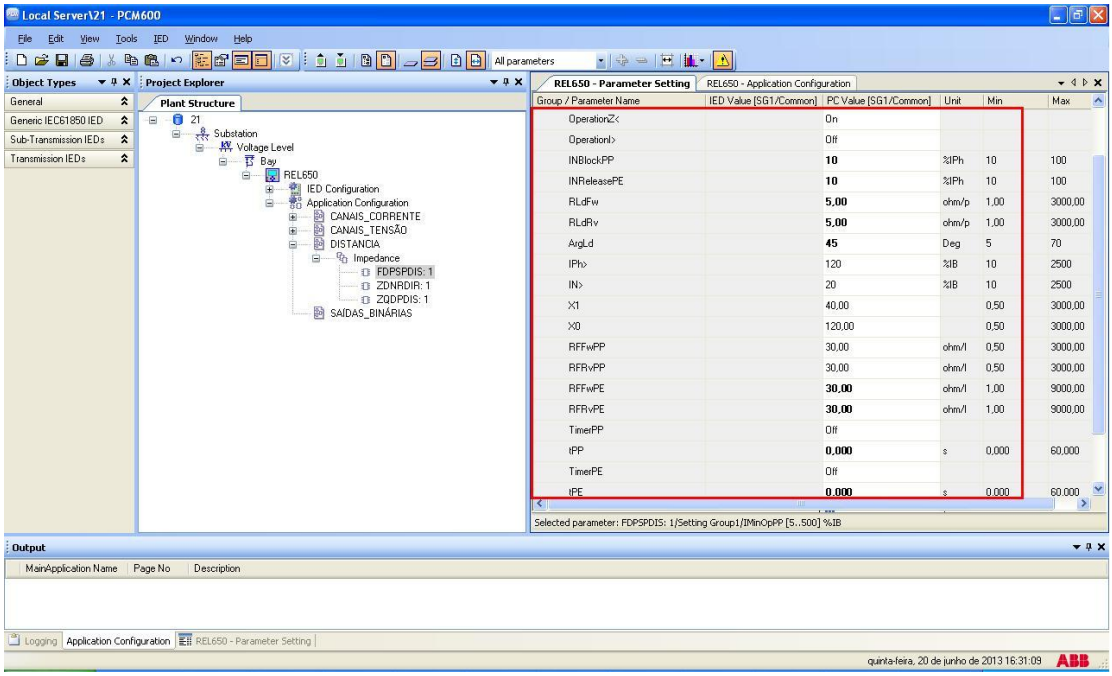

Figure 60

The last two parameters, not shown in the previous figure, must be set to their minimum values.

Save all settings by clicking on the icon highlighted in green and then right-clicking on the relay icon and submitting the changes. In the following message click *"Yes"*.

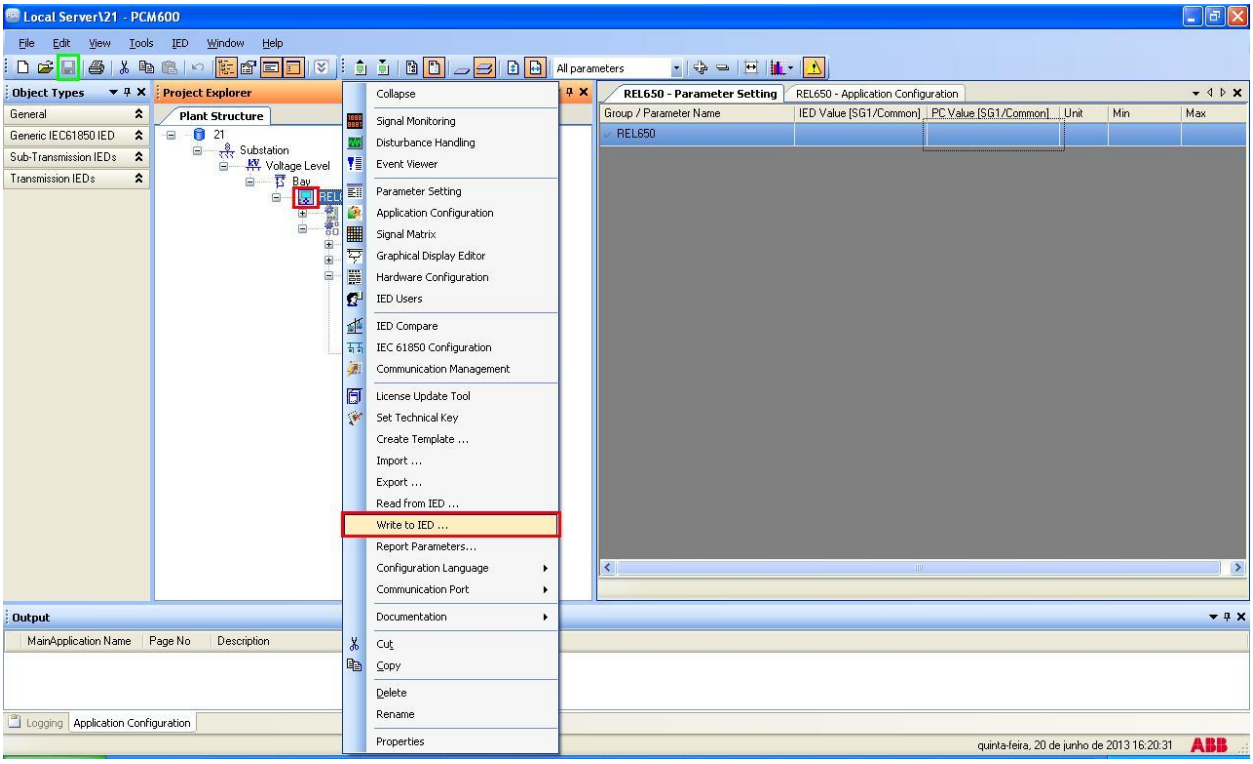

Figure 61

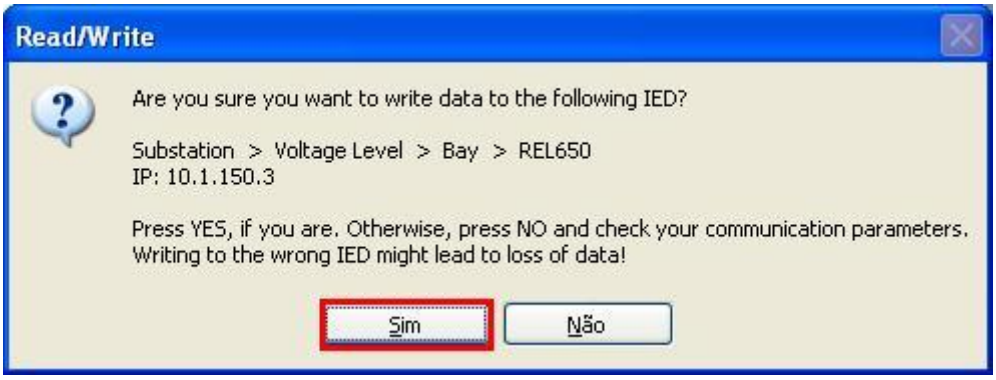

Figure 62

4. Distance software adjustments

4.1 *Opening Distance*

Click on the CTC application manager icon.

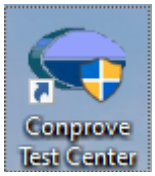

Figure 63

click on the software icon *"Distance"*.

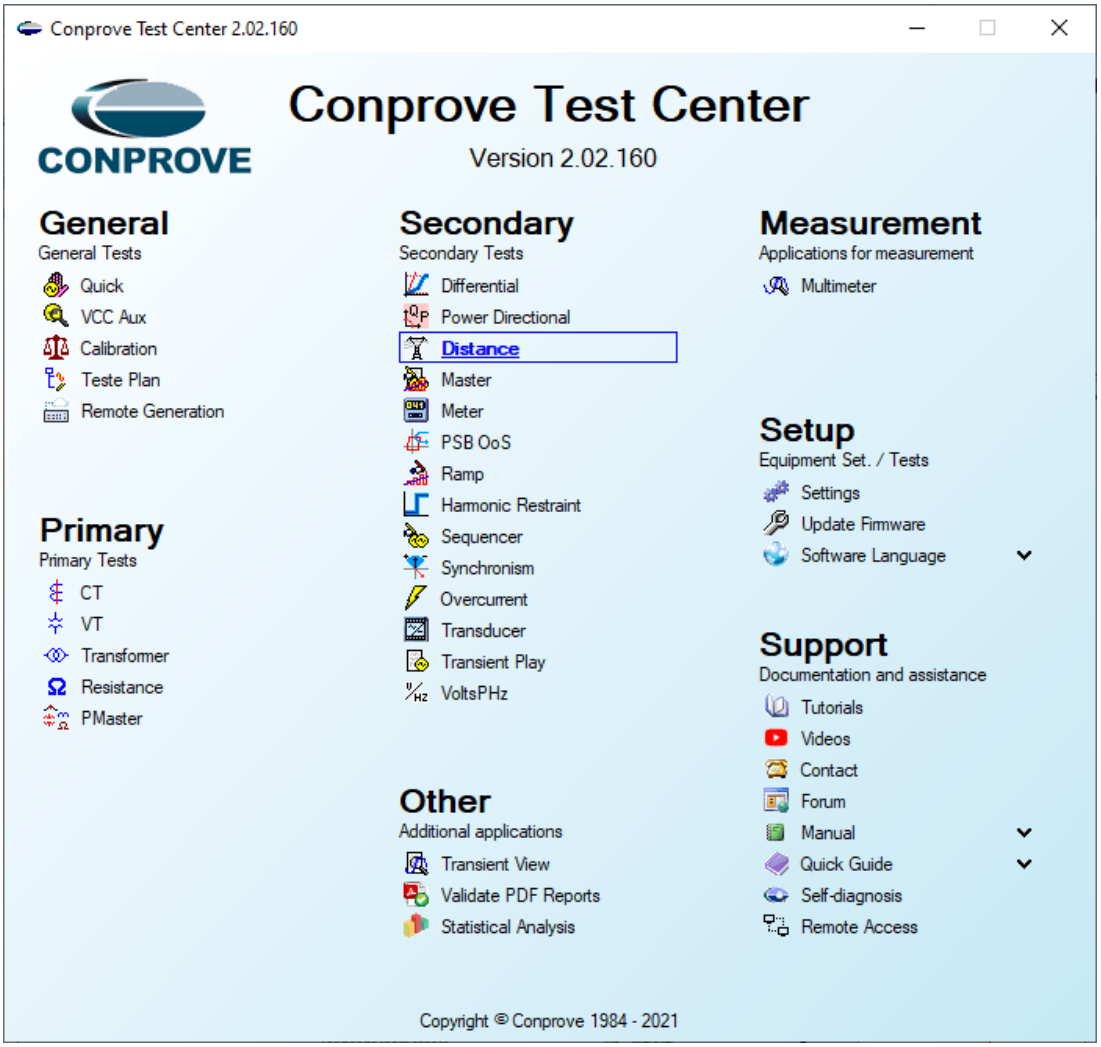

Figure 64

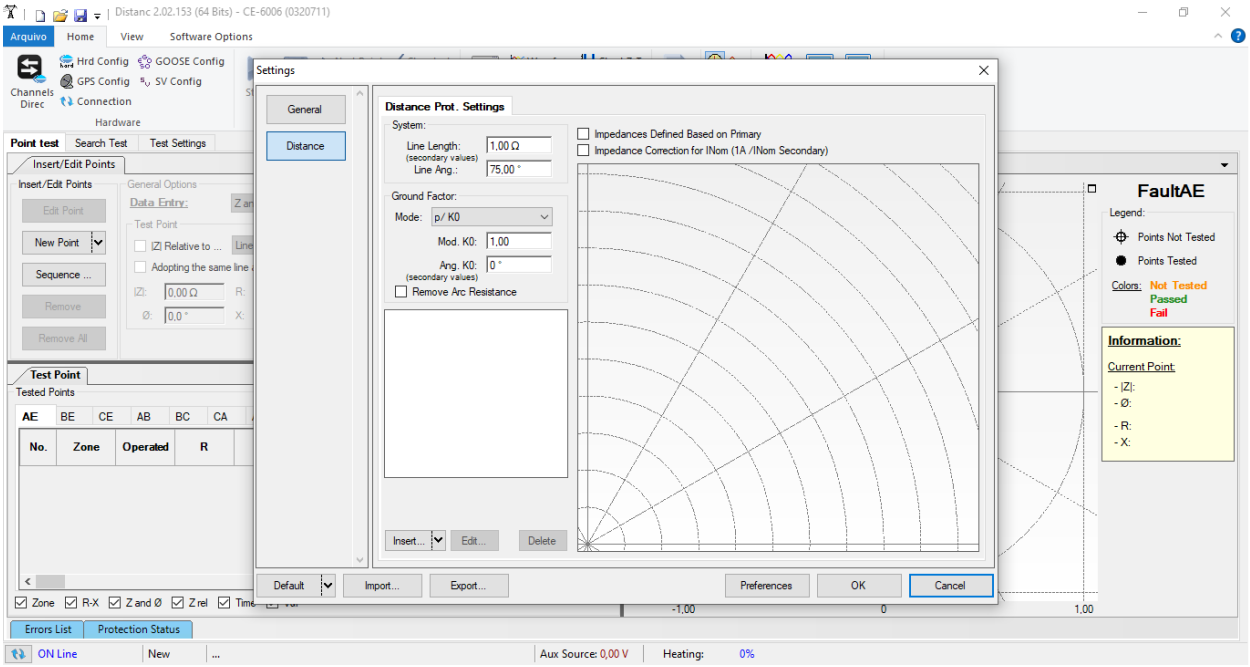

Figure 65

4.2 *Configuring the Settings*

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

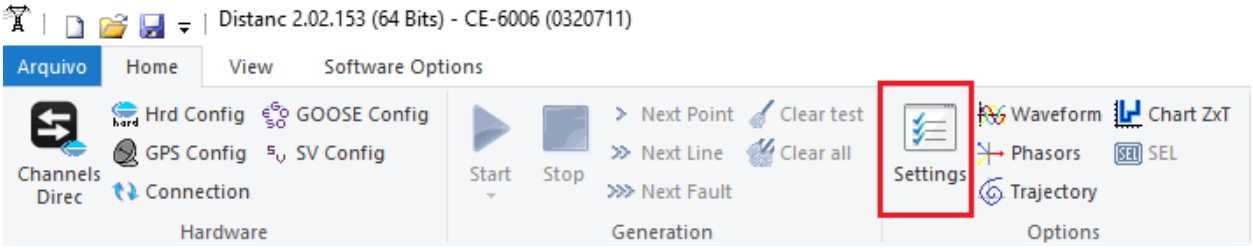

Figure 66

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.

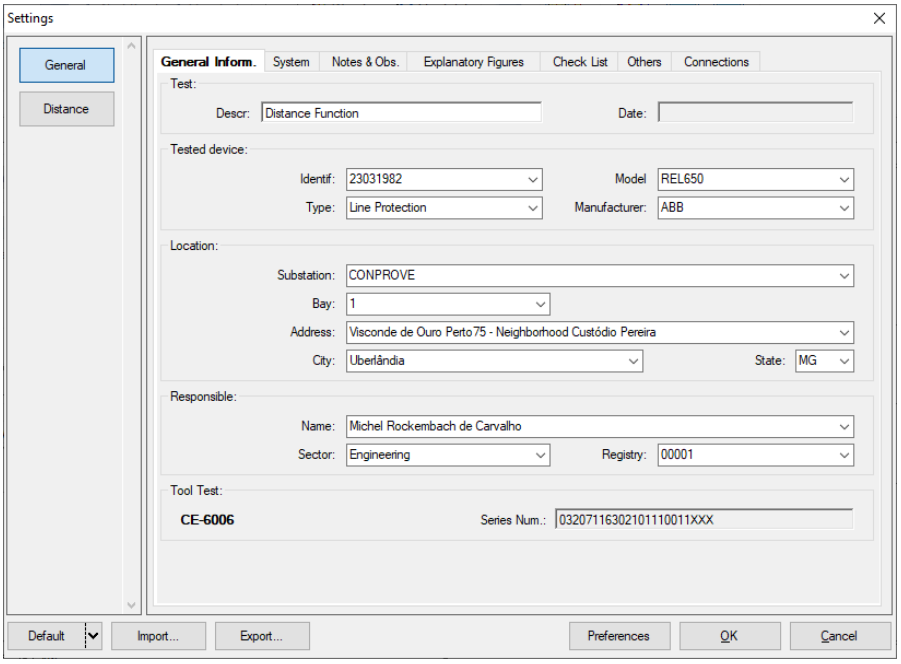

Figure 67

4.3 *System*

In the following screen, within the *"Nominal"* sub tab, the values of frequency, 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.

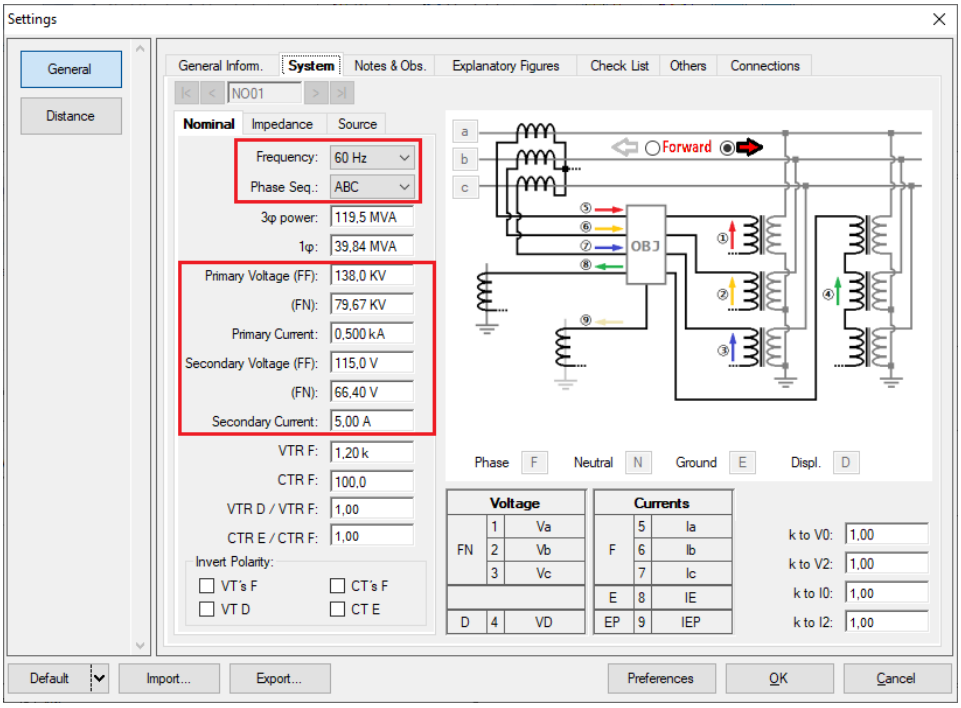

Figure 68

There are other tabs where the user can enter notes and observations, 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.

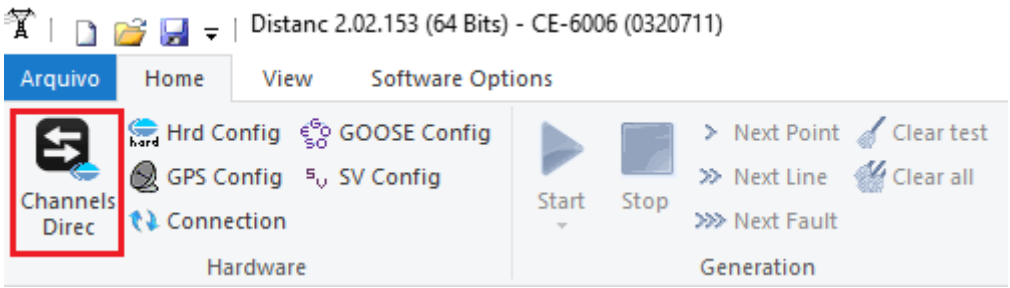

Figure 69

Then click on the highlighted icon to configure the hardware.

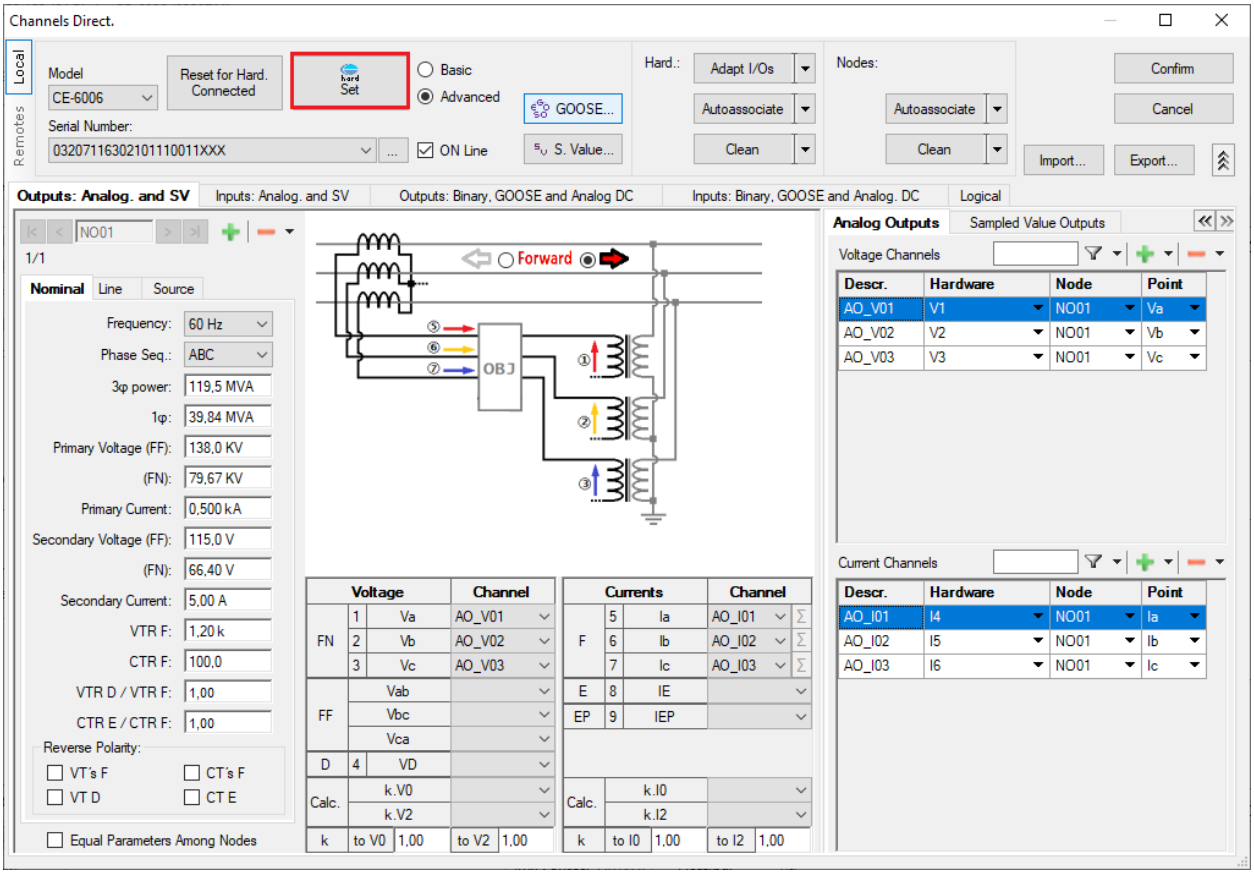

Figure 70

Choose the channel configuration, adjust the auxiliary source and the stopping method of the binary inputs. To finish click on "OK".

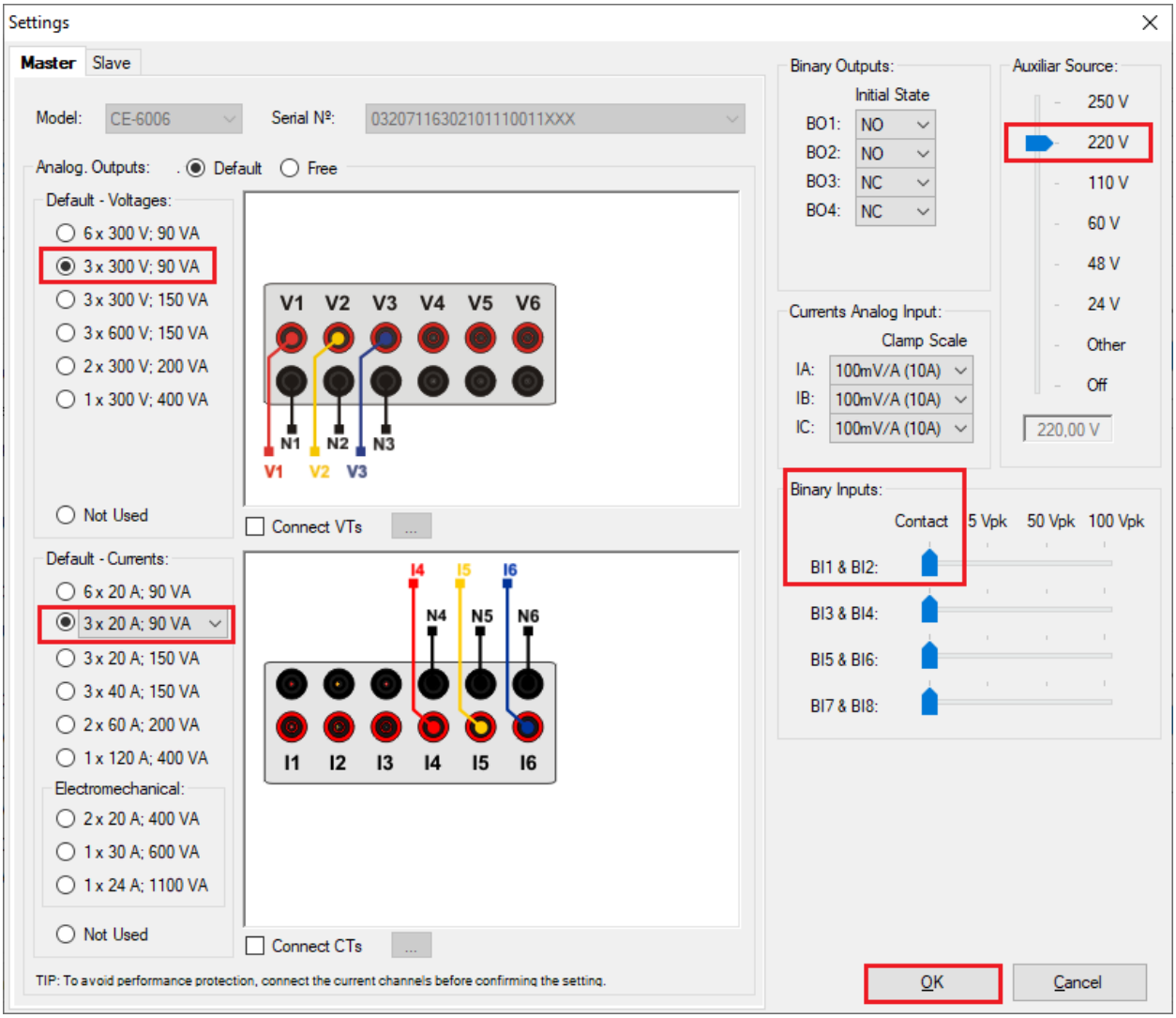

Figure 71

On the next screen choose *"Basic"* and on the next window (not shown) choose *"YES"*, finally click on *"Confirm"*.

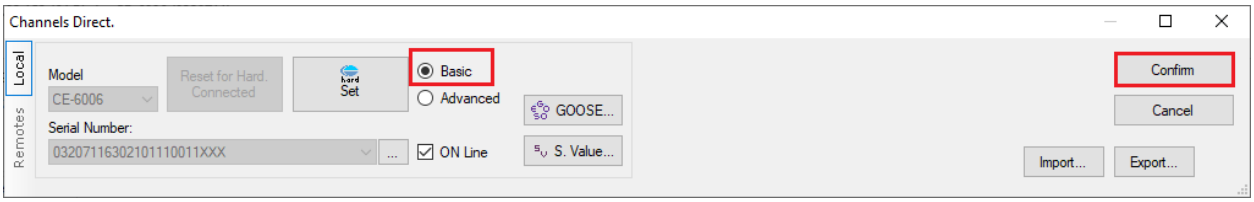

Figure 72

6. Distance Adjustments

Note: The ABB REL650 relay has peculiar characteristics for each type of fault. For the software to perform the test properly, 9 types of zones must be inserted, the first three being for phase-to-ground faults, the fourth, fifth and sixth for phase-phase faults and the last three for three-phase faults. This must be done because for each type of fault the characteristics of the zones are modified by the relay itself.

6.1 *Distance screen > Distance Prot. Settings*

Return to the *"Distance Prot. Settings"* screen, with the first screen showing the parameters of length, line angle and ground compensation factor. For this specific test there is no need to configure them.

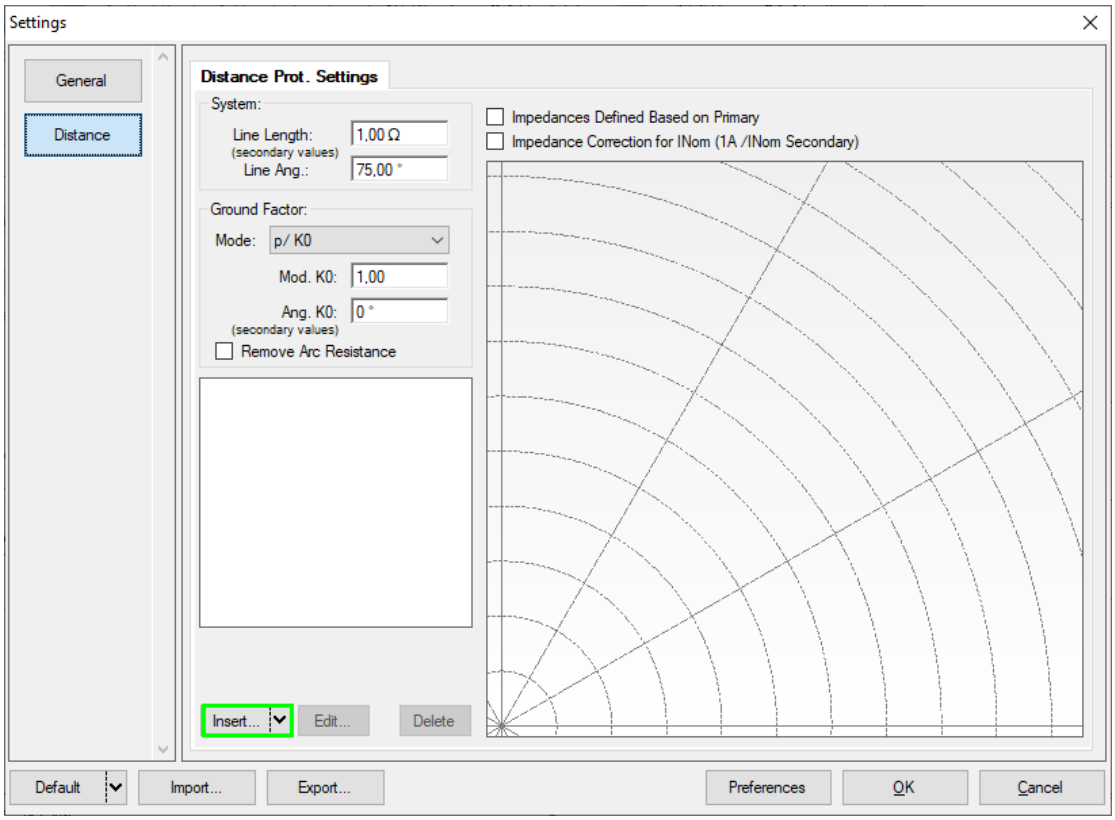

Figure 73

6.2 *Inserting the Zones (Line-Earth)*

The first zone to be inserted will be Zn01_LE. Click on the *"Insert"* field highlighted in green in the previous figure. In the settings screen, first choose the relay mask *"ABB Rel650- Quadr."*. You must adjust the zone name, actuation time, choose the fault type as LE (loop), adjust the tolerances and enter the zone characteristics. After the settings click *"OK"*.

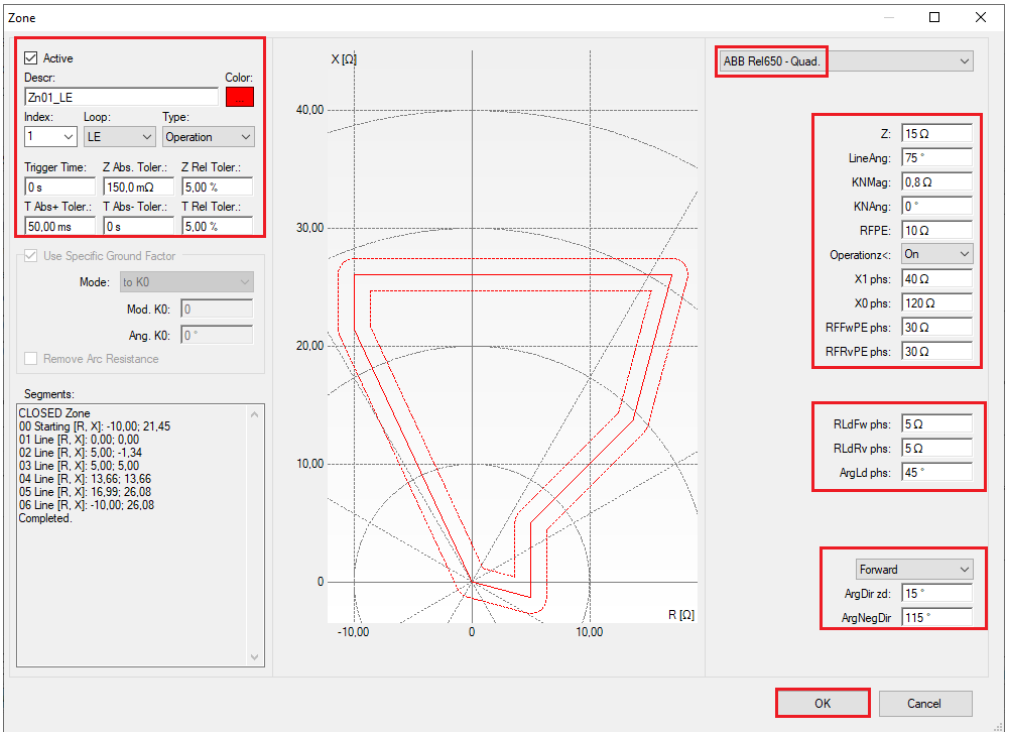

Figure 74

Clicking *"Insert"* adjusts the values for zone 2 of ground faults. The same parameters set for zone-1 must be modified to enter zone 2 (LE).

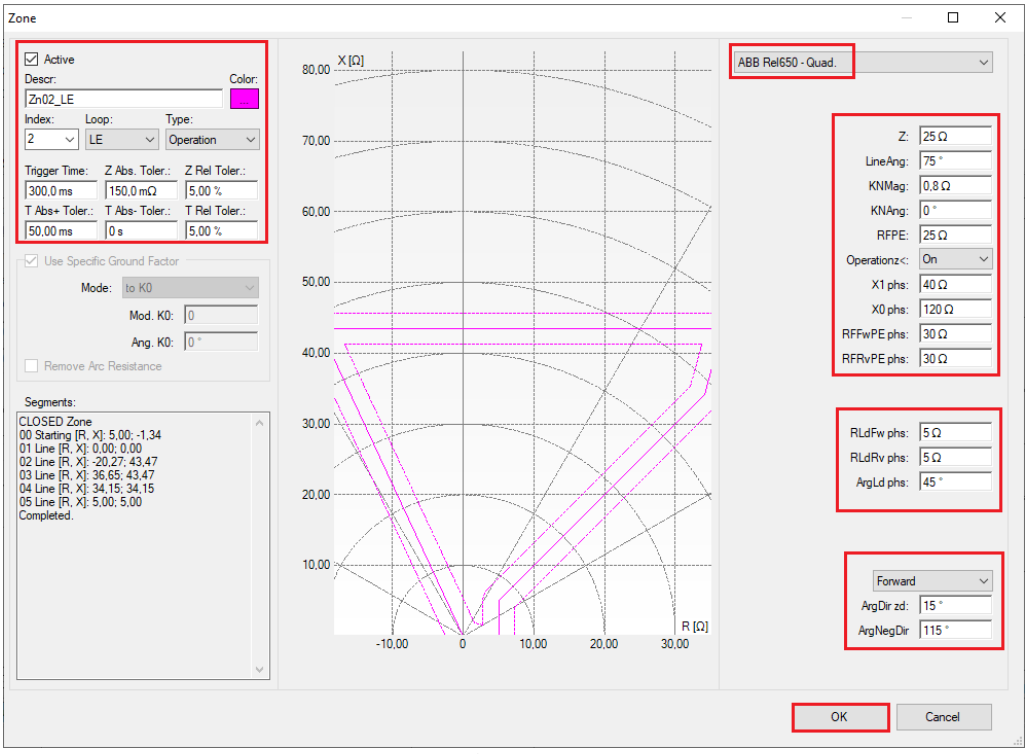

Figure 75

Clicking *"Insert"* adjusts the values for zone 3 of ground faults. The same parameters set for zone-1 must be modified to enter zone 3 (LE).

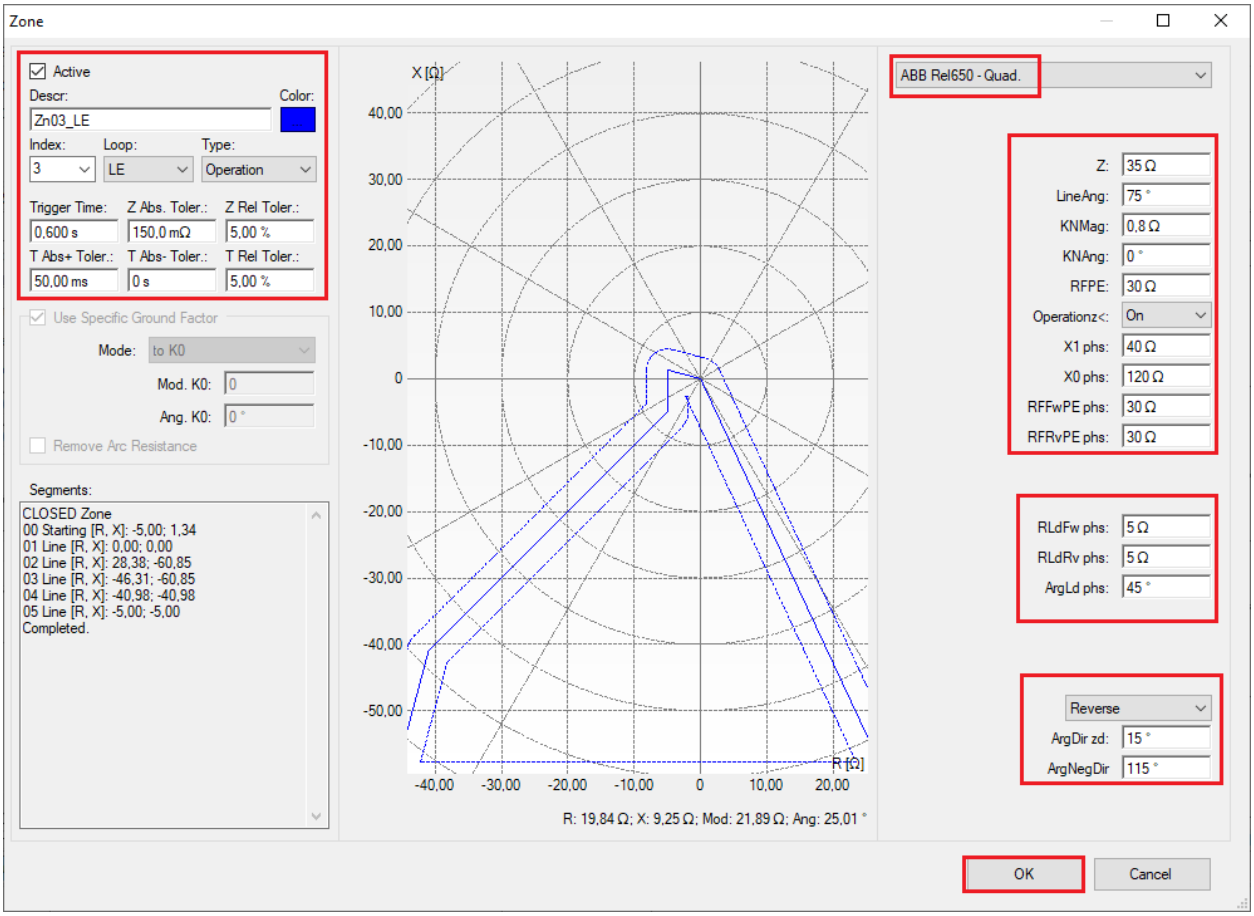

Figure 76

6.3 *Inserting the Zones (Phase-Phase)*

Enter zone 1_FF, zone 2_FF and zone3_FF. The following three figures show the parameters for each zone to be set in the Distance software.

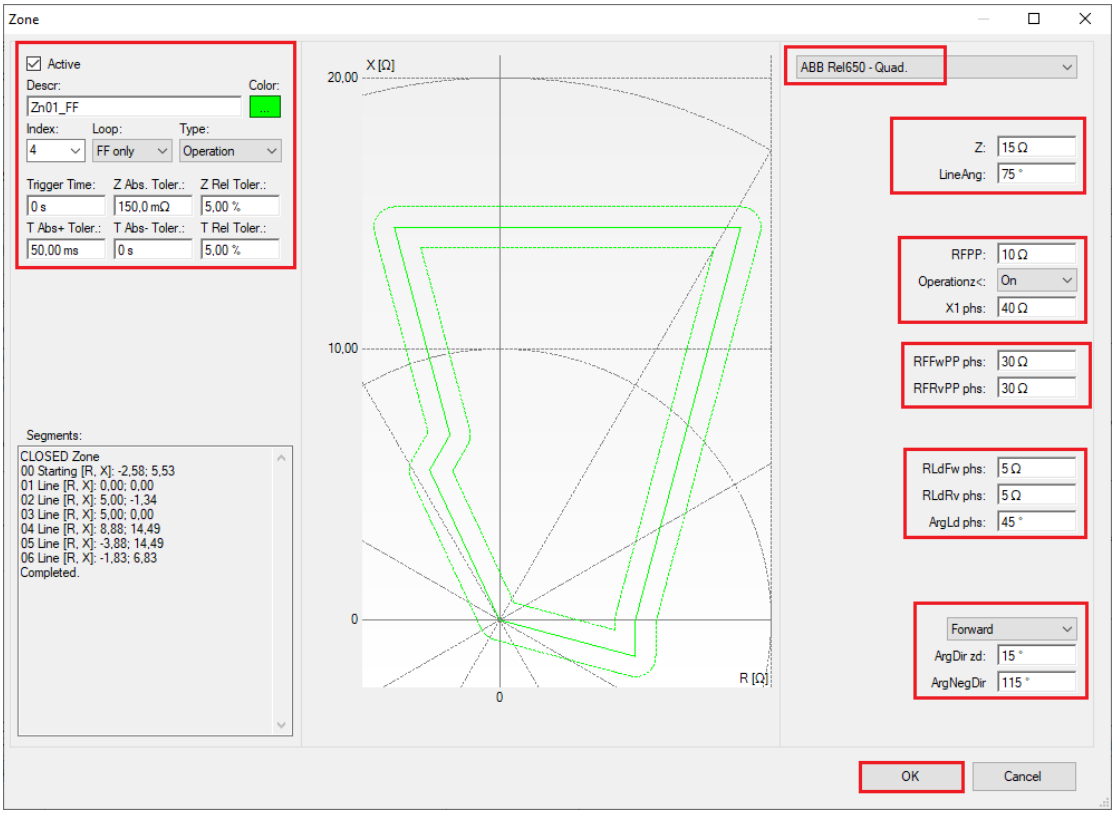

Figure 77

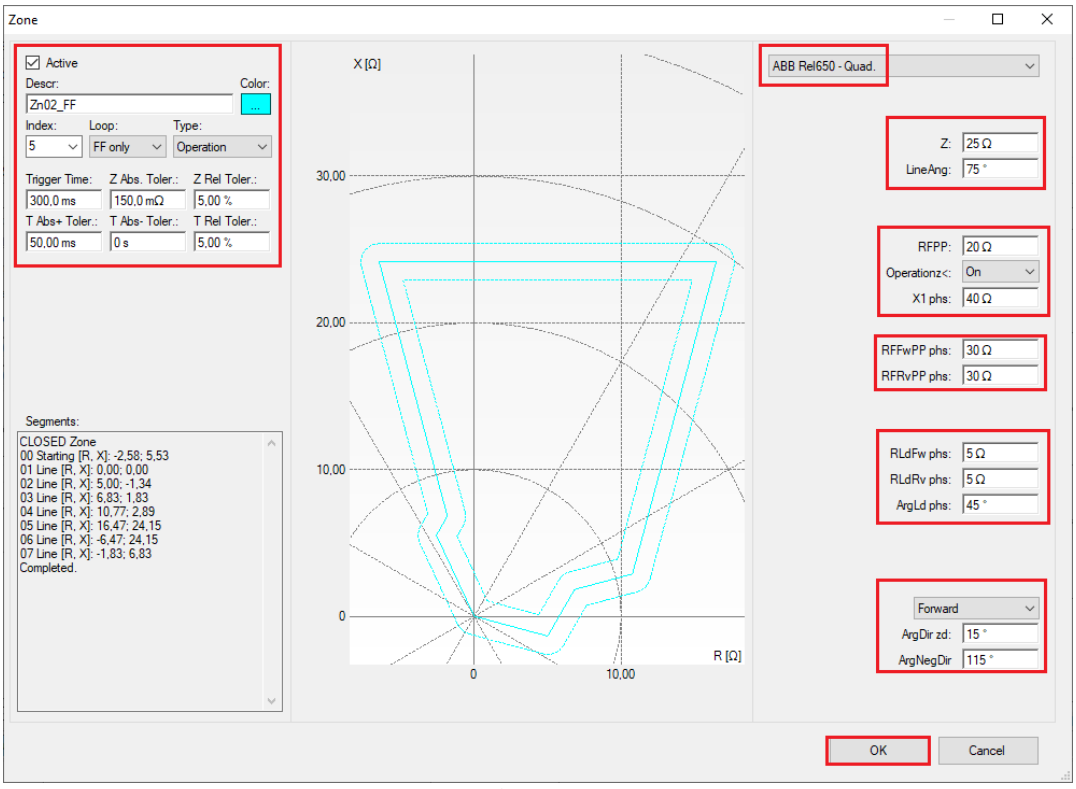

Figure 78

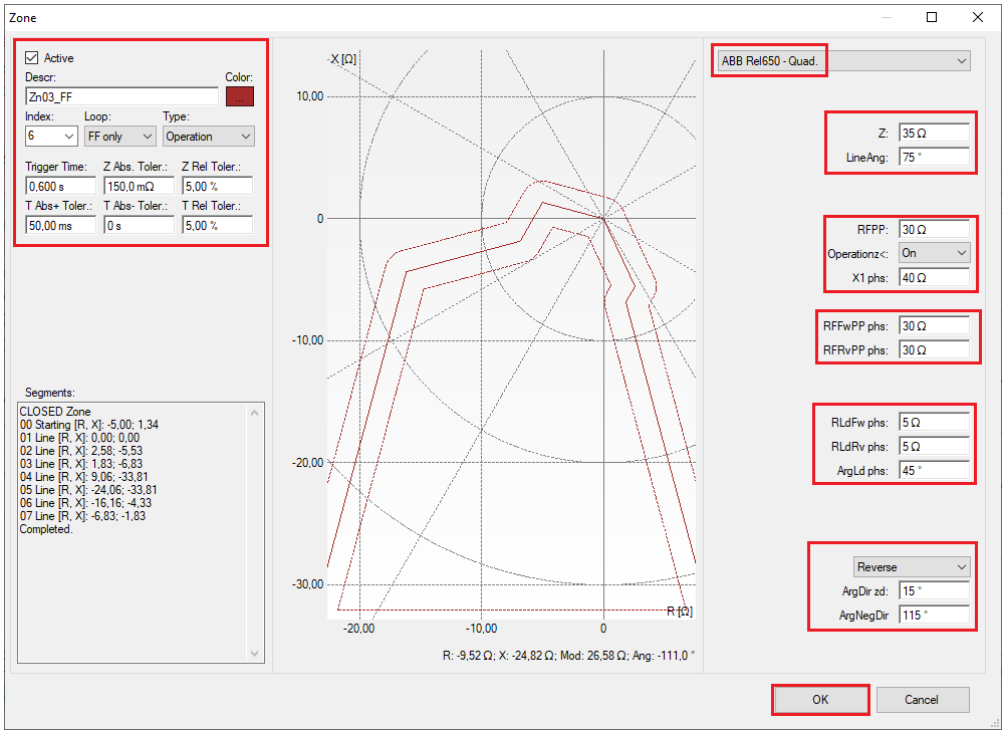

Figure 79

6.4 *Inserting the Zones (Three Phase)*

The following three figures show the parameters of each zone for three-phase faults to be adjusted in the Distance software.

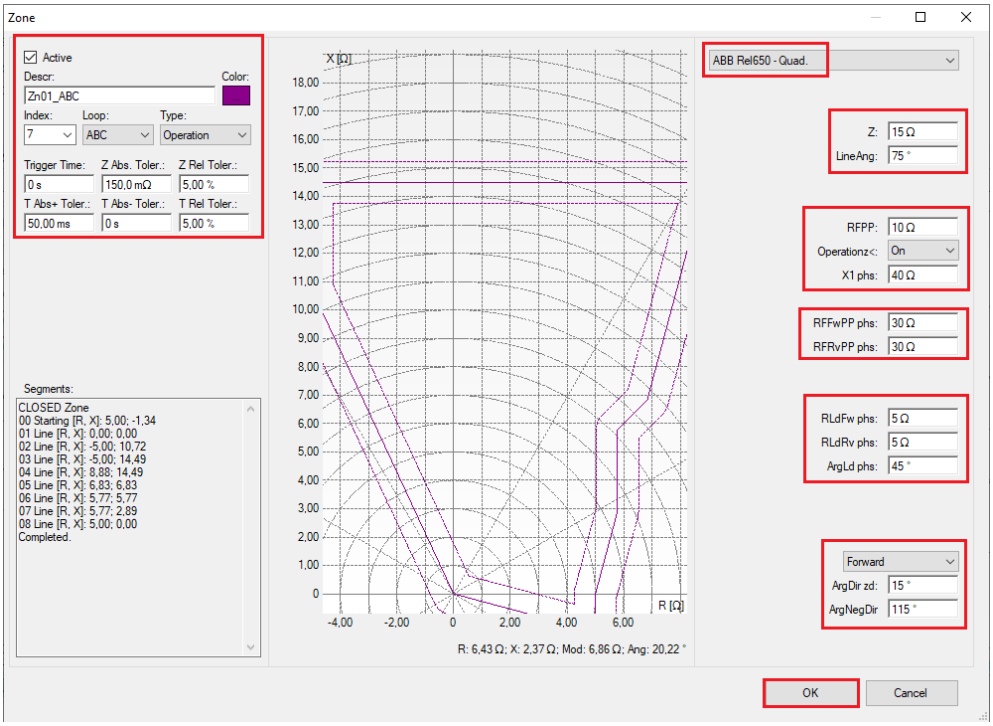

Figure 80

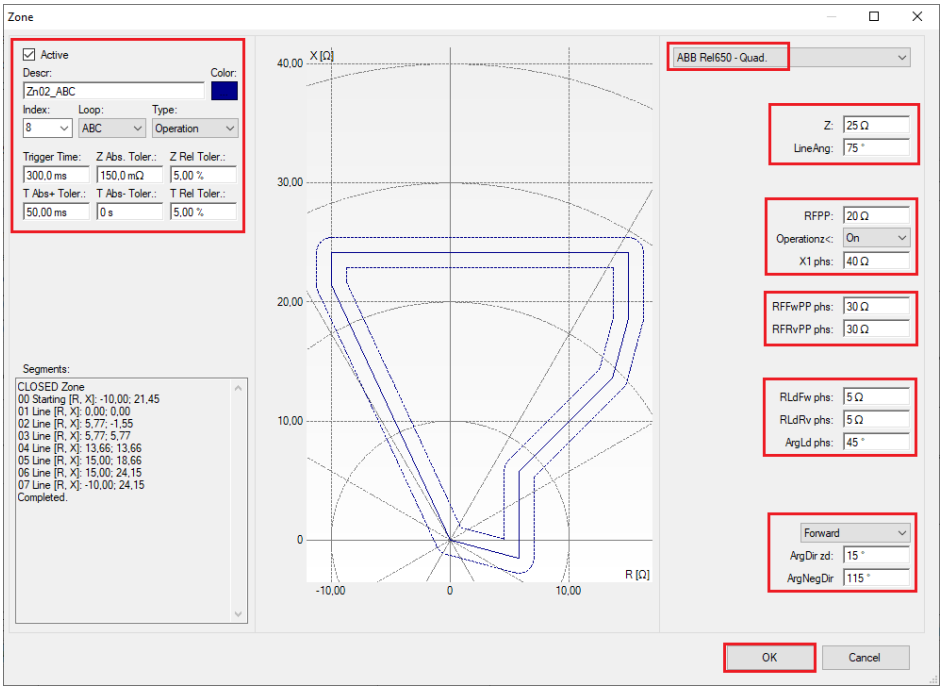

Figure 81

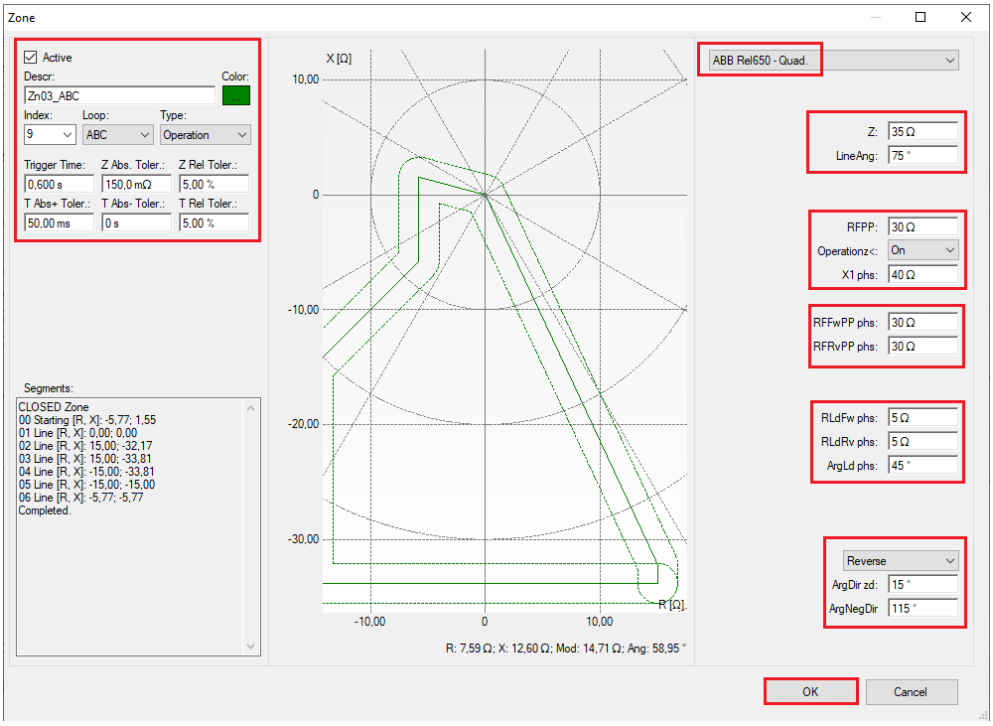

Figure 82

<u>NOTE: The REL650 has its impedance settings referenced to the primary. One should therefore check the following option. (It is necessary to mark it first before performing the line length and angle adjustment).</u>

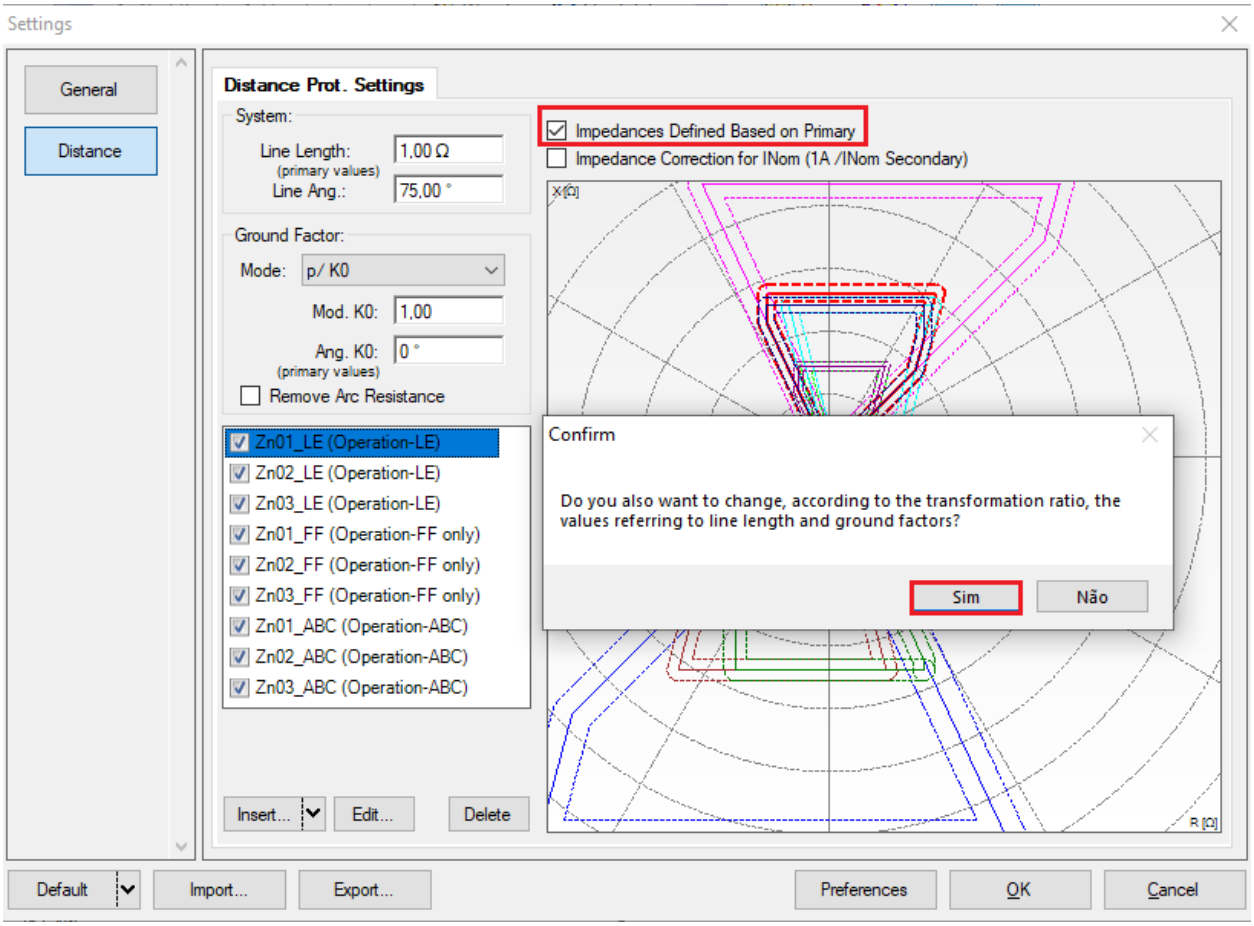

Figure 83

If the user does not check this option when clicking *"OK"* in the previous figure, the following message is displayed.

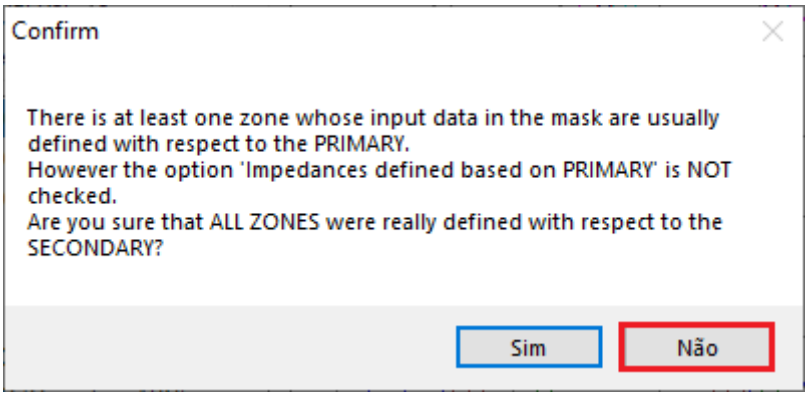

Figure 84

In this case, click on *"No"* and check the option *"Impedance Defined Based Primary"*.

7. Test Structure for Function 21

7.1 *Test Settings*

By clicking on the test settings tab, the user must enter a pre-fault in the *"balanced nominal voltages and zero currents"* mode so that the test takes place properly. Another important setting is the binary input used as a stop interface, which in this example is set to BI1.

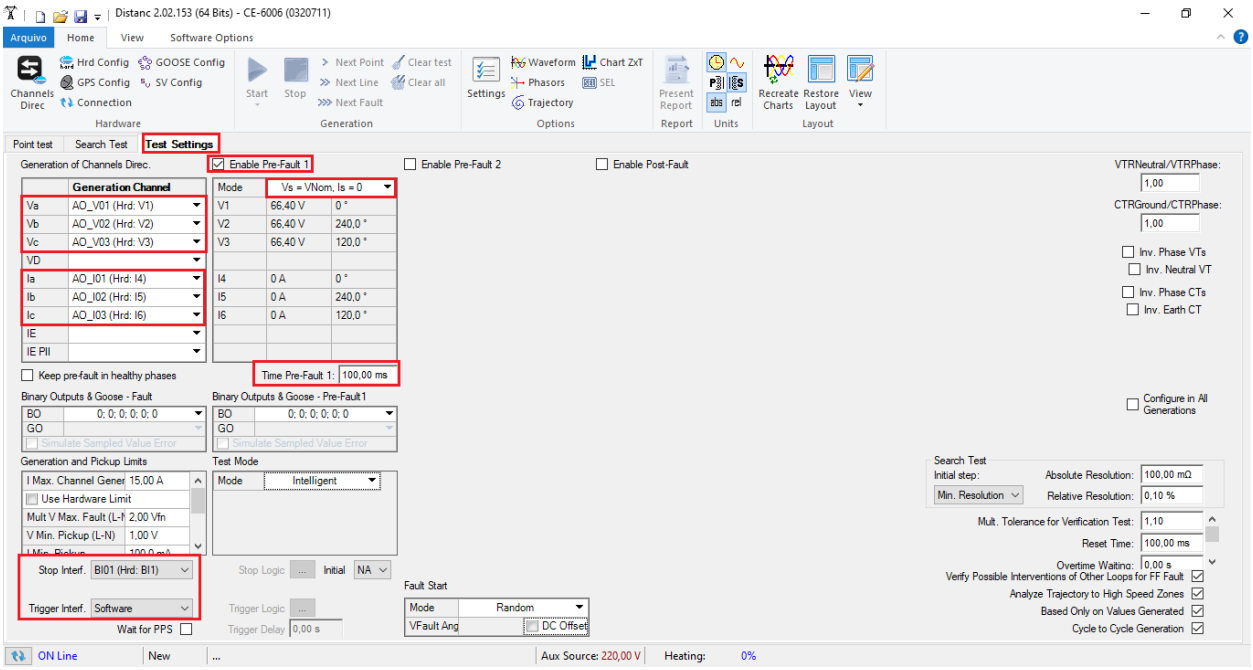

Figure 85

7.2 *Search Screen*

Click on the *"Search Test"* tab. To facilitate the test, a *"Sequence"* of lines is inserted to perform the search. To do this, position the mouse cursor in the central region of zones 1 and 2 and check the impedance value.

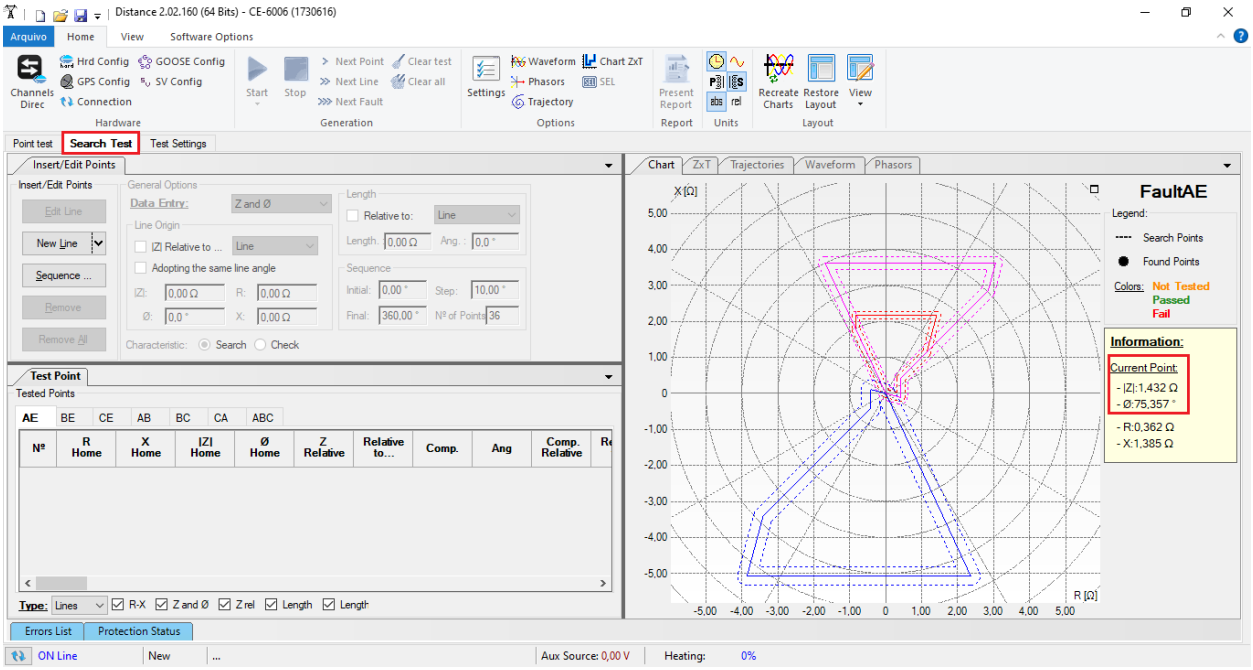

Figure 86

7.3 *Phase-Earth Fault*

The starting point is |Z| equal to 1.40 Ω e θ equal to 75 °. From that point and with a length of 4.5Ω, the angle varies from 0 to 360° with a step of 30°. So click on the *"Sequence"* button and then on the AE fault type.

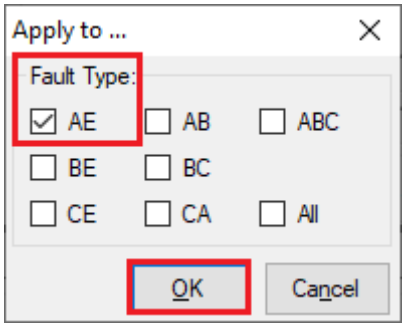

Figure 87

The following figure shows the settings for creating the sequence of lines to be tested:

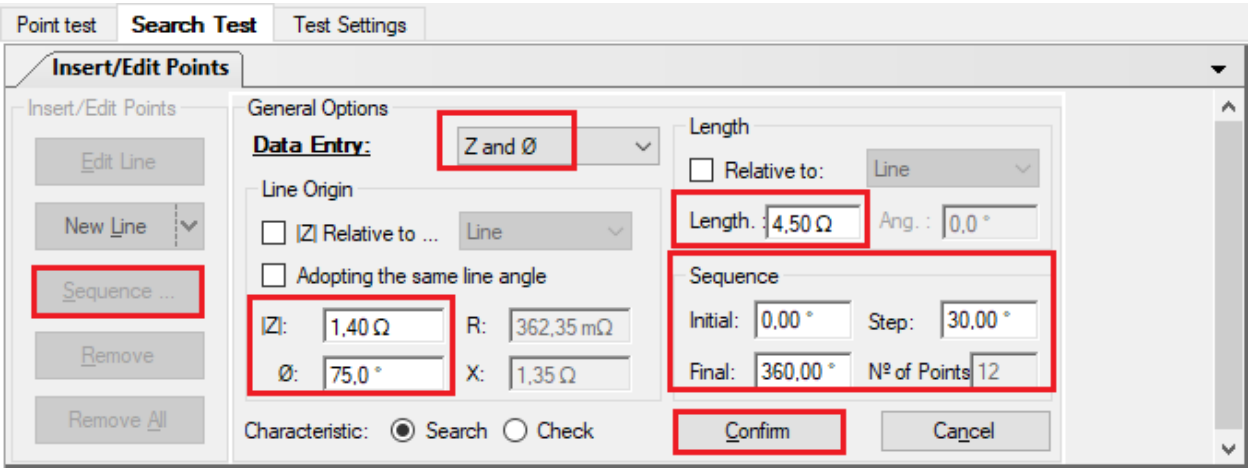

Figure 88

After confirmation the lines are created automatically.

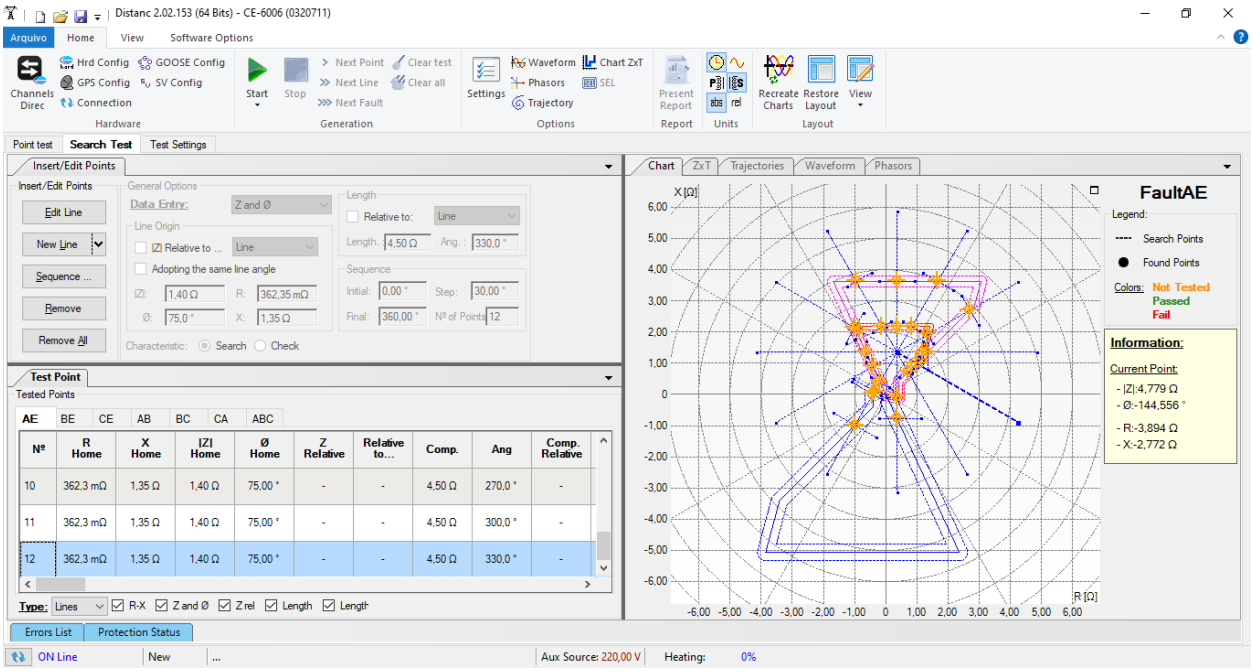

Figure 89

Repeat the reasoning of the last four figures and create a sequence of lines having as the point of origin a central impedance value in zone 3.

Start the generation by clicking on the icon below or through the shortcut *"Alt + G"*.

Figure 90

The final result is shown below showing the characteristics of the zones.

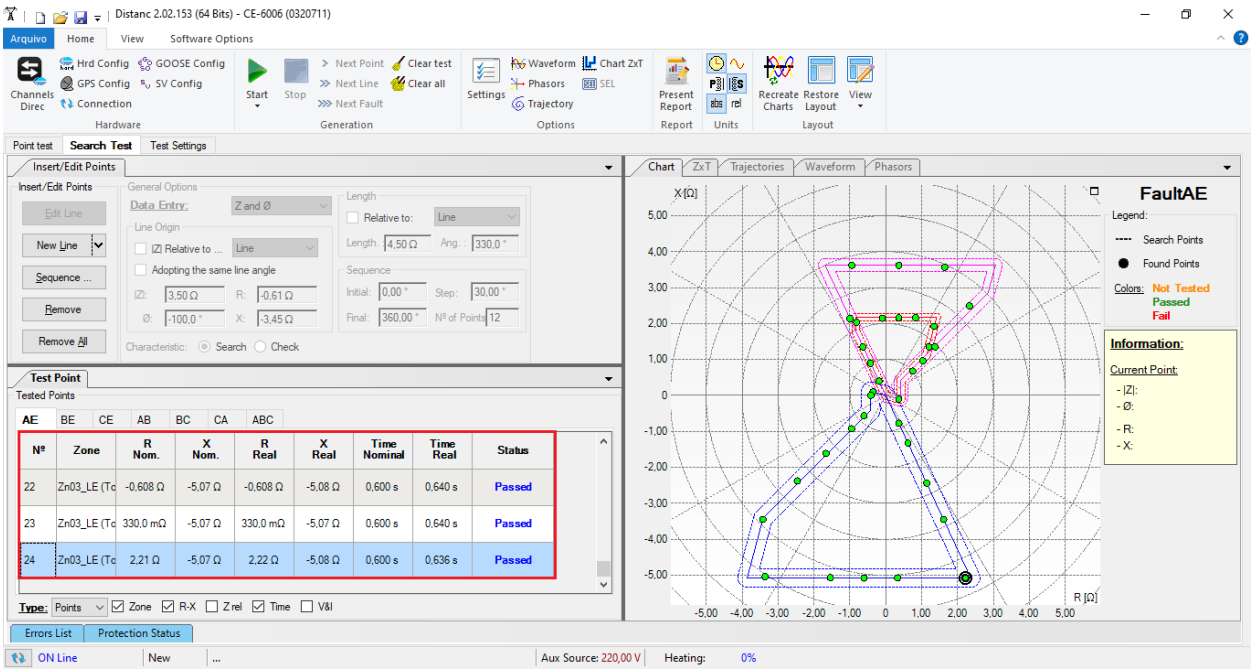

Figure 91

7.4 *Phase-Phase Fault*

Repeat the idea from the previous test for phase-to-phase faults. By clicking on the *"Sequence"* field, change the *"Fault Type"* to AB.

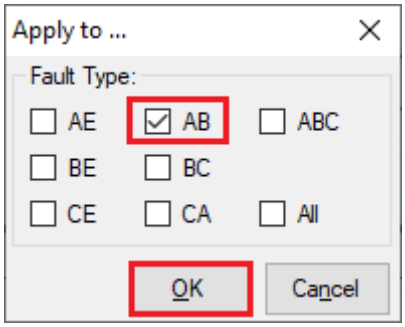

Figure 92

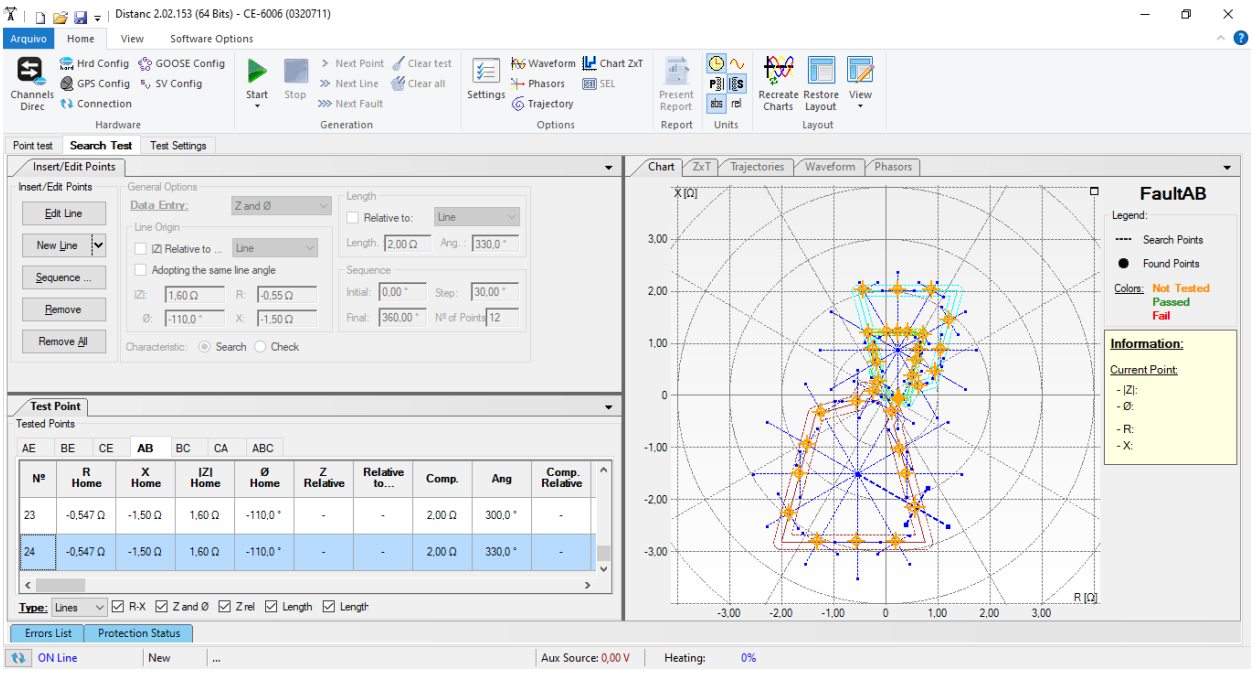

Figure 93

The final result is shown below.

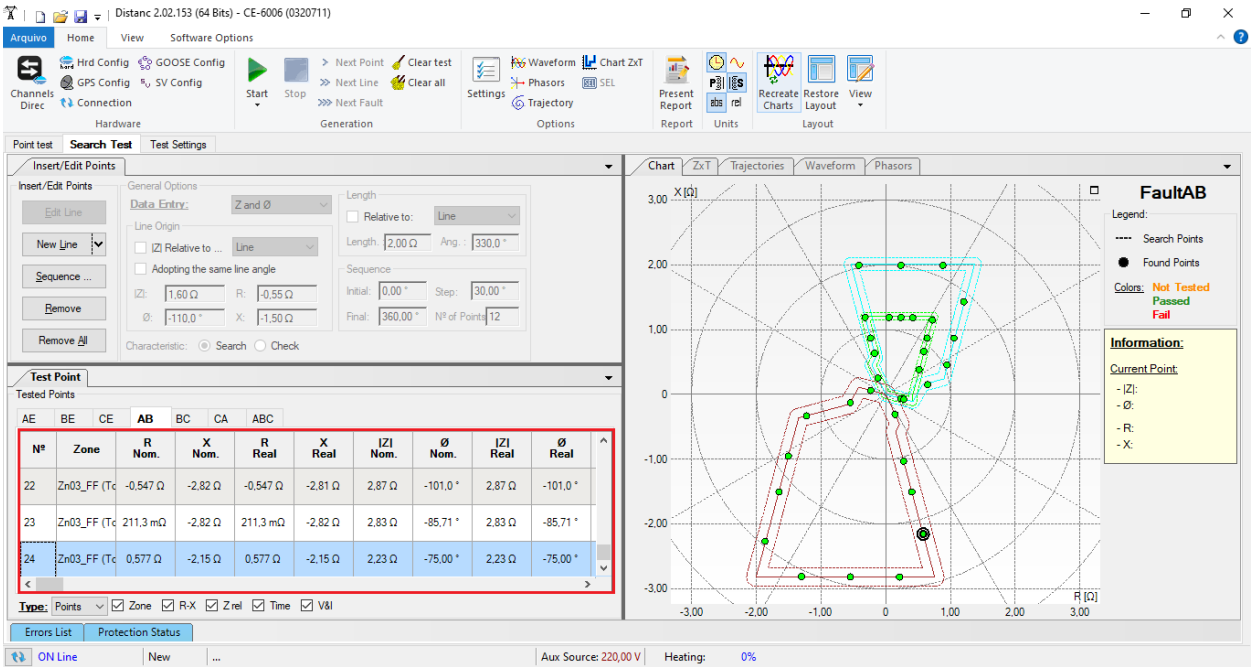

Figure 94

7.5 *Three-Phase Fault*

For three-phase faults keep the reasoning from the previous tests. By clicking on the *"Sequence"* field, change the *"Fault Type"* to ABC.

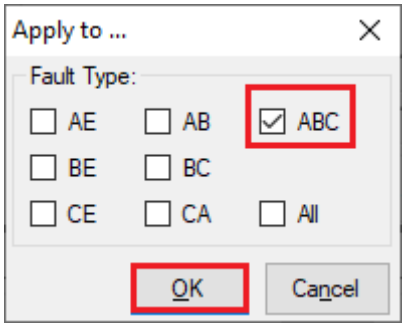

Figure 95

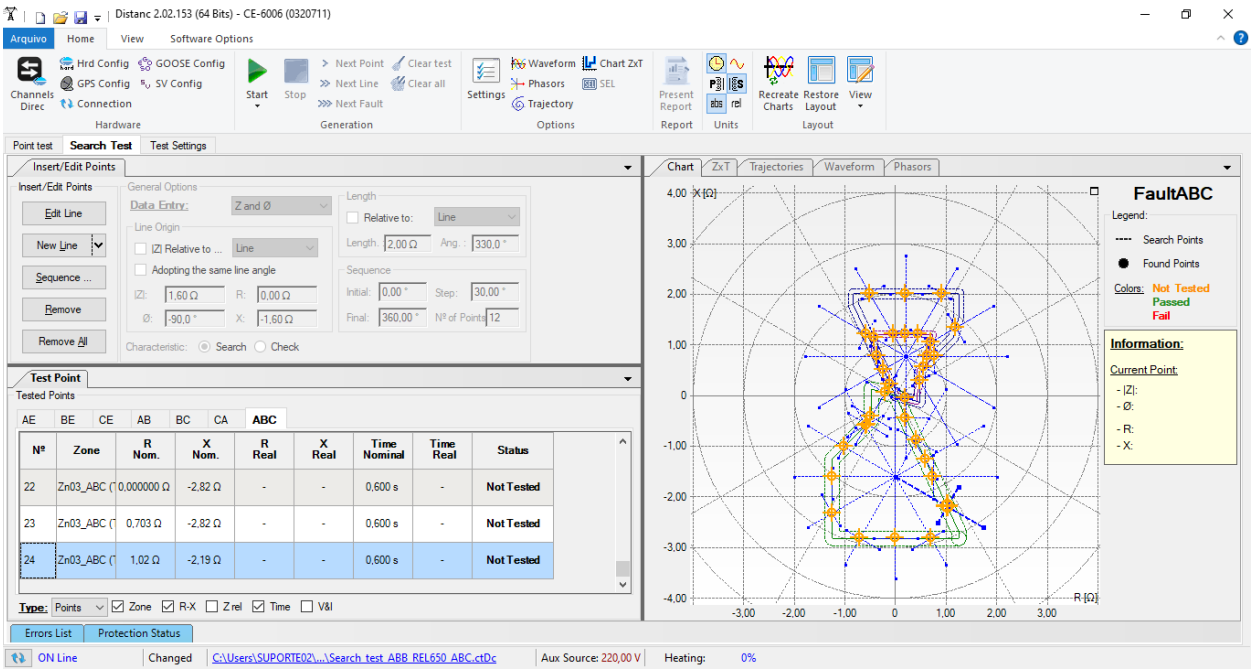

Figure 96

The final result is shown below.

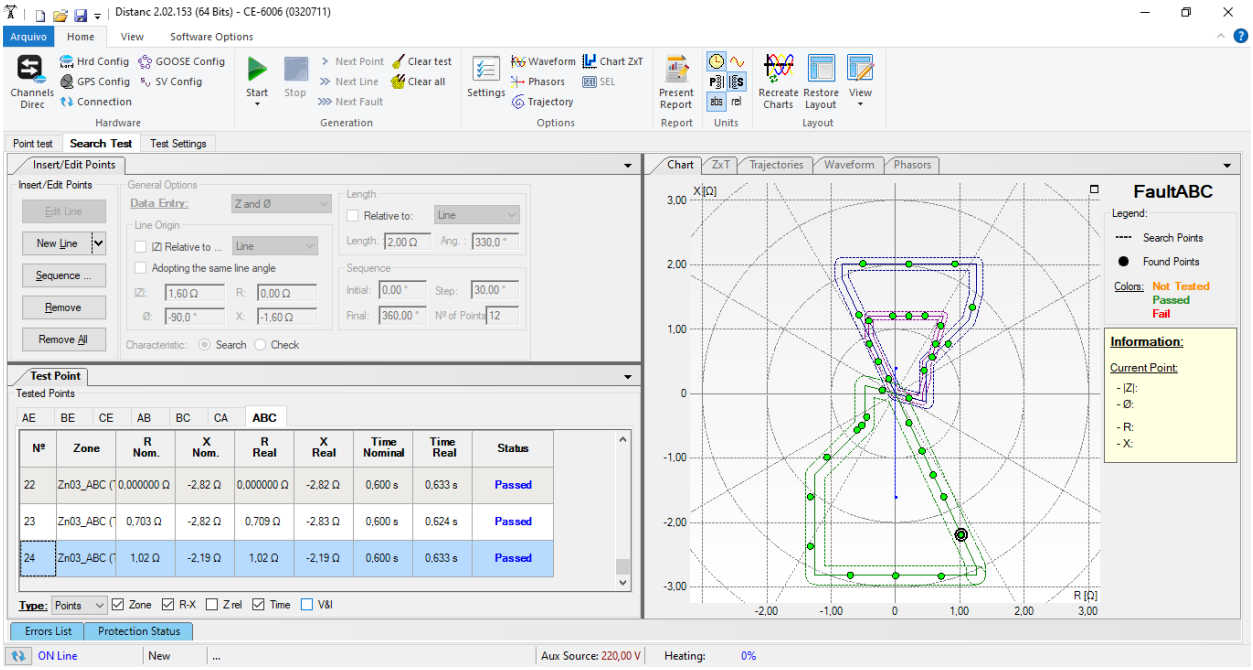

Figure 97

8. Report

After finishing the test, click on the icon highlighted 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.

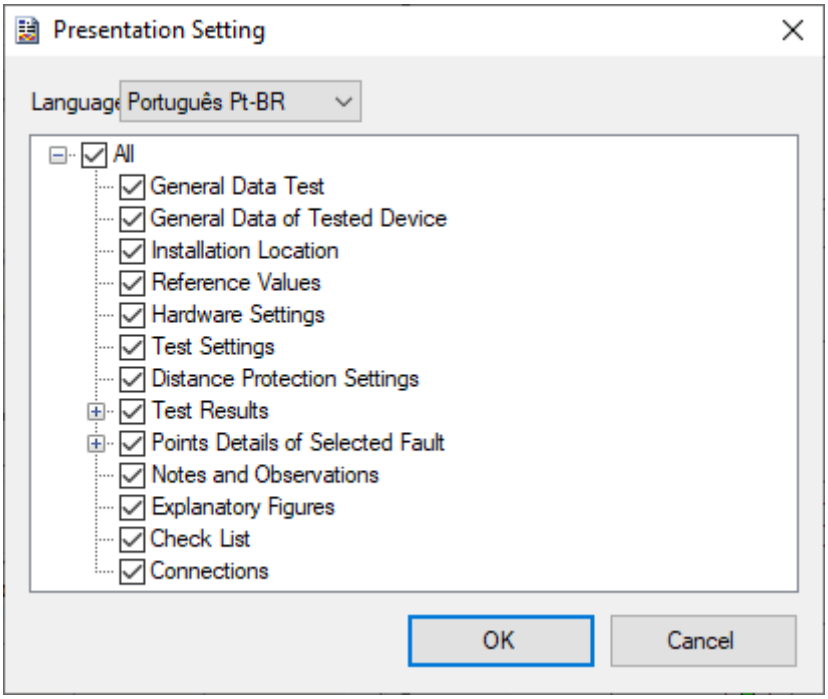

Figure 98

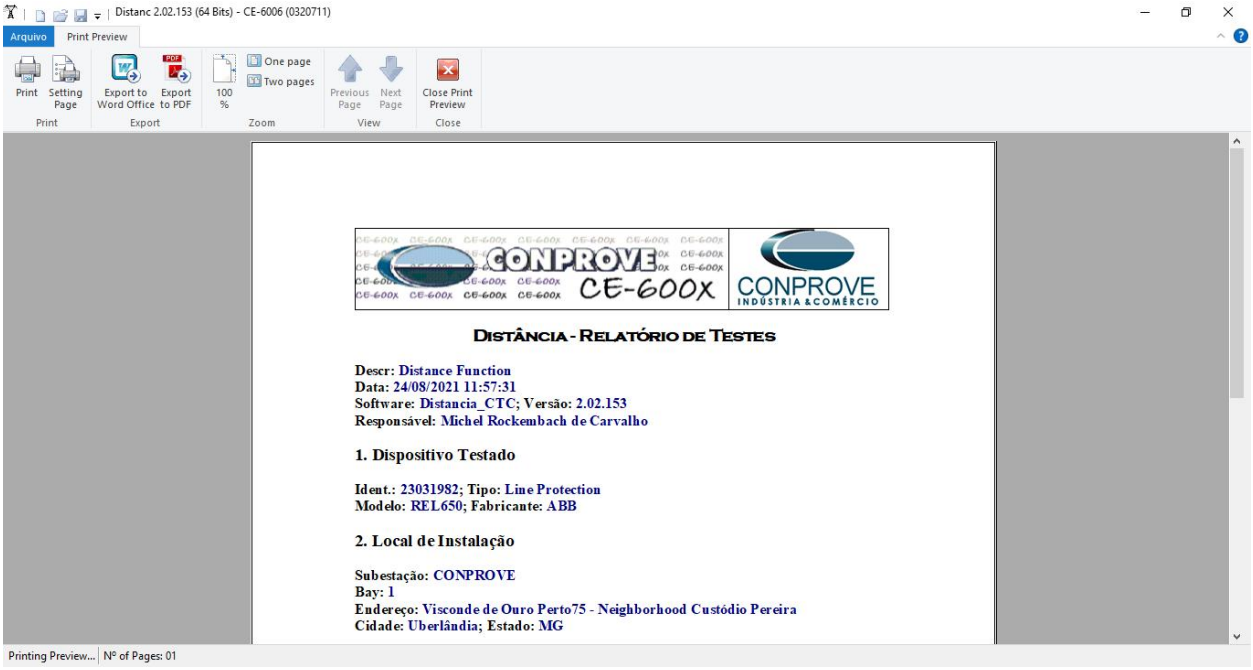
Distanc 2.02.153 (64 Bits) - CE-6006 (0320711)
Arquivo
Print Preview
Print
Setting Page
Export to Word Office
Export to PDF
100 %
One page
Two pages
Previous Page
Next Page
Close Print Preview
Print
Export
Zoom
View
Close
CONPROVE
CE-600X
CONPROVE
INDÚSTRIA &COMÉRCIO
DISTÂNCIA - RELATÓRIO DE TESTES
Descr: Distance Function
Data: 24/08/2021 11:57:31
Software: Distancia_CTC; Versão: 2.02.153
Responsável: Michel Rockembach de Carvalho
1. Dispositivo Testado
Ident.: 23031982; Tipo: Line Protection
Modelo: REL650; Fabricante: ABB
2. Local de Instalação
Subestação: CONPROVE
Bay: 1
Endereço: Visconde de Ouro Perto75 - Neighborhood Custódio Pereira
Cidade: Uberlândia; Estado: MG
Printing Preview...
Nº of Pages: 01

Figure 99

APPENDIX A

A.1 Terminal Designations

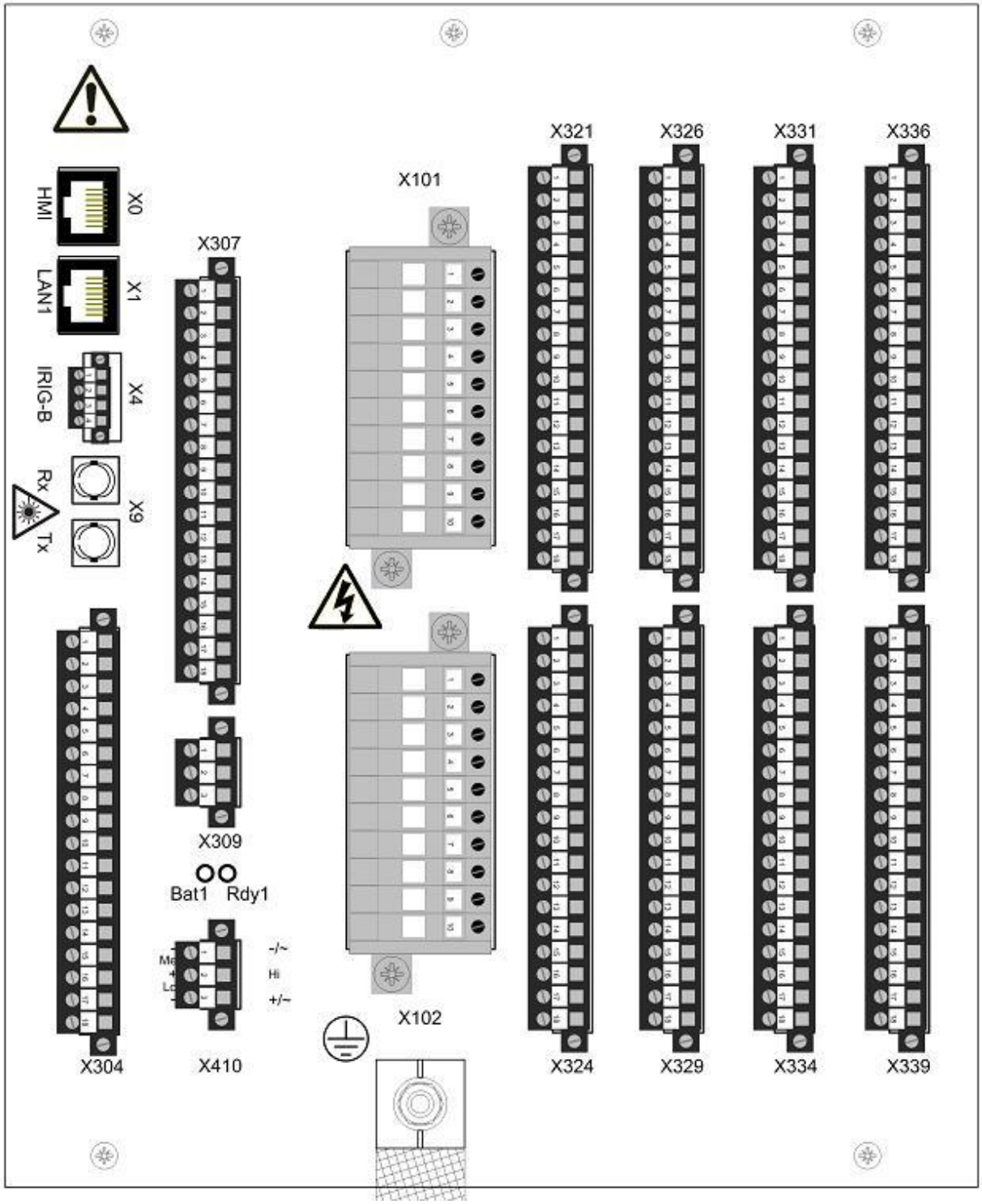

Figure 100

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 19: ZQDPDIS Technical data

Function	Range or value	Accuracy
Number of zones	5 with selectable direction	-
Minimum operate residual current	(5-30)% of IBase	± 1,0 % of I_r
Minimum operate current, phase-to-phase and phase-to-earth	(10-30)% of IBase	± 1,0 % of I_r
Positive sequence impedance reach for zones	0.005 - 3000.000	± 5.0% static accuracy ± 2.0 degrees static angular accuracy Conditions: Voltage range: (0.1-1.1) x U_r Current range: (0.5-30) x I_r Angle: at 0 degrees and 85 degrees
Fault resistance, phase-to-earth	(1.00-9000.00) Ω/loop	
Fault resistance, phase-to-phase	(1.00-3000.00) Ω/loop	
Line angle for zones	(0 - 180) degrees	
Magnitude of earth return compensation factor KN for zones	0.00 - 3.00	-
Angle for earth return compensation factor KN for zones	(-180 - 180) degrees	-
Dynamic overreach	<5% at 85 degrees measured with CVT's and 0.5<SIR<30	-
Impedance zone timers	(0.000-60.000) s	± 0.5% ± 10 ms
Operate time	30 ms typically	-
Reset ratio	105% typically	-
Reset time	35 ms typically	-

APPENDIX B

Equivalence of software parameters and the relay under test.

Distance Software		ABB REL650 Relay	
Parameter	**Figure**	**Parameter**	**Figure**
Secondary Current	68	CT sec	19
Secondary Voltage	68	VT sec	20
Zn01_LE		Zone 1	
Trigger Time	74	tPE1	55
Z	74	Z1	55
LineAng	74	LineAng	55
KNMag	74	KNMag1	55
KNAng	74	KNAng1	55
RFPE	74	RFPE1	15
Operationz<	74	OperationZ<	60
X1 phs	74	X1	60
X0 phs	74	X0	60
RFFwPE phs	74	RFFwPE	60
RFRvPE phs	74	RFRvPE	60
RLdFw phs	74	RLdFw	60
RLdRv phs	74	RLdRv	60
AngLd phs	74	AngLd	60
FORWARD	74	DirMode1	55
AngDir zd	74	AngDir	59
AngNegDir	74	AngNegRes	59
Zn01_FF		Zone 1	
Trigger Time	77	tPP1	55
Z	77	Z1	55
RFPP	77	RFPP1	55
X1 phs	77	X1	60
RFFwPP phs	77	RFFwPP	60
RFRvPP phs	77	RFRvPP	60
RLdFw phs	77	RLdFw	60
RLdRv phs	77	RLdRv	60
AngLd phs	77	AngLd	60
FORWARD	77	DirMode1	55
AngDir zd	77	AngDir	59
AngNegDir	77	AngNegRes	59

Distance Software		ABB REL650 Relay	
Parameter	Figure	Parameter	Figure
Zn01_ABC		Zone 1	
Trigger Time	80	tPE1	55
Z	80	Z1	55
LineAng	80	LineAng	55
KNMag	80	KNMag1	55
KNAng	80	KNAng1	55
RFPP	80	RFPE1	55
Operationz<	80	OperationZ<	60
X1 phs	80	X1	60
X0 phs	80	X0	60
RFFwPP phs	80	RFFwPP	60
RFRvPP phs	80	RFRvPP	60
RLdFw phs	80	RLdFw	60
RLdRv phs	80	RLdRv	60
AngLd phs	80	AngLd	60
FORWARD	80	DirMode1	55
AngDir zd	80	AngDir	59
AngNegDir	80	AngNegRes	59

Note: To register the zones PE, PP and ABC remember to register the Loop in the Distance software. Zones 2 and 3 have equivalence in the way they are parameterized, being analogous to Zone 1.