INSTRUMENTOS PARA TESTES ELÉTRICOS

Test Tutorial

Equipment Type: Protection Relay

Brand: SIEMENS

Model: 7SA611

Functions: 21 or PDIS – Distance

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

Objective: Search and Point Test of Zones with Quadrilateral Characteristics

Version Control:

Version	Descriptions	Date	Author	Reviewer
1.0	Initial Version	06/08/2021	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 contacting 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 tested 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 tested and also be aware of safety standards and regulations.

Copyright

1. Relay connection to CE-6006

Appendix A shows the relay terminal designations.

1.1 *Auxiliary Source*

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

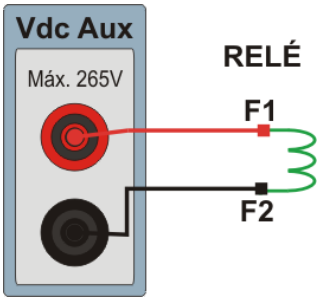

Figure 1

1.2 *Current and Voltage Coils*

To establish the voltage coil connection, connect V1, V2 and V3 channels with the relay terminal pins R15, R17 and R18 and the common ones to pin R16. To establish the connection of the current coils, connect I4, I5 and I6 channels with pins Q1, Q3 and Q5 of the relay terminal and make a short circuit between pins Q2, Q4 and Q6, finally connect pin Q6 to Q8 and connect the current channel commons to pin Q7.

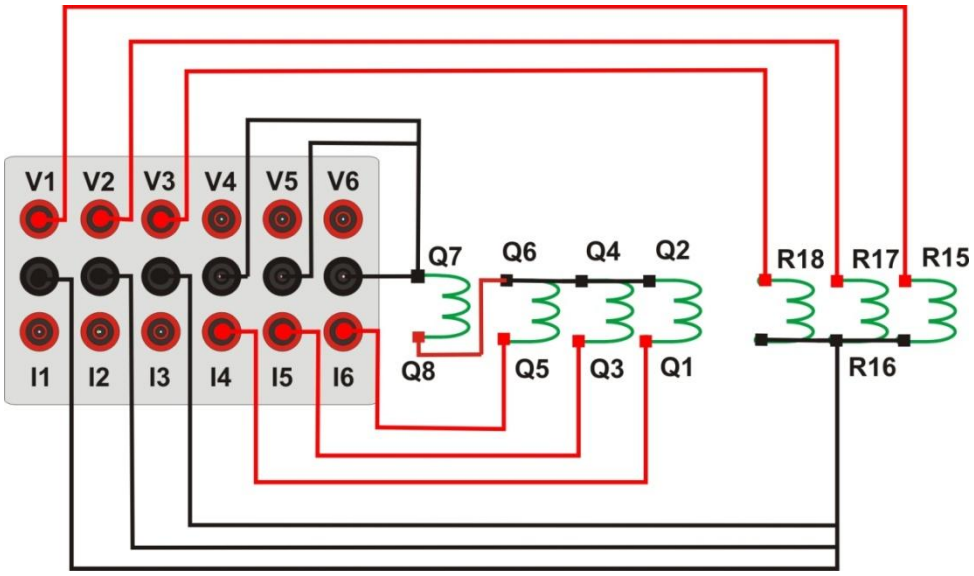

Figure 2

1.3 *Binary Inputs*

Connect the CE-6006 binary input to the relay binary output, BI1 to pin R1 and its common to R5 in this way, the trip signal sent by the relay is monitored.

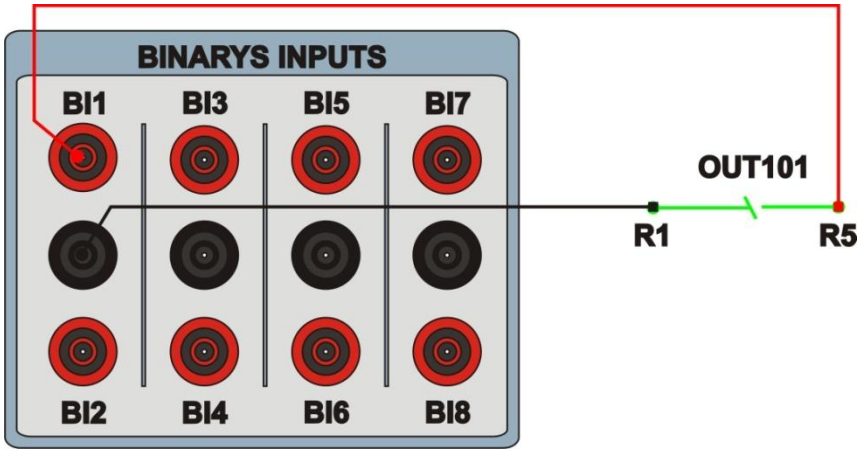

Figure 3

2. Communication with 7SA6 relay

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

Figure 4

When opening the program, the substation that contains the relay (7SA6) 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.

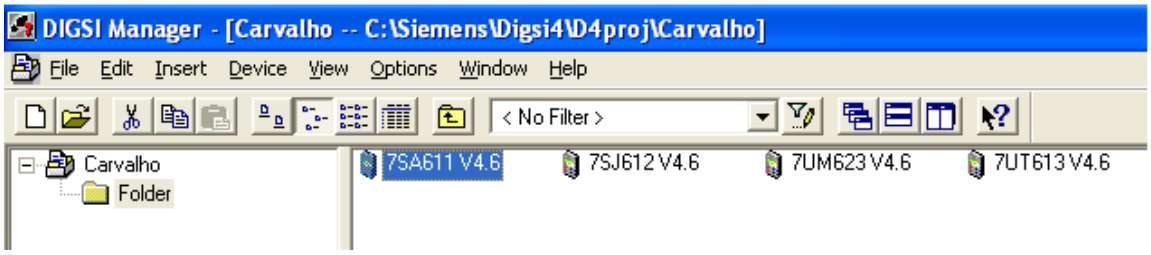

Figure 5

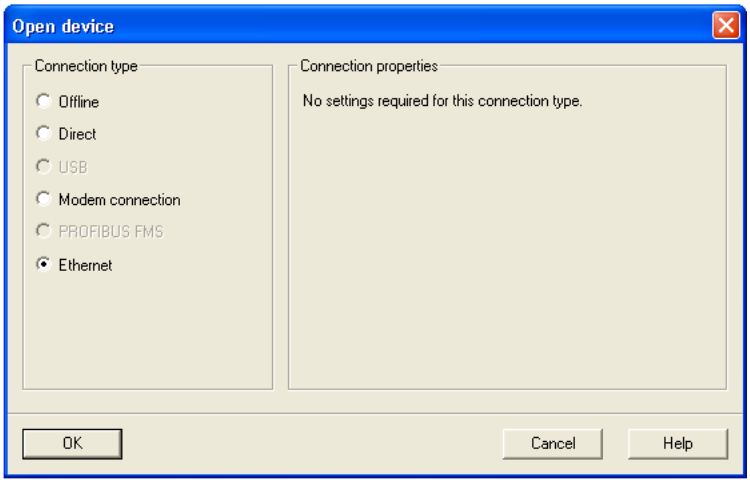

Figure 6

3. Parameterization of the 7SA6 relay

3.1 *Device Configurations*

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

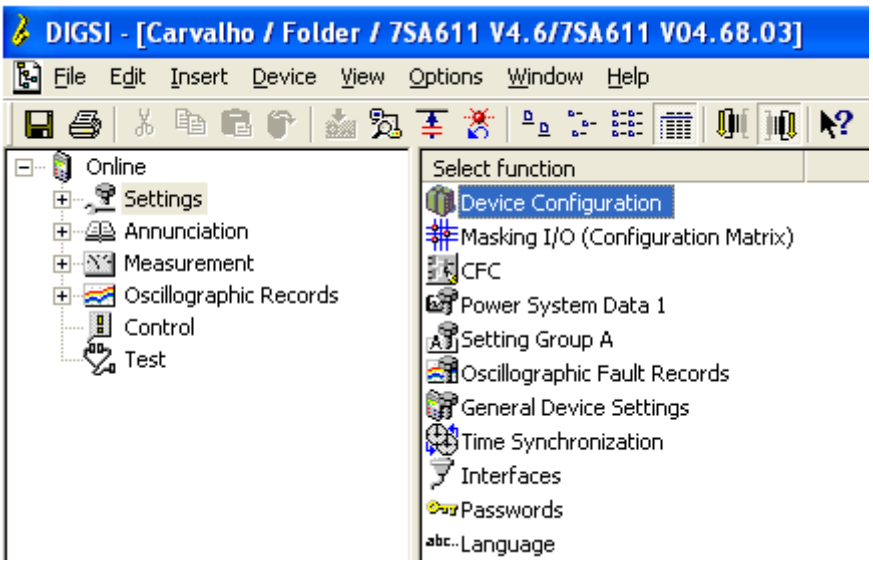

Figure 7

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

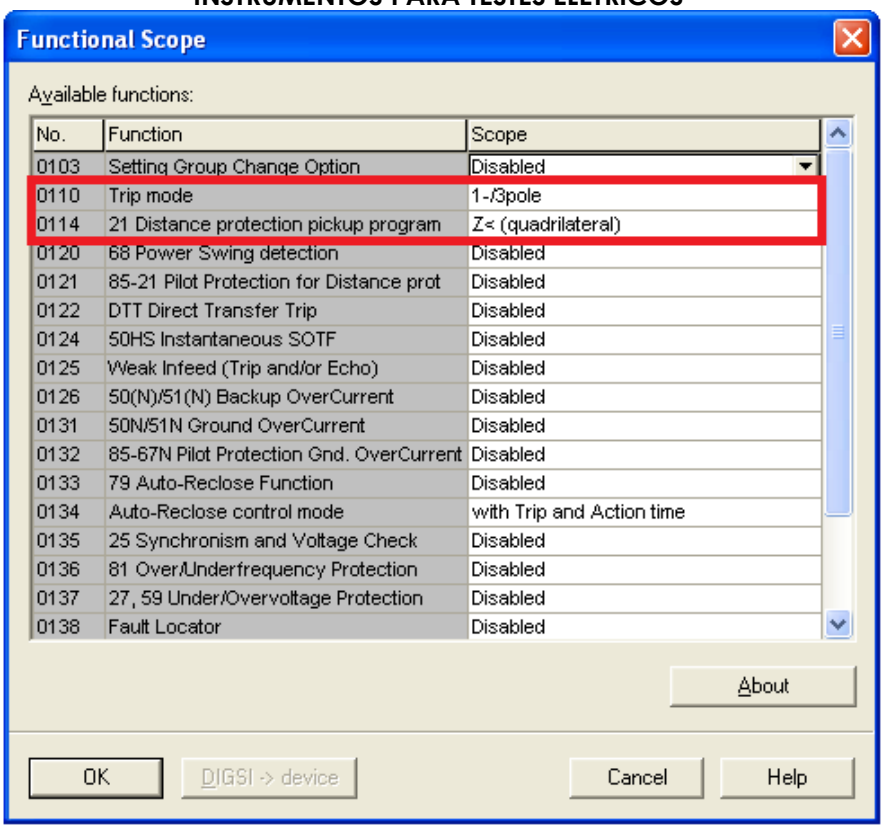

Figure 8

3.2 *Masking I/O*

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

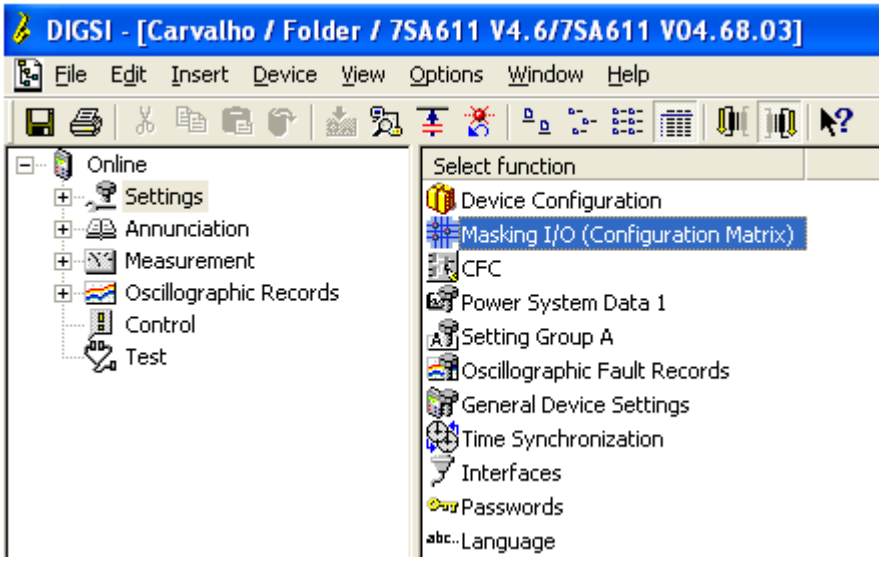

Figure 9

Binary output BO1 is designated for sending the trip of zones 1, 2, 3 and 4. In order to aid the test, LED 1 is used to signal the trip sending of zone 1, LED 2 to signal the zone 2 trip send, LED 3 to signal zone 3 trip send and LED 4 to signal zone 4 trip send.

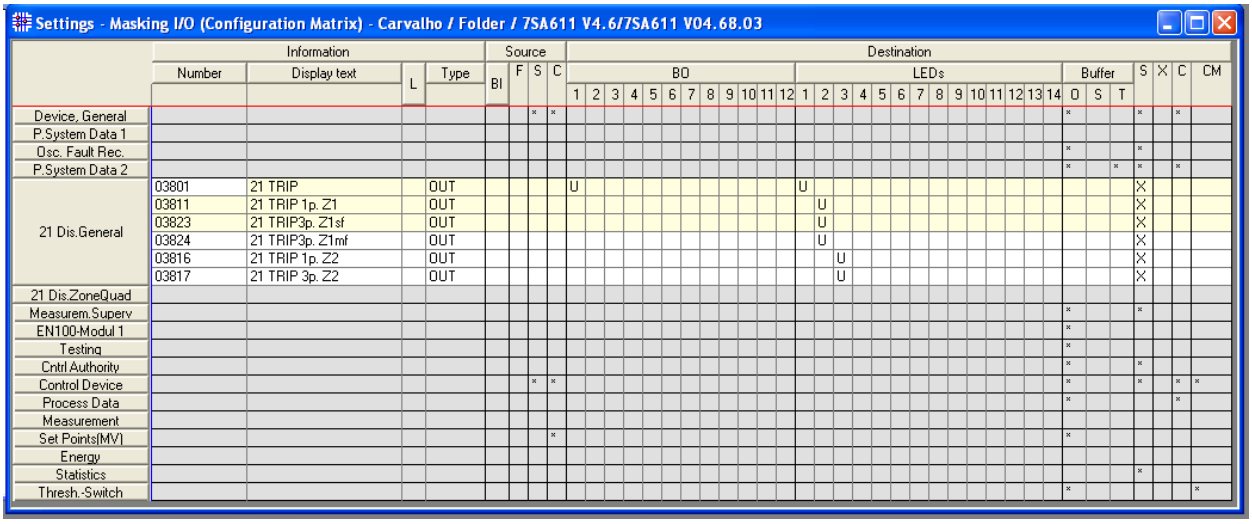

Figure 10

3.3 *Power System Data 1*

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

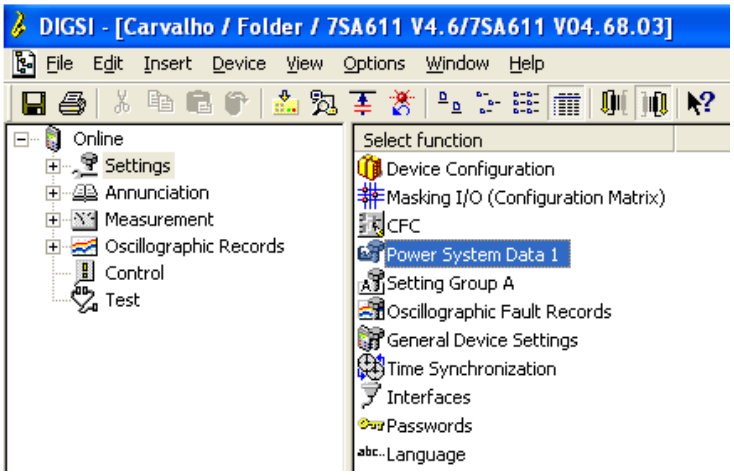

Figure 11

Those settings highlighted in red need special attention. Firstly, the VT and CT data are shown, then the system data and finally the breaker data.

3.4 *Transformers*

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

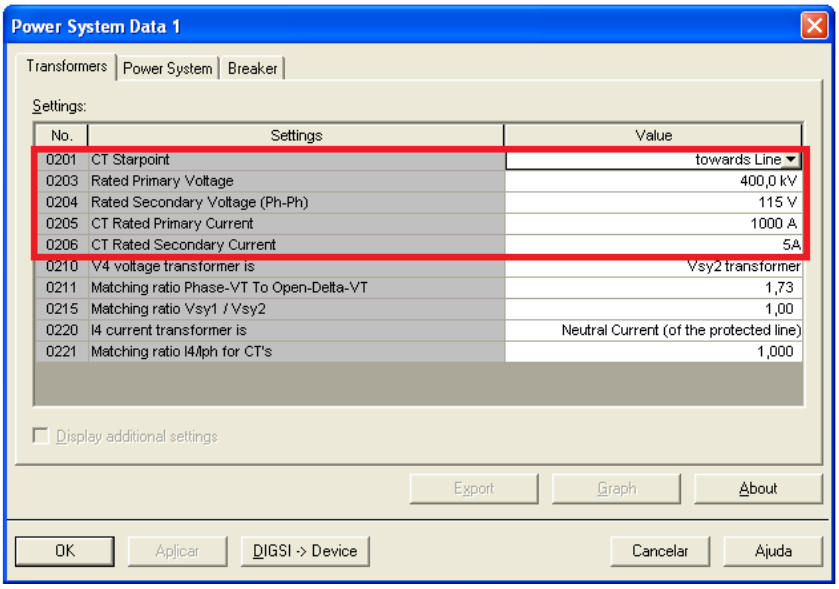

Figure 12

3.5 *Power System*

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

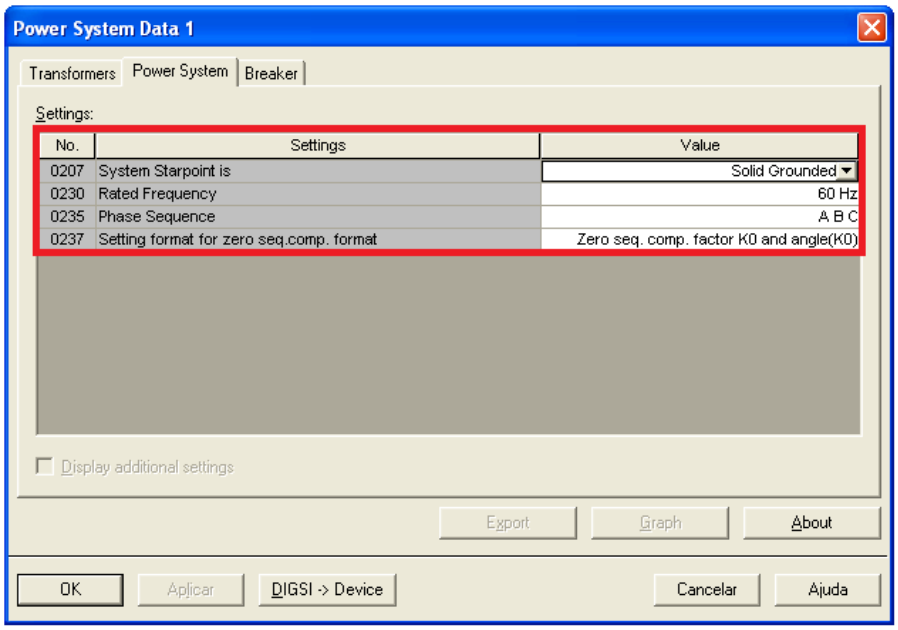

Figure 13

3.6 *Setting Group A*

This option sets important data about the protected transmission line and the parameters of the impedance function, whose calculations will be shown later.

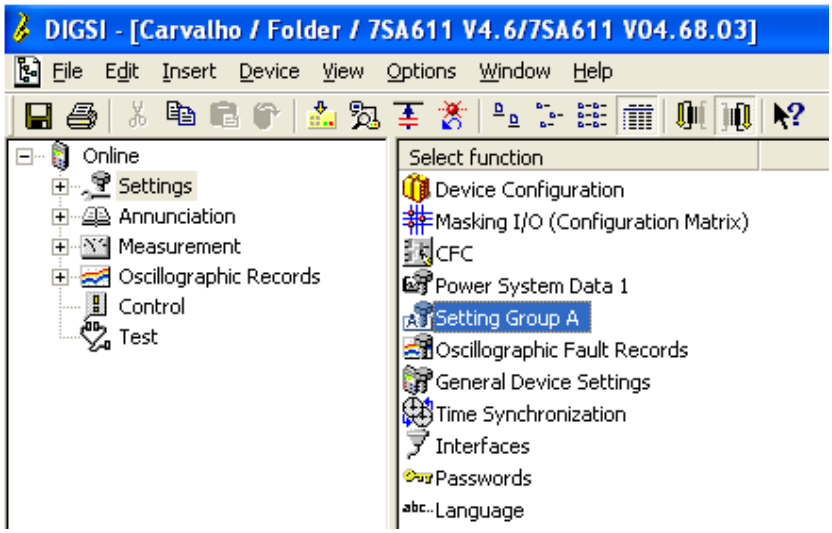

Figure 14

Double-click on the *"Power System Data 2"* option.

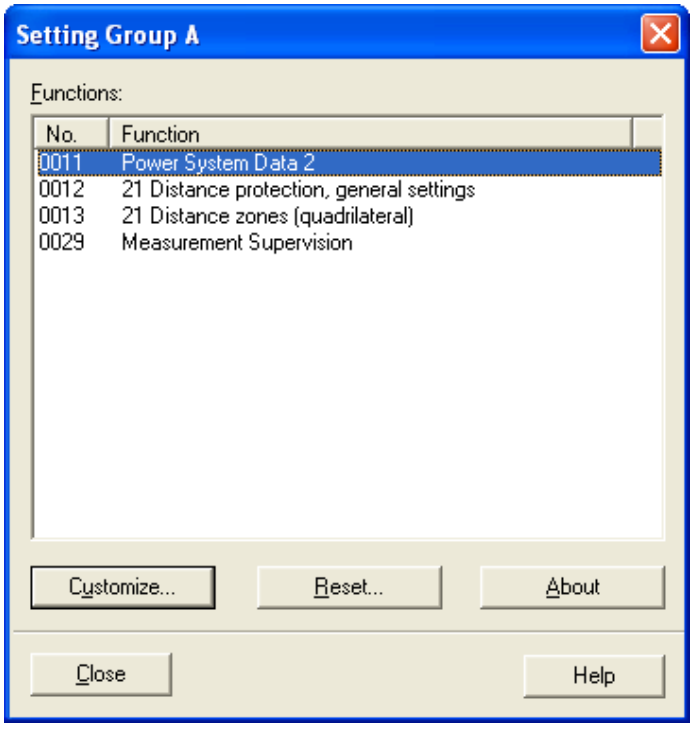

Figure 15

3.7 *Power System Data 2*

In the *"Power System"* tab, important data such as: measurement full scale voltage and current, line angle, slope angle of the distance characteristic and the compensation factors for ground faults are parameterized.

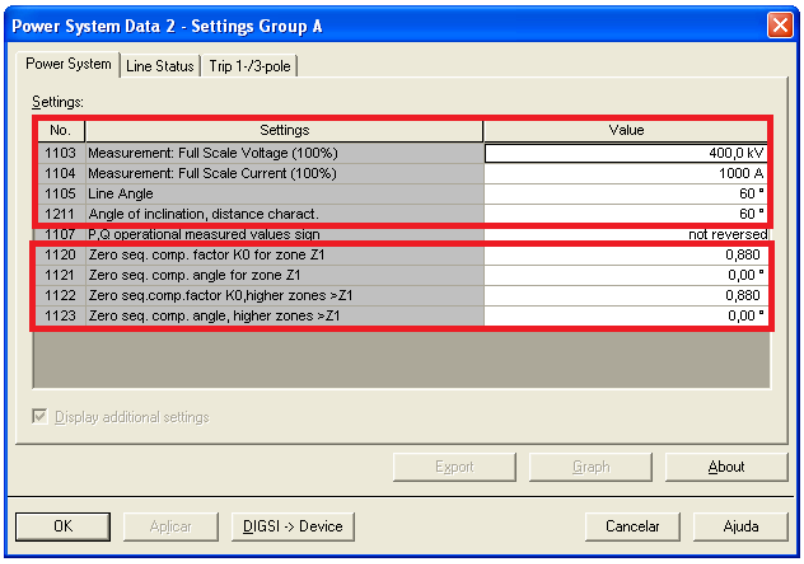

Figure 16

3.8 *21 Distance Protection/General settings*

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

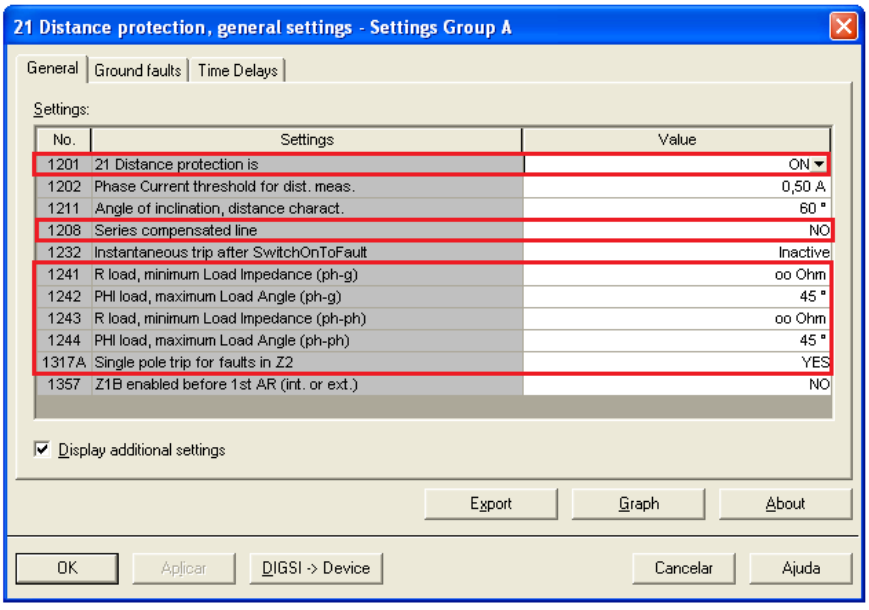

Figure 17

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

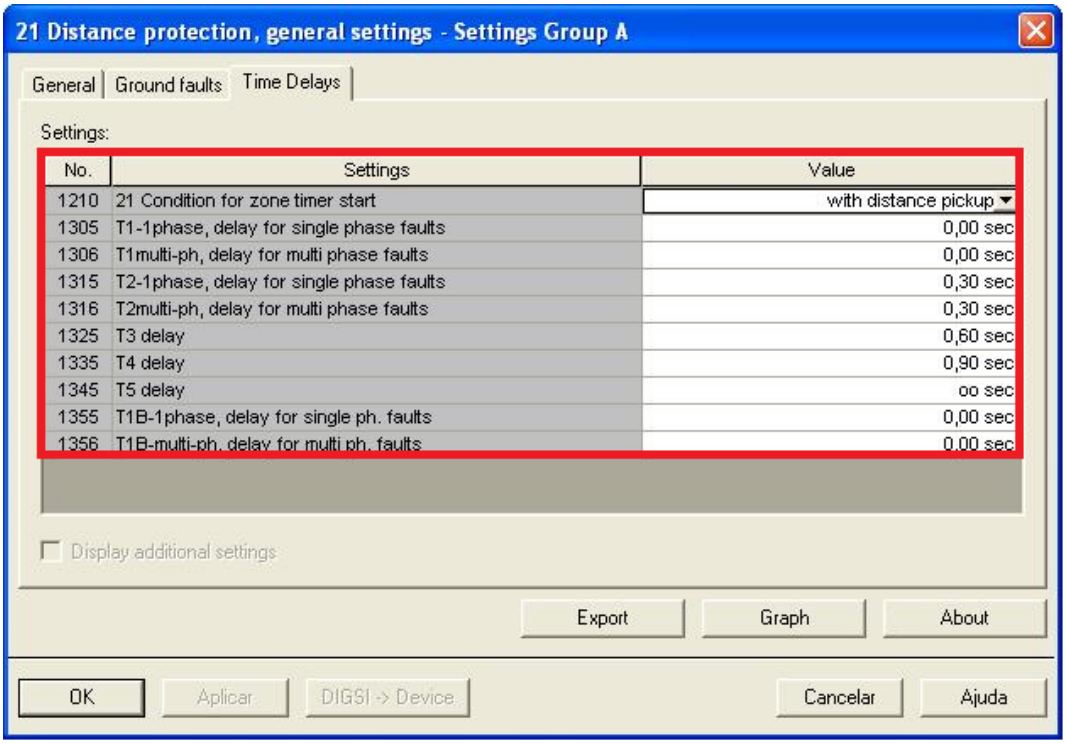

Figure 18

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 delays. In this test the Z1B zone will not be used.

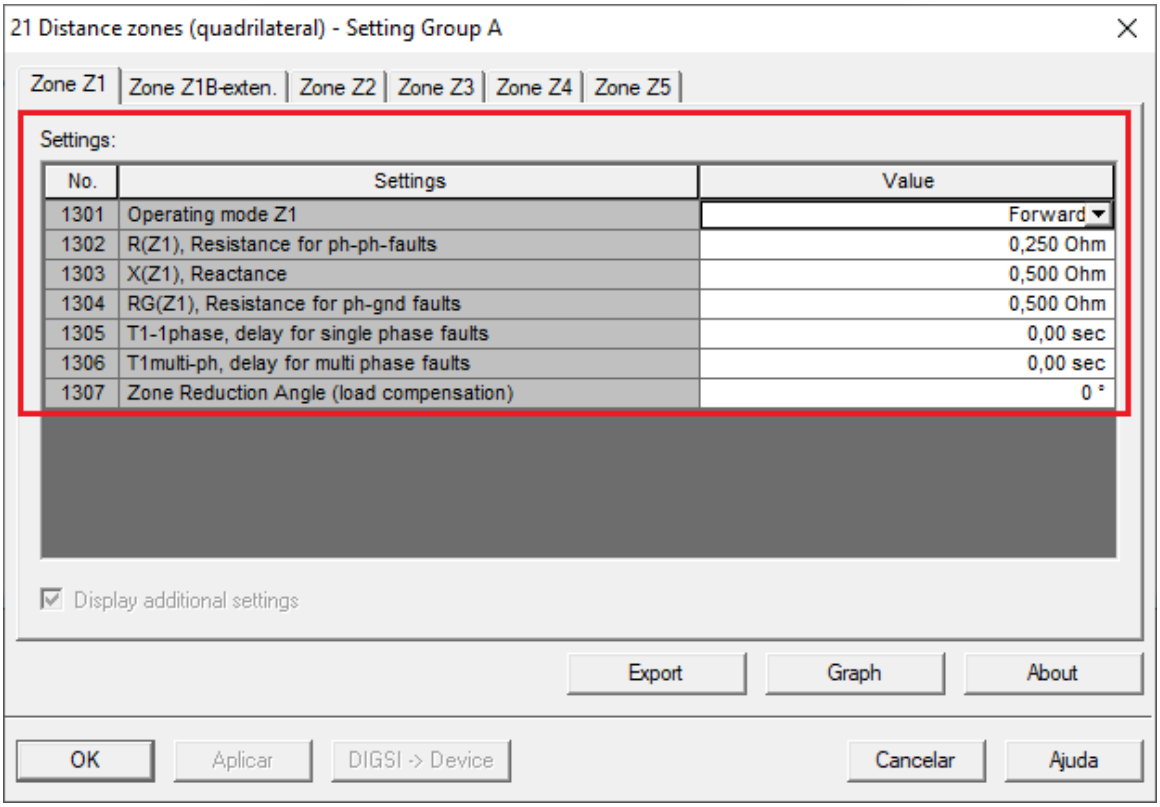

Figure 19

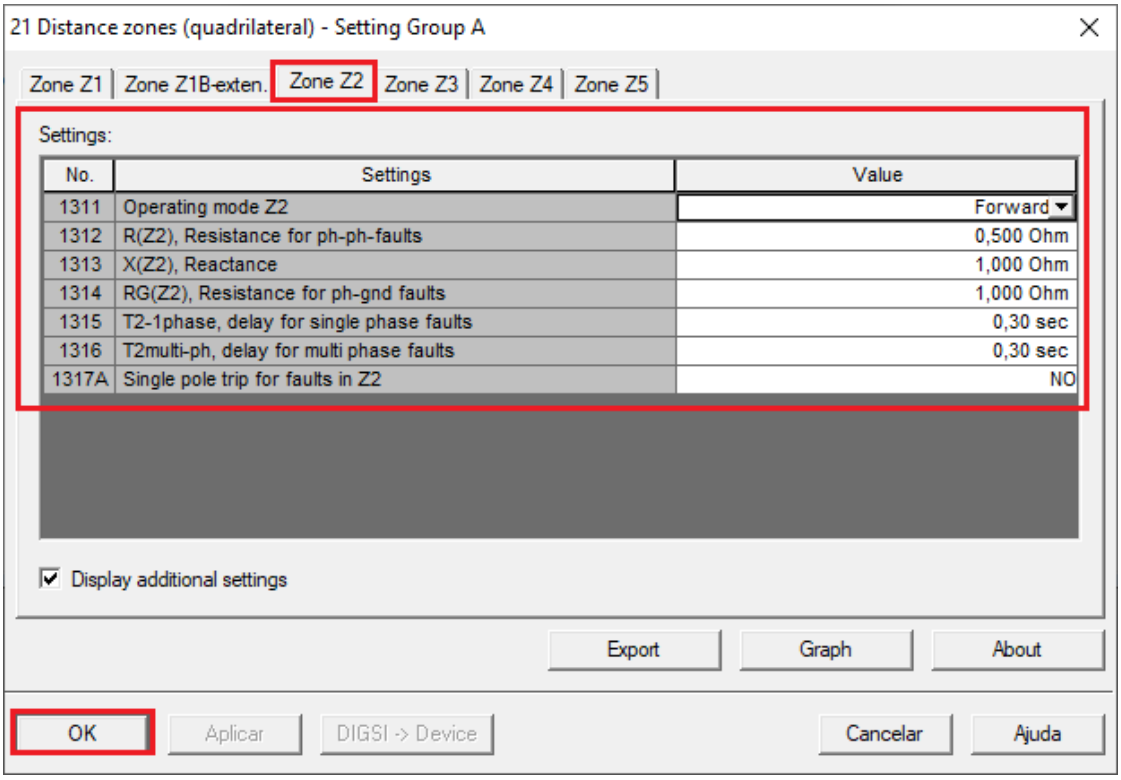

Figure 20

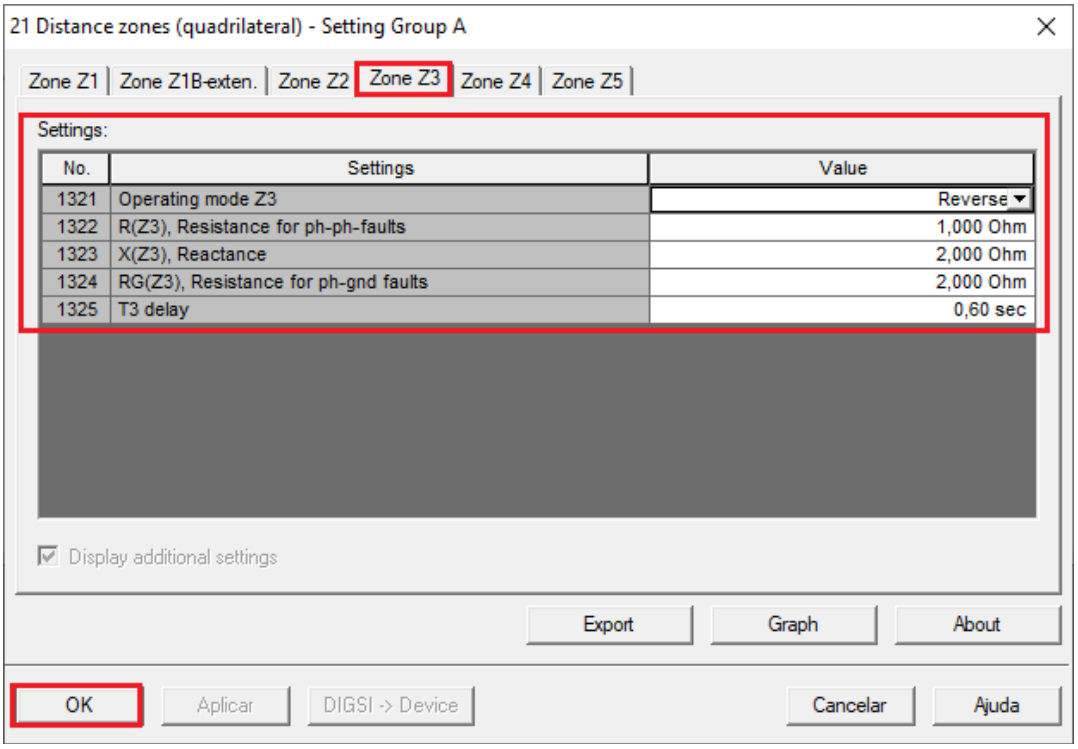

Figure 21

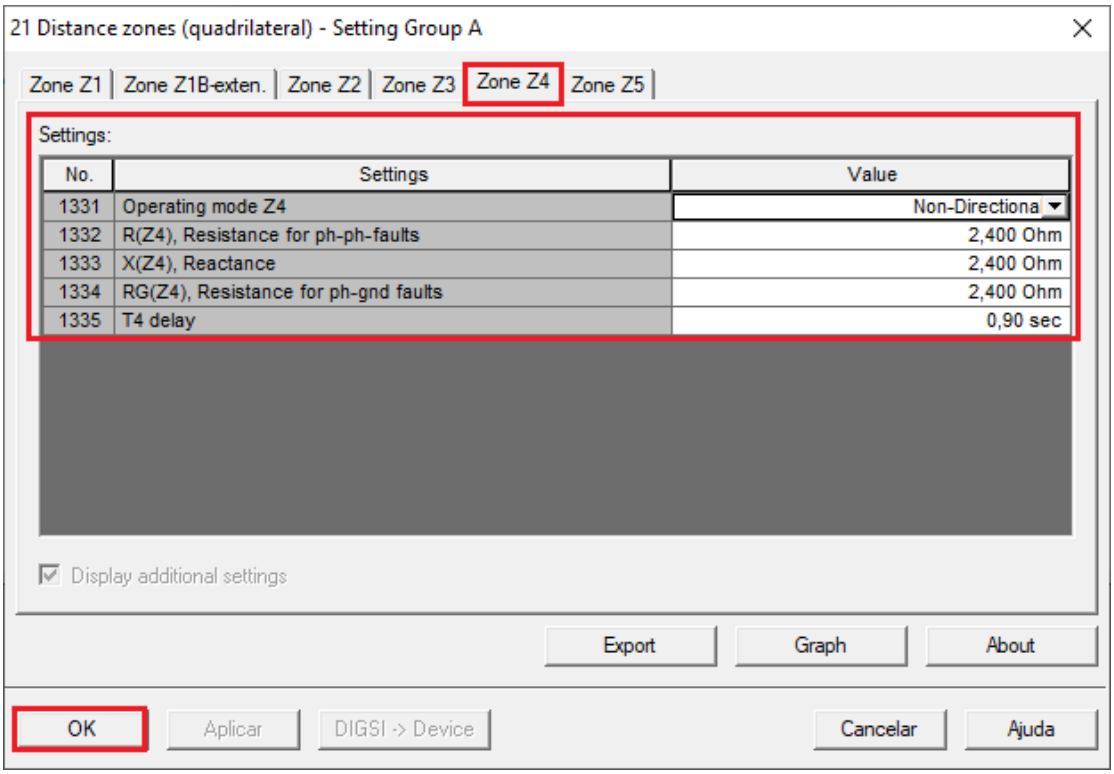

Figure 22

4. *Distance software adjustments*

4.1 *Opening Distance*

Click on the CTC application manager icon.

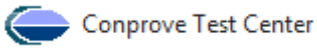

Figure 23

Click on the *"Distance"* software icon.

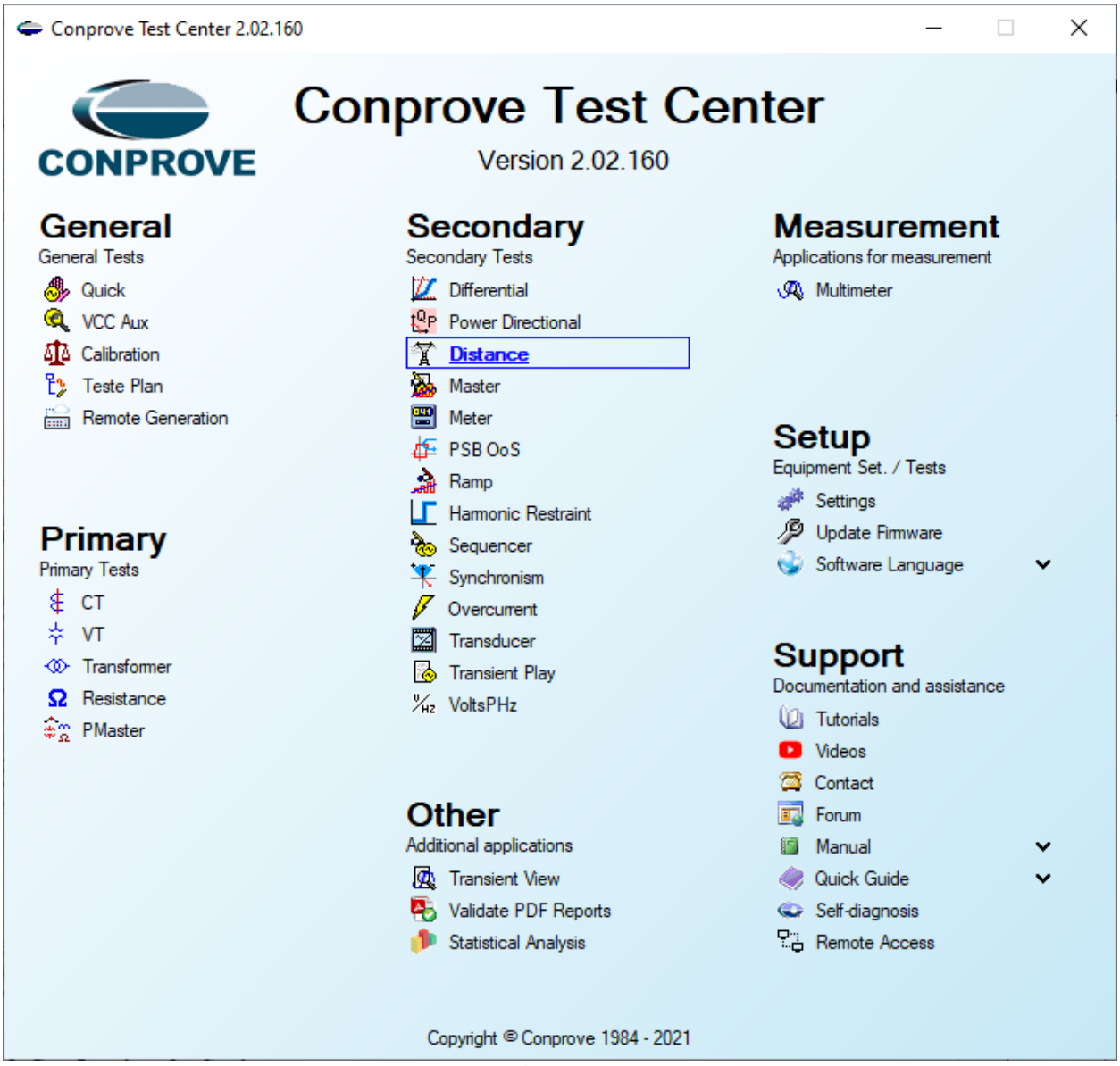

Figure 24

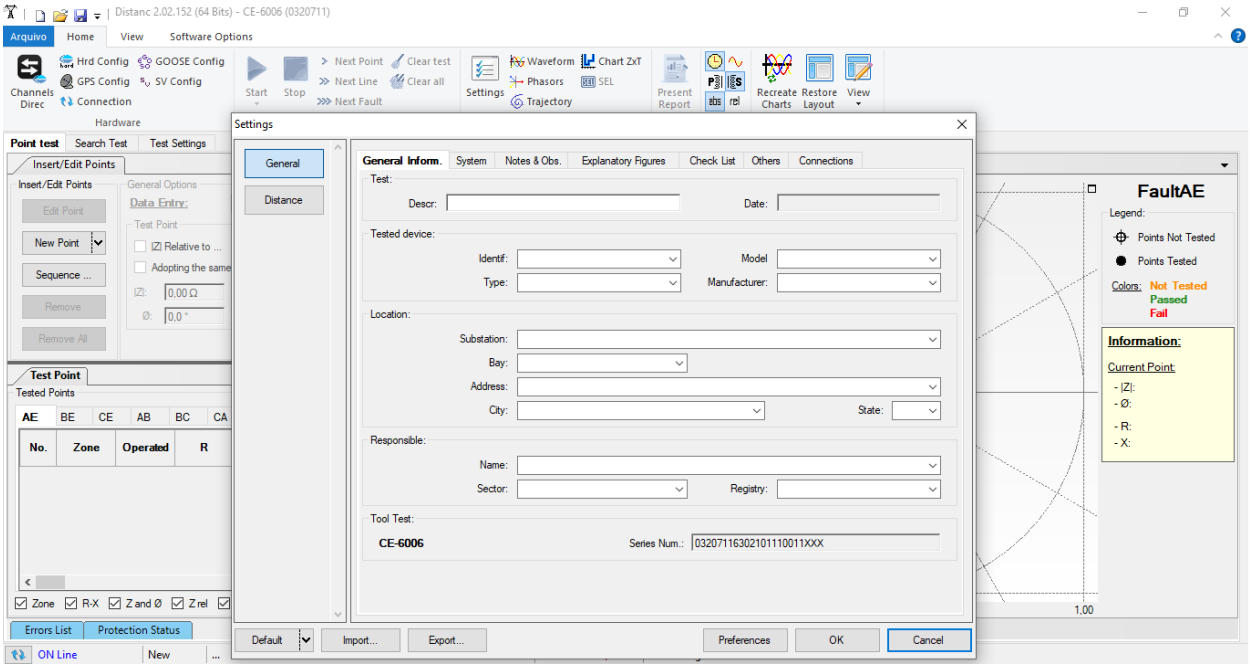

Figure 25

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.

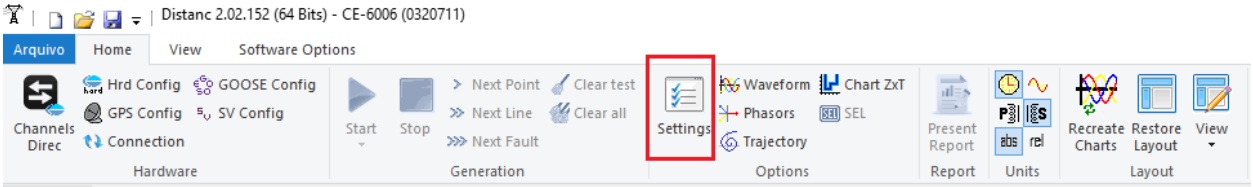

Figure 26

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

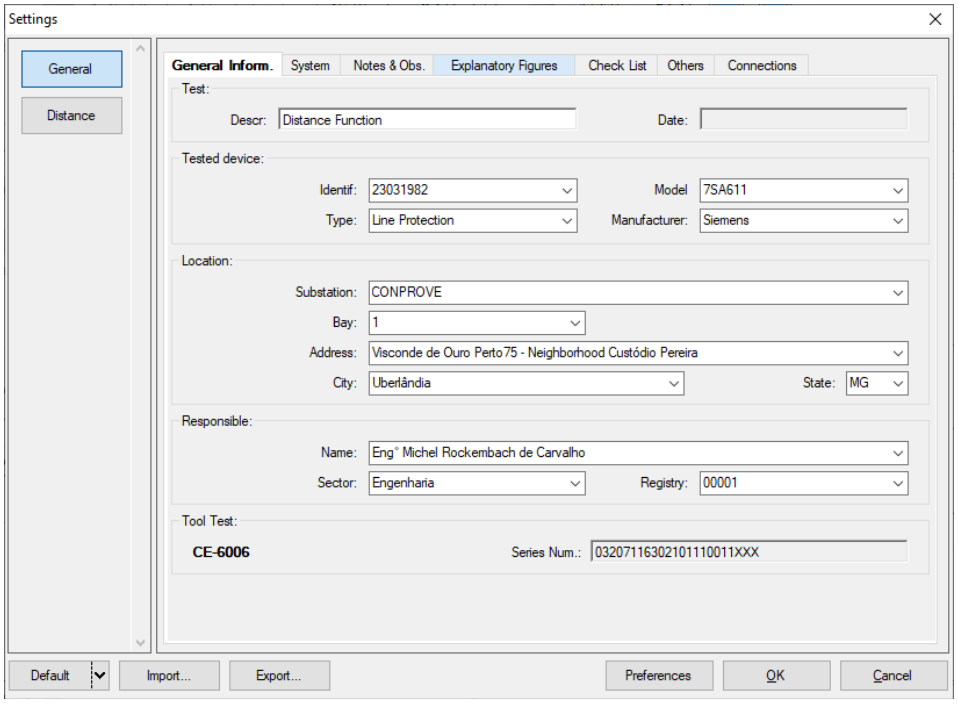

Figure 27

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 PTs and CTs are configured. There are also two sub-tabs *"Impedance"* and *"Source"* whose data is not relevant for this test.

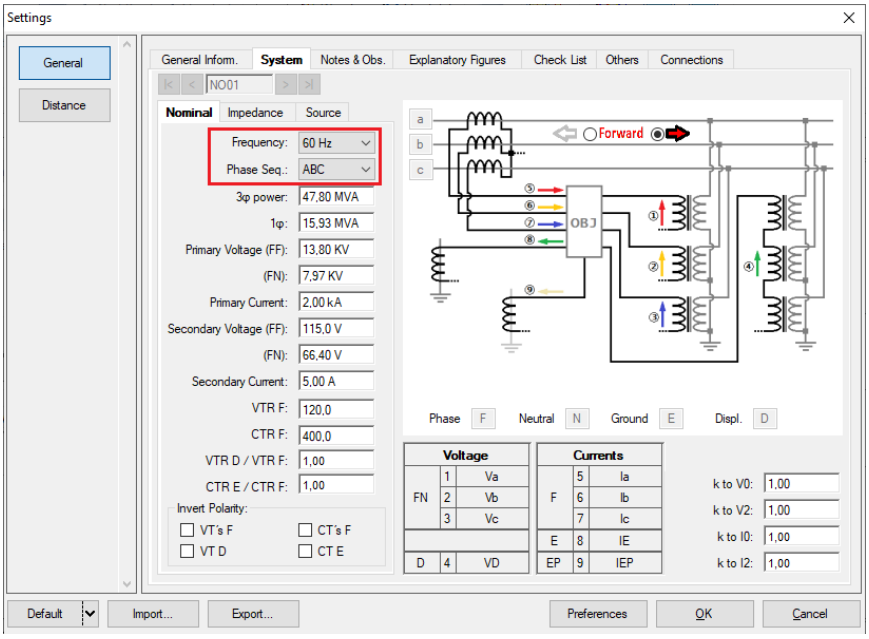

Figure 28

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.

4.4 *Distance Adjustments*

Note: The relay will be parameterized differently for phase-to-ground faults compared to two-phase and three-phase faults. For the software to perform the test properly, 8 types of zones must be inserted, the first four for two-phase and three-phase faults and the last four for phase-to-ground faults.

4.5 *Distance Screen > Adjust Prot. Distance*

The first step is to adjust the ground compensation factor.

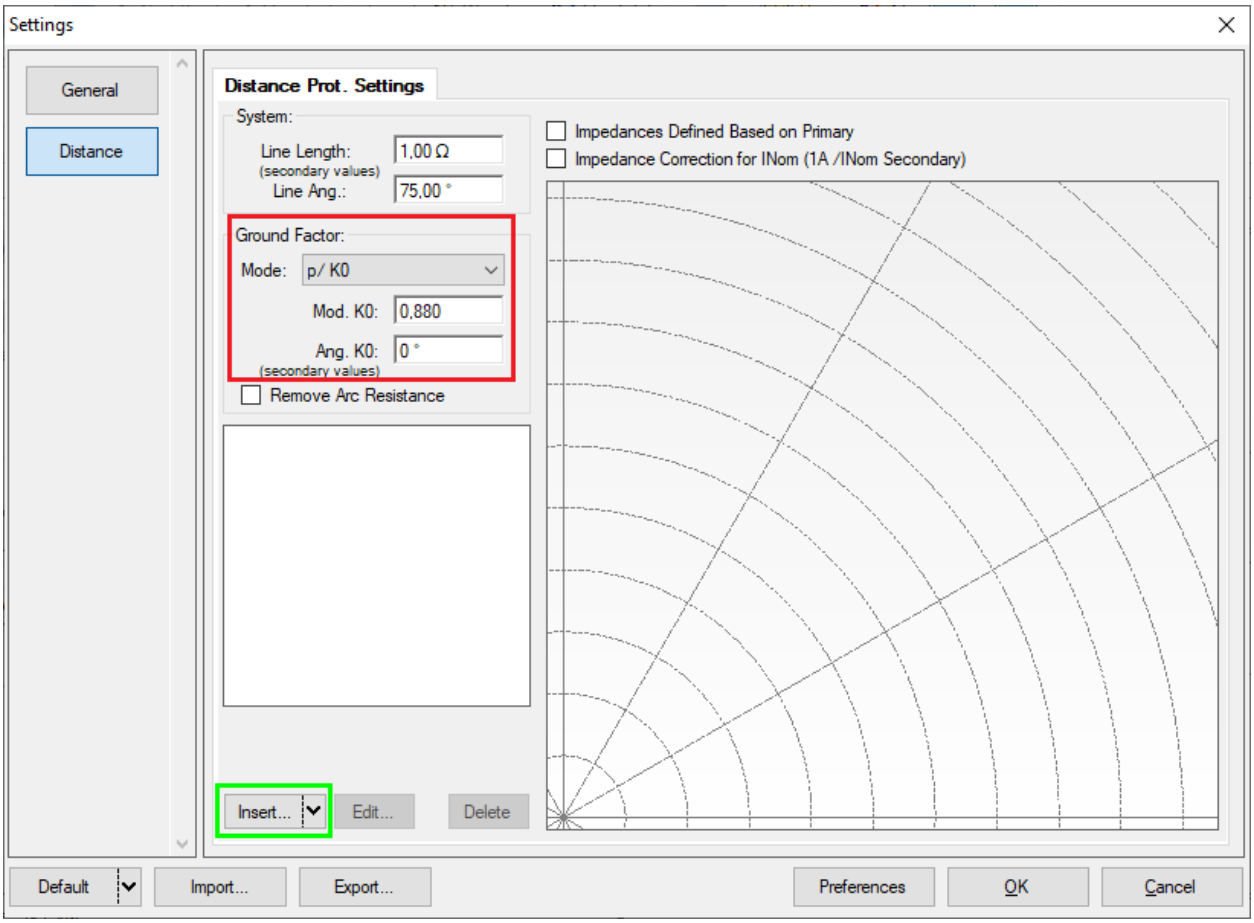

Figure 29

4.6 *Inserting Phase Zones*

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

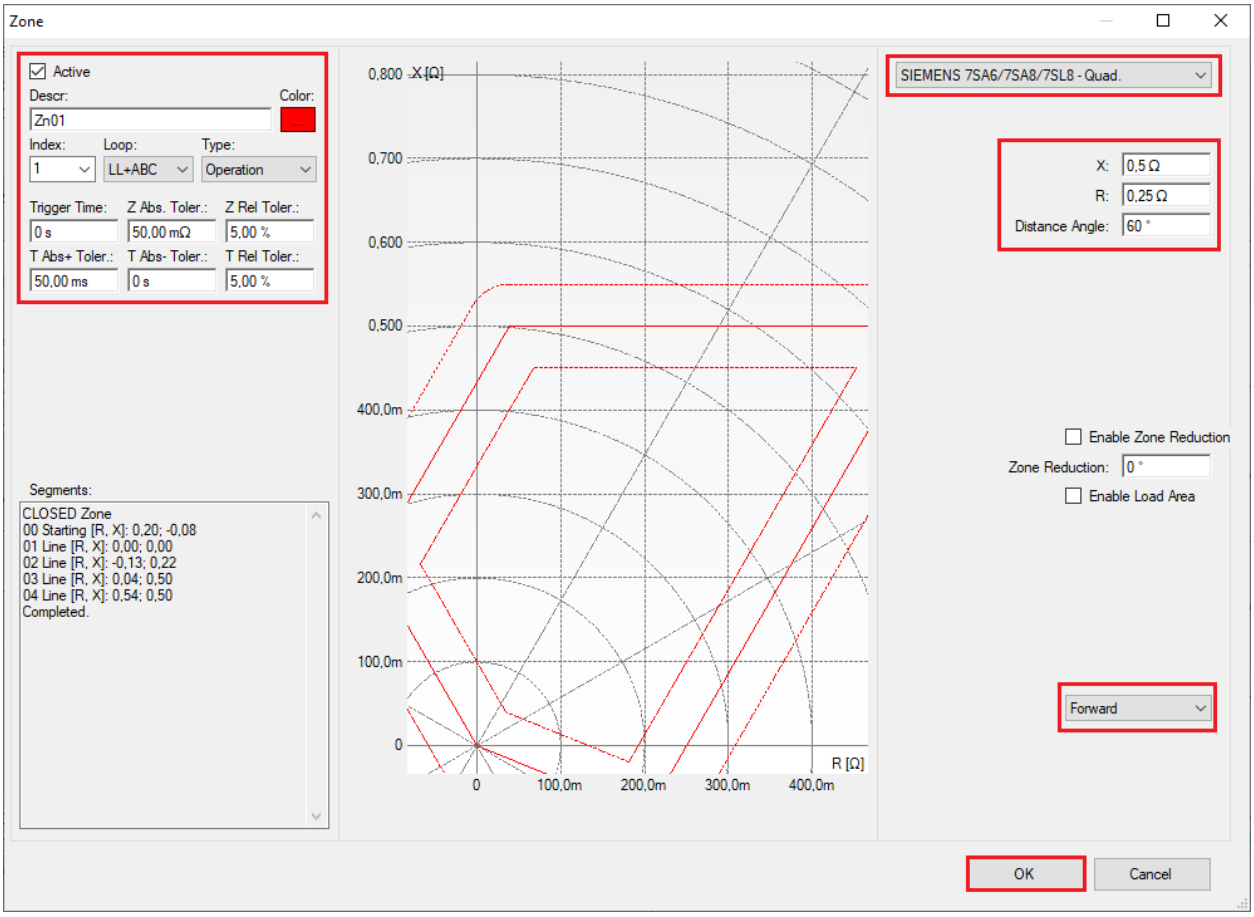

Figure 30

Clicking *"Insert"* again adjusts the values for zone 2.

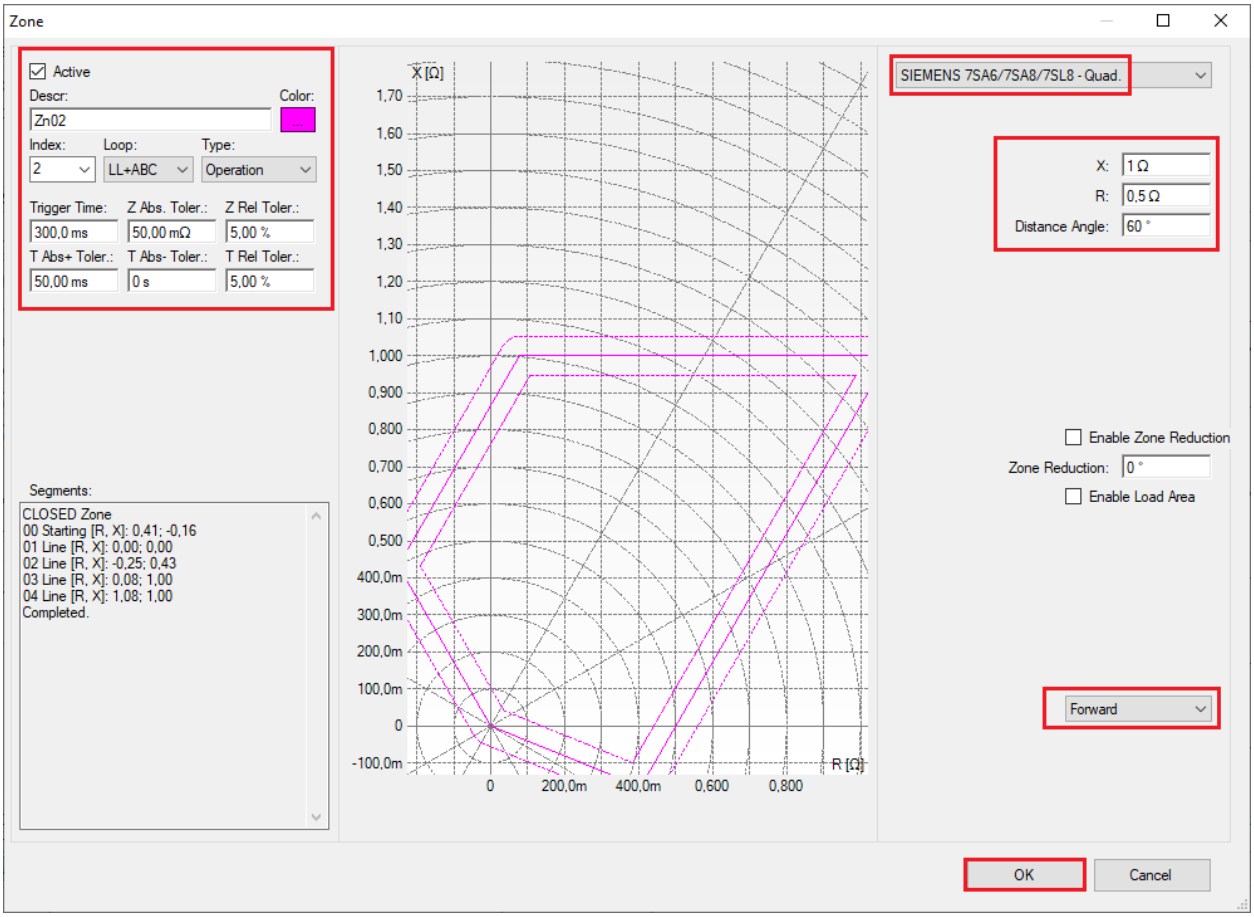

Figure 31

By clicking on *"Insert"* the values for zone 3 are adjusted.

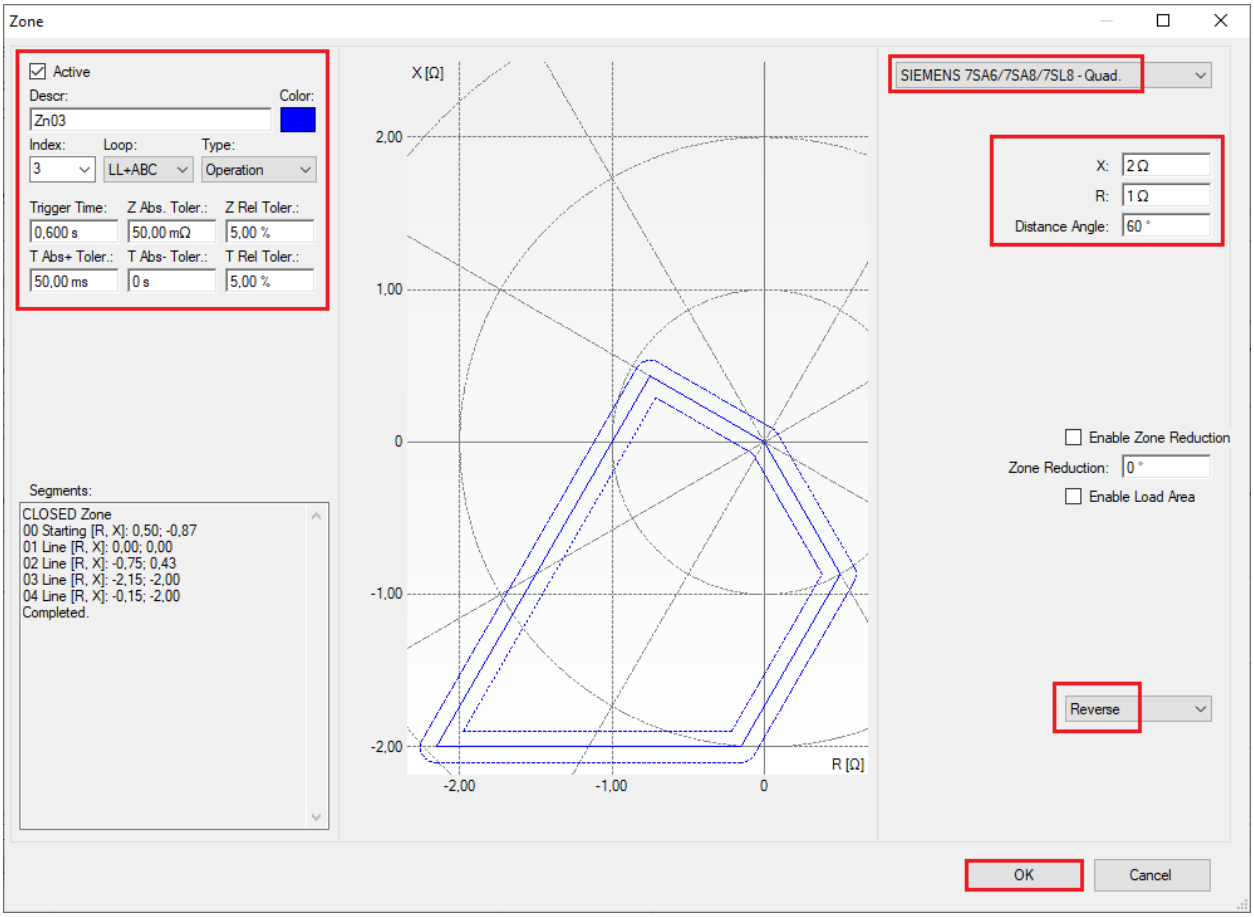

Figure 32

By clicking on *"Insert"* the values for zone 4 are adjusted.

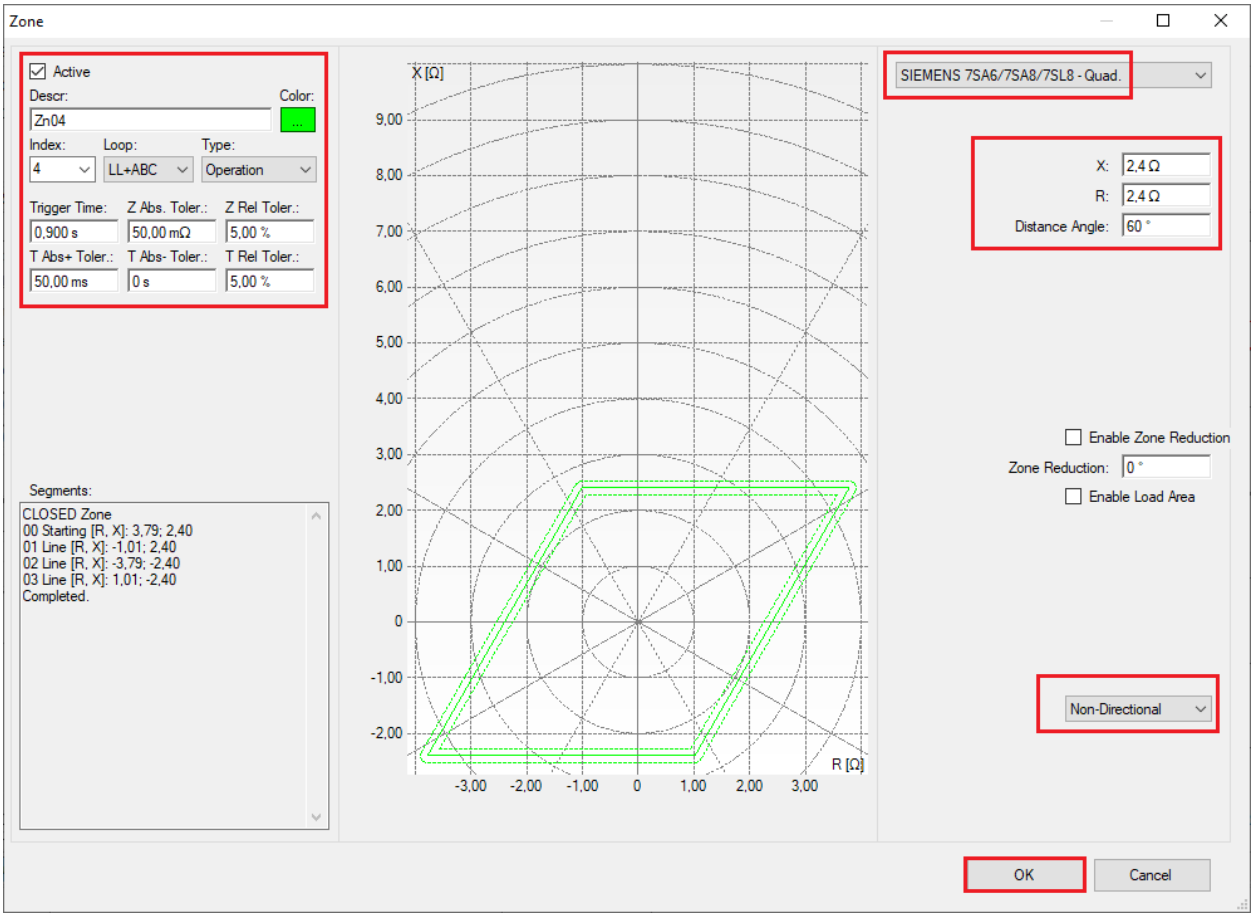

Figure 33

4.7 *Inserting the Zones (Line-Earth)*

The first FT zone to be entered will be zone-5 (LE). Change the name of zone 5 to *"Zn01_LE"*.Click on the *"Insert"* field highlighted in green in the Figure 29. In the settings screen, first select the relay mask *"SIEMENS 7SA6/7SA8/7SL8 - Quad."*.

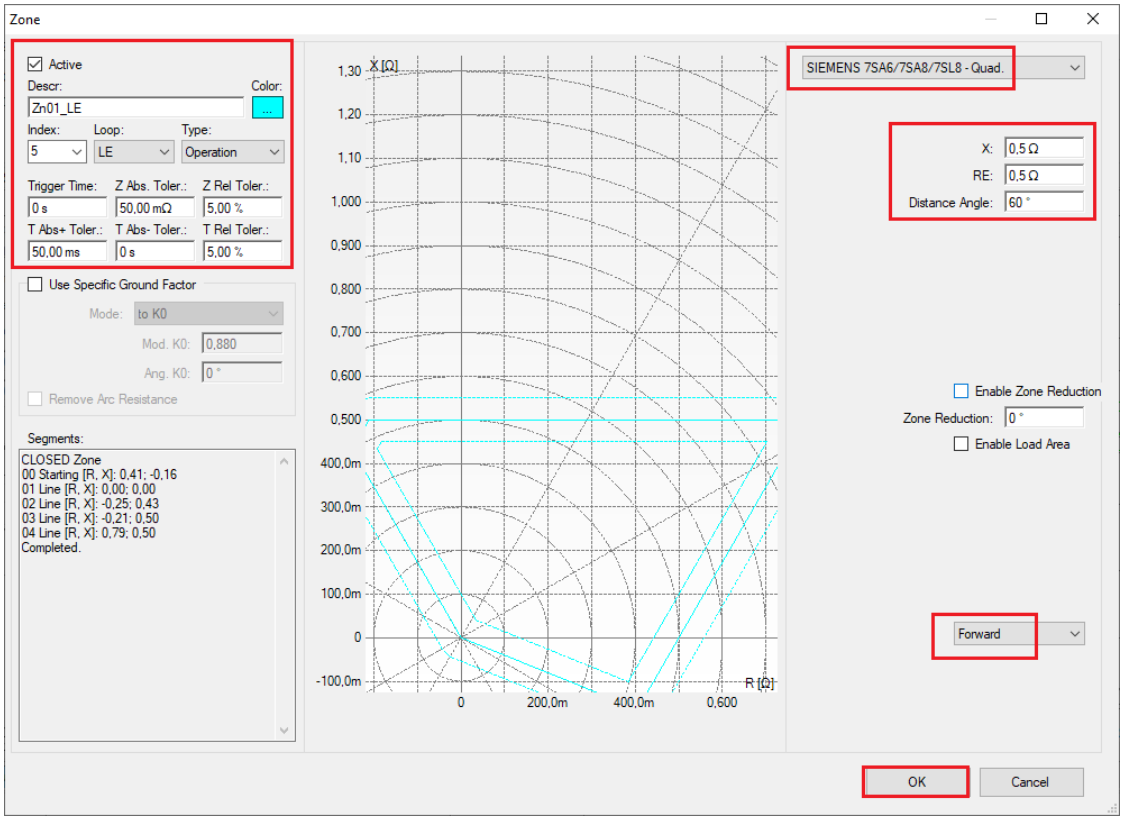

Figure 34

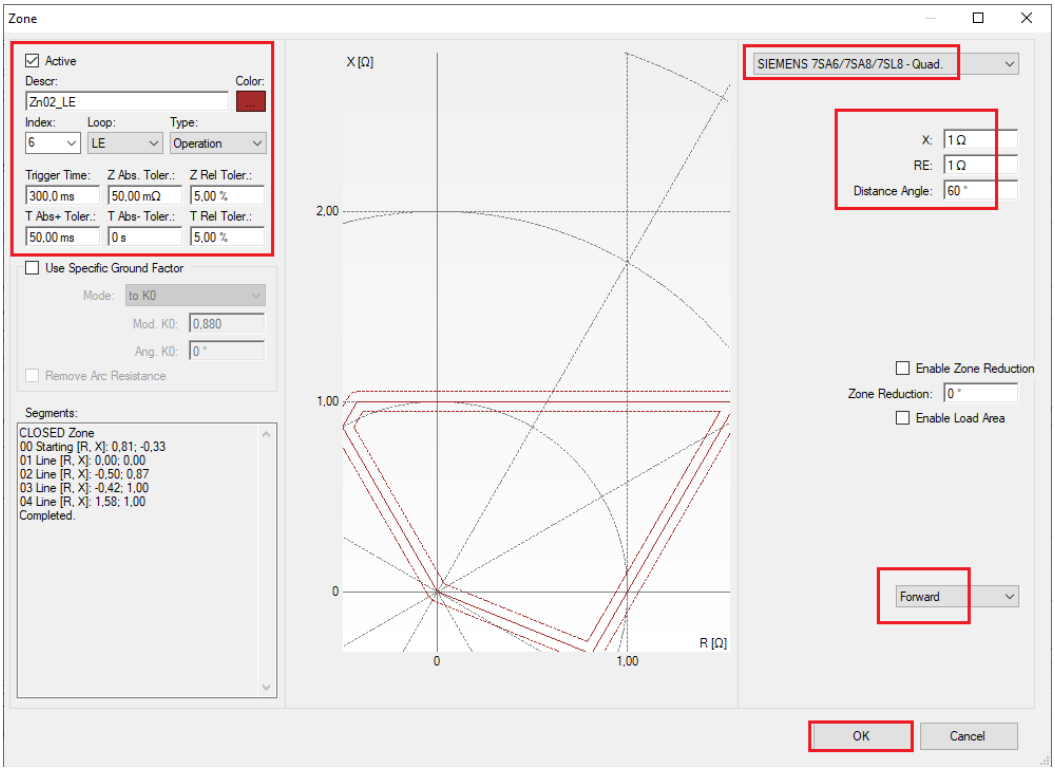

Figure 35

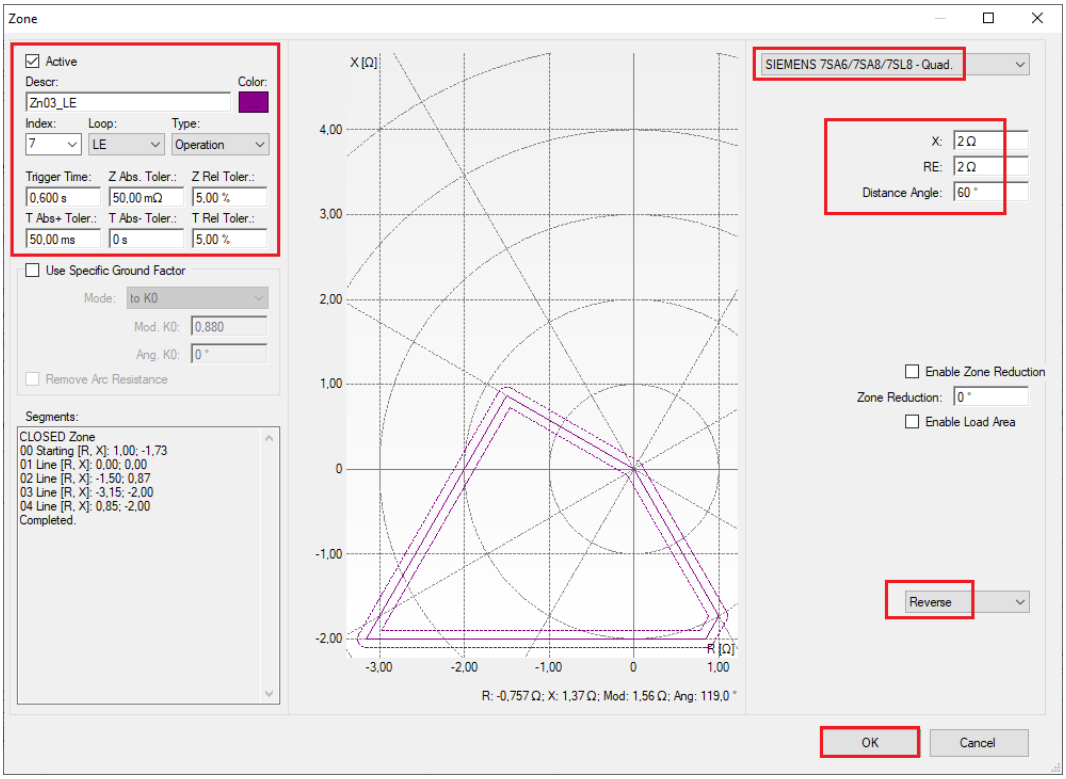

Figure 36

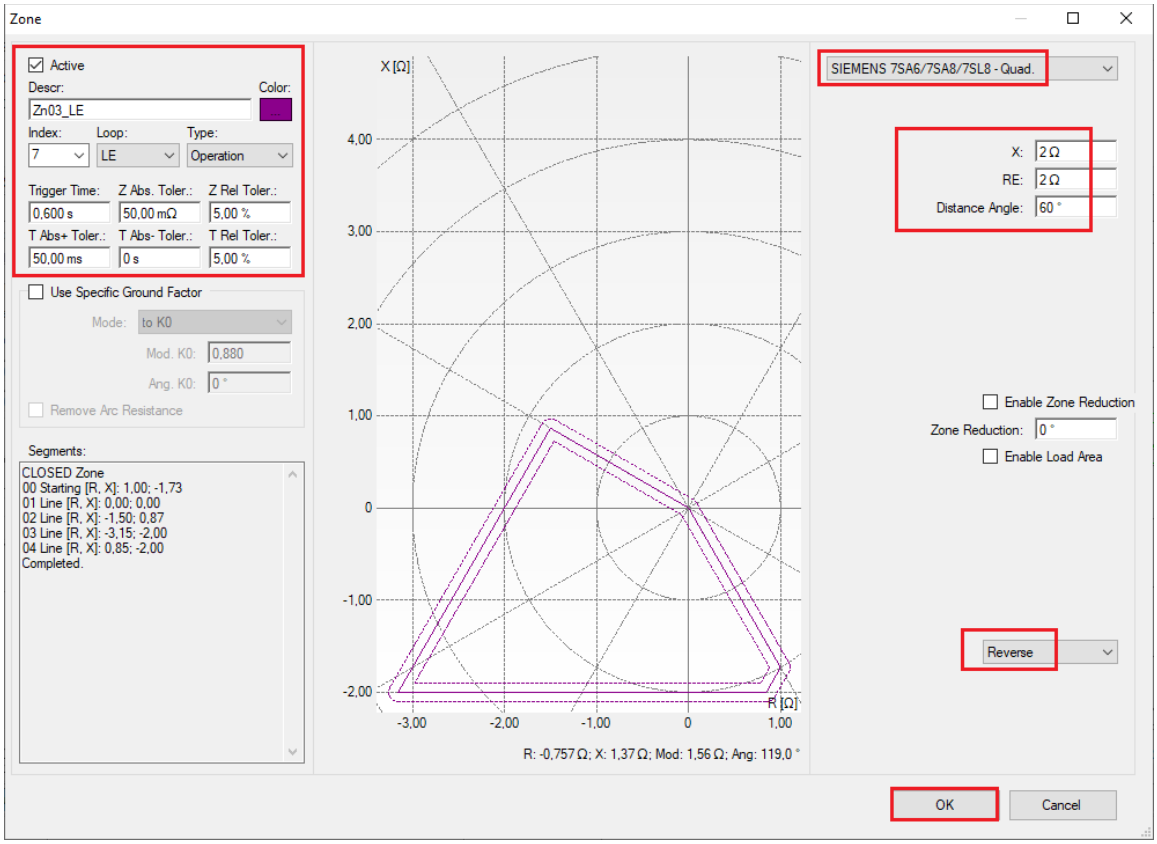

Figure 37

5. *Hardware Settings*

In the *"Home"* menu click on the *"Hrd Config"* button to configure the power supply, stipulate the configuration of the generation channels and the stopping method of the input binaries.

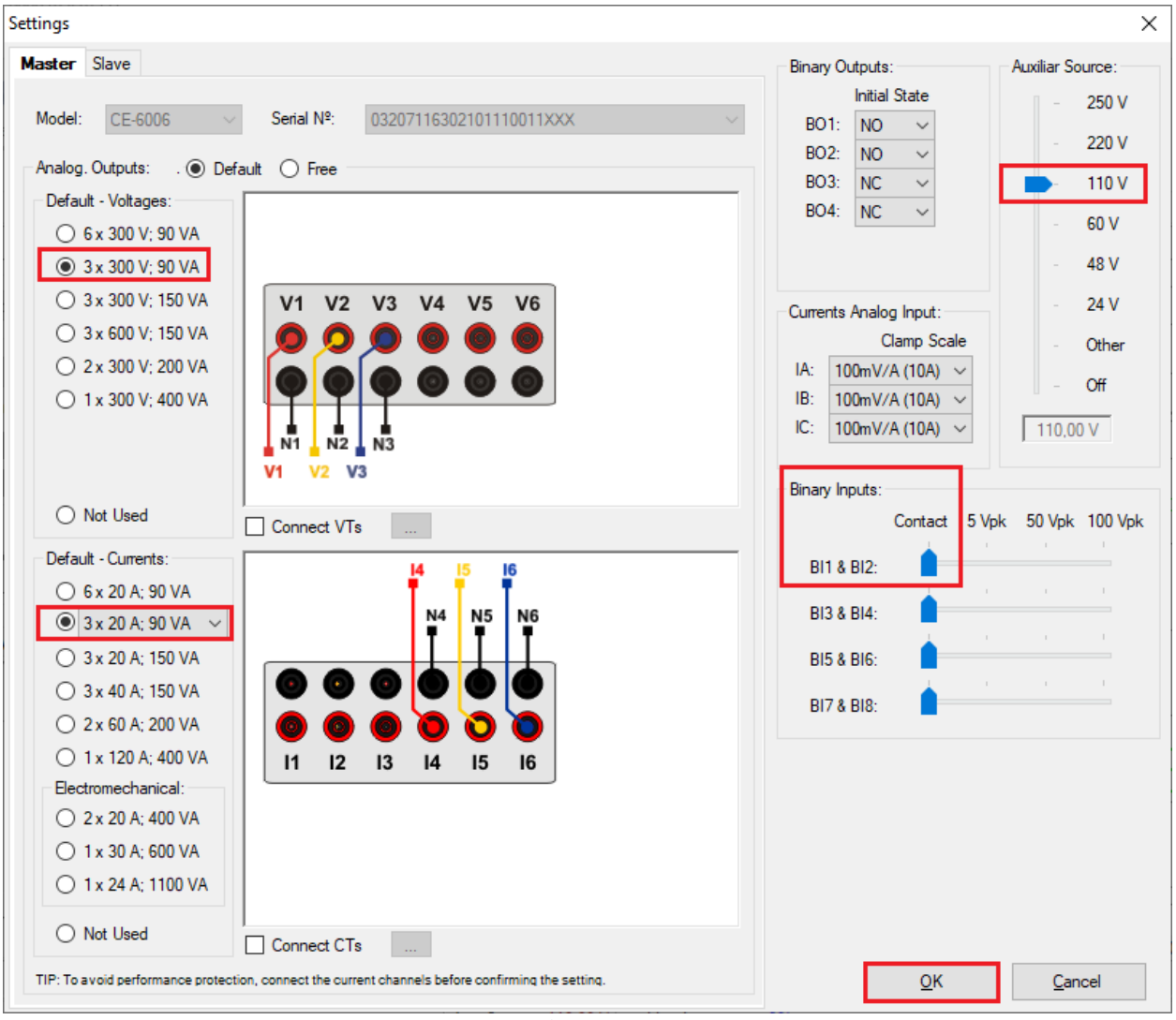

Figure 38

6. *Channels Direc*

After performing the hardware configuration, click on the highlighted icon to automatically associate the created channels with the nodes. Choose the *"Basic"* option for this.

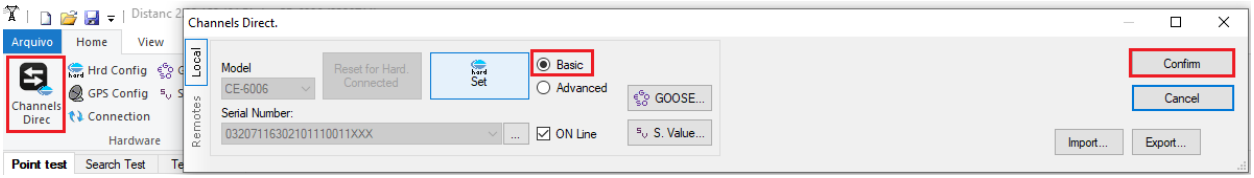

Figure 39

7. *Restore Layout*

Due to the great flexibility that the software presents allowing the user to choose which windows are displayed and in which position, the Restore Layout command is used to restore the default settings. Click on the *"Layout"* button and then on *"Recreate Charts"* repeat the process by clicking on *"Layout"* and *"Restore Layout"*. During the test, windows that are not relevant are excluded.

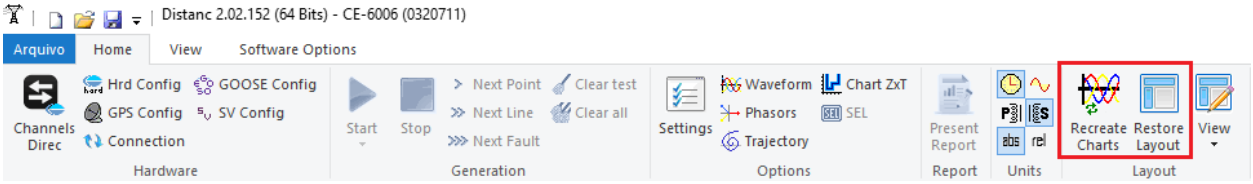

Figure 40

8. *Function 21 test structure*

8.1 *Test Settings*

By clicking on the Test Settings tab set the test mode to *"Intelligent"* and use binary input 1 for stop interface. Insert a pre-fault with nominal voltage and current equal to zero.

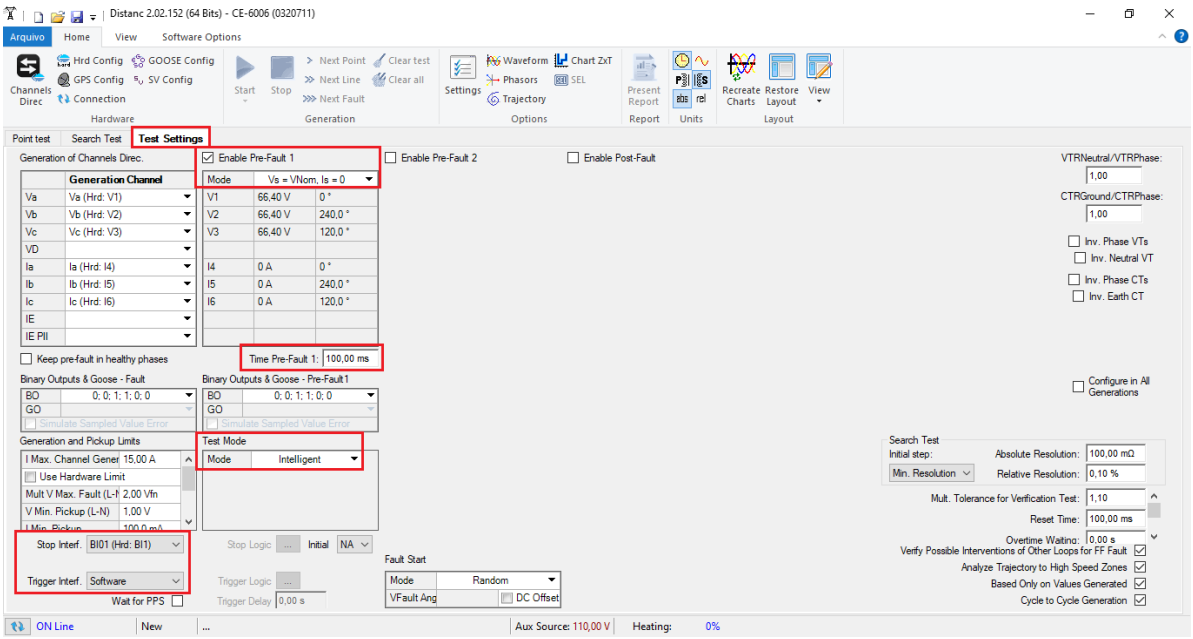

Figure 41

8.2 *Point Test for Zones 1,2,3 and 4*

8.2.1 Two-Phase and Three-Phase Loop

Click on the *"Point Test"* tab and then *"Sequence"* and choose the types of faults, in this case only three-phase and two-phase faults, that is, ABC, AB, BC and CA.

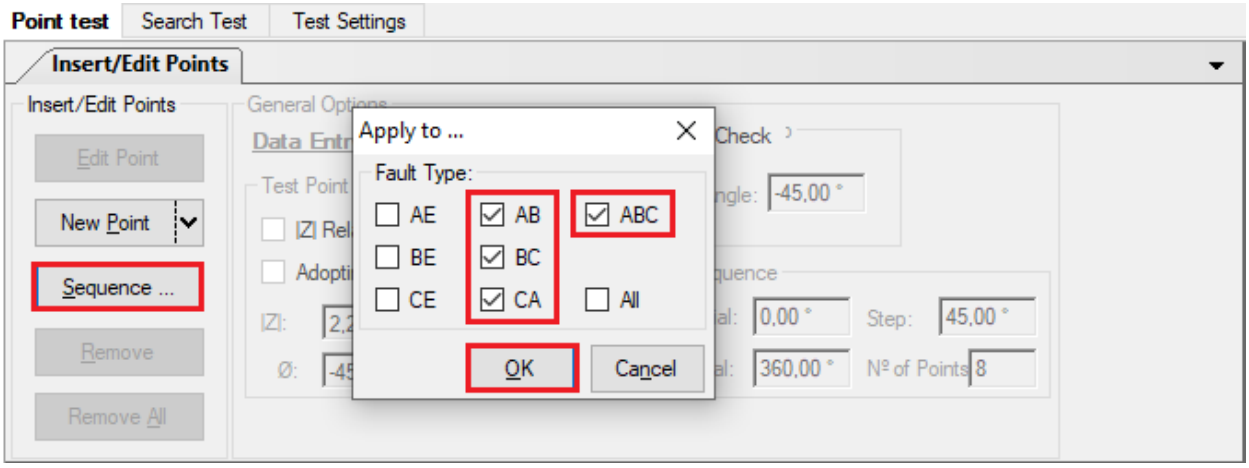

Figure 42

Choose a starting angle, ending angle and pitch. In this way the points are determined automatically.

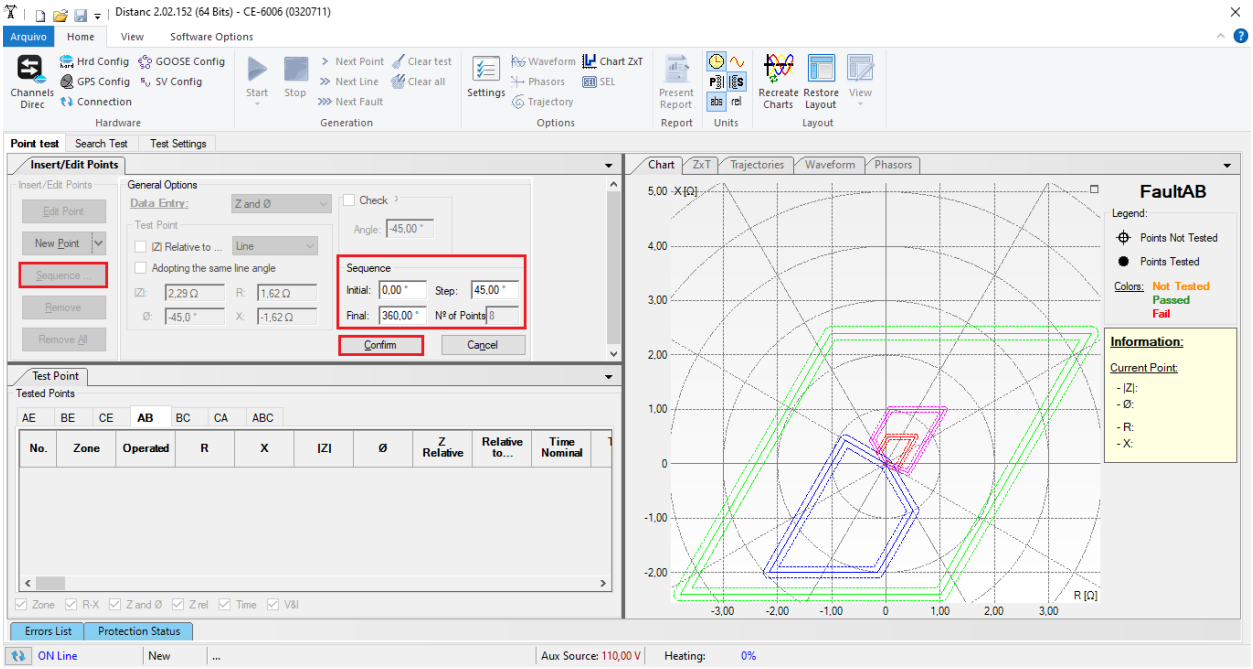

Figure 43

By clicking on the *"Confirm"* button the following points are created.

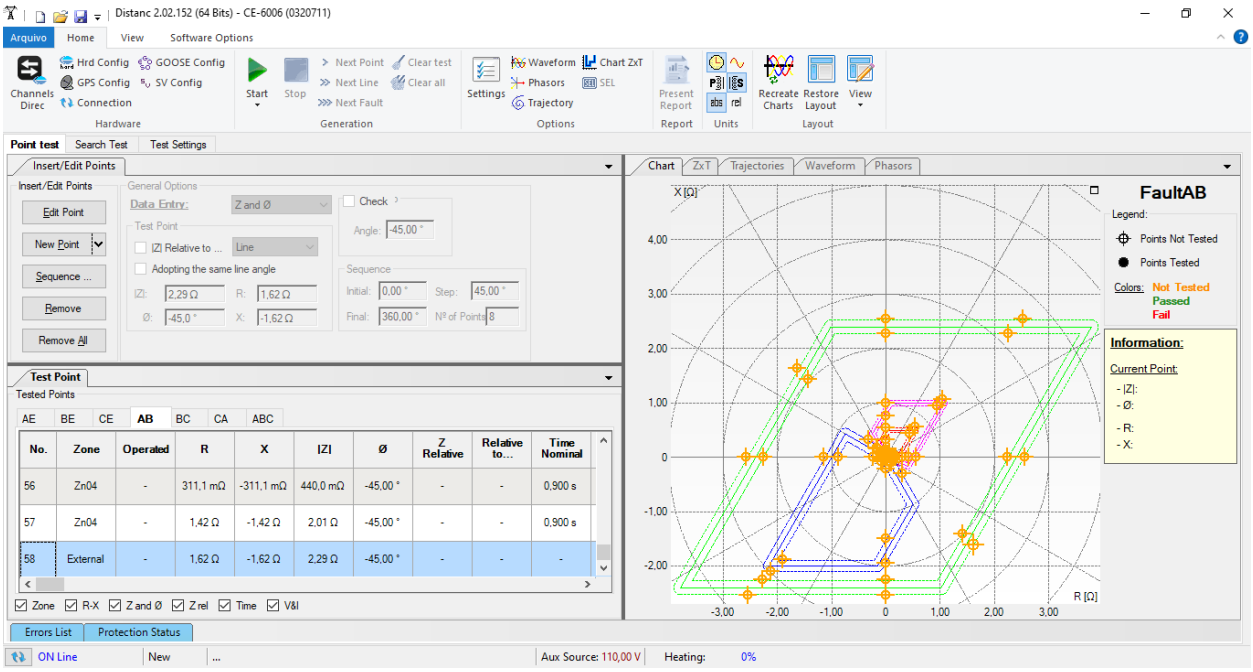

Figure 44

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

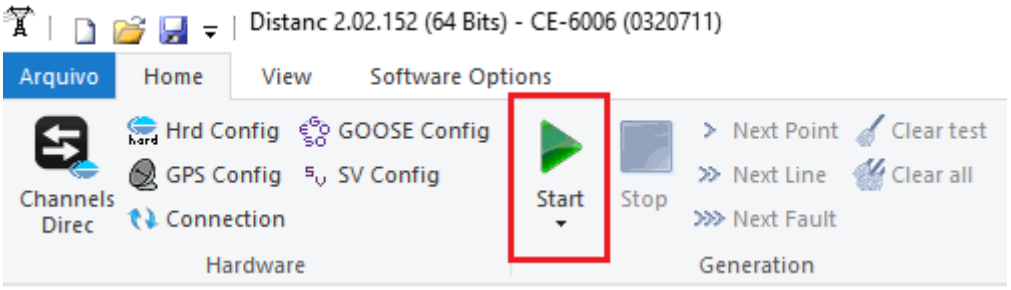

Figure 45

The final result is shown below with the characteristics of the zones. To zoom in, left click and drag defining the region to be zoomed in and then release the button.

8.2.2 Final Result A-B-C faults

By clicking on the *"ABC"* tab, the final result is verified. Note that all points are within the tolerances given by the manufacturer so that the test is approved.

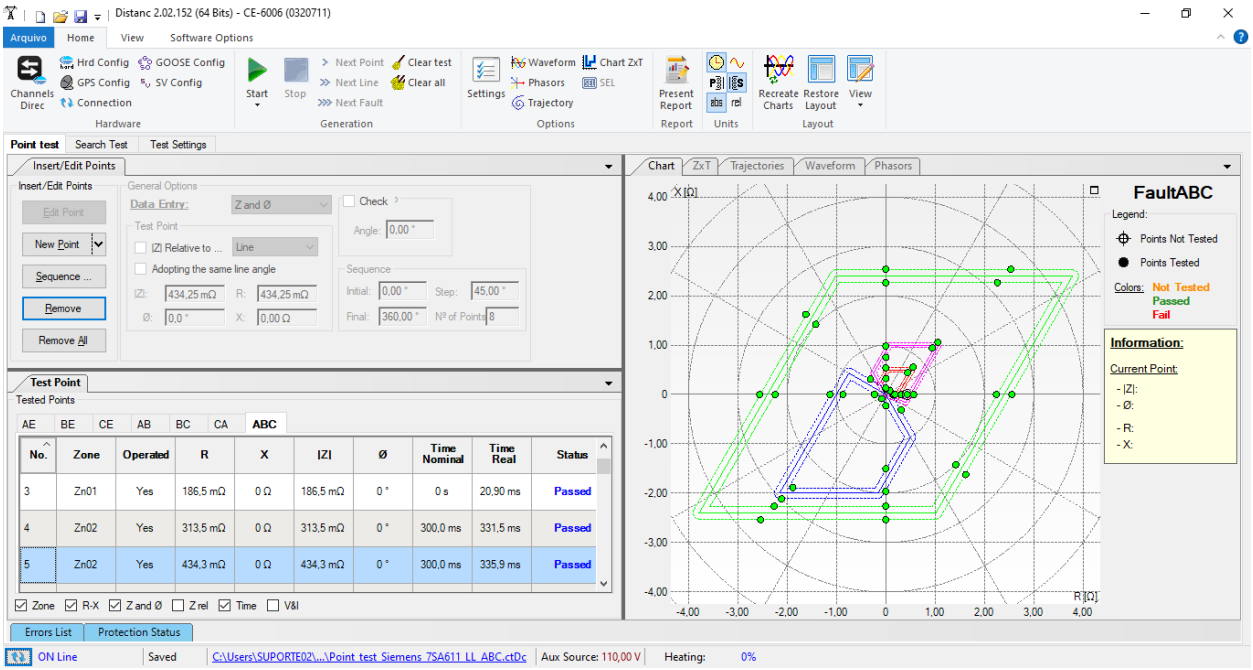

Figure 46

8.2.3 Single-phase Loop

Click on the *"Point Test"* tab and then *"Sequence"* and choose the fault types, in this case only single-phase faults, that is, AE, BE and CE.

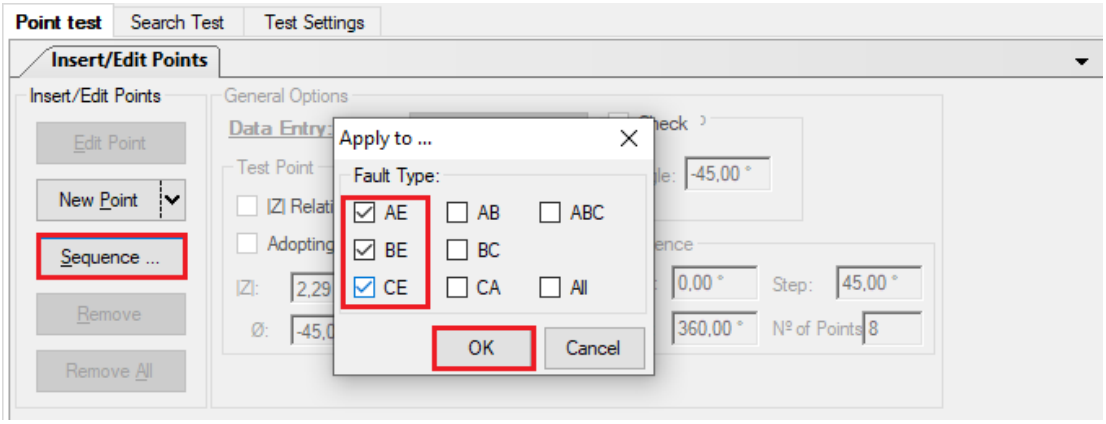

Figure 47

Choose a starting angle, ending angle and pitch. In this way the points are determined automatically.

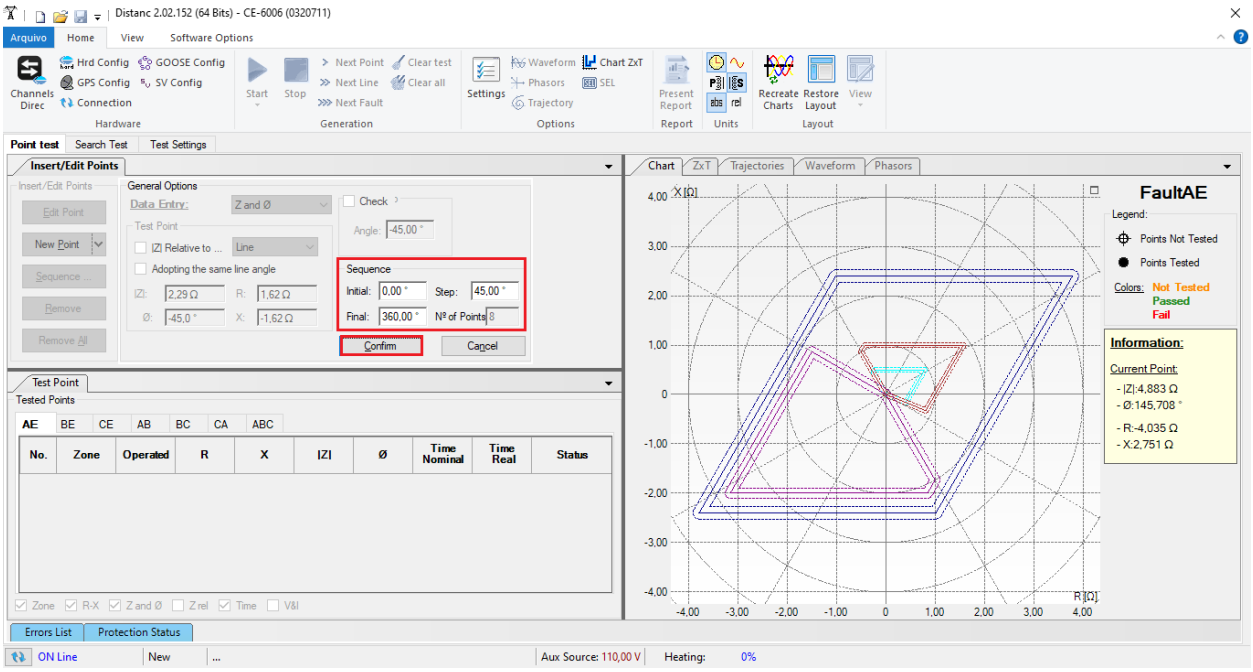

Figure 48

By clicking on the *"Confirm"* button the following points are created.

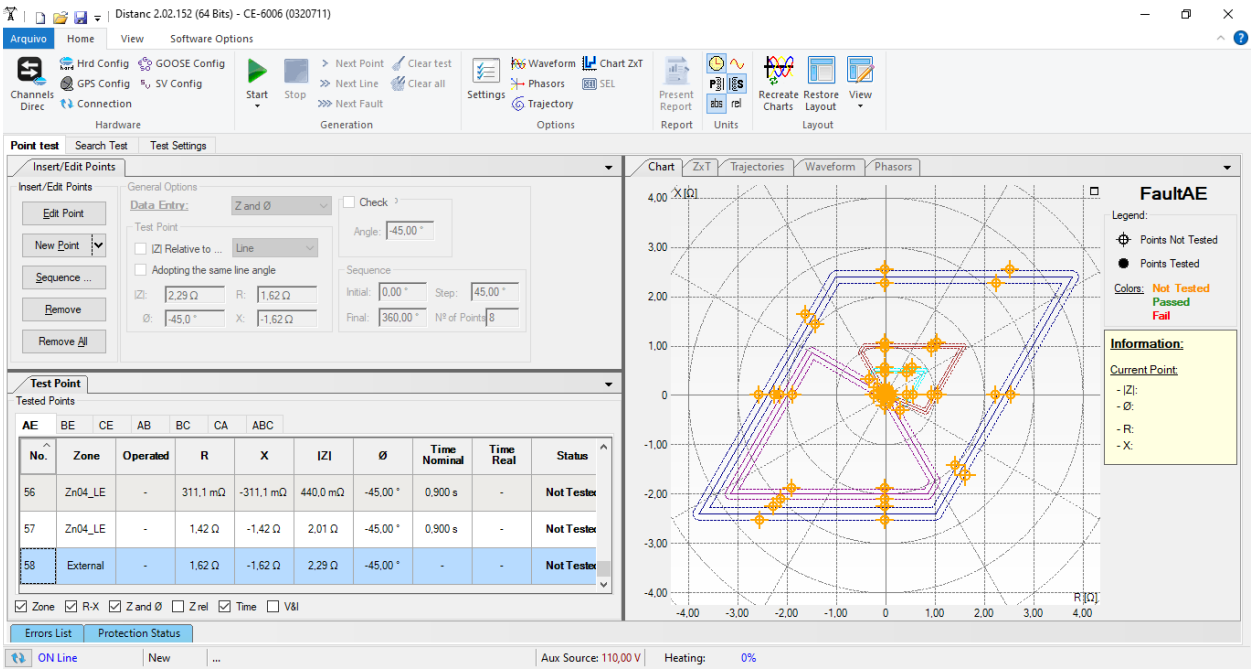

Figure 49

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

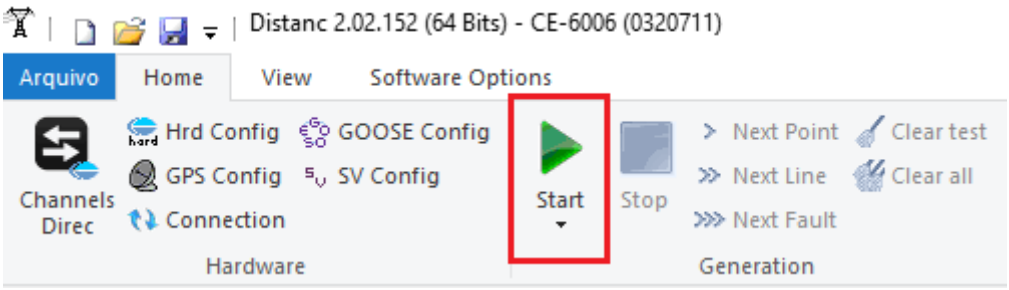

Figure 50

The final result is shown below with the characteristics of the zones. To zoom in, left click and drag defining the region to be zoomed in and then release the button.

8.2.4 Final Result AE Fault

By clicking on the *"AE"* tab, the final result is verified. It is observed that all points are within the tolerances given by the manufacturer so that the test is approved.

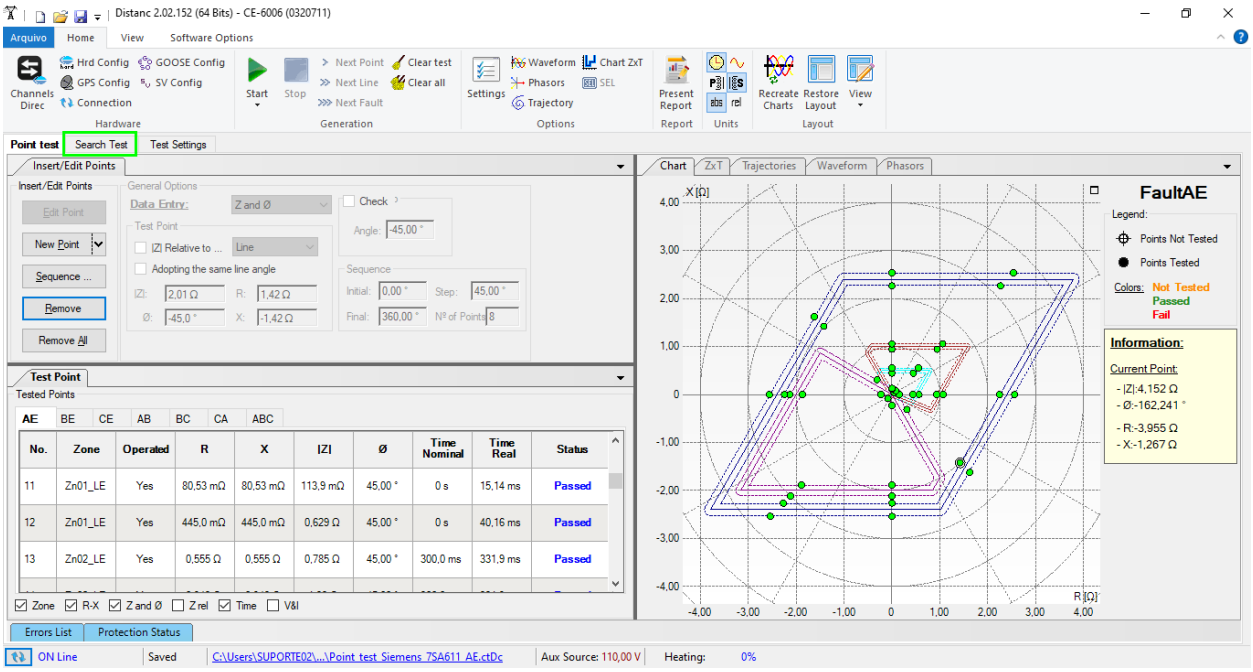

Figure 51

8.3 *Search Test for Zones 1,2,3 and 4*

8.3.1 Two-Phase and Three-Phase Loop

Click on the *"Search Test"* tab highlighted in green in the previous figure and then, on the *"Insert/Edit Points"* tab click on the *"Sequence"* button. Choose the fault types, in this case only three-phase and two-phase faults, or ABC, AB, BC and CA.

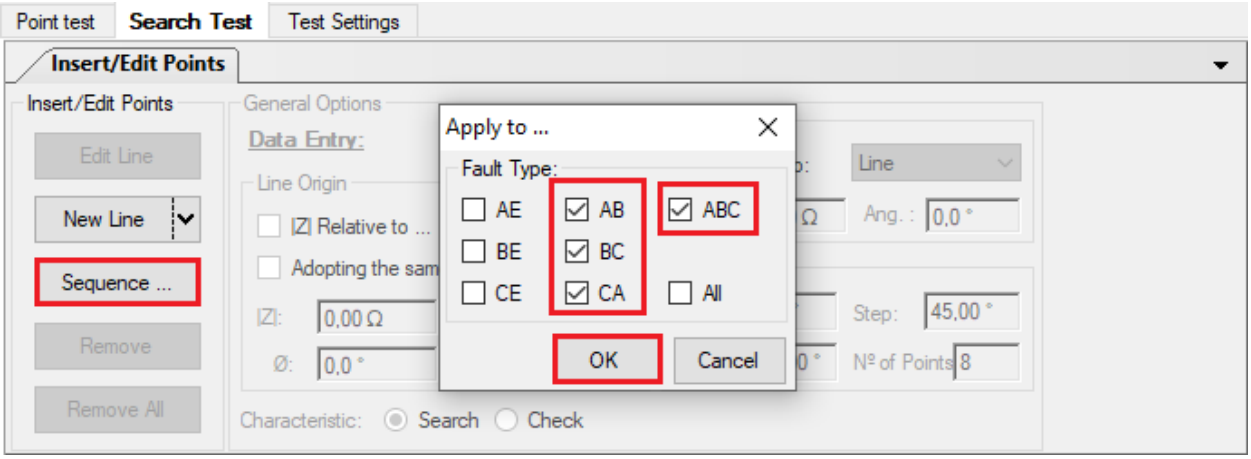

Figure 52

Choose a start point as the origin, set a length value, choose a start angle, end angle, and pitch. In this way the search lines are drawn automatically.

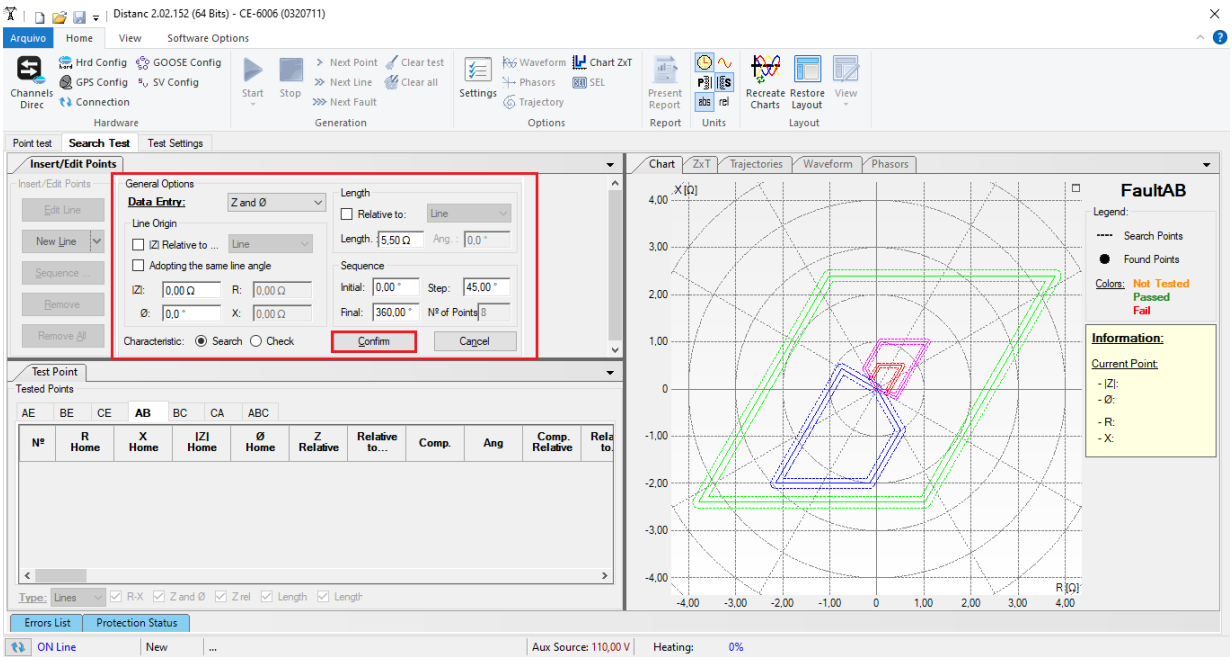

Figure 53

By clicking on the *"Confirm"* button the following search lines are created.

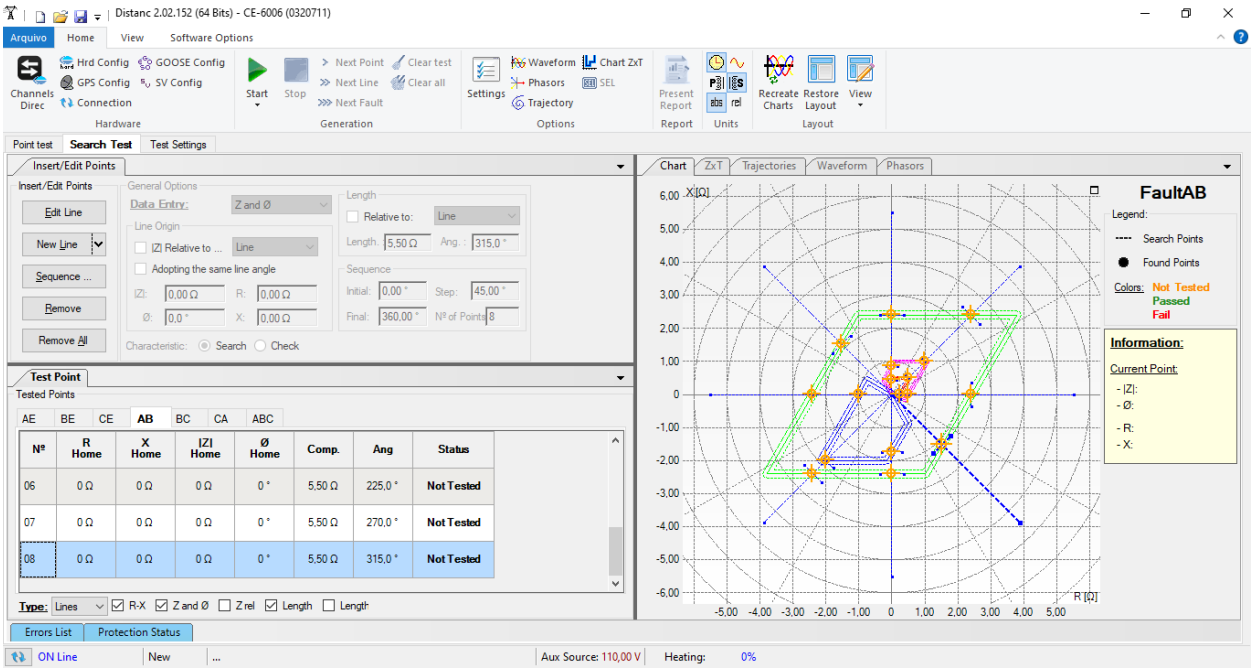

Figure 54

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

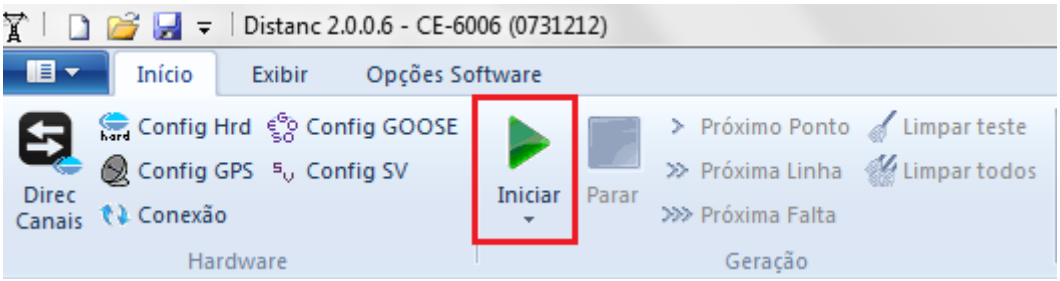

Figure 55

The final result is shown below with the characteristics of the zones. To zoom in, left click and drag defining the region to be zoomed in and then release the button.

8.3.2 Final Result A-B-C Fault

By clicking on the *"ABC"* tab, the final result is verified. It is observed that all points are within the tolerances given by the manufacturer so that the test is approved.

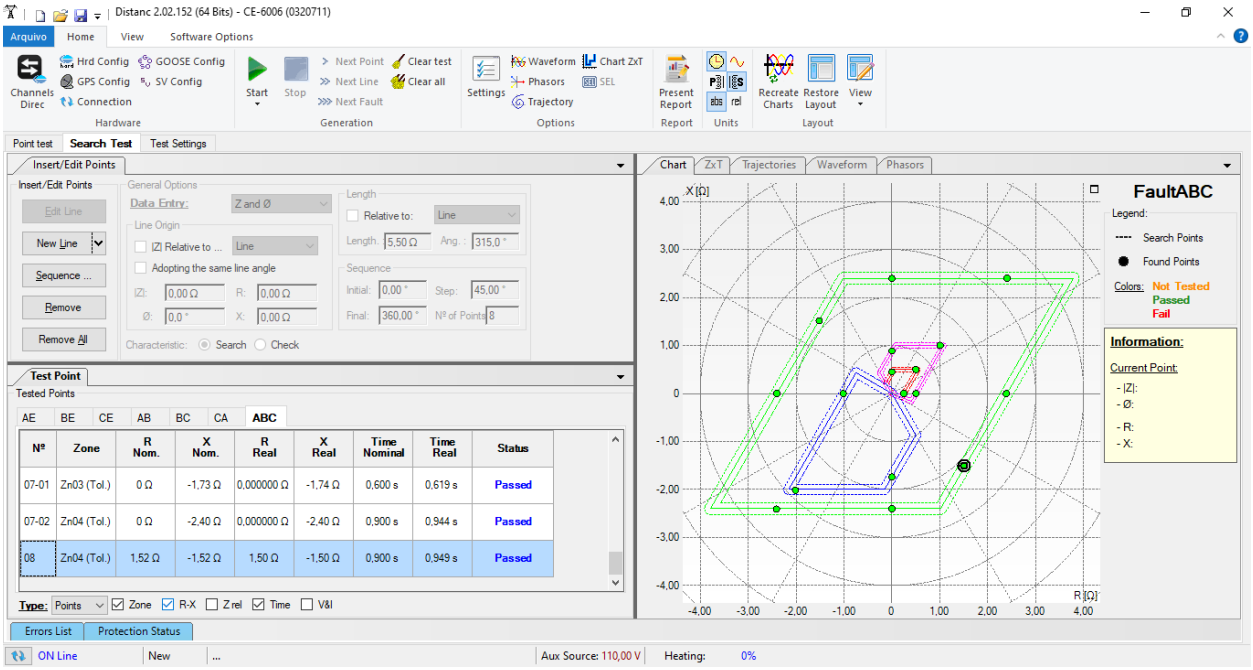

Figure 56

8.3.3 Single-phase Loop

Click on the *"Point Test"* tab and then *"Sequence"* chooses the fault types in this case only single-phase faults, or AE, BE and CE.

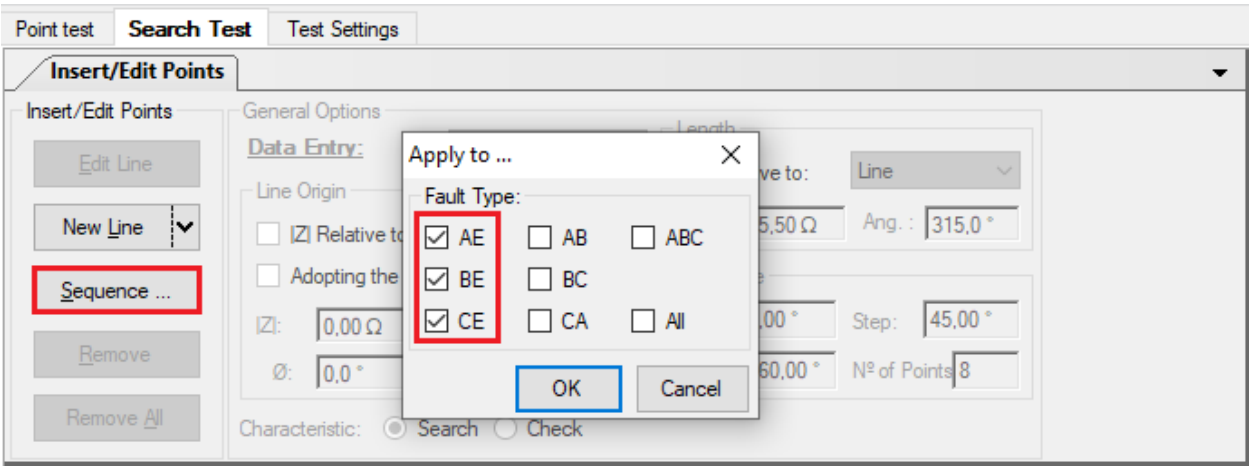

Figure 57

Choose a initial angle, final angle and step. In this way the points are determined automatically.

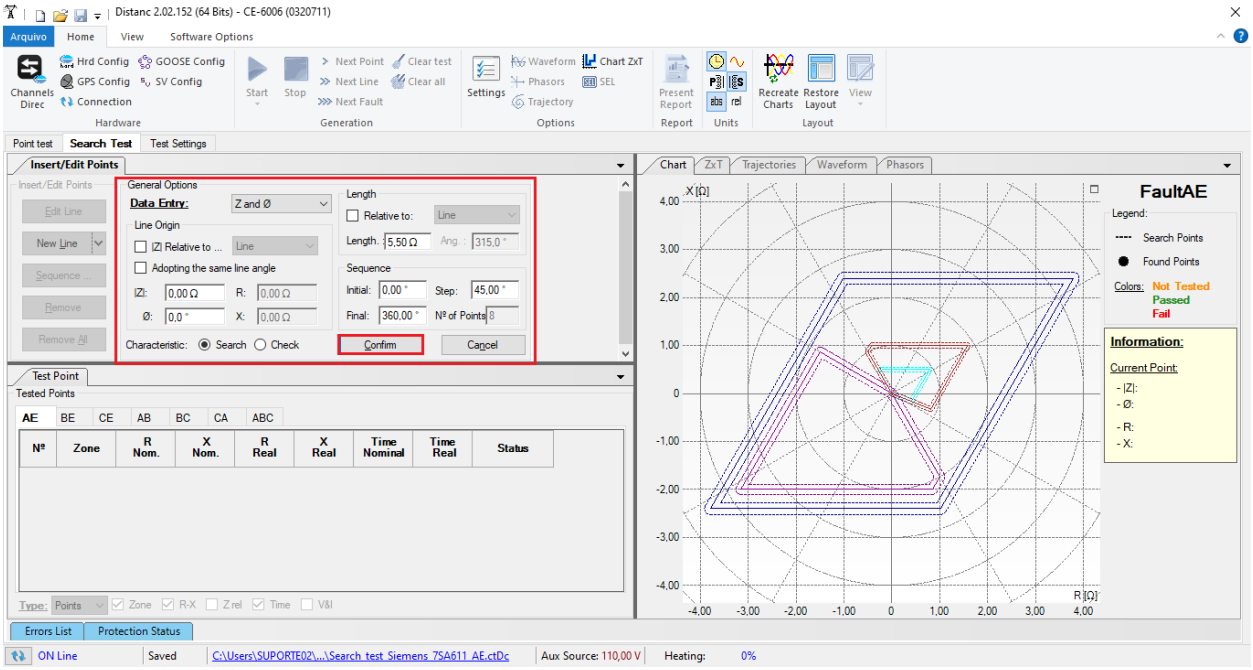

Figure 58

By clicking on the *"Confirm"* button the following lines are created.

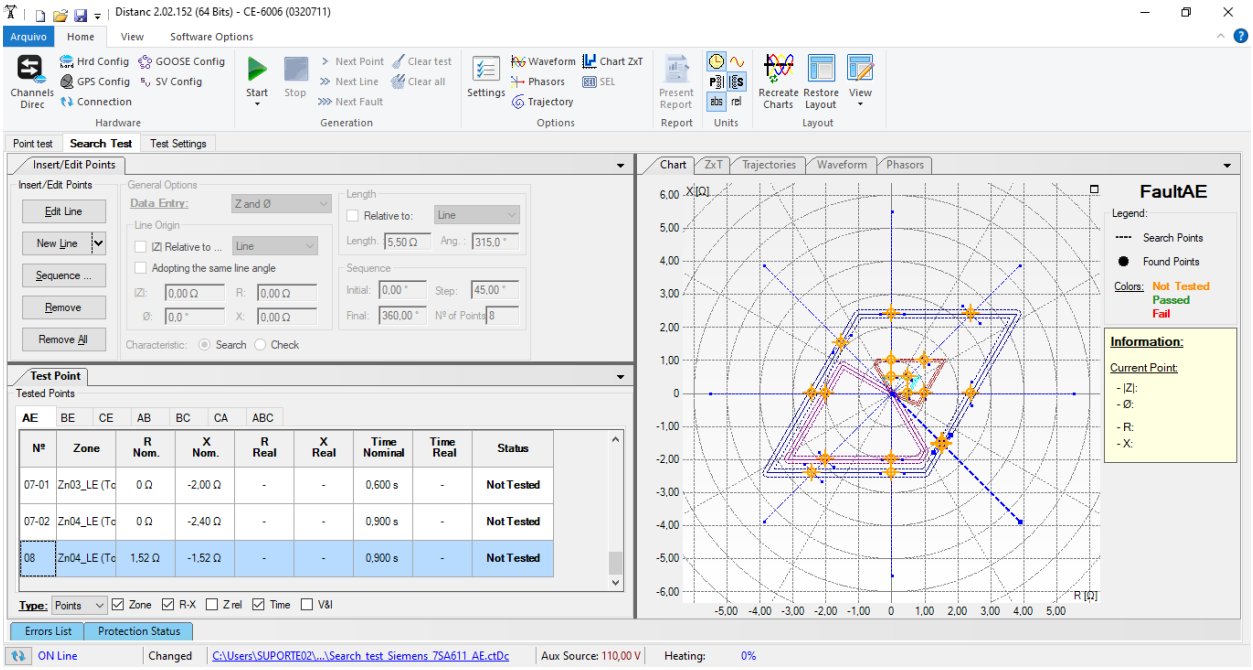

Figure 59

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

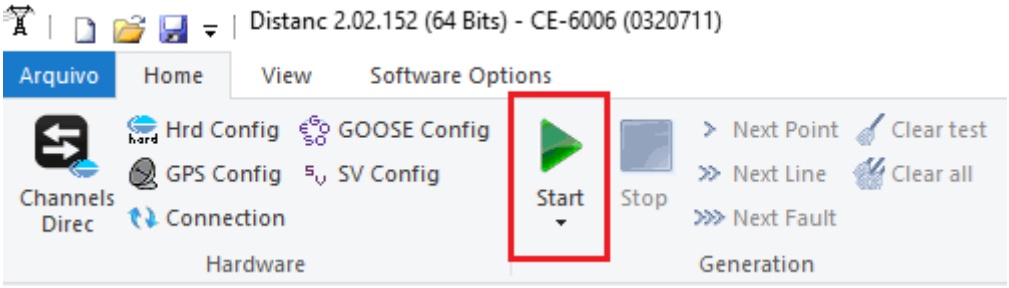

Figure 60

The final result is shown below with the characteristics of the zones. To zoom in, left click and drag defining the region to be zoomed in, and then release the button.

8.3.4 Final Result AE Fault

The final result is shown below with the characteristics of the zones. To zoom in, left click and drag defining the region to be zoomed in, and then release the button.

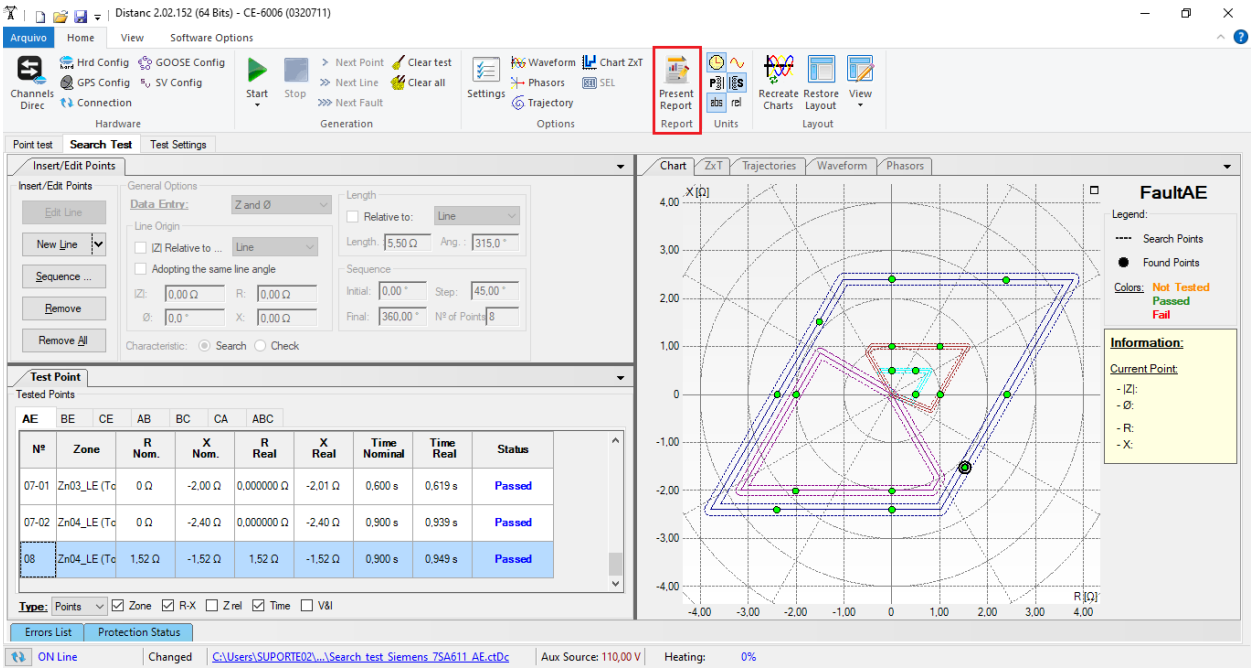

Figure 61

9. 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.

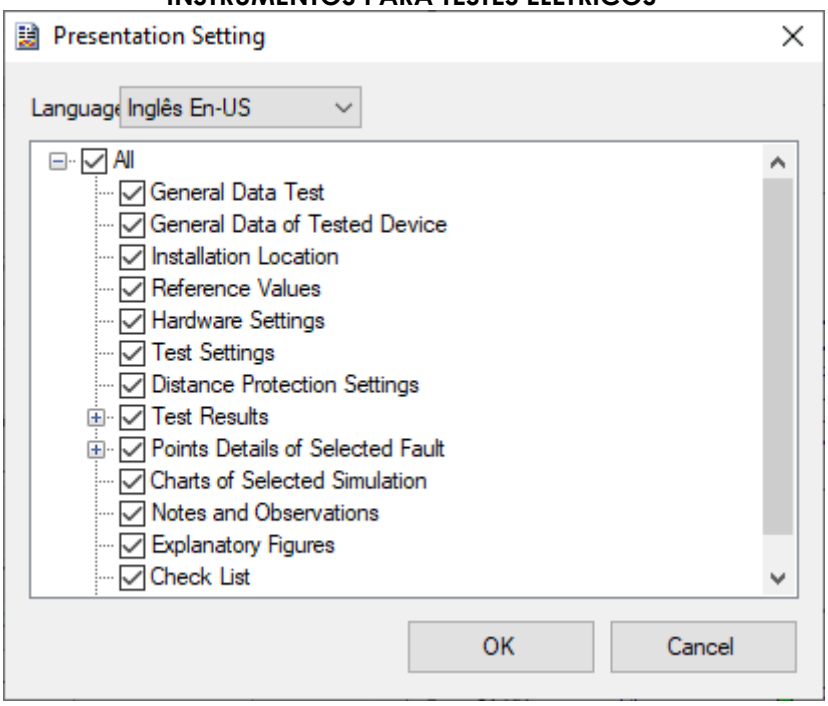

Figure 62

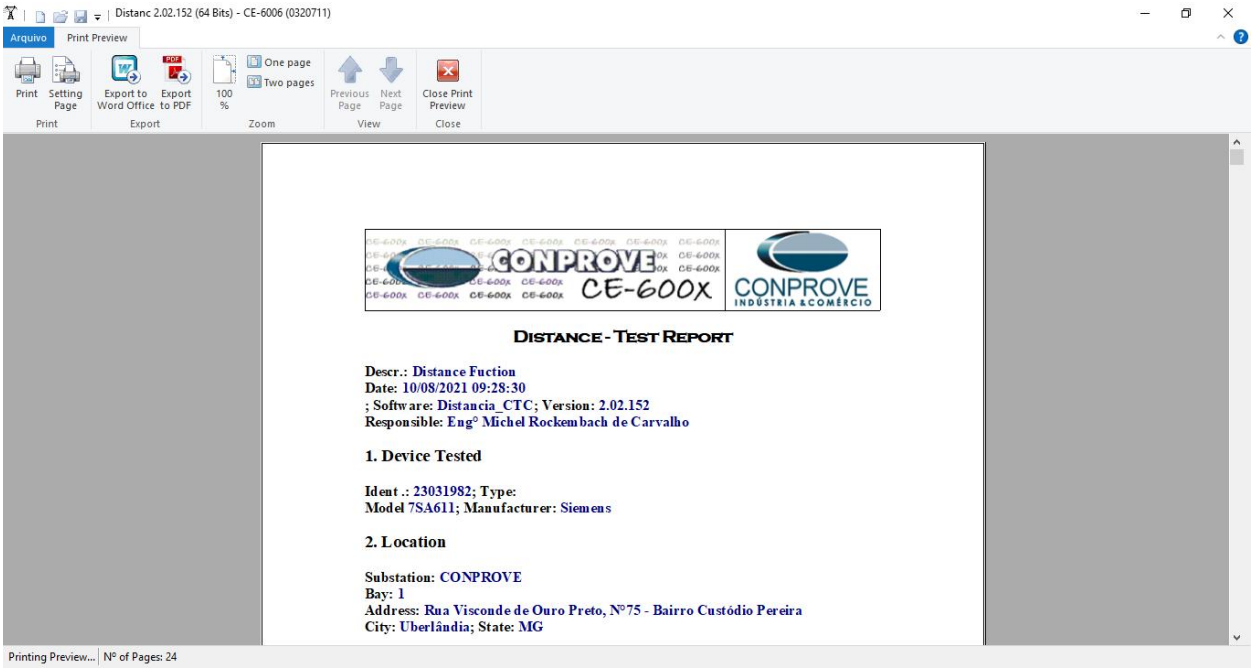

Figure 63

APPENDIX A

A.1 Terminal Designations

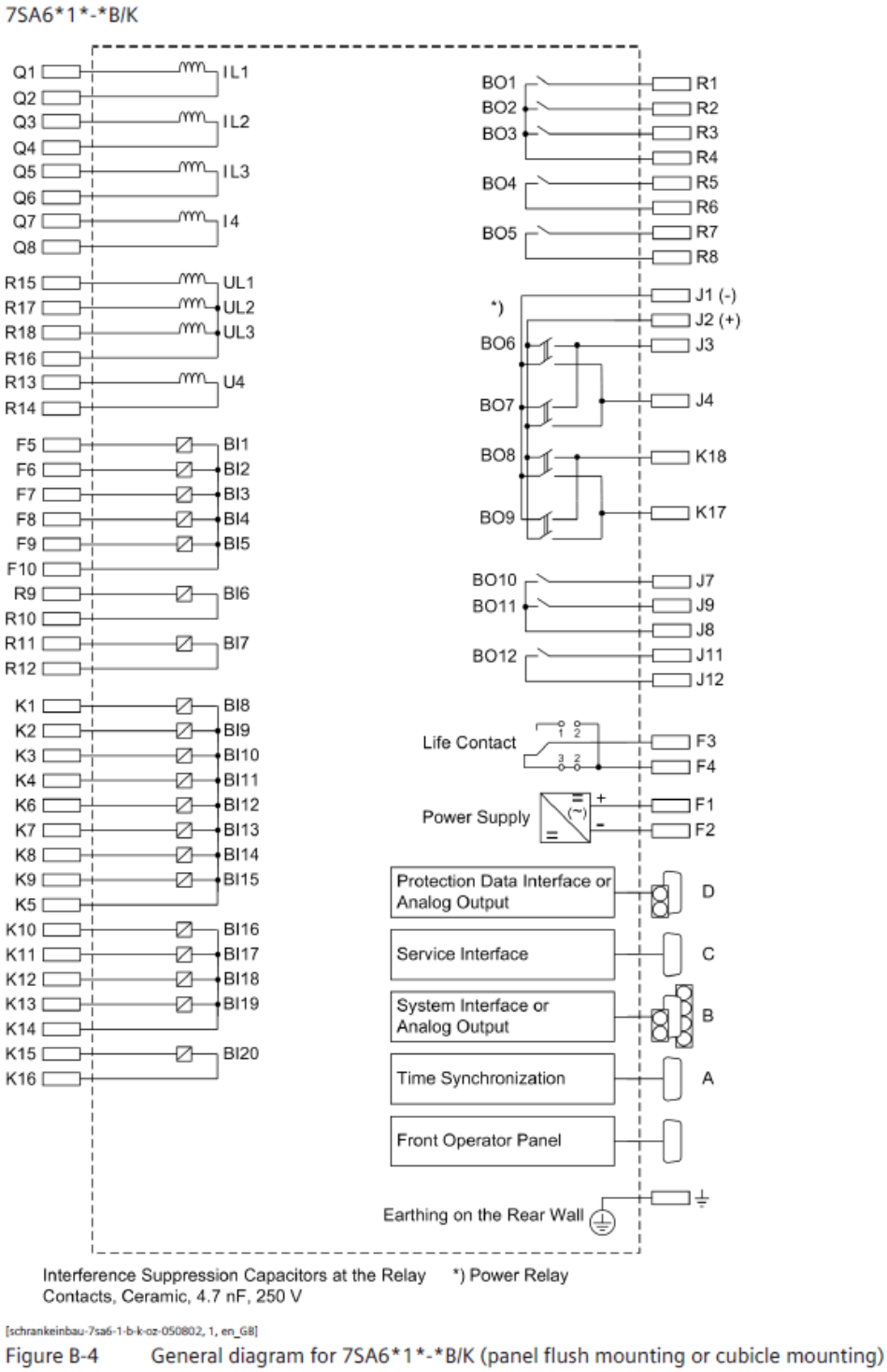

Figure B-4 General diagram for 7SA6*1*-*B/K (panel flush mounting or cubicle mounting)

Figure 64

A.2 Technical Data

Table 1

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 $0° \le \varphi_k \le 90°$	

Table 2

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 3

Distance Software		Siemens 7SA611 Relay	
Parameter	**Figure**	**Parameter**	**Figure**
Mod Z0/Z1	29	Zero seq. comp. K0 for Z1	16
Ang Z0/Z1	29	Zero seq. comp. Angle for Z1	16
Zn1		Phase Distance Z1	
Distance Angle	30	Angle of inclination, distance charact.	16
Forward/Reverse/Non-Directional	30	Operating mode Z1	19
R	30	R(Z1), Resistance for ph-ph faults	19
X	30	X(Z1), Reactance	19
Trigger Time	30	T1 multi-ph, delay for multiphase faults	19
Zone Reduction	30	Zone Reduction Angle	19
Zn2		Phase Distance Z2	
Distance Angle	31	Angle of inclination, distance charact.	16
Forward/Reverse/Non-Directional	31	Operating mode Z2	20
R	31	R(Z2), Resistance for ph-ph faults	20
X	31	X(Z2), Reactance	20
Trigger Time	31	T2 multi-ph, delay for multiphase faults	20
Zone Reduction	31	Zone Reduction Angle	20
Zn3		Phase Distance Z3	
Distance Angle	32	Angle of inclination, distance charact.	16
Forward/Reverse/Non-Directional	32	Operating mode Z3	21
R	32	R(Z3), Resistance for ph-ph faults	21
X	32	X(Z3), Reactance	21
Trigger Time	32	T3 multi-ph, delay for multiphase faults	21
Zone Reduction	32	Zone Reduction Angle	21
Zn4		Phase Distance Z4	
Distance Angle	33	Angle of inclination, distance charact.	16
Forward/Reverse/Non-Directional	33	Operating mode Z4	22
R	33	R(Z4), Resistance for ph-ph faults	22
X	33	X(Z4), Reactance	22
Trigger Time	33	T4 multi-ph, delay for multiphase faults	22
Zone Reduction	33	Zone Reduction Angle	22

Software Distance		Siemens 7SA611 Relay	
Parameter	**Figure**	**Parameter**	**Figure**
Zn1_LE		**Ground Distance Z1**	
Distance Angle	**34**	**Angle of inclination, distance charact.**	**16**
Forward/Reverse/Non-Directional	**34**	**Operating mode Z1**	**19**
RE	**34**	**RG(Z1), Resistance for ph-gnd faults**	**19**
X	**34**	**X(Z1), Reactance**	**19**
Trigger Time	**34**	**T1 1-ph, delay for multiphase faults**	**19**
Zone Reduction	**34**	**Zone Reduction Angle**	**19**
Zn2_Terra		**Ground Distance Z2**	
Distance Angle	**35**	**Angle of inclination, distance charact.**	**16**
Forward/Reverse/Non-Directional	**35**	**Operating mode Z2**	**20**
RE	**35**	**RG(Z2), Resistance for ph-gnd faults**	**20**
X	**35**	**X(Z2), Reactance**	**20**
Trigger Time	**35**	**T2 1-ph, delay for multiphase faults**	**20**
Zone Reduction	**35**	**Zone Reduction Angle**	**20**
Zn3_LE		**Ground Distance Z3**	
Distance Angle	**36**	**Angle of inclination, distance charact.**	**16**
Forward/Reverse/Non-Directional	**36**	**Operating mode Z3**	**21**
RE	**36**	**RG(Z3), Resistance for ph-gnd faults**	**21**
X	**36**	**X(Z3), Reactance**	**21**
Trigger Time	**36**	**T3 1-ph, delay for multiphase faults**	**21**
Zone Reduction	**36**	**Zone Reduction Angle**	**21**
Zn4_LE		**Ground Distance Z4**	
Distance Angle	**37**	**Angle of inclination, distance charact.**	**16**
Forward/Reverse/Non-Directional	**37**	**Operating mode Z4**	**22**
RE	**37**	**RG(Z4), Resistance for ph-gnd faults**	**22**
X	**37**	**X(Z4), Reactance**	**22**
Trigger Time	**37**	**T4 1-ph, delay for multiphase faults**	**22**
Zone Reduction	**37**	**Zone Reduction Angle**	**22**