INSTRUMENTOS PARA TESTES ELÉTRICOS

Test Tutorial

Equipment Type: Protection Relay

Brand: SIEMENS

Model: 7SA611

Function: 68 or RPSB - Power Swing Blocking (PSB) & 78 or PPAM - Out of step (OoS)

Tool Used: CE-6006, CE-6707, CE6710, CE-7012 or CE7024

Objective: Test of PSB and OoS in Conditions of Synchronous, Asynchronous and Faulted Power Oscillations.

Version Control:

Version	Descriptions	Date	Author	Reviewer
1.0	Initial Version	06/04/2022	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 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 test should 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 should 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 7SA611 relay in the PSB_OoS software

1. Relay Connection to CE-6710

Appendix A-1 shows the relay terminal designations.

1.1 *Auxiliary Source*

Connect the positive (red terminal) of the Auxiliary Source to pin F1 (UH+) of the relay and the negative (black terminal) of the Aux Source Vdc to pin F2 (UH-) of the relay.

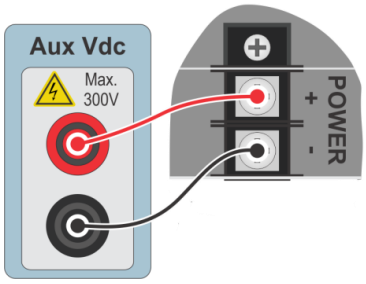

Figure 1

1.2 *Current and Voltage Coils*

To establish the connection of voltage coils, connect channels V1, V2 and V3 with pins R15, R17 and R18 of the relay terminal and common to pin R16. To establish the connection of the current coils, connect channels I1, I2 and I3 with pins Q1, Q3 and Q5 of the relay terminal and make a short circuit between pins Q2, Q4 and Q6.

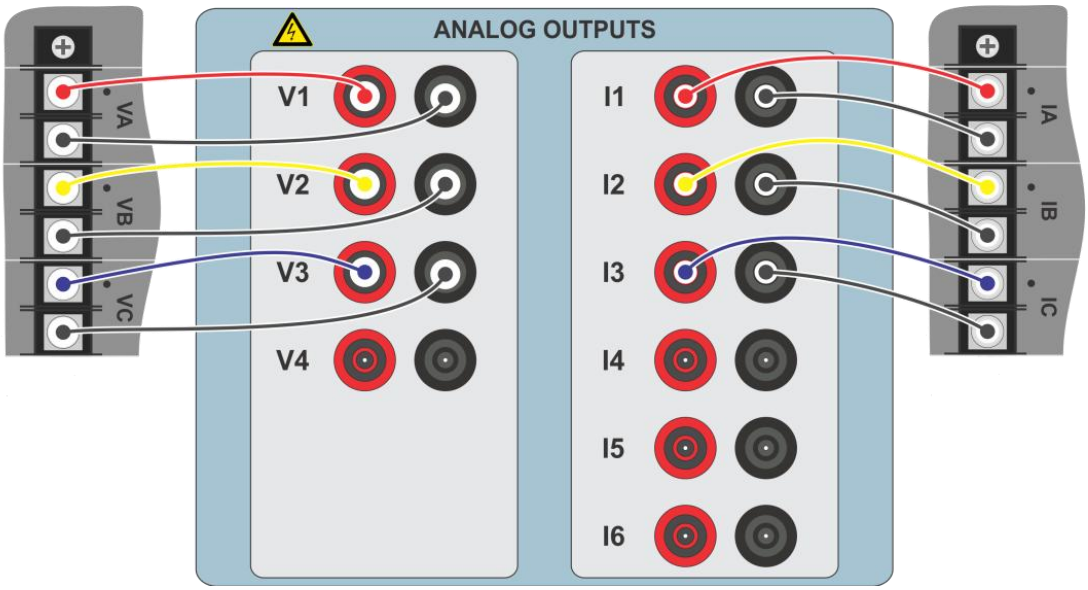

Figure 2

1.3 *Binary Inputs*

Connect the binary inputs of the CE-6710 to the binary outputs of the relay:

- BI1 to pin R1 and its common to pin R4.
- BI2 to pin R3 and its common to pin R4.
- BI3 to pin R5 and its common to pin R4.

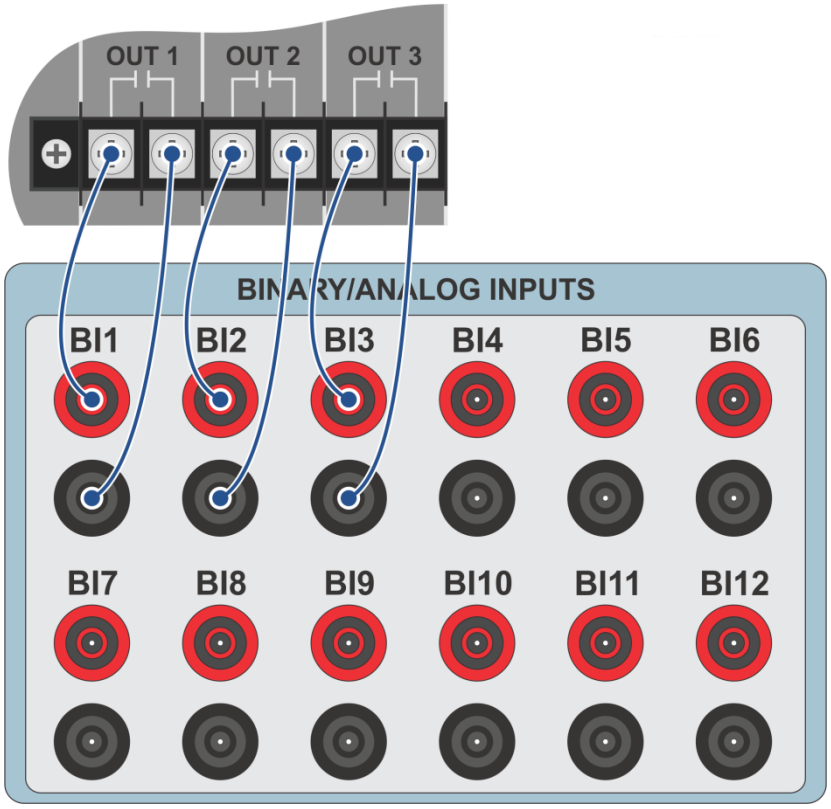

Figure 3

2. Communication with the 7SA61 relay

First, open *"DIGSI"* and connect an Ethernet (or serial) cable from the notebook to the relay. Then double click on the software icon.

Figure 4

After opening the program, the substation that contains the relay in question (7SA61) is selected. After selecting the relay, right-click and select the *"Open Object"* option and then select the connection mode, as shown in the following figures.

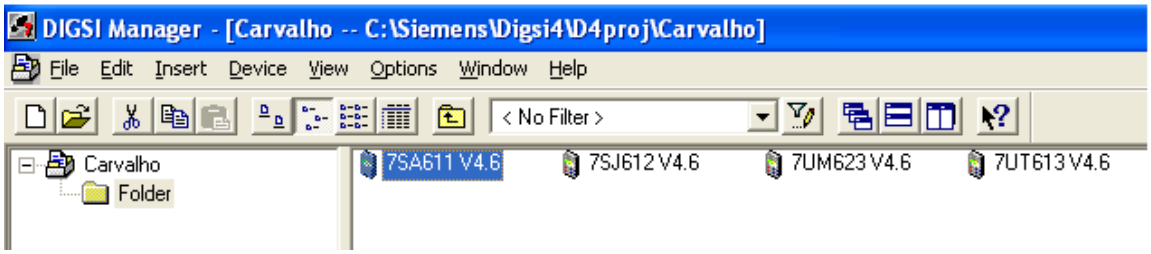

Figure 5

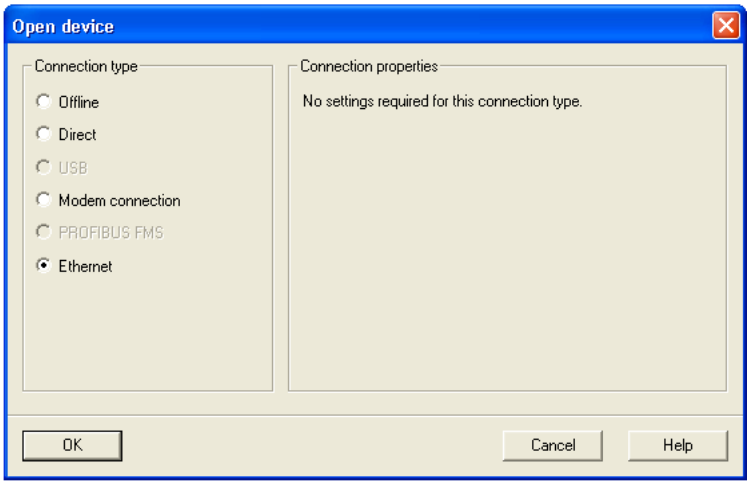

Figure 6

3. Parameterization of relay 7SA61

3.1 *Device Configurations*

After the connection has been established, access the relay's general settings by double-clicking the left button on *"Settings"* repeat the operation for *"Device Configuration"*.

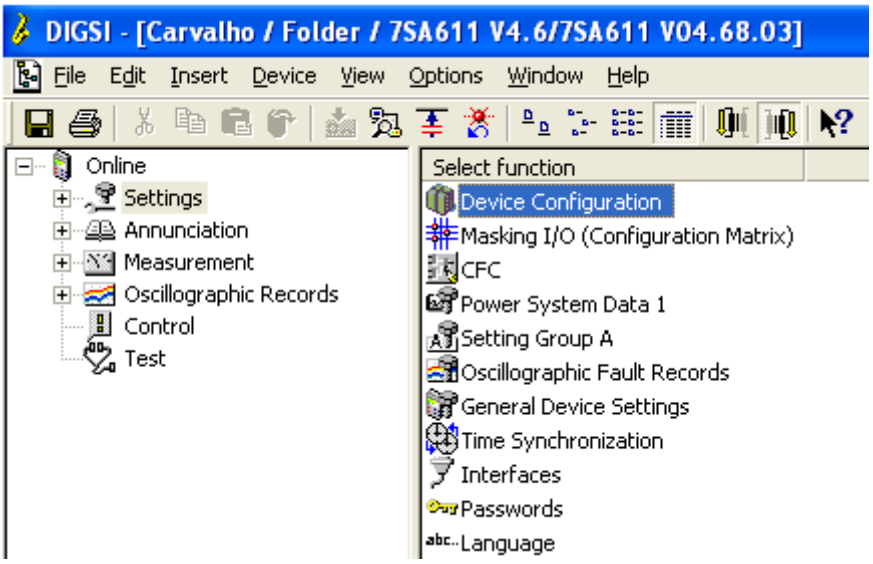

Figure 7

On the *"Functional Scope"* screen, disable all functions leaving only the *"21 Distance protection pickup program"* and *"68 Power Swing detection"* functions enabled. This prevents trips from other functions from interfering with the test. After the adjustments, click *"OK"*.

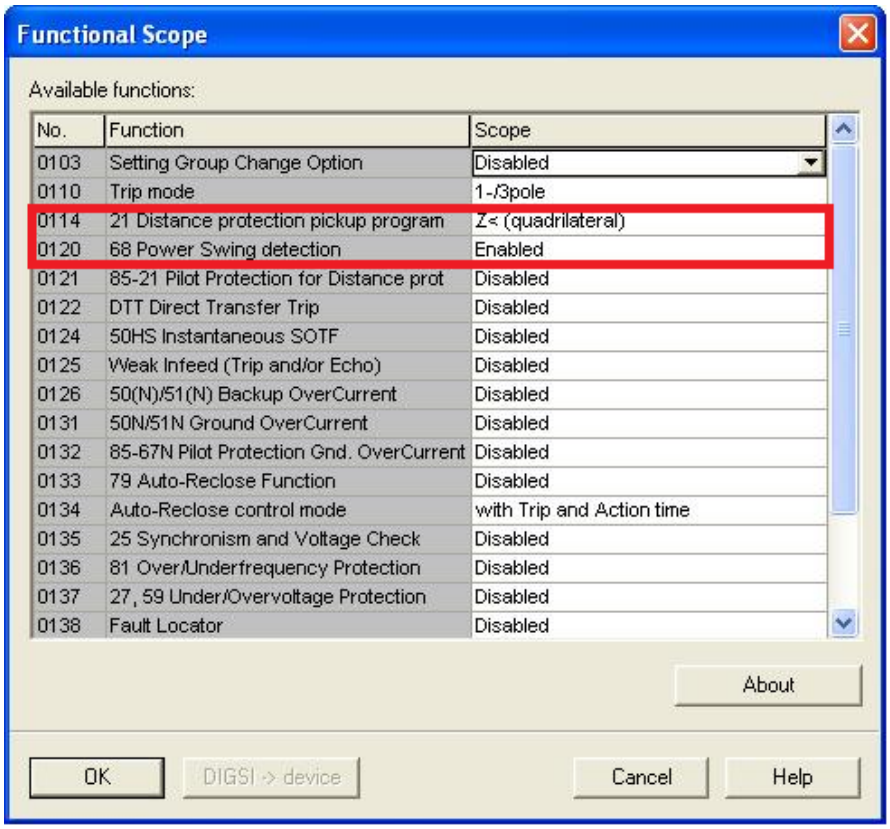

Figure 8

3.2 *Masking I/O*

The next step is to adjust the relay output. To access these parameters, double-click the left button on *"Masking I/O (Configuration Matrix)"* as shown in the next figure.

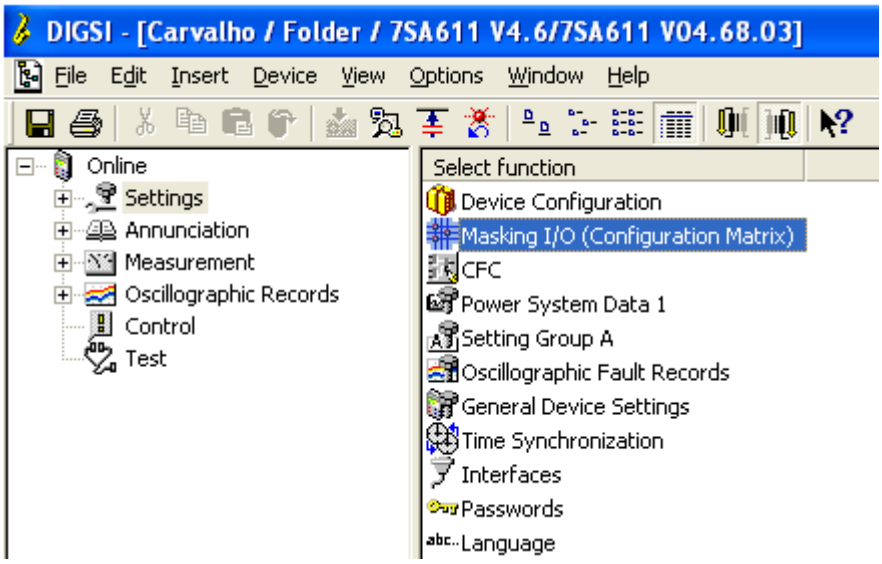

Figure 9

Binary output BO1 is designated for sending the tripping of zones 1, 2, 3 and 4. In order to aid the test, LED 1 is used to signal the tripping of zone 1, LED 2 to signal the zone 2 tripping, LED 3 to signal zone 3 tripping and LED 4 to signal zone 4 tripping. Binary output BO3 is designed for power swing blocking, to signal the signal sending, use LED 5.

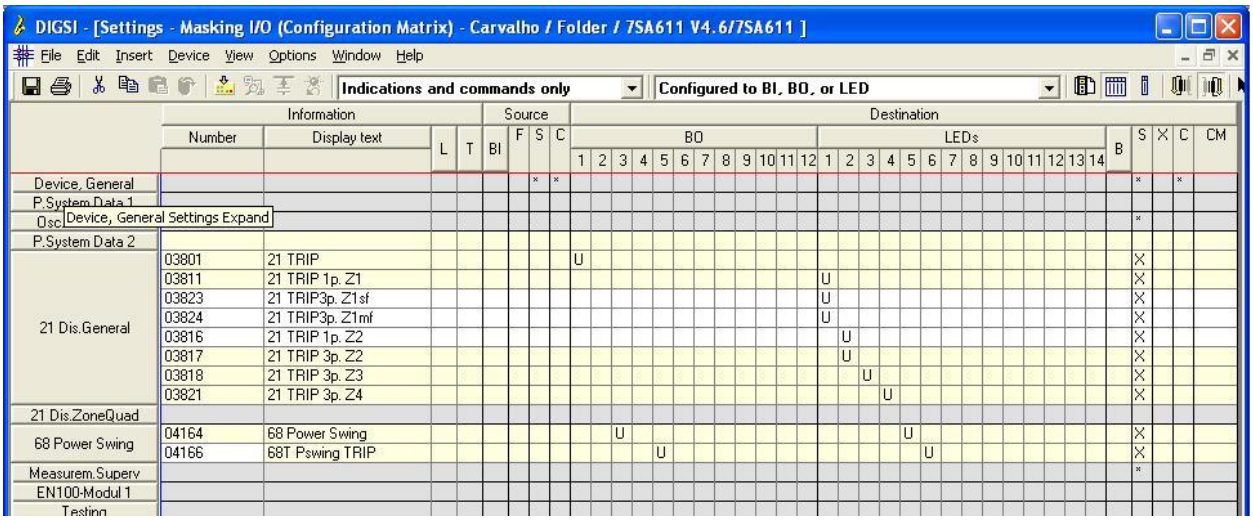

Figure 10

3.3 *Power System Data 1*

Double-click on *"Power System Data 1"* to access the system settings.

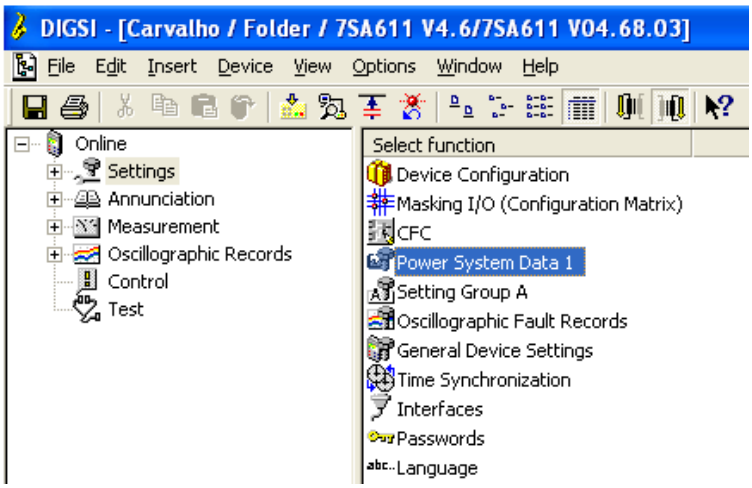

Figure 11

Those settings highlighted in red in the next couple of figures need special attention. First the VT and CT data are shown, then the system data and finally the circuit breaker data.

3.4 *Transformers*

In the *"Transformers"* tab, configure the CT and VT ratio of the system**.**

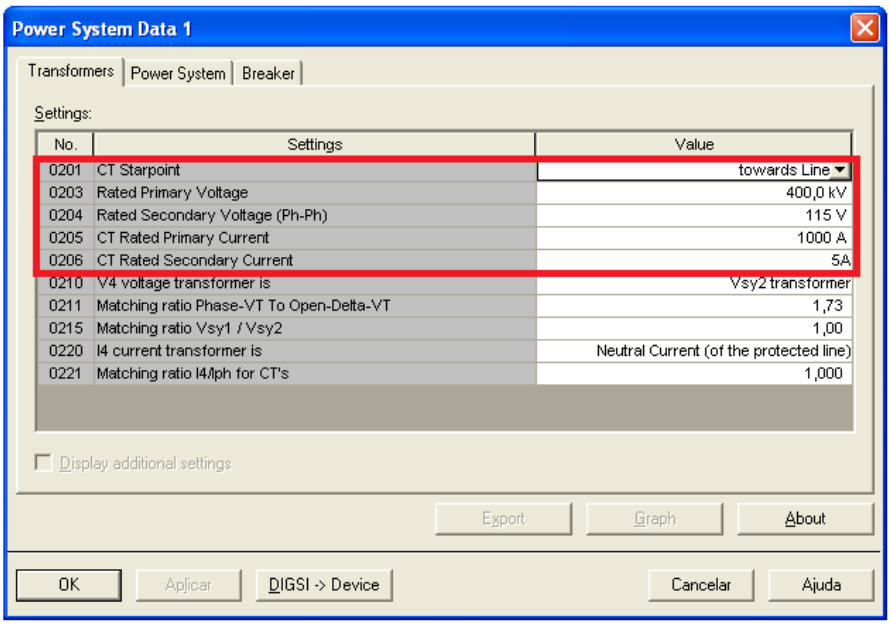

Figure 12

3.5 *Power System*

In the *"Power System"* tab, the rated frequency, the phase sequence, whether the system is grounded and how the ground compensation for ground faults will be performed.

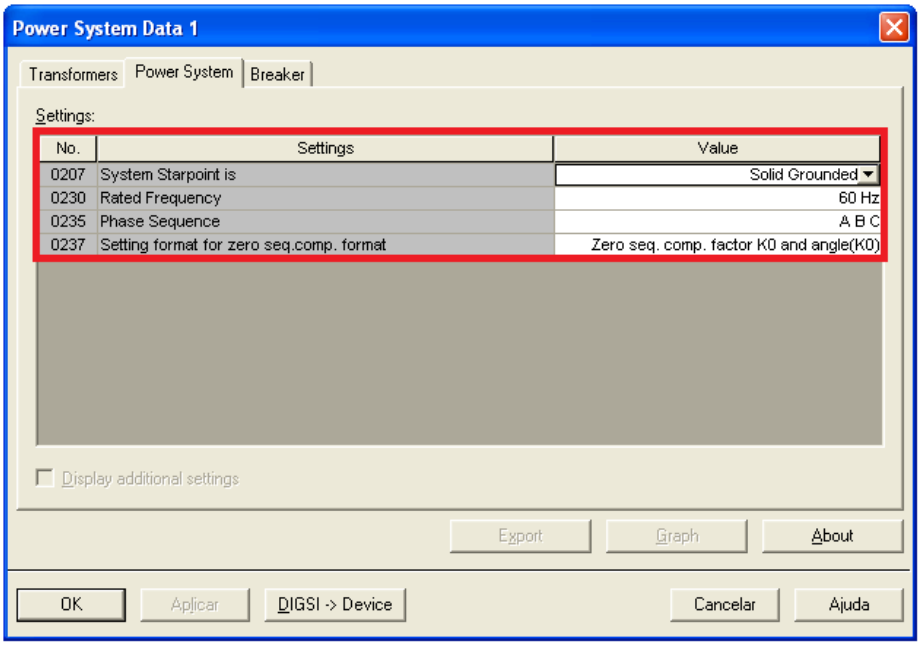

Figure 13

3.6 *Setting Group A*

In this option, important data about the protected transmission line and the parameters of the impedance function are set, whose calculations will be shown later.

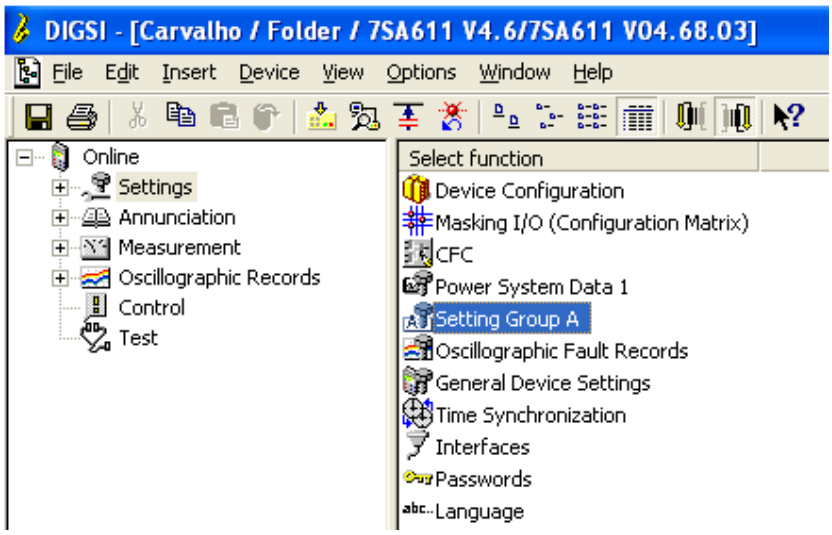

Figure 14

With a double click on the option *"Power System Data 2"*.

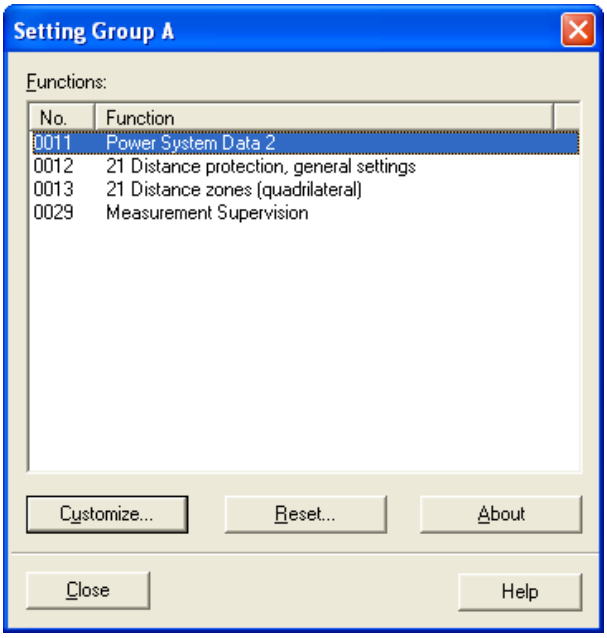

Figure 15

3.7 *Power System Data 2*

In the *"Power System"* tab, important data are parameterized, such as: full-scale measurement of voltage and current, line angle, slope angle of the distance characteristic and compensation factors for earth faults. The other tabs are not relevant for this test.

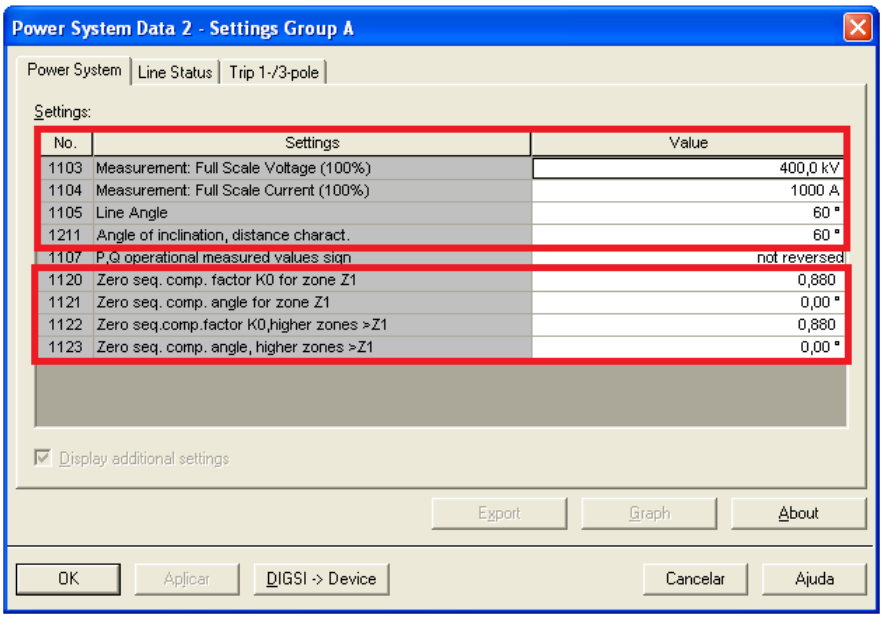

Figure 16

3.8 *21 Distance protection/ General settings*

The next step in the *"General"* tab is to activate function 21, disable the series line compensation and adjust the load compensation, which in this case will be infinite.

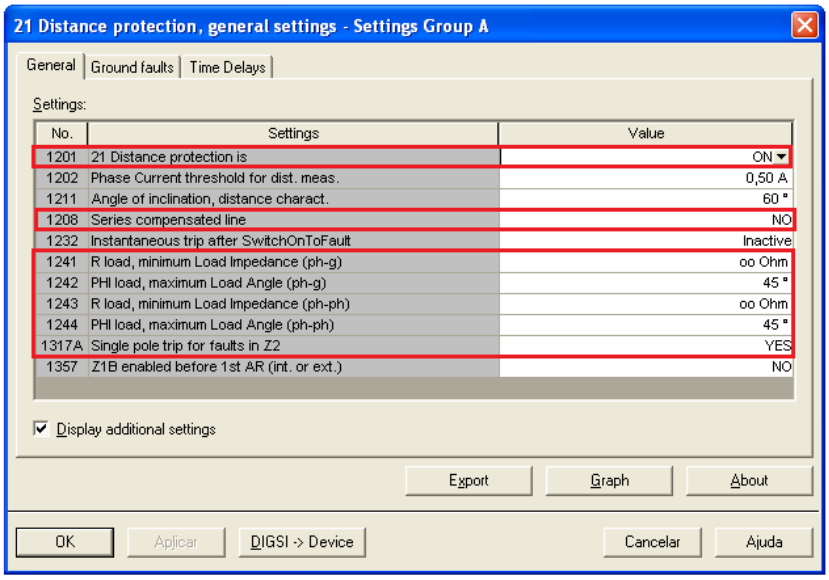

Figure 17

In the *"Time Delays"* tab, the time delays of each zone are adjusted, both for three-phase faults and for ground faults.

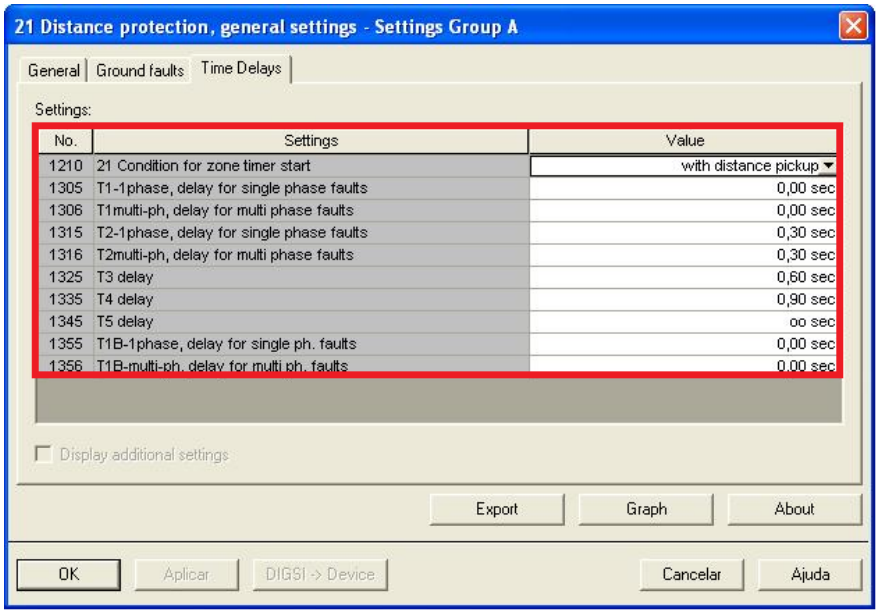

Figure 18

3.9 *21 Impedance Distance Zones (Quadrilateral)*

Set the impedance values of zones 1, 2, 3 and 4 for three-phase/single-phase faults and their respective time delays. In this test, the Z1B zone will not be used.

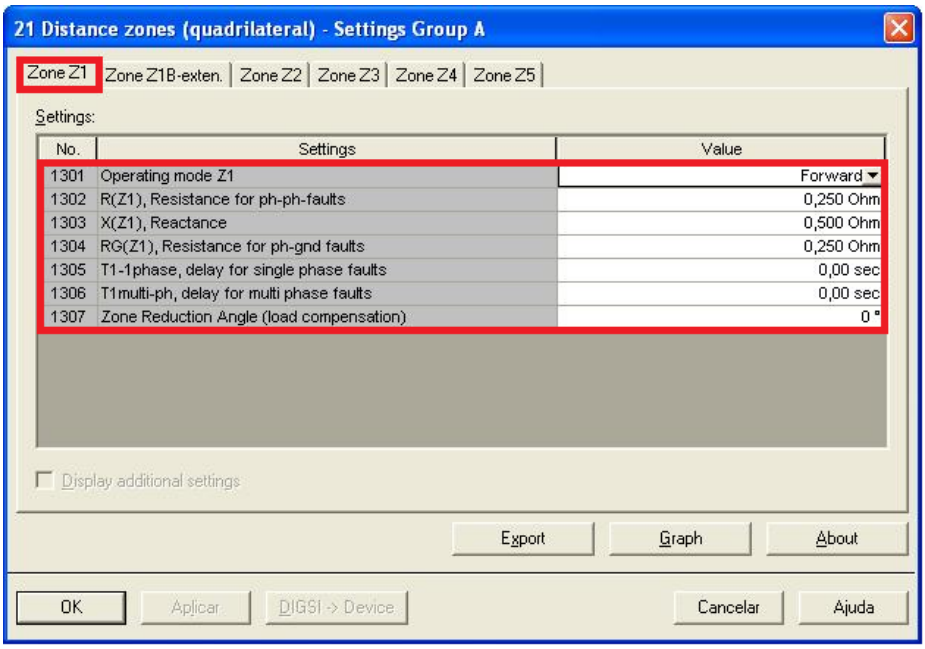

Figure 19

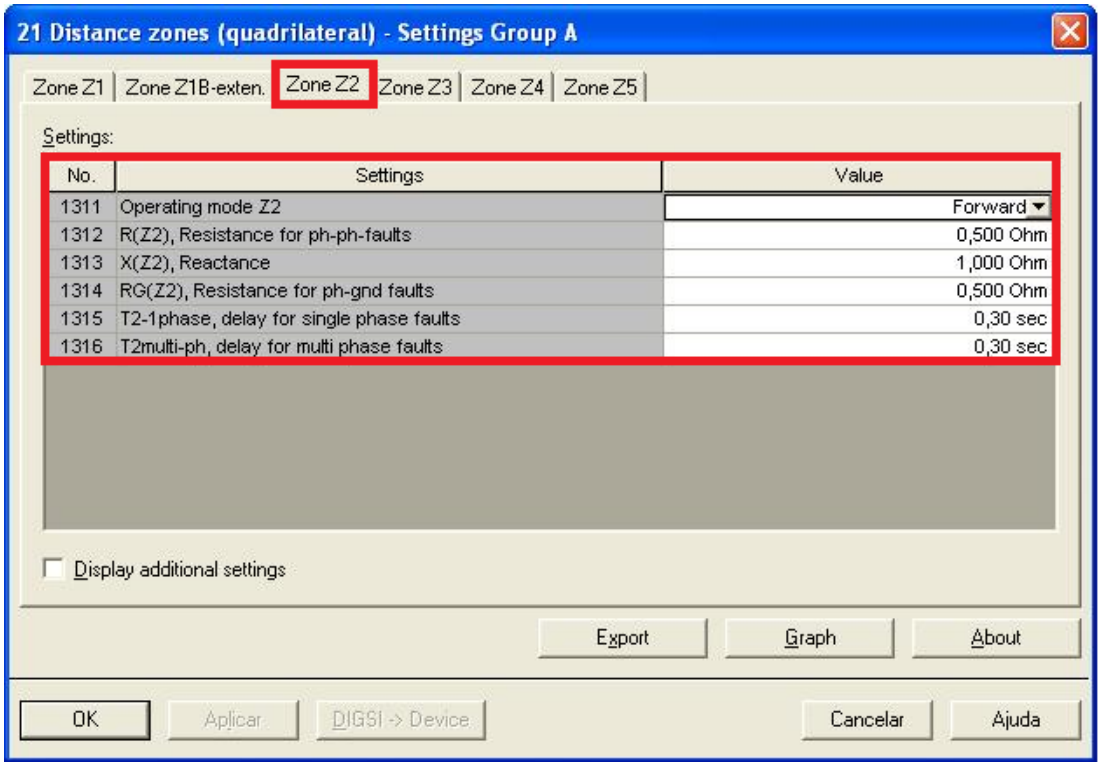

Figure 20

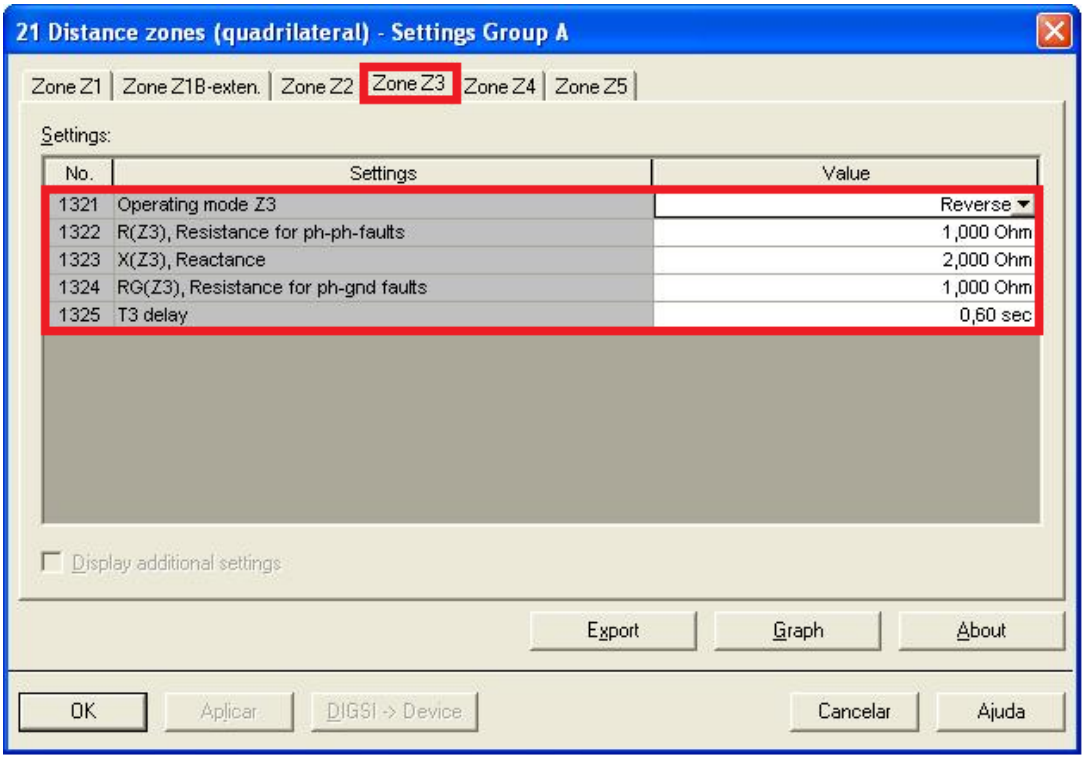

Figure 21

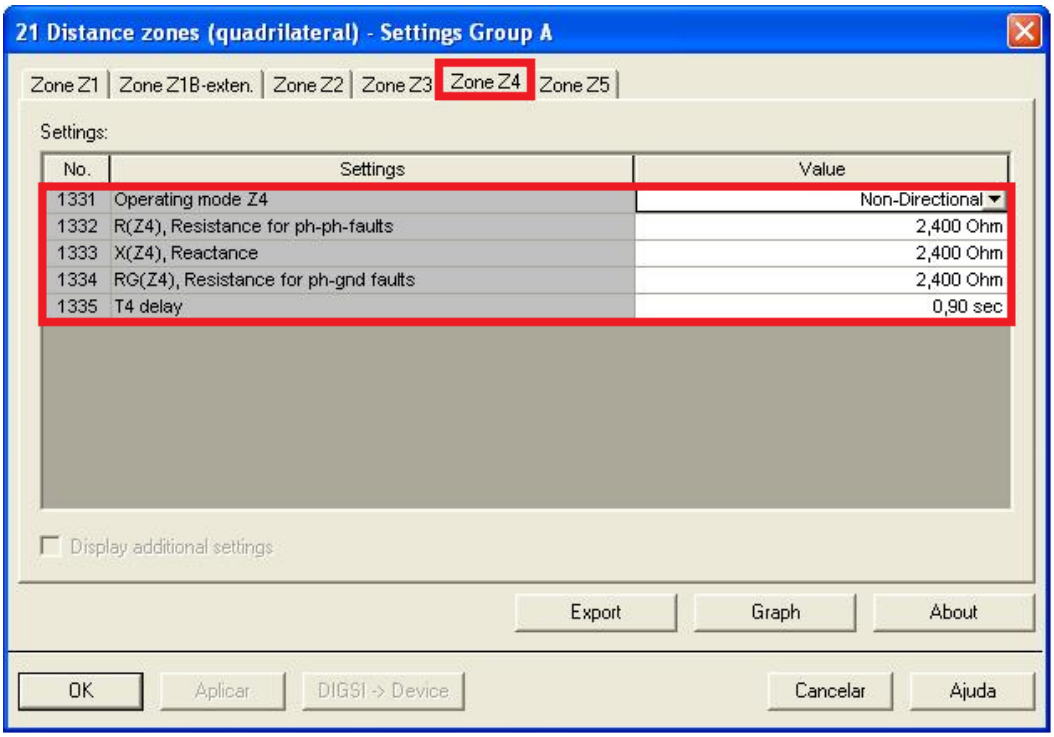

Figure 22

3.10 *68 Power Swing Detection*

The next step is to activate function 68, activate the power swing trip and determine the tripping time after power swing blocking.

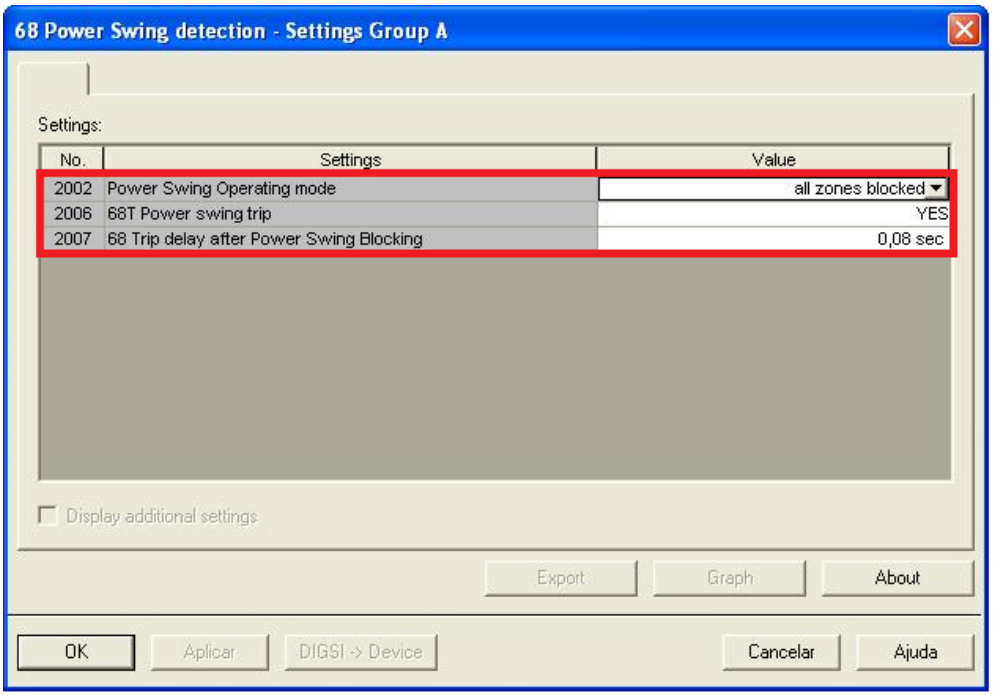

Figure 23

4. PSB OoS software adjustments

4.1 *Opening the PSB OoS*

Click on the *"CTC"* application manager icon.

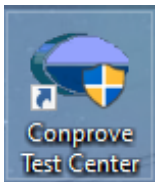

Figure 24

Click the *"PSB OoS"* software icon.

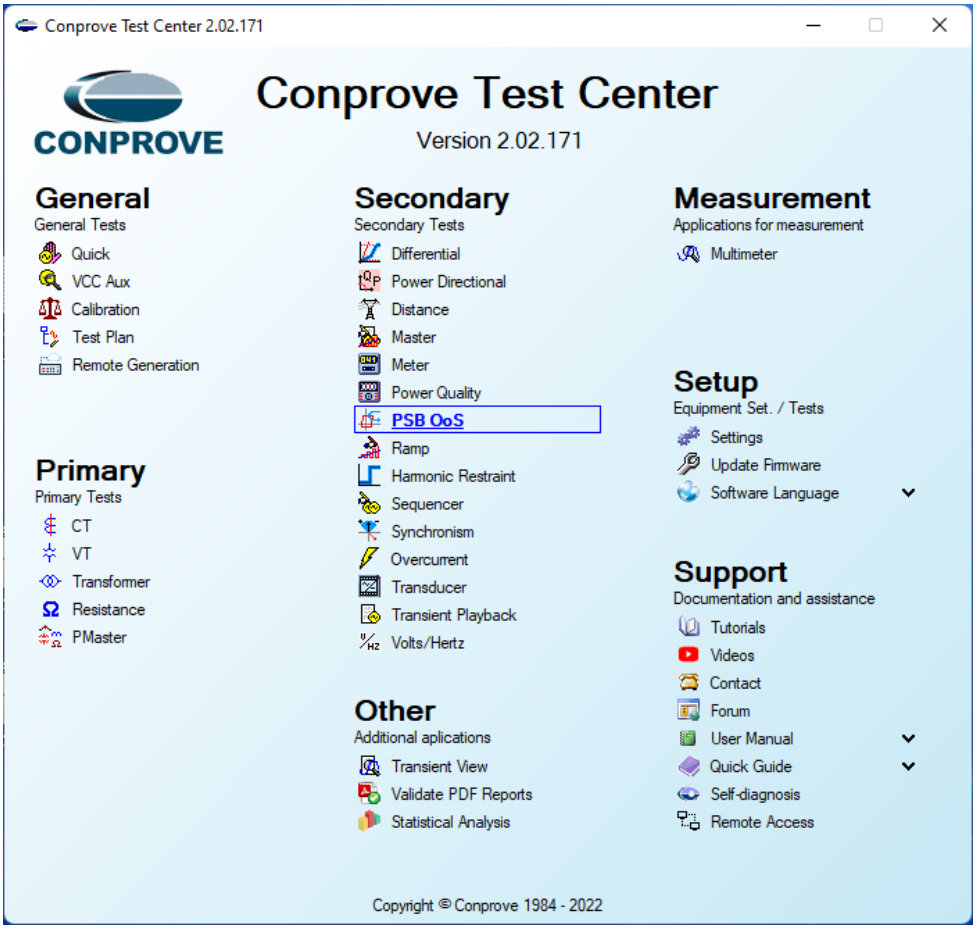

Figure 25

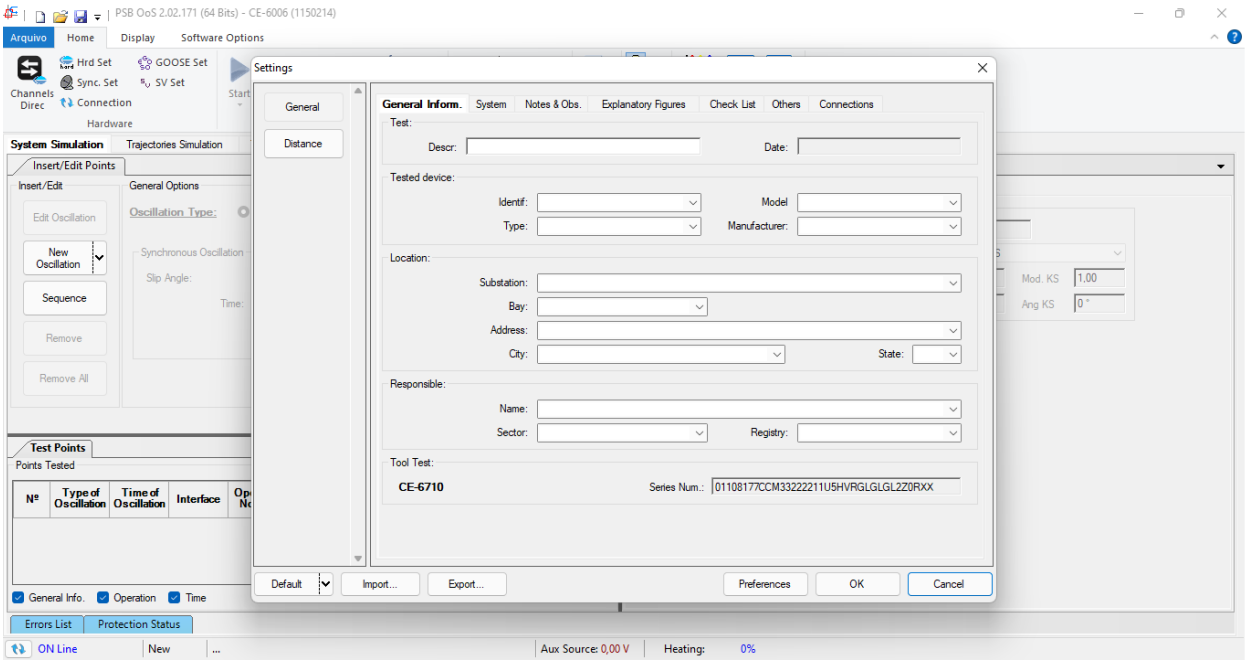

Figure 26

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.

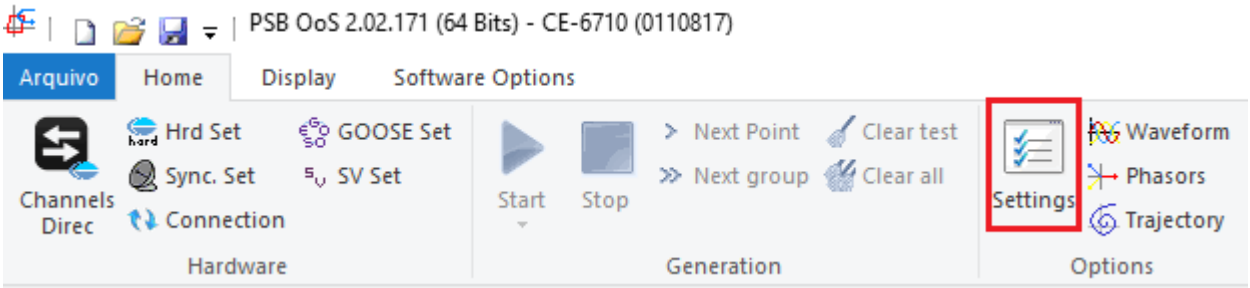

Figure 27

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.

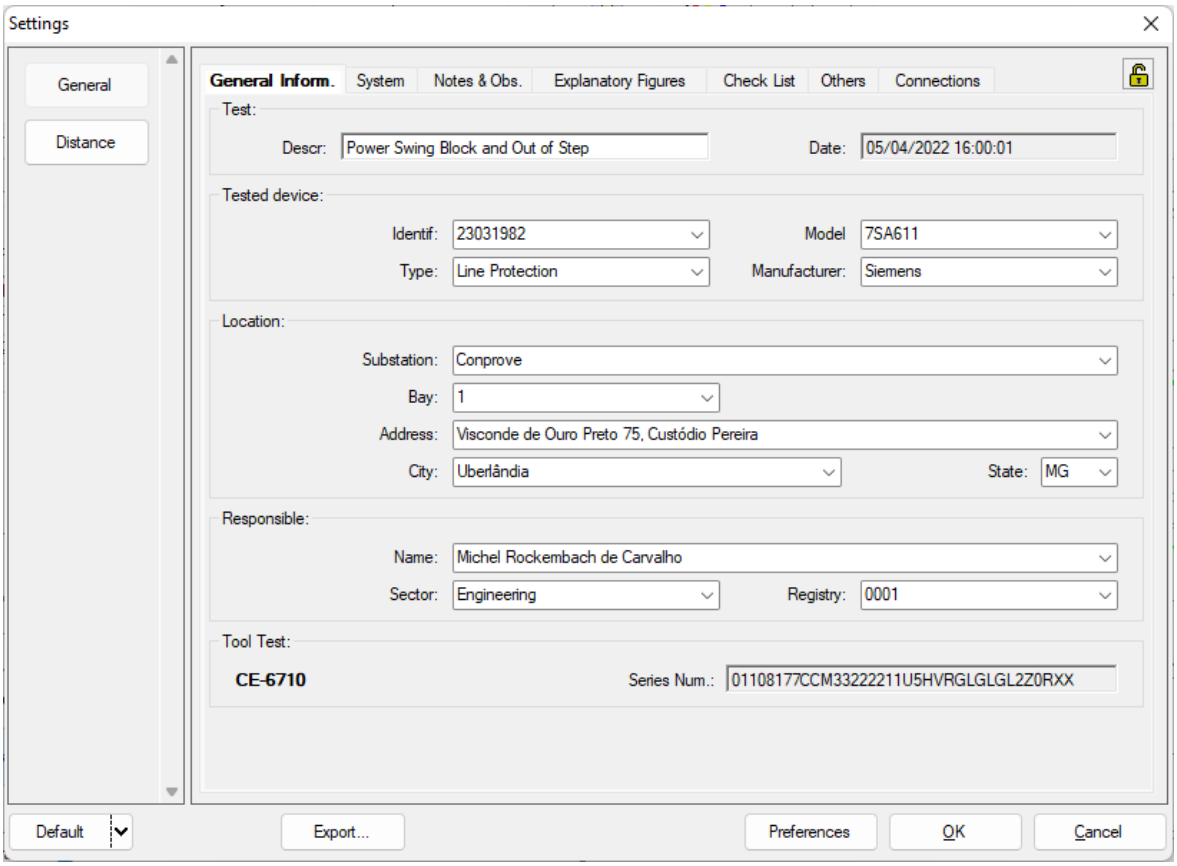

Figure 28

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.

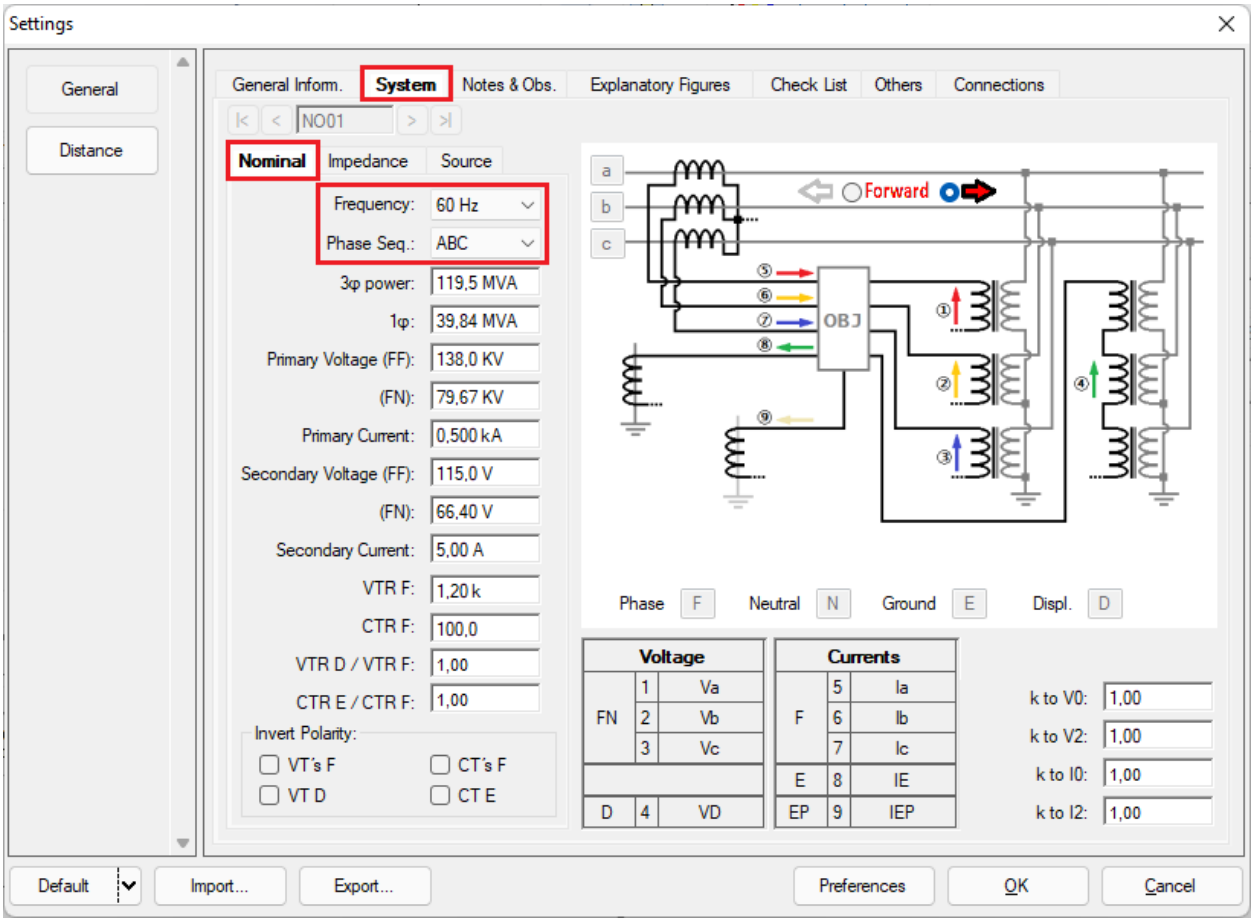

Figure 29

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. Distance Adjustments

Note: The relay will only be parameterized for two-phase and three-phase faults. For the software to perform the test properly, 4 types of zones must be inserted, all for two-phase and three-phase faults.

5.1 *Distance screen > Distance Prot. Settings*

If the user wants to test a ground fault during power swing blocking, it is necessary to register 4 more distinct zones and adjust the ground compensation factor, highlighted in red in the figure below.

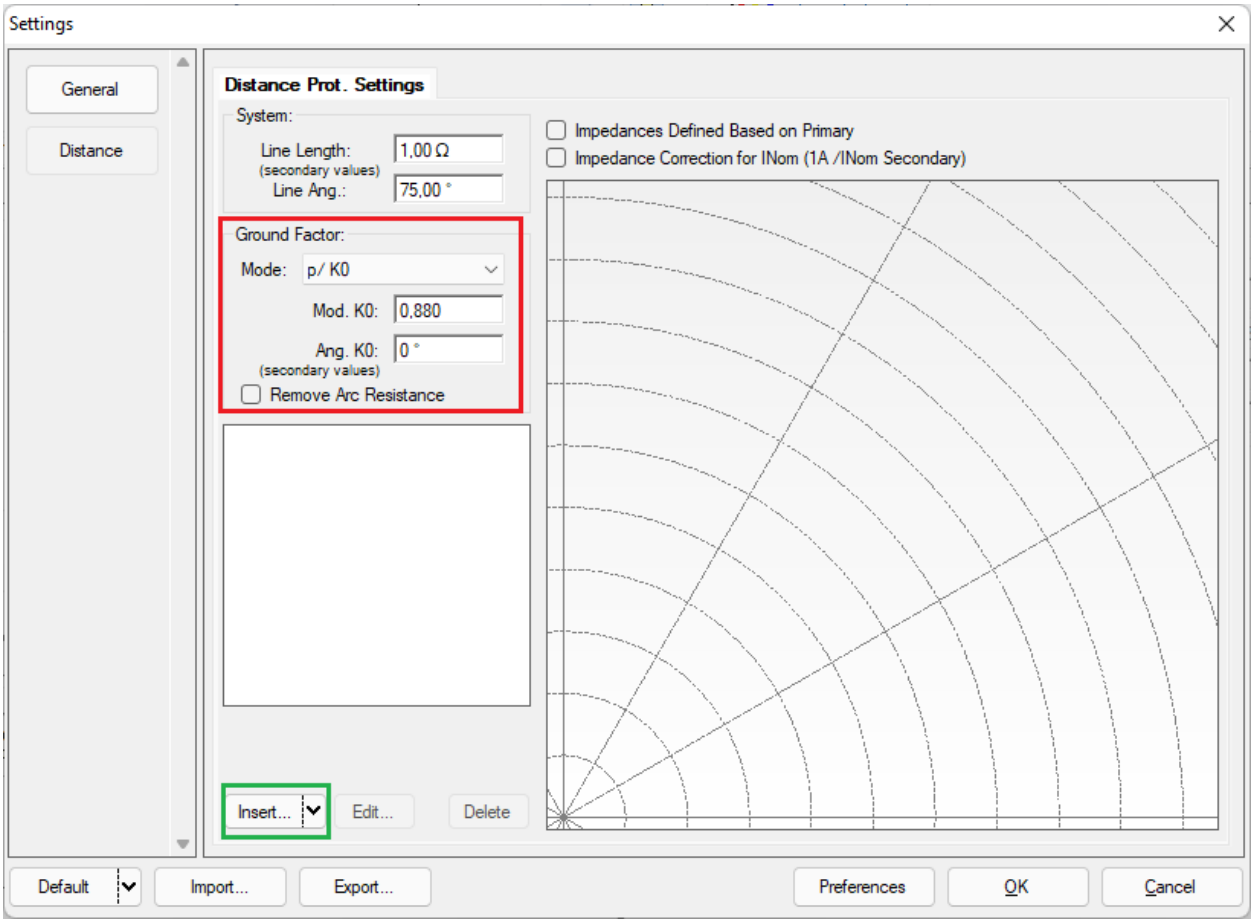

Figure 30

5.2 *Inserting Phase Zones*

Note: <u>There is an extremely practical and fast way to import the characteristic of the zones. See Appendix C.</u>

The first zone to be entered will be zone-1 (LL+ABC). Click on the *"Insert"* field highlighted in green in the previous figure. On the settings screen, first choose the relay mask *"Siemens 7SA6/7SA8/7SL8 - Quadr."*. You must adjust the actuation time, choose the type of fault (loop) and insert the characteristics of the zone and the directionality. Adjust the tolerance values and finally click *"OK"*.

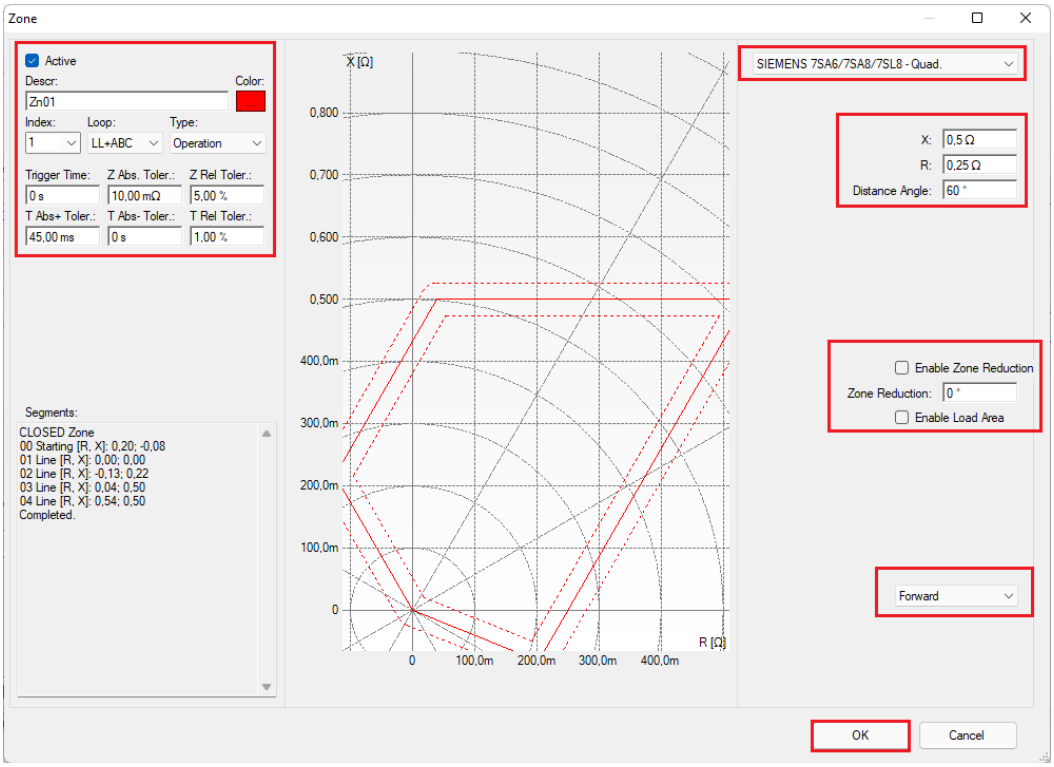

Figure 31

Click on *"Insert"* again and adjust the values for zone 2.

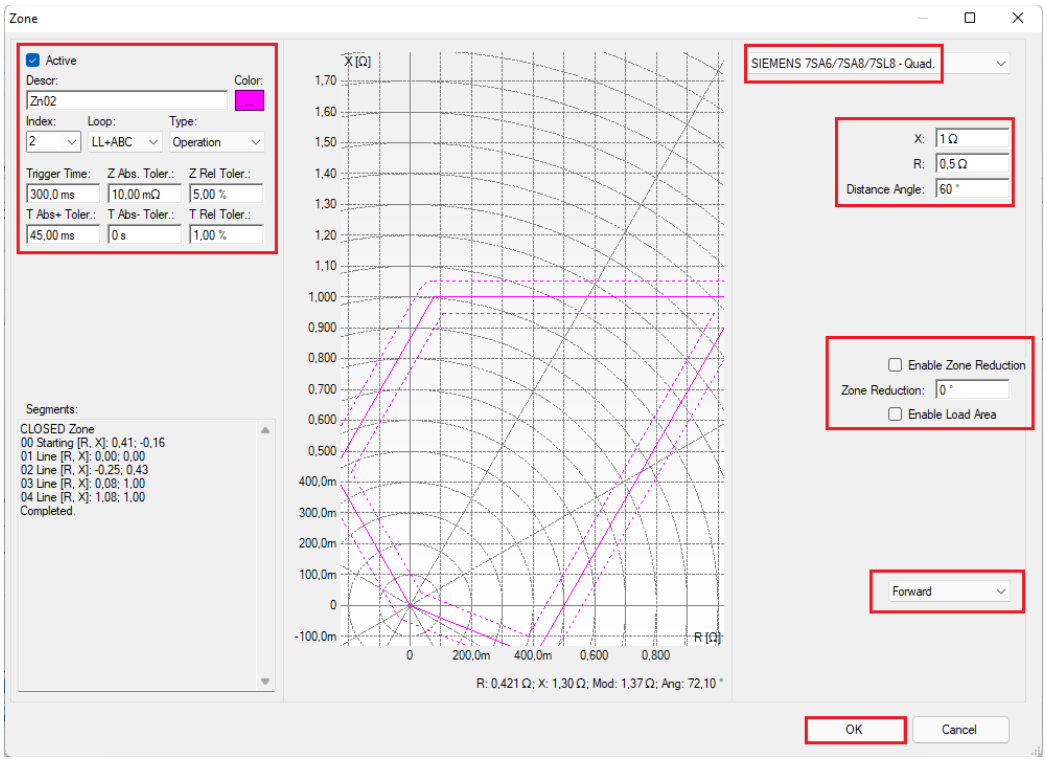

Figure 32

By clicking on *"Insert"* one more time, the values for zone 3 must be adjusted.

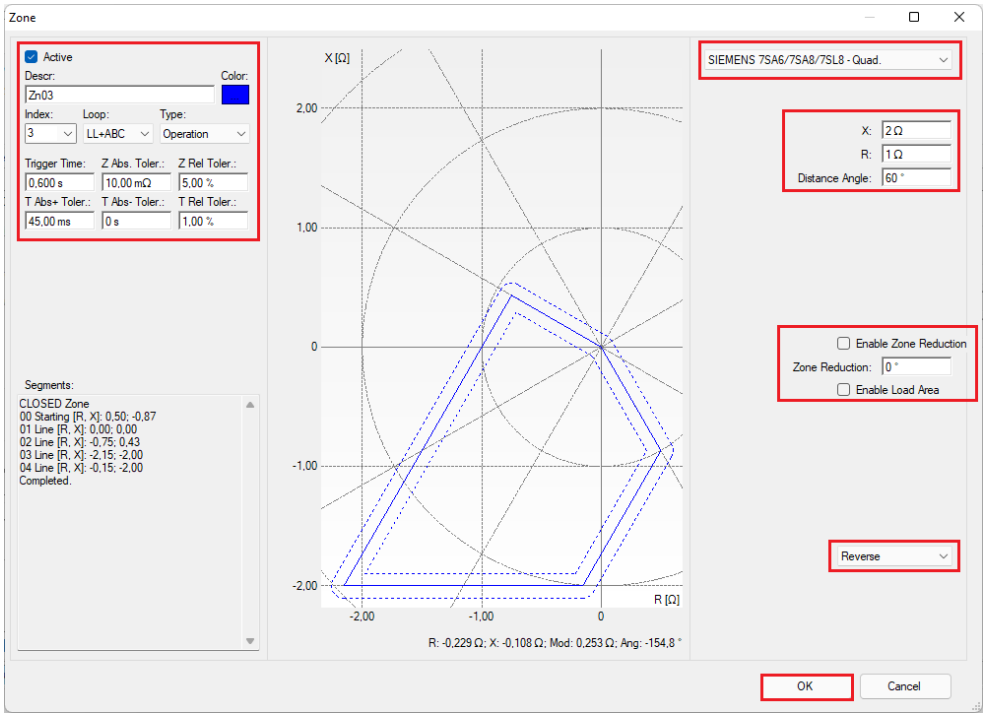

Figure 33

Repeat the process for zone 4.

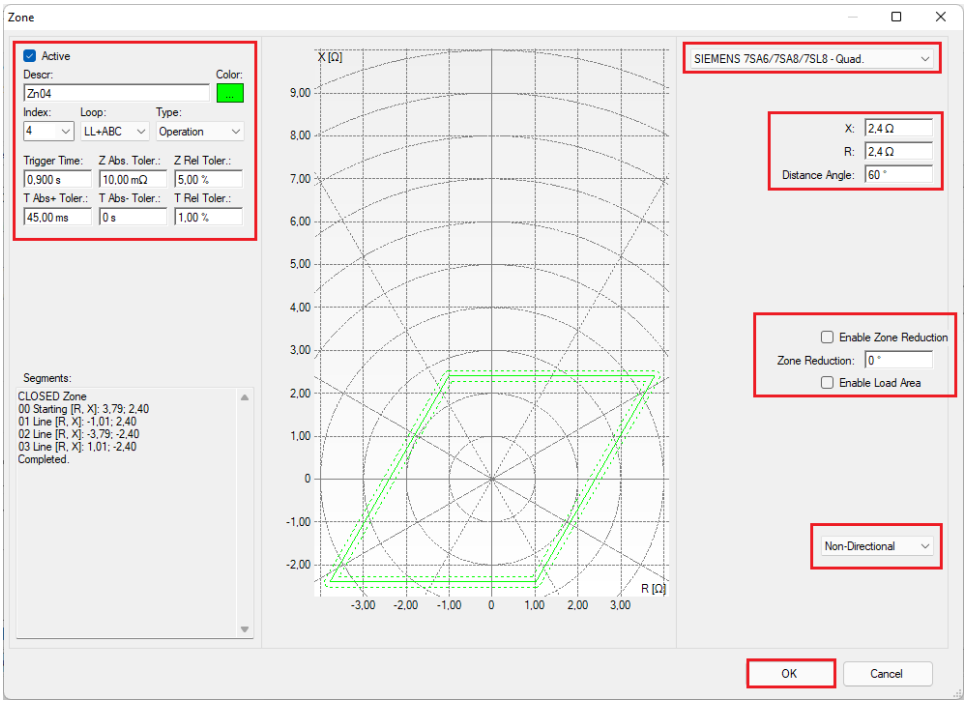

Figure 34

6. Channel Targeting and Hardware Configurations

Click on the icon illustrated below.

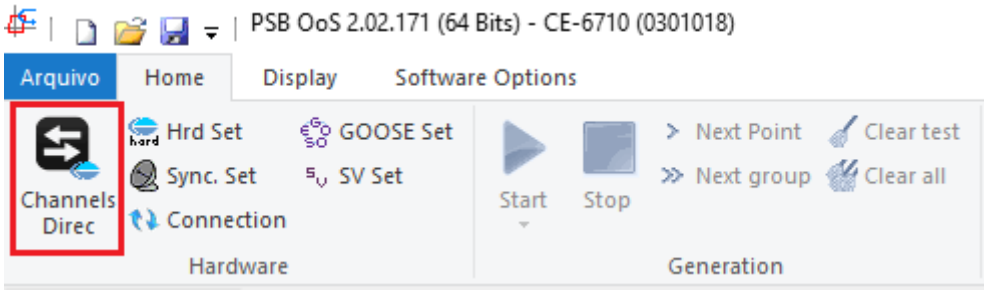

Figure 35

Then click on the highlighted icon to configure the hardware.

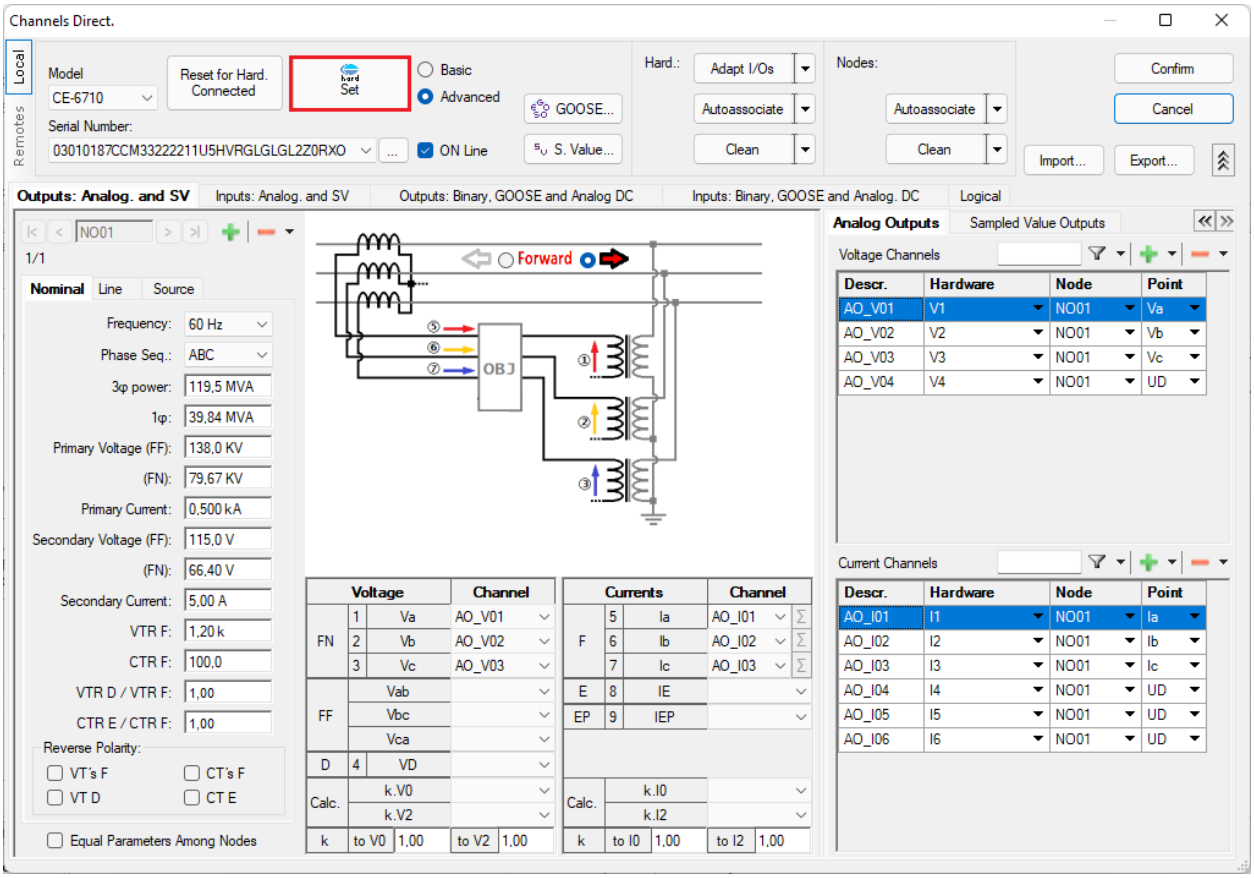

Figure 36

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

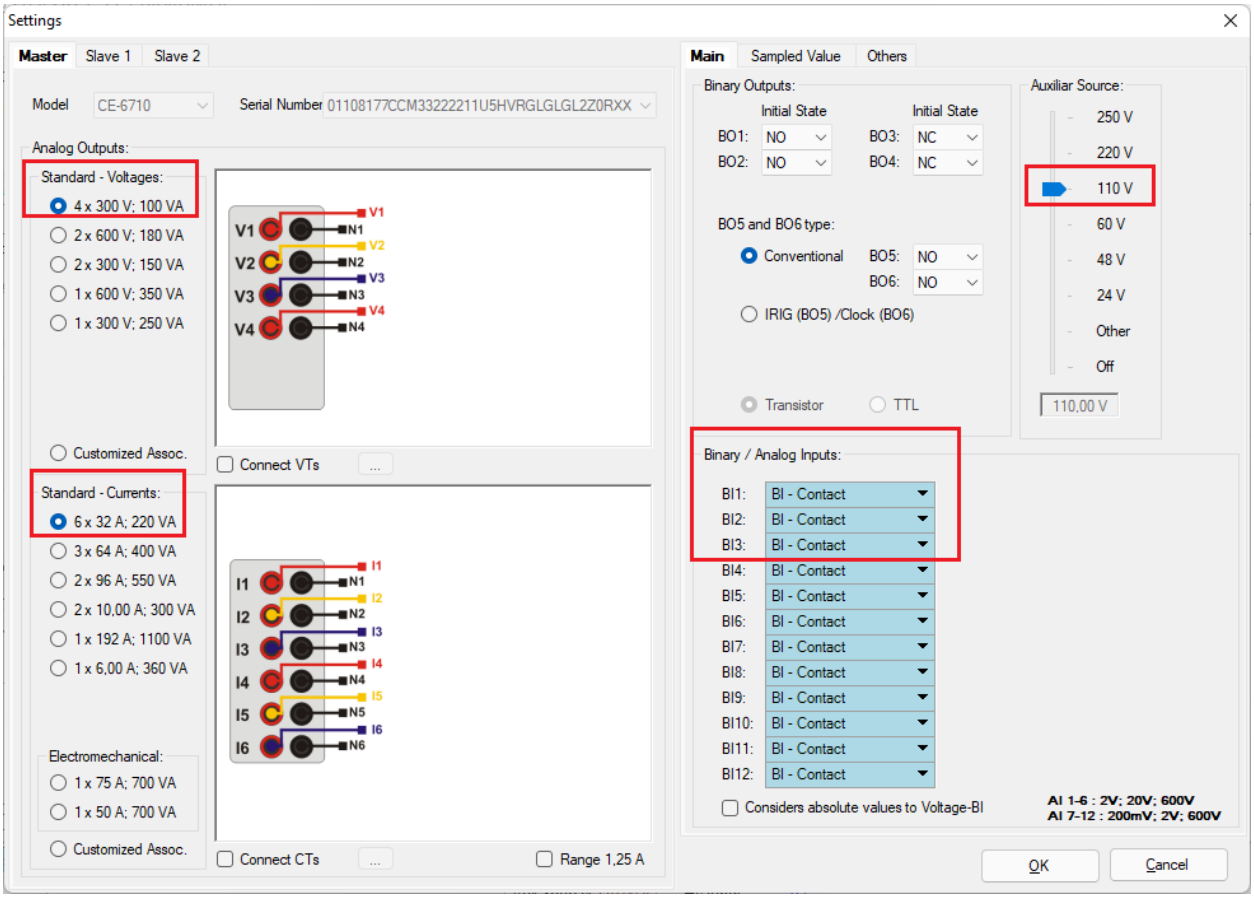

Figure 37

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

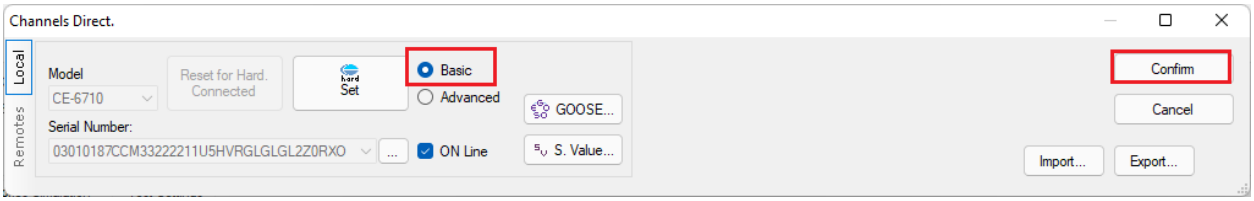

Figure 38

7. Restore Layout

Due to the great flexibility that the software presents, allowing the user to choose which windows are presented and in which position, this command is used to restore the default settings. Click on *"Recreate Charts"* and on *"Restore Layout"*.

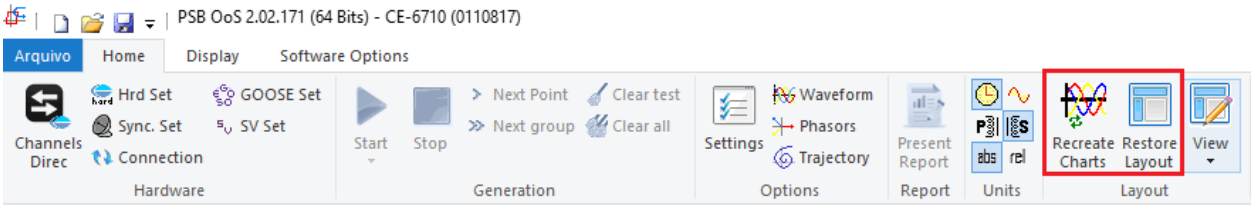

Figure 39

8. Test structure for PSB_OoS functions

8.1 *Test Settings*

By clicking on the *"Test Settings"* tab, the user must direct the channels and adjust the binary inputs as follows:

- BI01 = Dist Trip;
- BI02 = PSB Alarm;
- BI03 = Trip OoS.

Enable a pre-simulation condition with nominal conditions and 0.1s.

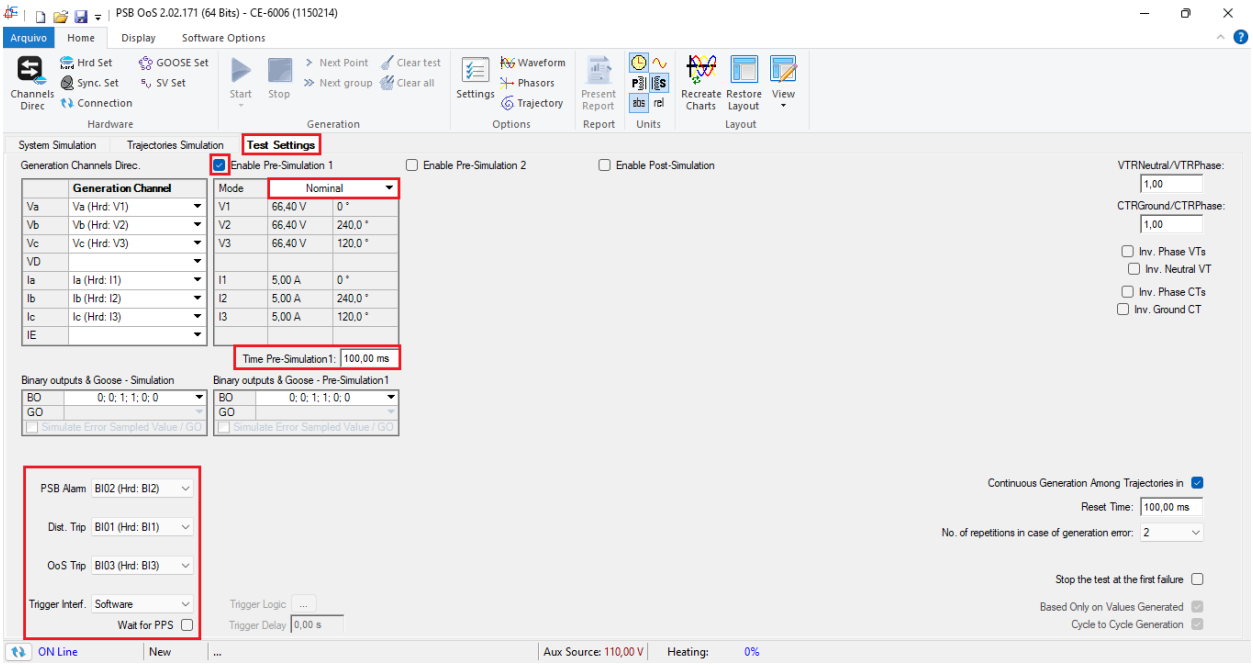

Figure 40

8.2 *System Simulation*

For the *"System Simulation"* test, a study must be carried out in order to simplify the system to two voltage sources with a line between them so that the power oscillations will occur according to these parameters. As we do not have this study, we chose the option *"Trajectories Simulation"*.

8.3 *Synchronous Oscillation Trajectory Simulation*

In the following test, a synchronous oscillation is simulated, where the activation of the Power Swing Alarm is expected. To perform the test click on *"New Trajectory"* then choose the number of points, impedance and angle values. The next step is to enter the rate of change of the impedance which must be different from "*0*". Choose the value of dZ/dt equal to 20.0 Ω /s.

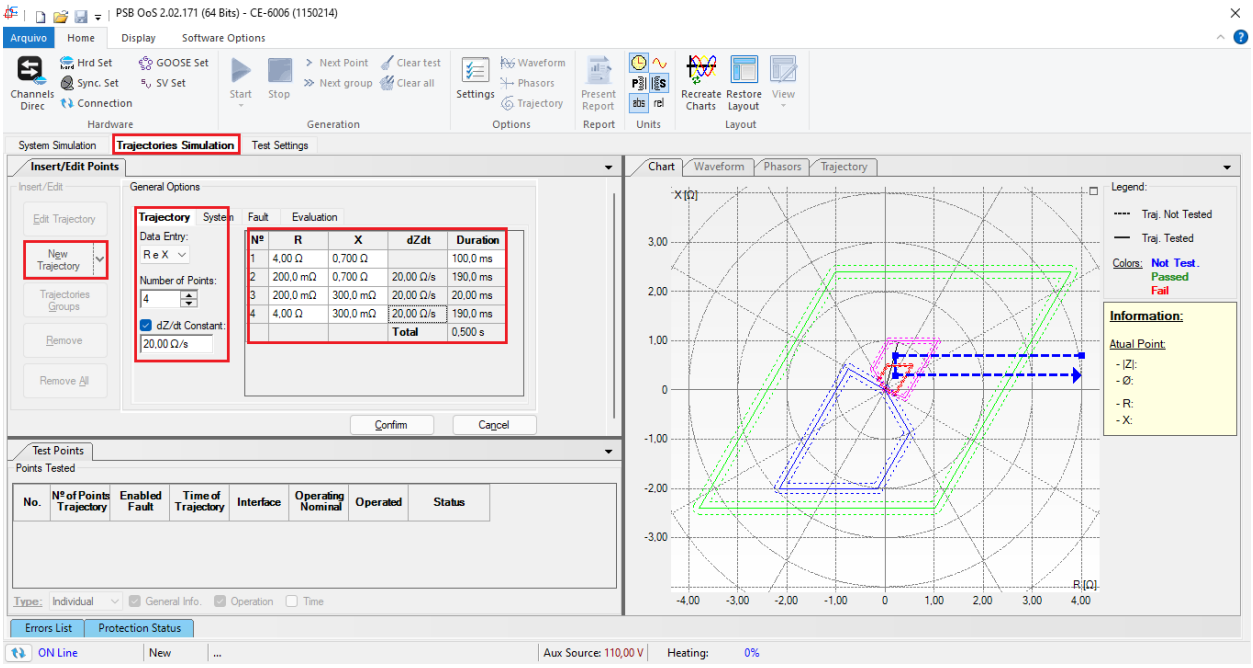

Figure 41

The next step is to configure the *"System"* tab.

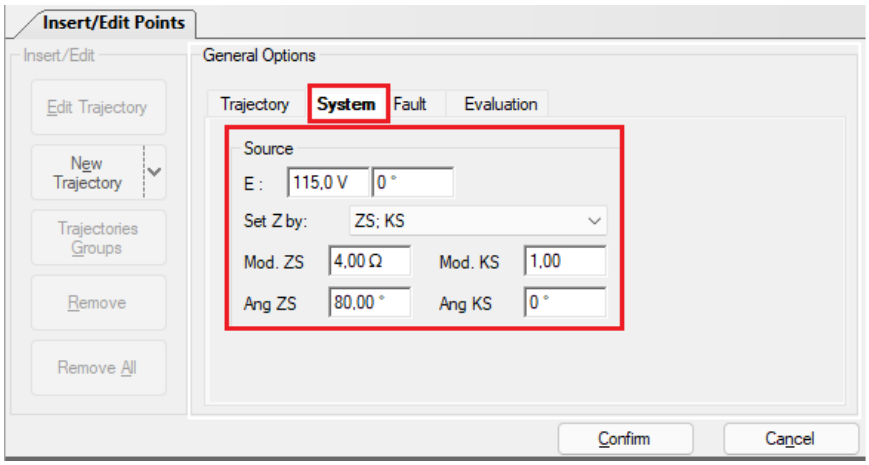

Figure 42

It is not necessary to make any adjustments in the *"Fault"* tab. The next step in the *"Evaluation"* tab is to set the *"Operation"* field to *"Yes"* and the *"Interface"* to *"PSB Alarm"* then click on *"Confirm"*.

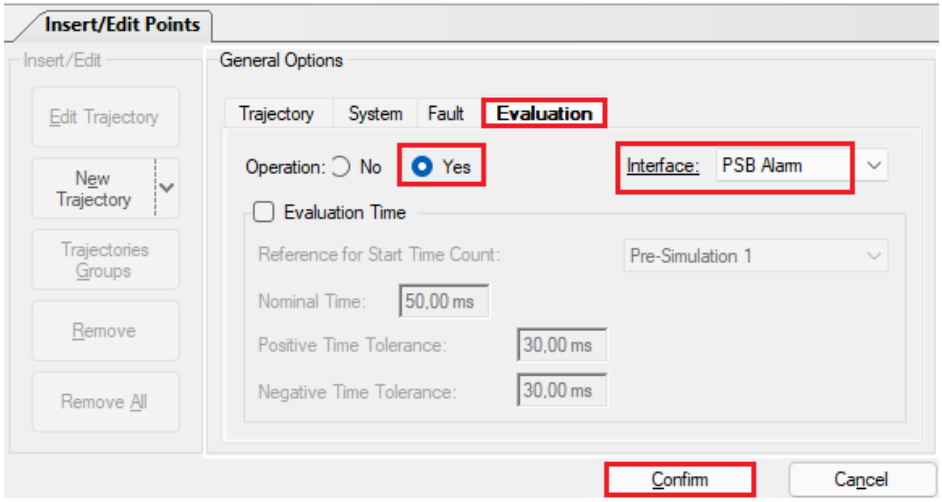

Figure 43

Start the generation by clicking on the icon highlighted below or using the command *"Alt +G"*.

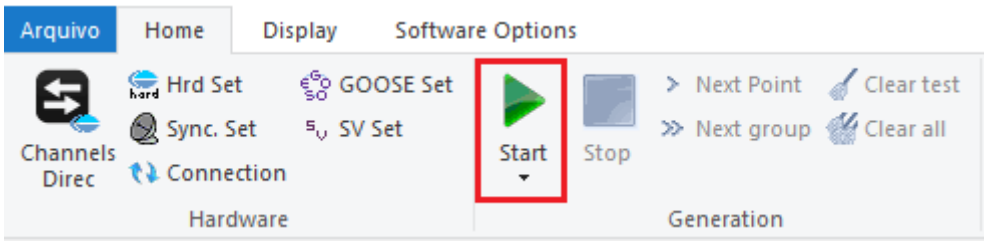

Figure 44

After the end of the test, it is possible to visualize the waveforms, actuation of the binary inputs and the impedance and power trajectories.

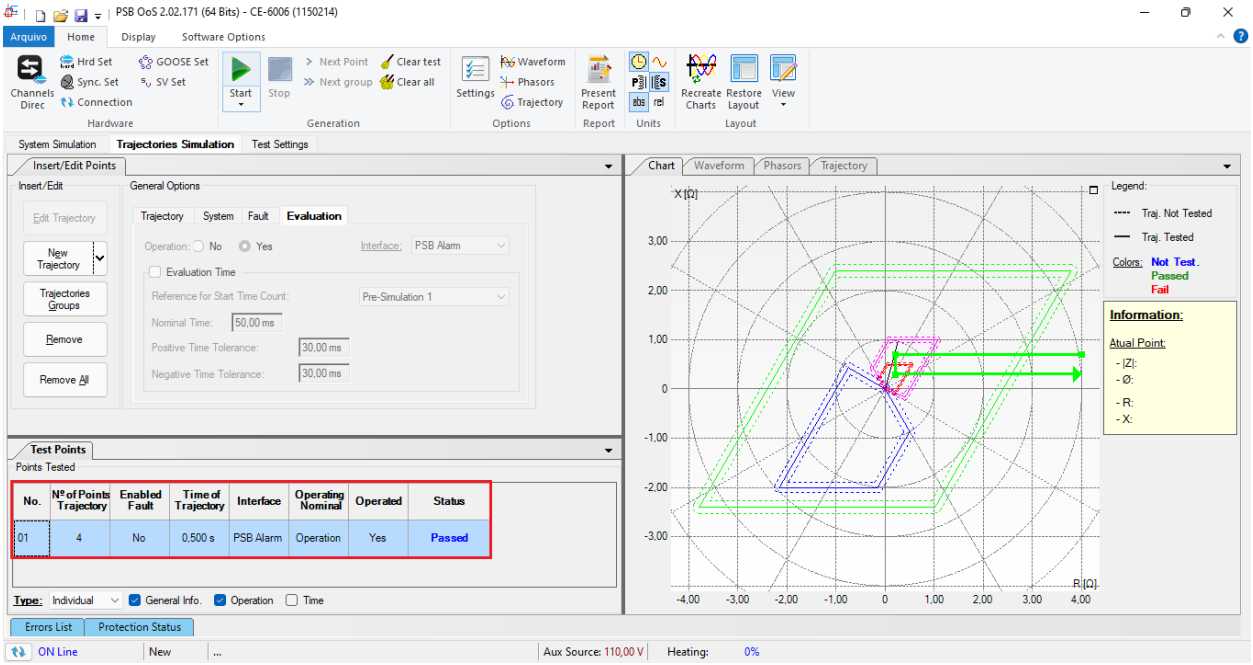

Figure 45

8.4 *Simulation of Asynchronous Oscillation Trajectories*

Click on the *"New Trajectory"* icon, use the highlighted points and keep the impedance variation of the previous test.

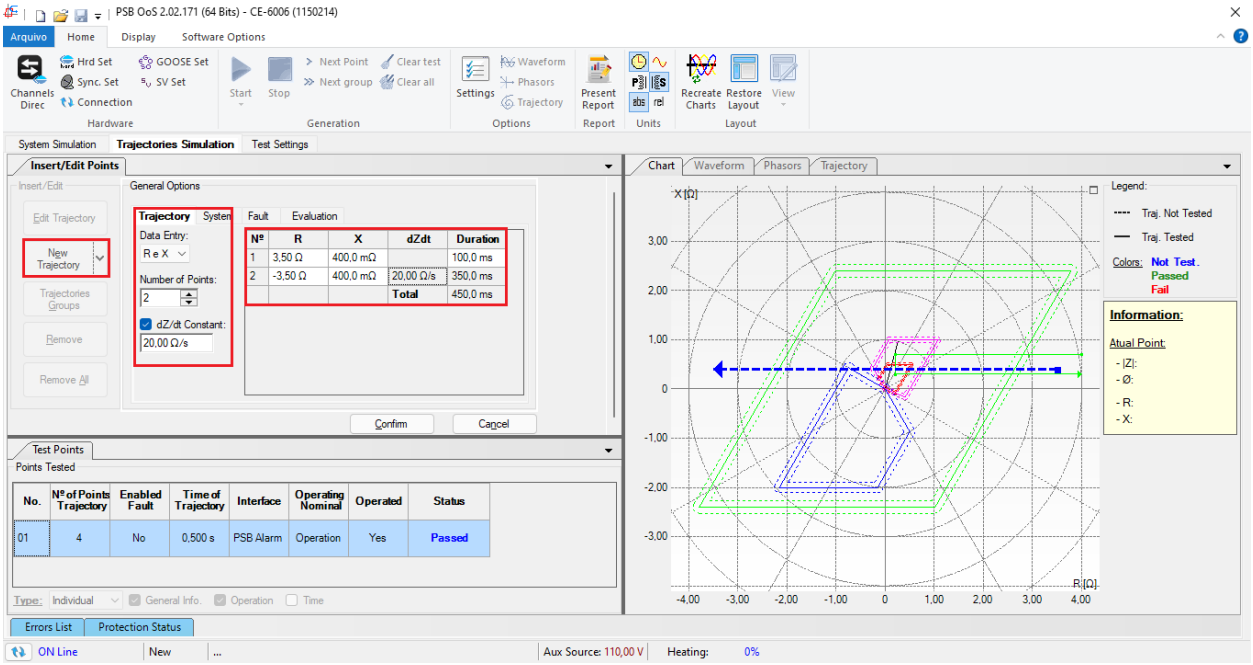

Figure 46

Keep the previous test settings in the *"System"* tab.

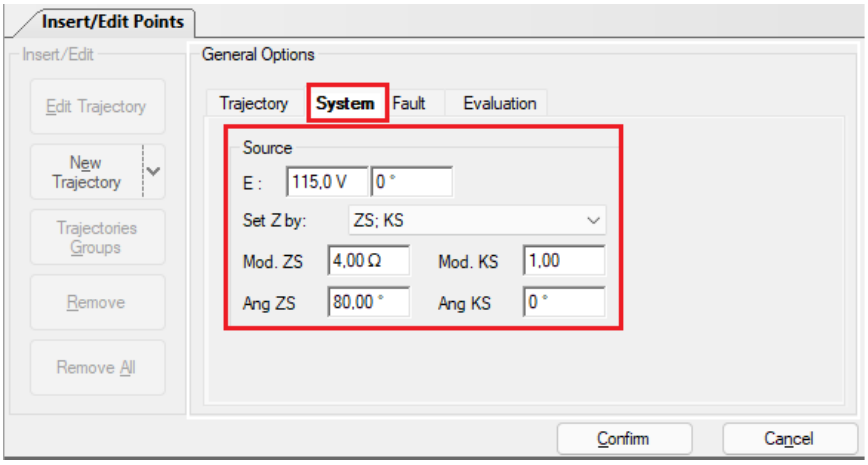

Figure 47

The next adjustment is in the *"Evaluation"* field, where the *"Operation"* should be set to *"Yes"* and the *"Interface"* to *"Trip OoS"*.

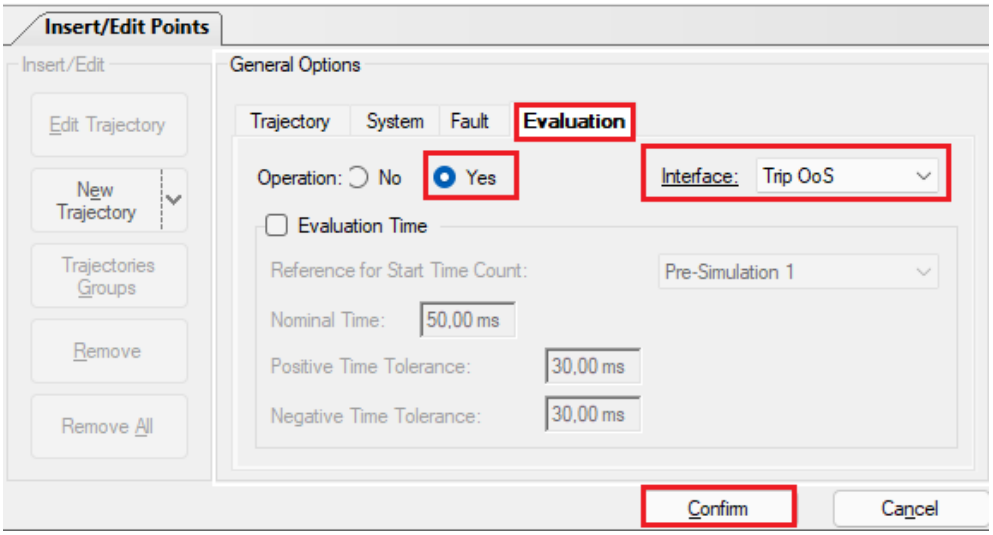

Figure 48

After generating the signals, check the waveforms, the performance of the binary, the impedance trajectory and the time between the blinders following the final result.

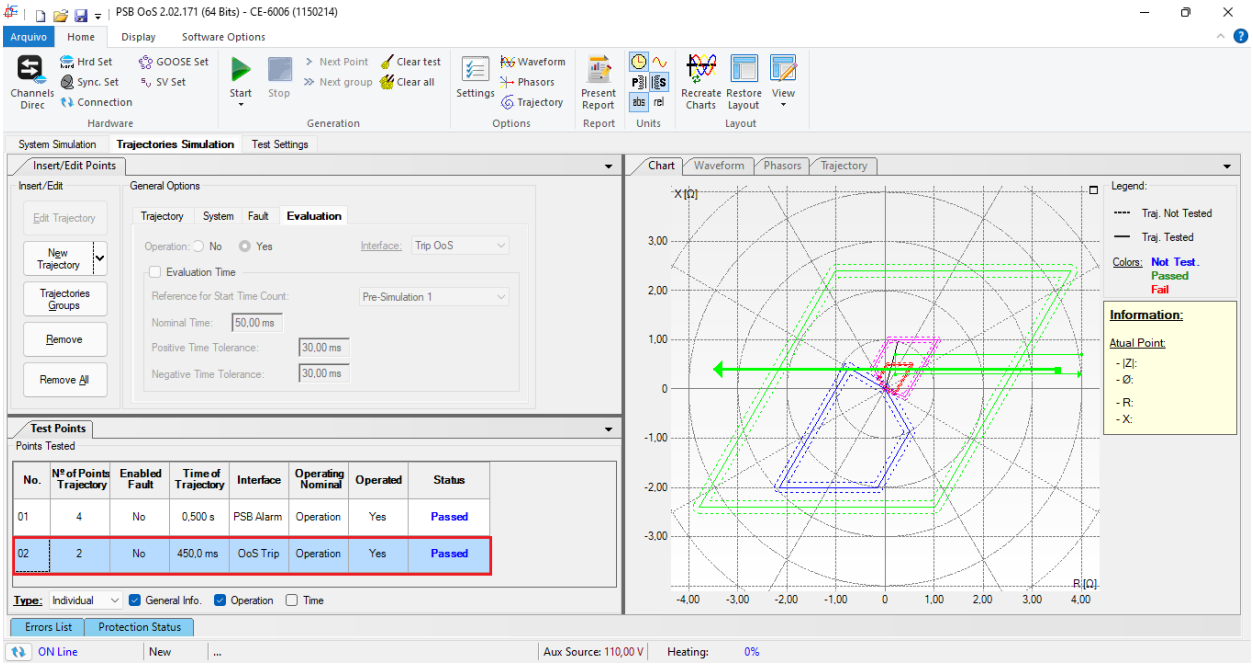

Figure 49

8.5 *Simulation of Three-Phase Fault Trajectories*

In this test, the performance of the distance trip is verified. In this case, a dZ/dt of 100.00Ω/s should be set. To do this, make the following adjustments:

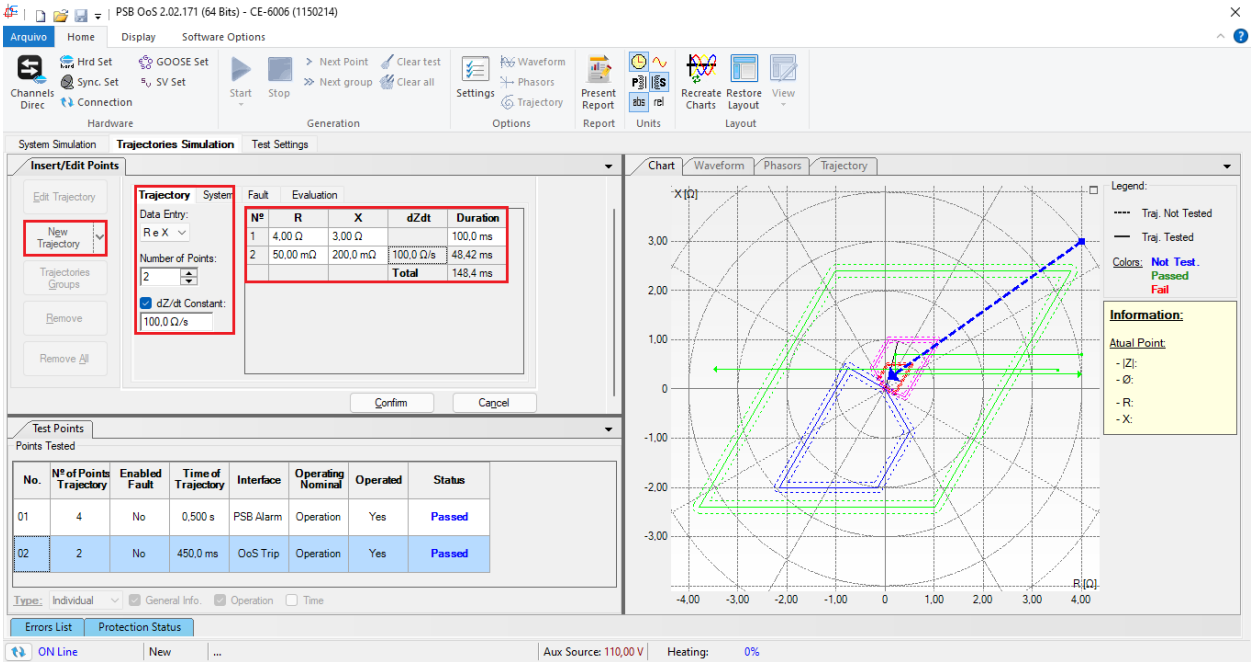

Figure 50

The parameters of the *"System"* tab are the same as in the previous test. The *"Fault"* field must be set as follows:

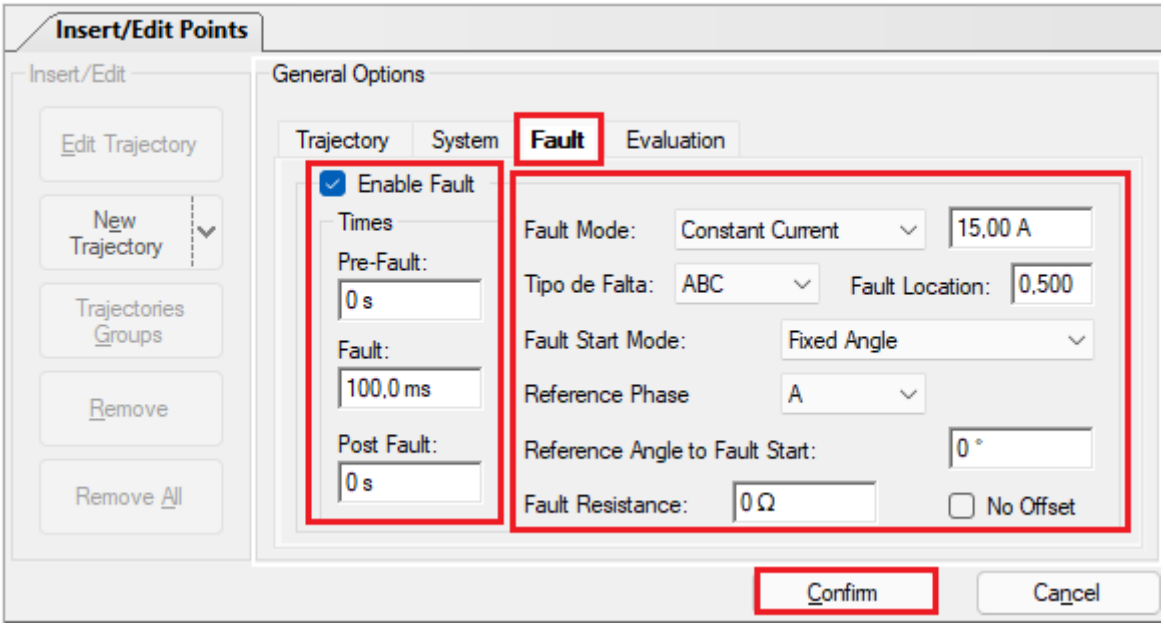

Figure 51

In the *"Evaluation"* option, make the following adjustments:

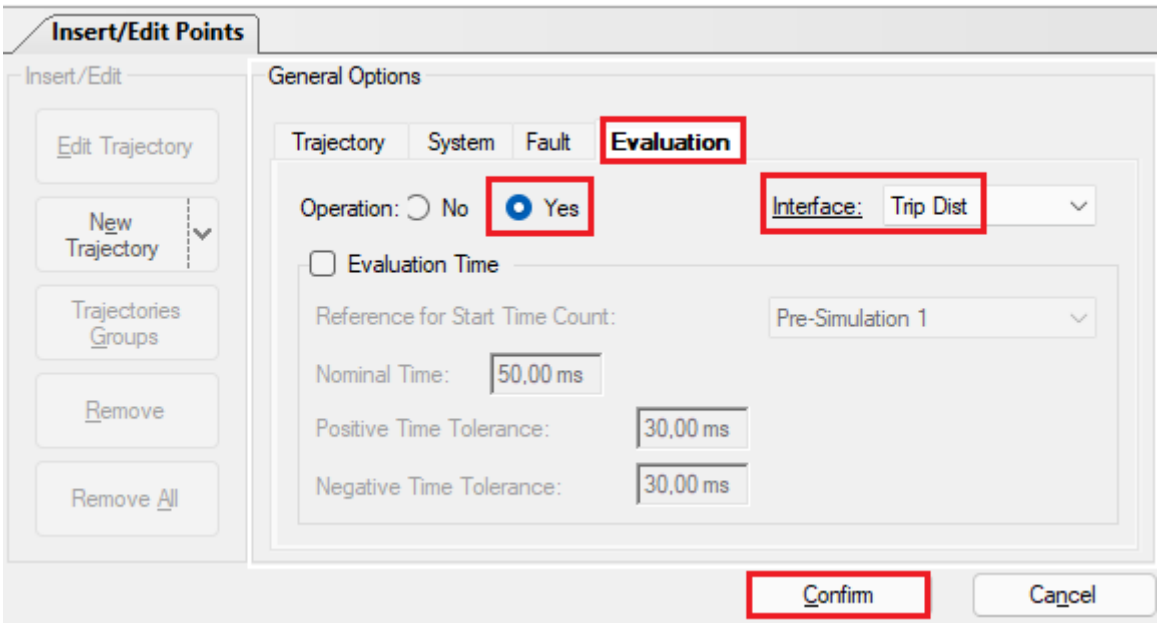

Figure 52

After generating the signals, check the waveforms, the performance of the binary, the impedance trajectory and the time between the blinders following the final result.

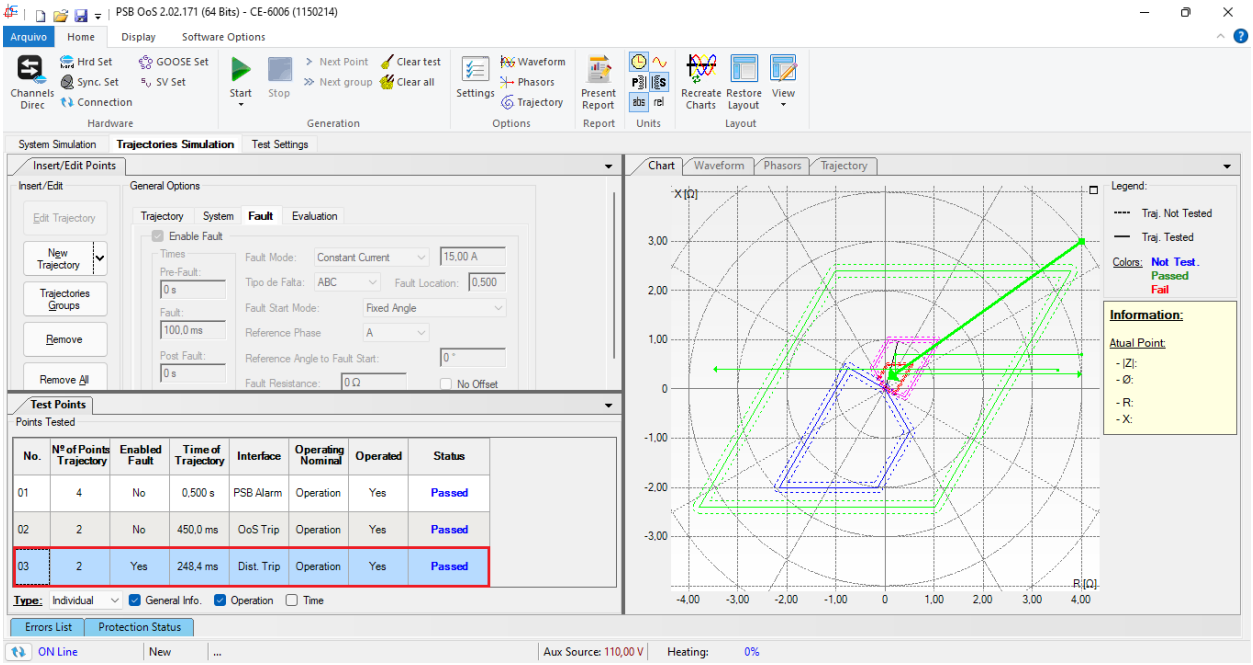

Figure 53

9. Report

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

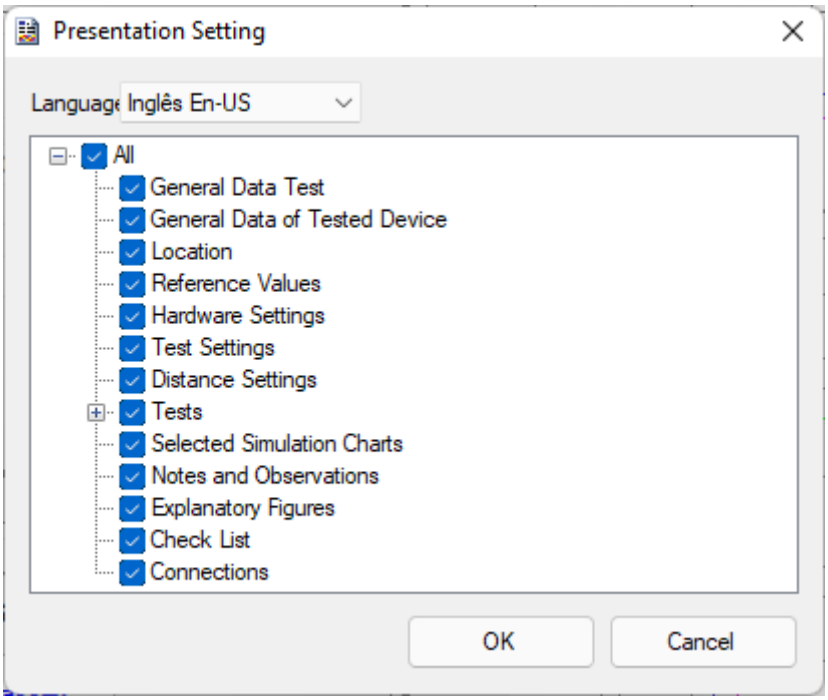

Figure 54

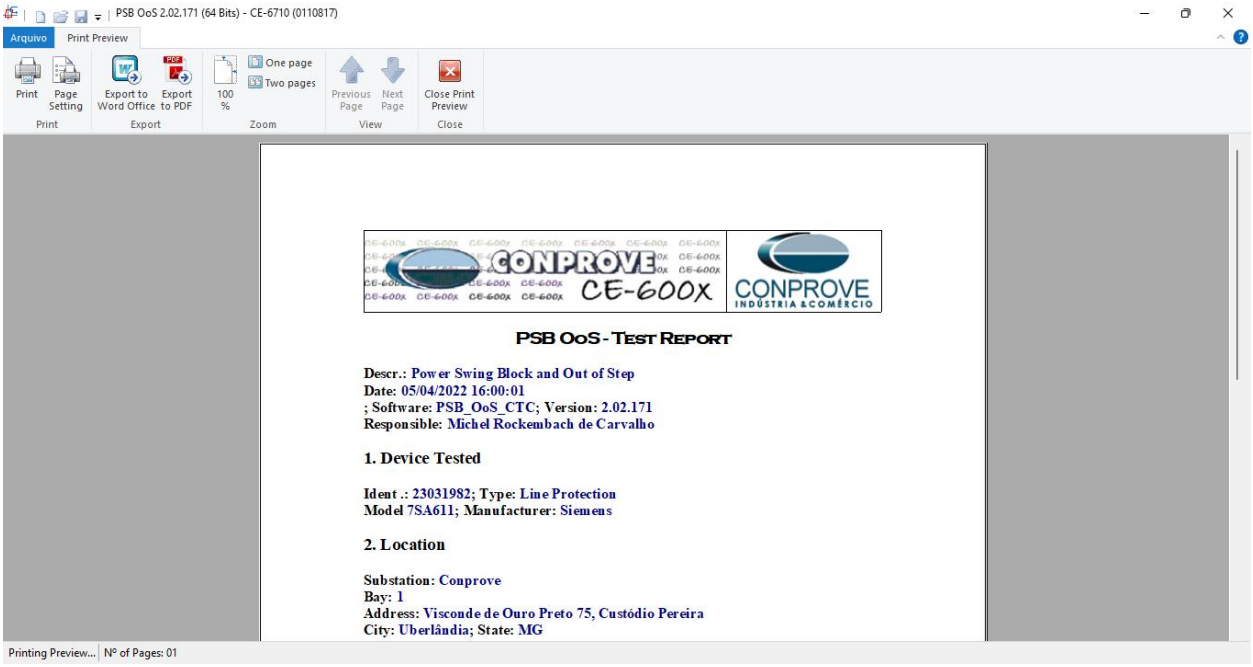
PSB OoS 2.02.171 (64 Bits) - CE-6710 (0110817)
Arquivo
Print Preview
Print
Page Setting
Export to Word Office
Export to PDF
100 %
One page
Two pages
Previous Page
Next Page
Close Print Preview
Zoom
View
Close
CONPROVE
CE-600X
CONPROVE
INDÚSTRIA &COMÉRCIO
PSB OoS - Test Report
Descr.: Power Swing Block and Out of Step
Date: 05/04/2022 16:00:01
; Software: PSB_OoS_CTC; Version: 2.02.171
Responsible: Michel Rockembach de Carvalho
1. Device Tested
Ident .: 23031982; Type: Line Protection
Model 7SA611; Manufacturer: Siemens
2. Location
Substation: Conprove
Bay: 1
Address: Visconde de Ouro Preto 75, Custódio Pereira
City: Uberlândia; State: MG
Printing Preview...
Nº of Pages: 01

Figure 55

APPENDIX A

A.1 Terminal Designations

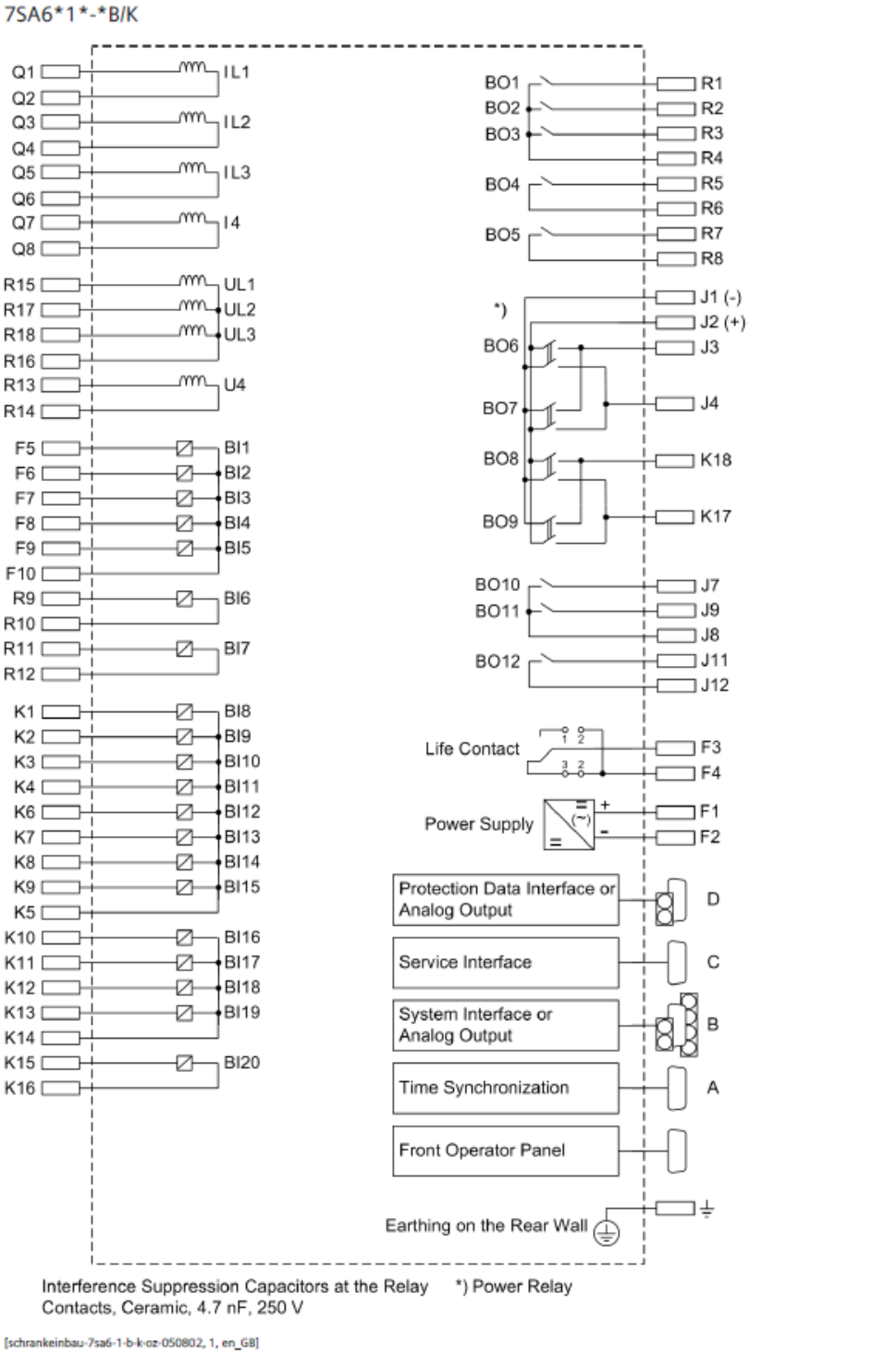

Figure 56

A.2 Technical data

α = Threshold angle for the increased resistance tolerance		10° to 90°	Increments1°
Determination of Direction			
For all types of faults		With phase-true, memorized or cross-polarized voltages	
Directional sensitivity		Dynamically unlimited Stationary approx. 1 V	
Each zone can be set to operate in forward or reverse direction, non-directional or ineffective.			
Load trapezoid:			
R_{load} = minimum load resistance	for I_N = 1 A	0.100 Ω to 600.000 Ω; ∞	Increments0.001 Ω
	for I_N = 5 A	0.020 Ω to 120.000 Ω; ∞	
φ_{load} = maximum load angle		20° to 60°	Increments1°
Dropout to pickup ratio			
- Currents		Approx. 0.95	
- Impedances		Approx. 1.06	
Measured value correction		Mutual impedance matching for parallel lines (ordering option)	
Measuring tolerances for sinusoidal measured values		$\left\|\frac{\Delta X}{X}\right\| \le 5\ \%$ for $30° \le \varphi_k \le 90°$ $\left\|\frac{\Delta R}{R}\right\| \le 5\ \%$ for $0° \le \varphi_k \le 60°$ $\left\|\frac{\Delta Z}{Z}\right\| \le 5\ \%$ for $0° \le \varphi_k \le 90°$	

Times

Shortest trip time	Approx. 17 ms (50 Hz) /15 ms (60 Hz) with fast relay and Approx. 12 ms (50 Hz) /10 ms (60 Hz) with high-speed relay	
Dropout time	Approx. 30 ms	
Stage timers	0.00 s to 30.00 s; ∞ for all zones; separate time setting possibilities for single-phase and multiphase faults for the zones Z1, Z2, and Z1B	Increments 0.01 s
Time expiry tolerances	1 % of setting value or 10 ms	
The set times are pure delay times. The interval from fault inception to trip command is made up of the set delay time plus the measuring time. The minimum measuring time is 10 ms, for faults close to the set zone boundary the maximum measuring time is approximately 40 ms.		

APPENDIX B

Equivalence of software parameters and the relay under test.

Table 1

PSB_OoS Software		Siemens 7SA611 Relay	
Parameter	**Figure**	**Parameter**	**Figure**
Mod Z0/Z1	30	Zero seq. comp. K0 for Z1	16
Ang Z0/Z1	30	Zero seq. comp. Angle for Z1	16
Zn1_Fase		Phase Distance Z1	
Distance Angle	31	Angle of inclination, distance charact.	16
Forward/Reverse/Non-Directional	31	Operating mode Z1	19
R	31	R(Z1), Resistance for ph-ph faults	19
X	31	X(Z1), Reactance	19
Trigger Time	31	T1 multi-ph, delay for multiphase faults	19
Zone Reduction	31	Zone Reduction Angle	19
Zn2_Fase		Phase Distance Z2	
Distance Angle	32	Angle of inclination, distance charact.	16
Forward/Reverse/Non-Directional	32	Operating mode Z2	20
R	32	R(Z2), Resistance for ph-ph faults	20
X	32	X(Z2), Reactance	20
Trigger Time	32	T2 multi-ph, delay for multiphase faults	20
Zone Reduction	32	Zone Reduction Angle	20
Zn3_Fase		Phase Distance Z3	
Distance Angle	33	Angle of inclination, distance charact.	16
Forward/Reverse/Non-Directional	33	Operating mode Z3	21
R	33	R(Z3), Resistance for ph-ph faults	21
X	33	X(Z3), Reactance	21
Trigger Time	33	T3 multi-ph, delay for multiphase faults	21
Zone Reduction	33	Zone Reduction Angle	21
Zn4_Fase		Phase Distance Z4	
Distance Angle	34	Angle of inclination, distance charact.	16
Forward/Reverse/Non-Directional	34	Operating mode Z4	22
R	34	R(Z4), Resistance for ph-ph faults	22
X	34	X(Z4), Reactance	22
Temp. Disp.	34	T4 multi-ph, delay for multiphase faults	22
Zone Reduction	34	Zone Reduction Angle	22

APPENDIX C

In the DIGSI software, export the .RIO file. Open the *"21 Distance zones (quadrilateral)"* window and choose the *"Export"* option.

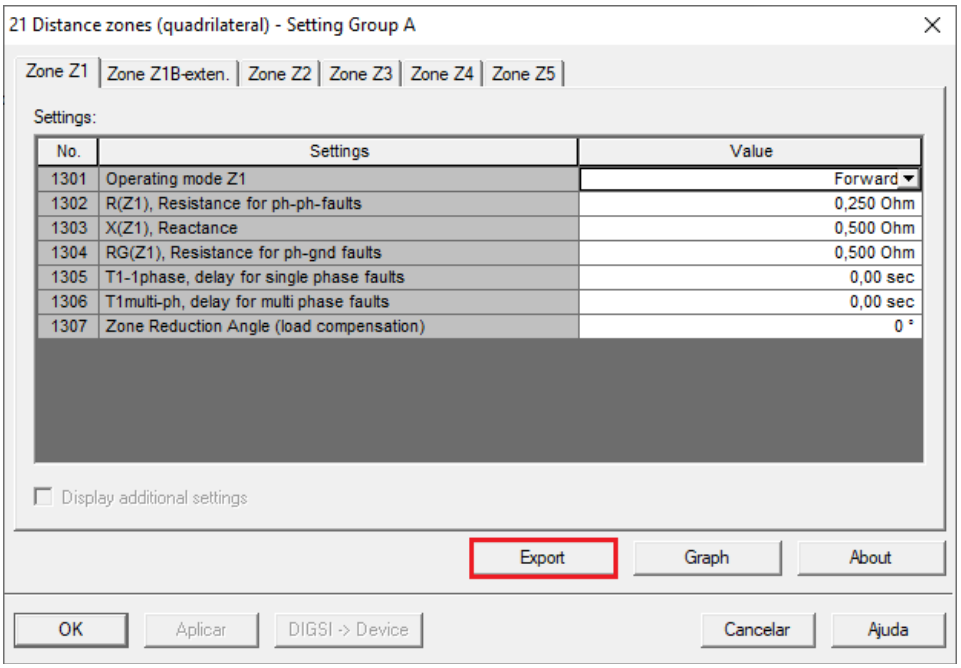

Figure 57

Click *"OK"* on the next screen.

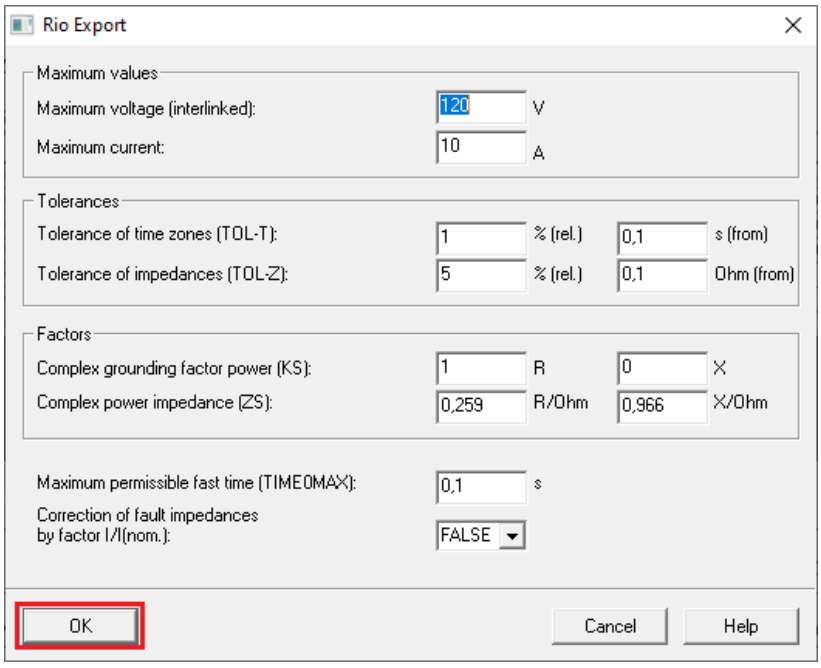

Figure 58

Choose a name and folder to save the file.

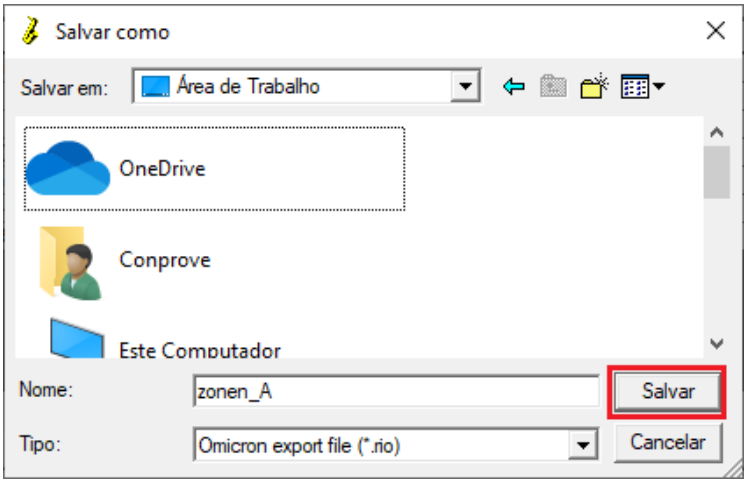

Figure 59

In the PSB OoS software, inside the *"Settings"* window, import the file in the *".RIO"* extension.

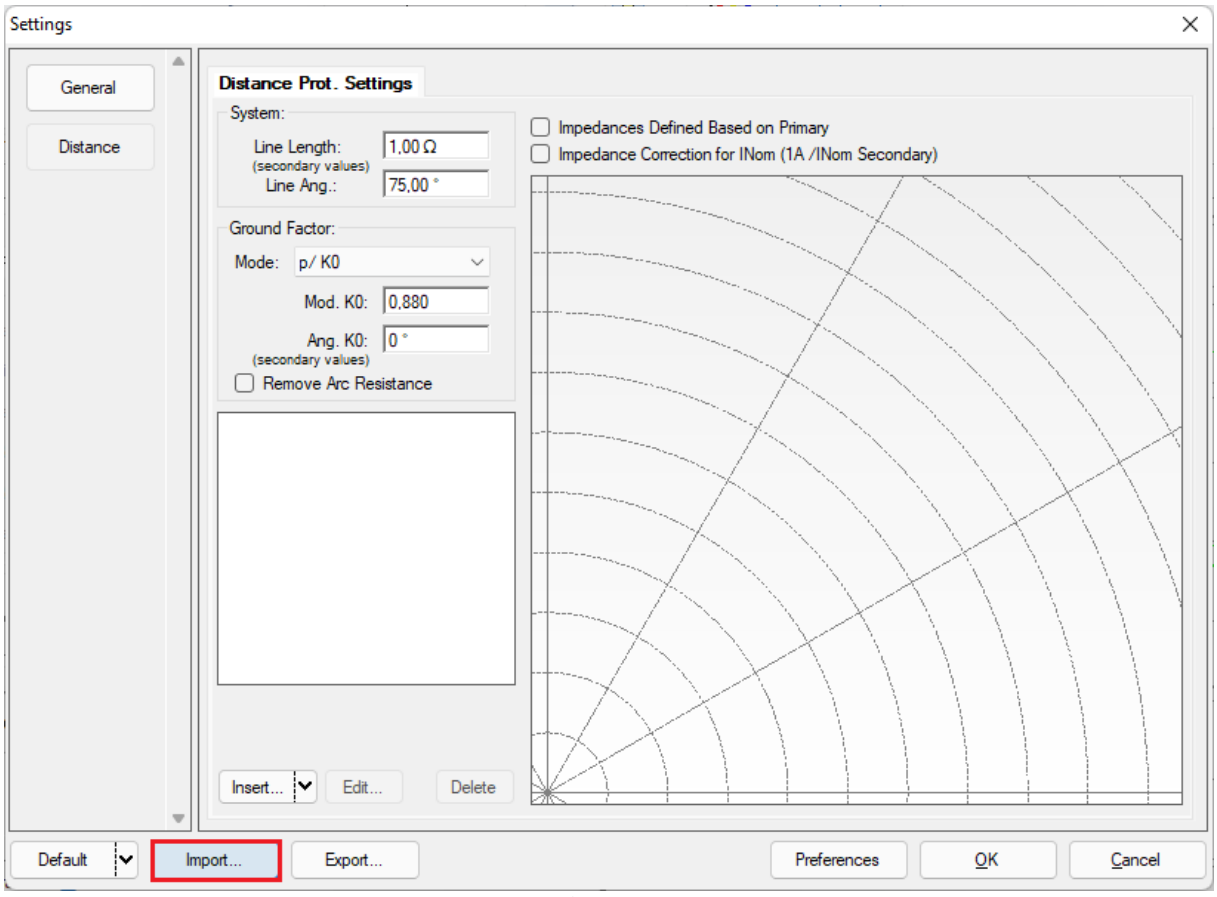

Figure 60

The figure below shows that all zones are registered, including earth fault zones.

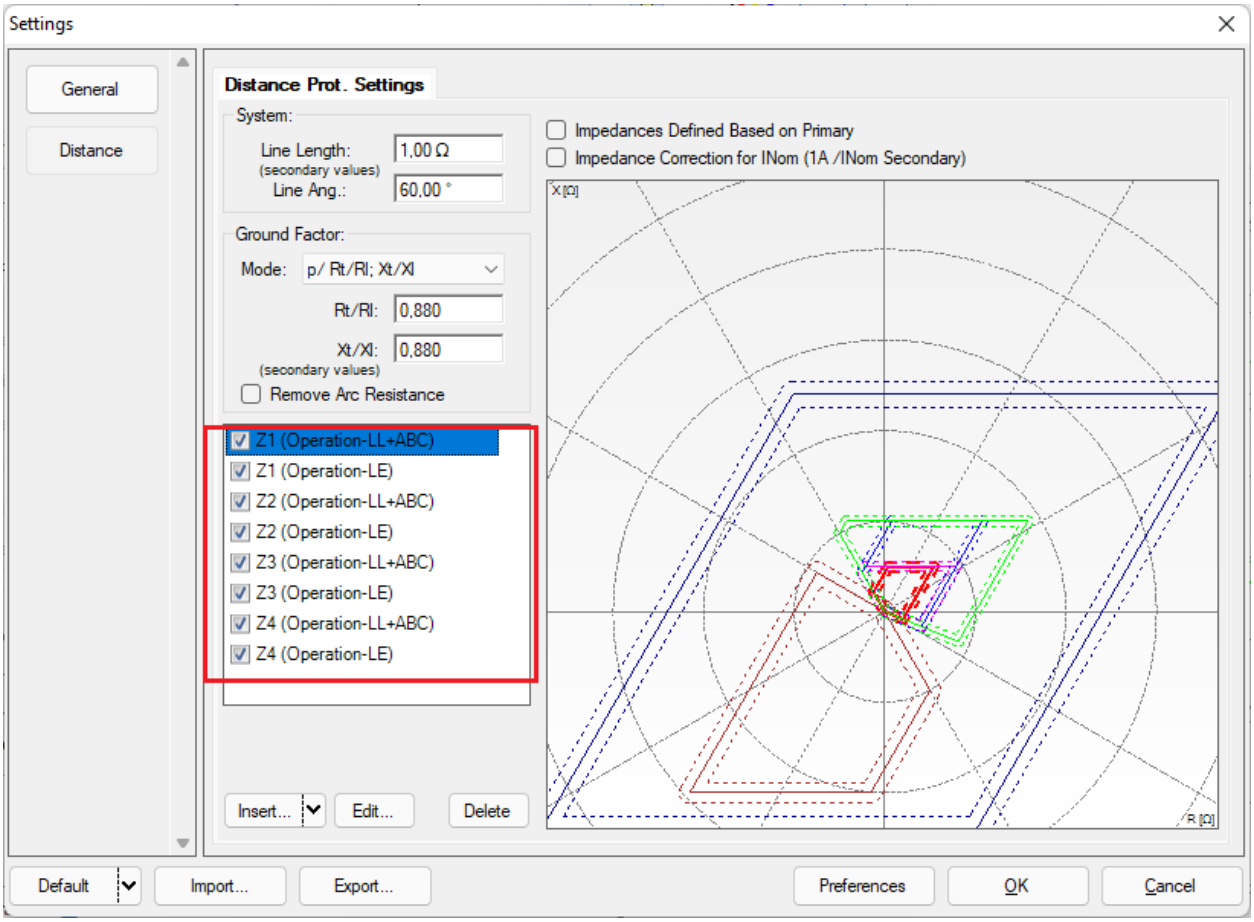

Figure 61