INSTRUMENTOS PARA TESTES ELÉTRICOS

Test Tutorial

Equipment Type: Protection Relay

Brand: GE

Model: D60

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

Tool Used: CE-6006; CE6707; CE-6710; CE-7012 or CE-7024

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

Version Control:

Version	Descriptions	Date	Author	Reviewer
1.0	Initial Version	28/03/2022	M.R.C.	G.C.D.P

Summary

Rua Visconde de Ouro Preto, 77 - Bairro Custódio Pereira - Uberlândia – MG - CEP 38405-202.
Phone (34) 3218-6800 Fax (34) 3218-6810
Home Page: www.conprove.com - E-mail: conprove@conprove.com.br

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

D60 Relay Power Swing Blocking and Out-of-Step Protection Philosophy

Power swing detection has both blocking and tripping functions. The impedance vector is measured according to 2 or 3 user-parameterized boundary characteristics.

1. Detection of Power Swing Blocking:

Three-step operation: Power swing time is measured when the impedance vector is between the outermost zones to the central zone. If the impedance enters the external zone and remains outside the central characteristic for a time longer than the time parameterized in POWER SWING PICKUP DELAY 1, the power swing blocking is performed. The release will be commanded when the impedance leaves the outermost characteristic, but not before the parameterized time.

Two-step operation: for the two-step mode, the sequence is identical, but it is the external and internal characteristics that will be used to measure the time.

2. Detection of Power Swing (TRIP):

Three-step operation: unstable power oscillations are identified by checking if the impedance has remained between the external and central characteristic for a finite time and between the central and internal characteristic also for a finite time. The first step is identical to detecting power swing. After the POWER SWING PICKUP DELAY 1 time is exceeded, lock 1 is adjusted over the period the impedance remains in the outer zone.
If then, at any time, the impedance stays between the external zone and the switch for a period longer than POWER SWING PICKUP DELAY 2, a lock 2 is set while the impedance remains inside the external zone.
If then, at any time, the impedance remains within the inner zone for a period longer than POWER SWING PICKUP DELAY 3, a lock 3 is set while the impedance remains within the outer zone. The element is therefore ready for tripping.
If fast TRIP mode is selected, power swing trip is commanded immediately and is locked for a time set in POWER SWING SEAL-IN DELAY. If “delayed” trip mode is selected, the element waits until the impedance leaves the internal characteristic and the POWER SWING PICKUP DELAY 4 time expires, thus setting a latch of 4, making the element ready to trip. The trip will only be commanded later when the impedance leaves the external characteristic.

Two-Step Operation: Two-Step Mode is similar to Three-Step with two exceptions. First, the initial stage monitors the time spent by the impedance vector between the outer and inner zones. Second, the stage involving the POWER SWING PICKUP DELAY 2 is skipped.
The element can be adjusted to use either mho or quadrilateral features as shown below. When set to Mho, the element also applies blinders (left and right). If blinders are not required, their settings must be parameterized high enough to effectively disable them.

1. Relay Connection to CE-6710

1.1 *Auxiliary Source*

Connect the positive (red terminal) of the Aux Source Vdc to pin B5b of the relay and the negative (black terminal) of the Aux Source Vdc to pin B6a of the relay.

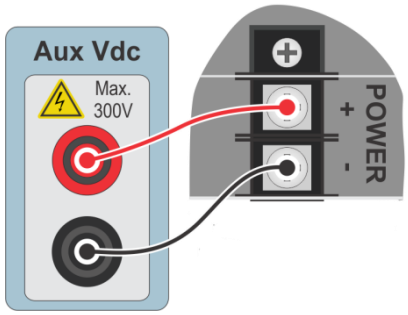


Figure 1

1.2 *Current and Voltage Coils*

To establish the connection of voltage coils, connect voltage channels V1, V2 and V3 to pins F5a, F6a and F7a of the relay and connect the commons of voltage channels to pins F5b, F6b and F7b of the relay: current I1, I2 and I3 of the CE-6710 to pins F1a, F2a and F3a of the relay respectively, connect the three commons of the CE-6710 to the pins F1b, F2b and F3b of the relay completing the connection.

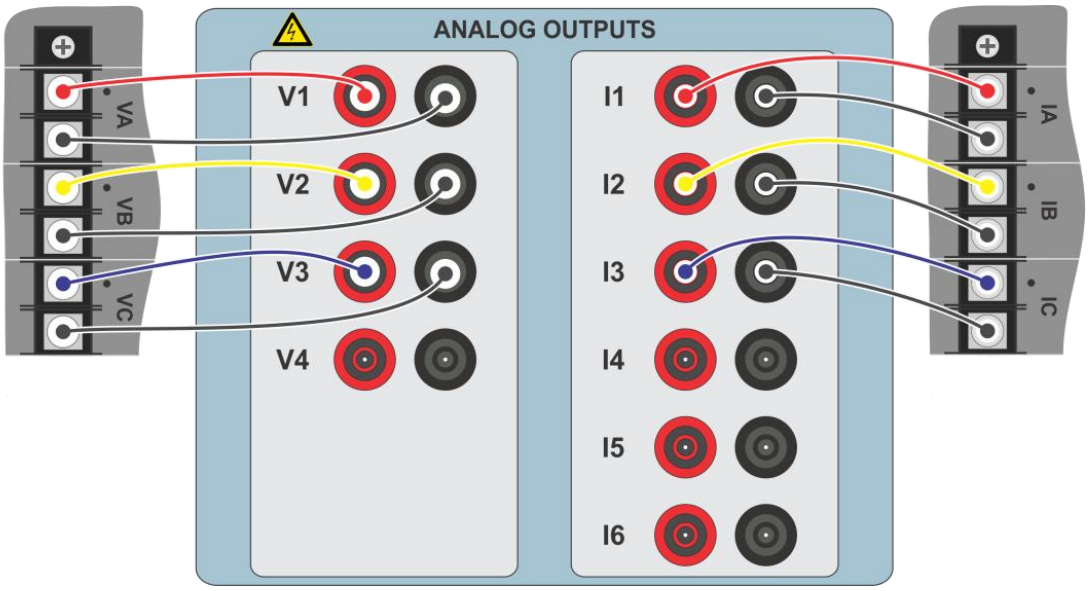


Figure 2

1.3 *Binary Inputs*

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

- BI1 to pin P1b and its common to pin P1c.
- BI2 to pin P2b and its common to pin P2c.
- BI3 to pin P3b and its common to pin P3c.

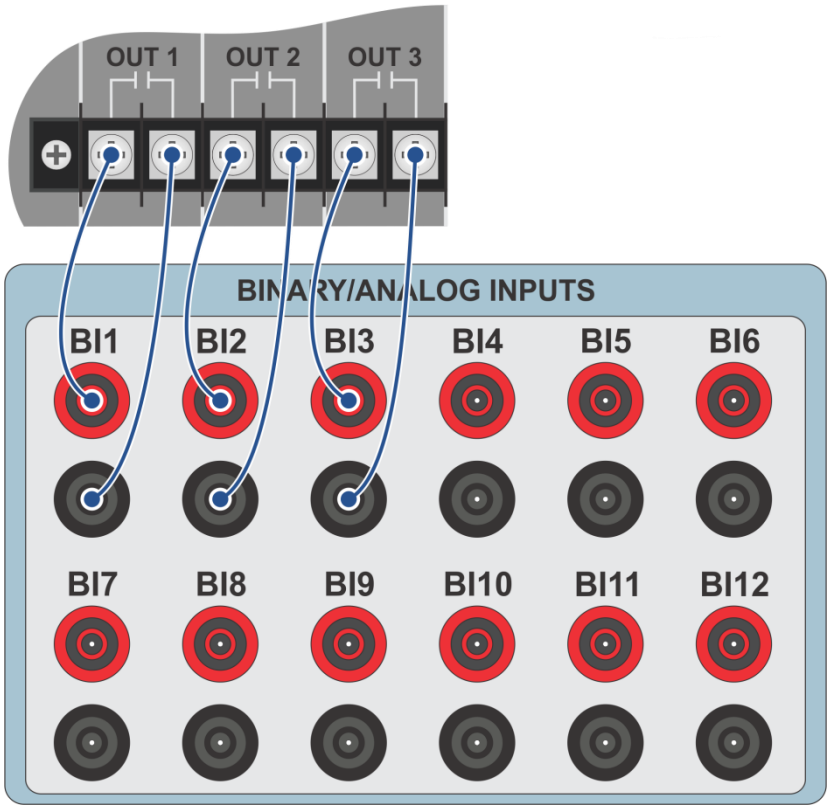


Figure 3

2. Communication with relay D60

Before starting the D60 relay test, open the *"EnerVista"* software and download the *"UR"* series software, if you already have it, click directly on:

Figure 4

Check the relay IP and adjust this value in *"Device Setup"* after inserting a new system. Then read the relay code by clicking on *"Read Order Code"* and finish by clicking on *"OK"*.

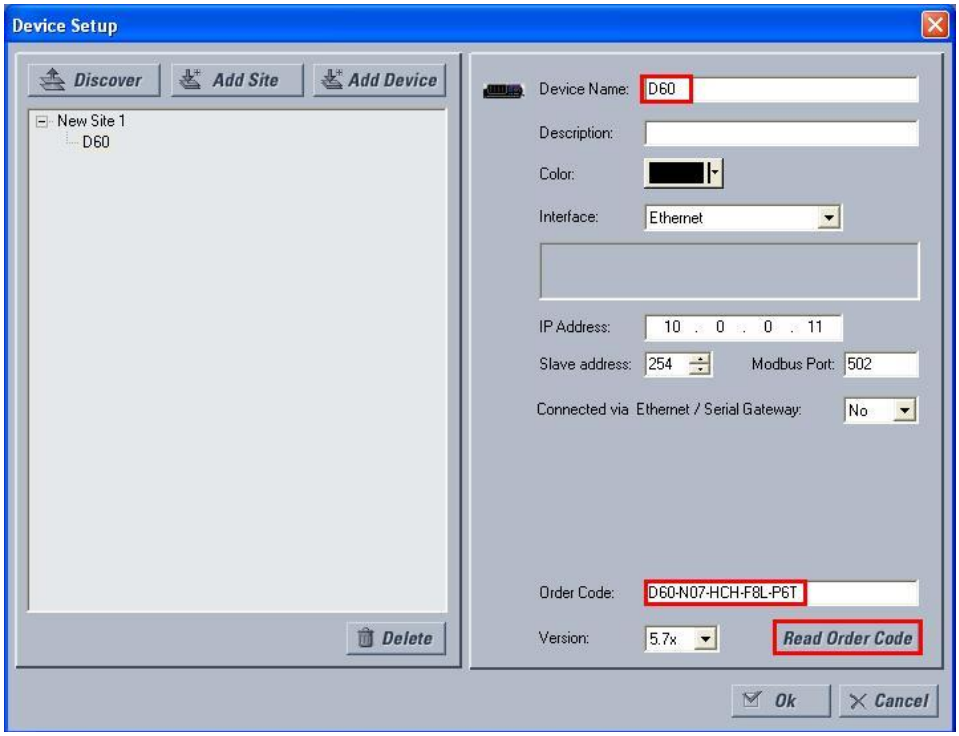


Figure 5

Then click on *"New Site 1"* and *"D60"* to access the relay configuration and close the *"Offline Window"* window by clicking on the button highlighted in green.

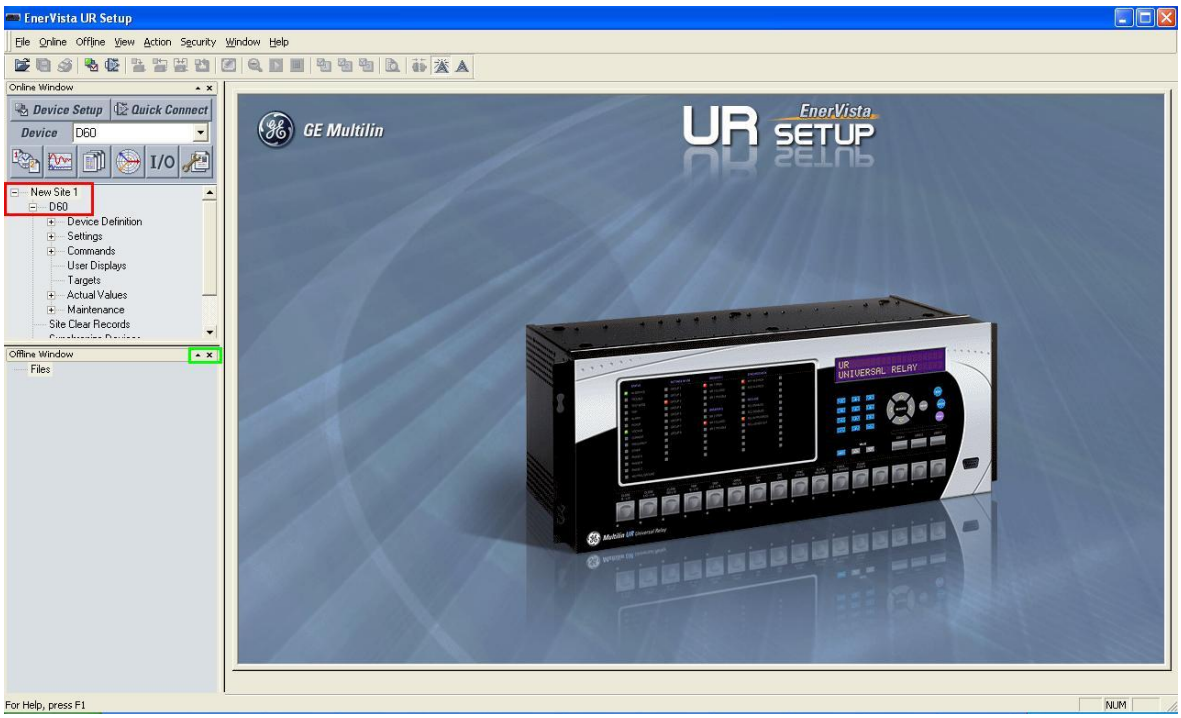


Figure 6

3. Parameterization of relay D60

3.1 *Current*

After the connection has been established, click on the *"+"* signs next to *"Settings"* > *"System Setup"* > *"AC Inputs"* and double-click on *"Current"*, in which you will be able to adjust the primary and secondary current values of the current transformer.

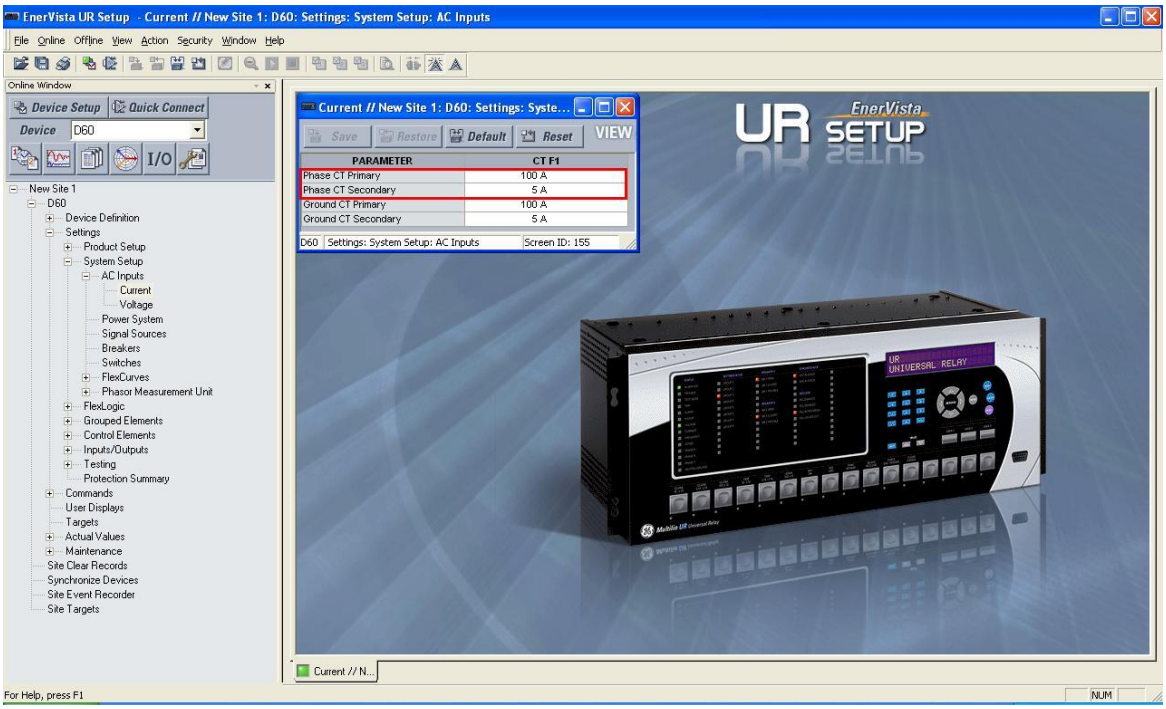


Figure 7

3.2 *Voltage*

Click on *"Voltage"* and then adjust the voltage transformer primary and secondary voltage values.

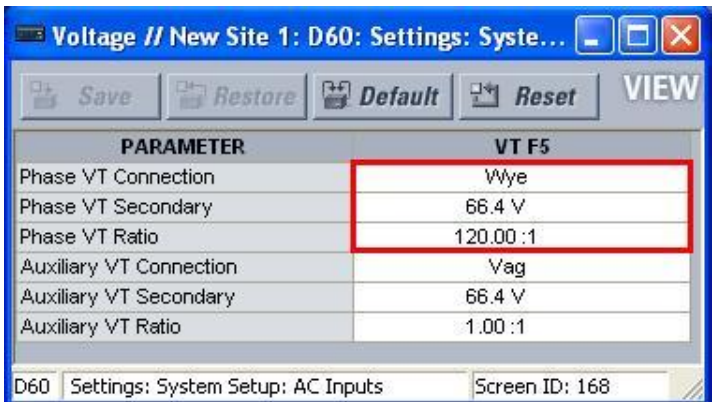


Figure 8

3.3 *Power system*

In this field, the nominal frequency, the phase sequence and the side used as reference are set.

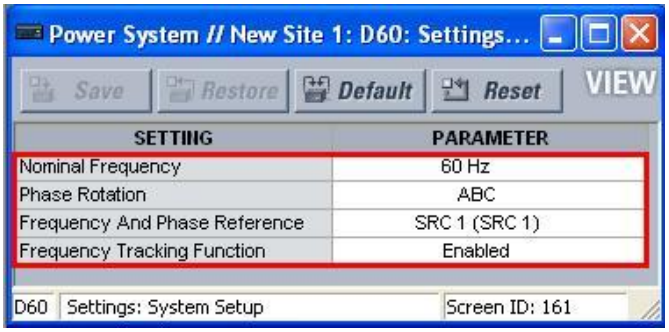


Figure 9

3.4 *Signal Source*

Set the current transformer to *"F1"* and the potential transformer to *"F5"* in *"Source 1"*.

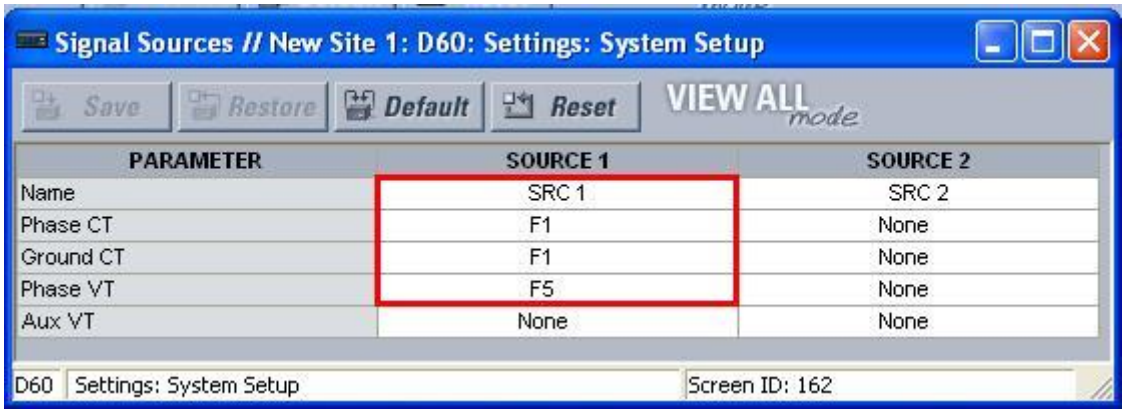


Figure 10

3.5 *Distance*

Click the *"+"* sign next to *"Grouped Elements" > "Group1" > "Distance"* and double-click *"Distance"* (not shown). In this window, the "*Source*" is defined with *"SRC1"*.

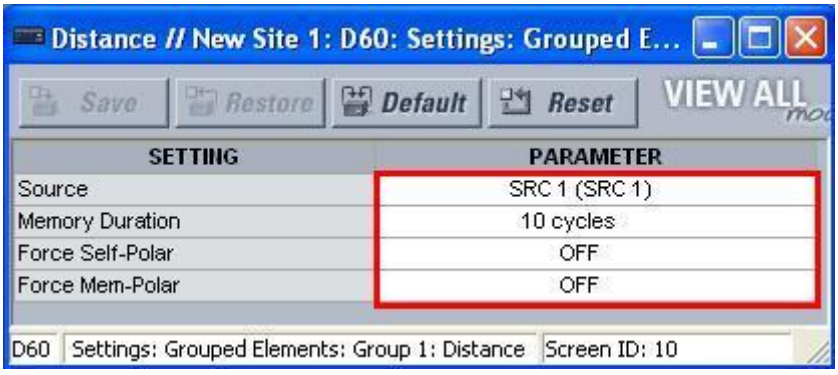
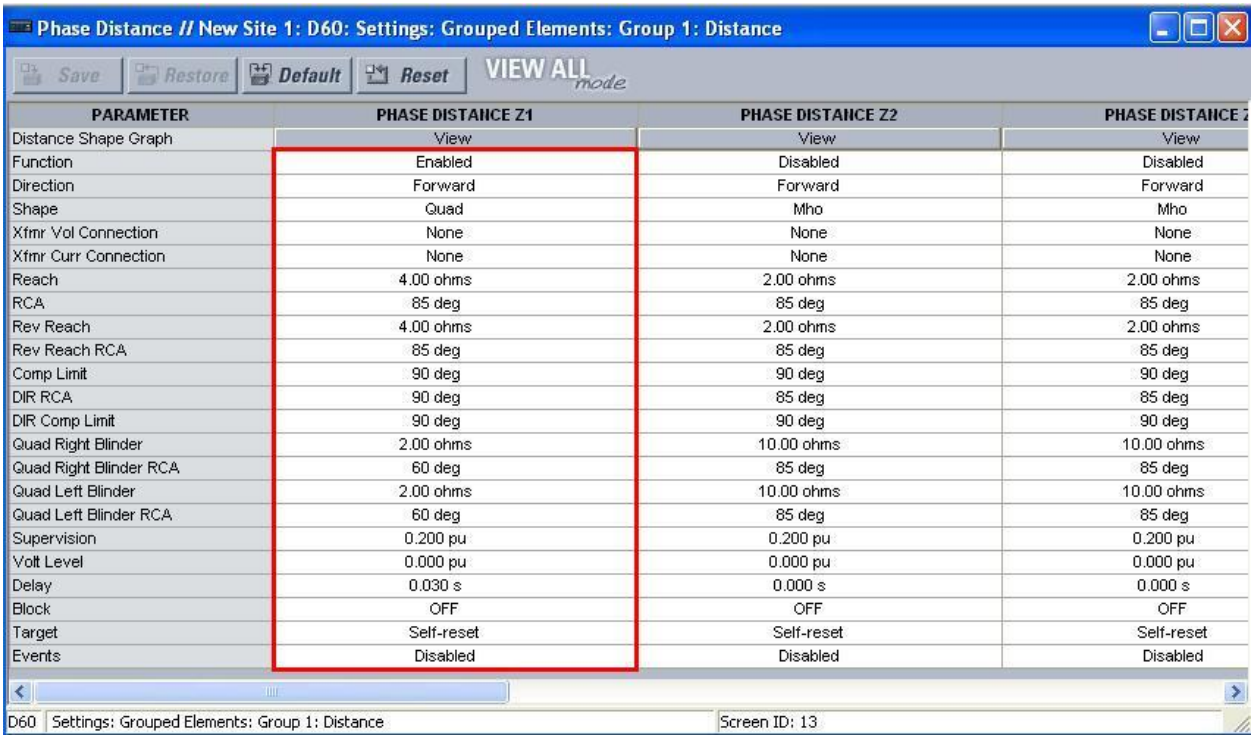


Figure 11

3.6 *Phase Distance*

Click the *"+"* sign next to *"Grouped Elements" > "Group1" > "Distance"* and double-click *"Phase Distance"* (not shown). In this window, the zone settings, directionality and operating time of the phase elements are defined. Although the relay allows the registration of up to 5 zones, in this test only zone 1 will be used.



PARAMETER	PHASE DISTANCE Z1	PHASE DISTANCE Z2	PHASE DISTANCE Z
Distance Shape Graph	View	View	View
Function	Enabled	Disabled	Disabled
Direction	Forward	Forward	Forward
Shape	Quad	Mho	Mho
Xfmr Vol Connection	None	None	None
Xfmr Curr Connection	None	None	None
Reach	4.00 ohms	2.00 ohms	2.00 ohms
RCA	85 deg	85 deg	85 deg
Rev Reach	4.00 ohms	2.00 ohms	2.00 ohms
Rev Reach RCA	85 deg	85 deg	85 deg
Comp Limit	90 deg	90 deg	90 deg
DIR RCA	90 deg	85 deg	85 deg
DIR Comp Limit	90 deg	90 deg	90 deg
Quad Right Blinder	2.00 ohms	10.00 ohms	10.00 ohms
Quad Right Blinder RCA	60 deg	85 deg	85 deg
Quad Left Blinder	2.00 ohms	10.00 ohms	10.00 ohms
Quad Left Blinder RCA	60 deg	85 deg	85 deg
Supervision	0.200 pu	0.200 pu	0.200 pu
Volt Level	0.000 pu	0.000 pu	0.000 pu
Delay	0.030 s	0.000 s	0.000 s
Block	OFF	OFF	OFF
Target	Self-reset	Self-reset	Self-reset
Events	Disabled	Disabled	Disabled

Figure 12

3.7 *Power Swing Detect*

Double-click on *"Power Swing Detect"*. In this option, you define the values for power swing or out-of-step detection. You must choose the zone type (Mho or Quadrilateral) and the number of zones (two or three). In this tutorial the fits are quadrilateral with two zones. To test the mho characteristic with 3 zones, the user just has to make an analogy to this tutorial.

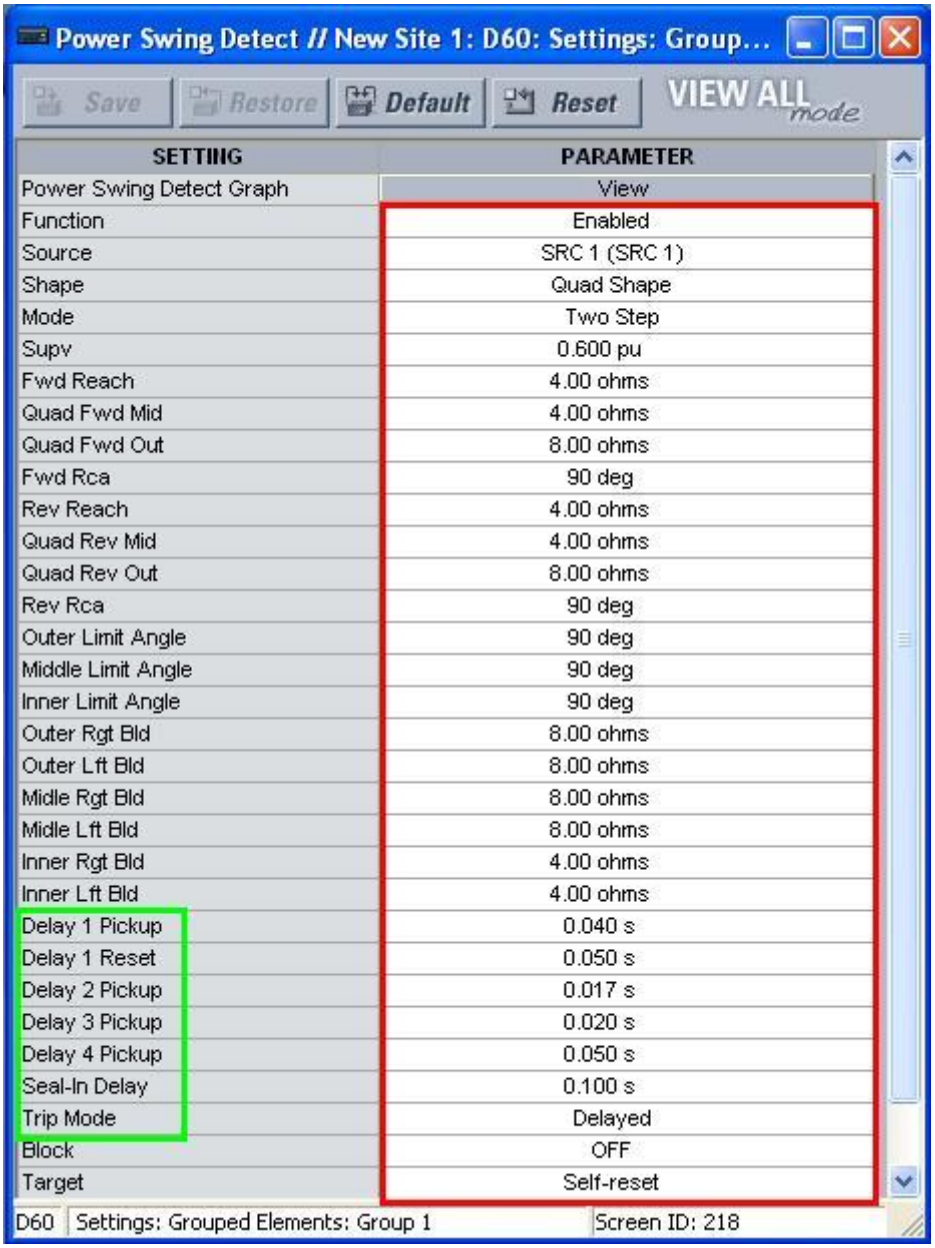


Figure 13

4. Binary Output Adjustments

4.1 *Contact Outputs*

Click on the *"+"* sign next to *"Inputs/Outputs"* and double-click on *"Contact Outputs"* (not shown). On this screen, the trips of the functions with the binary outputs of the relay are designated.

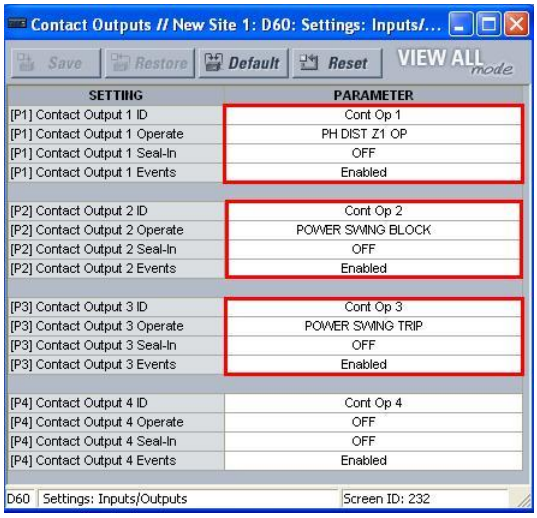


Figure 14

In appendix B the user finds an equivalence table between the relay software settings and the test case.

5. PSB OoS software adjustments

5.1 *Opening the PSB OoS*

Click on the CTC application manager icon.

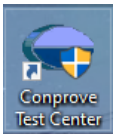


Figure 15

Click the *"PSB OoS*" software icon.

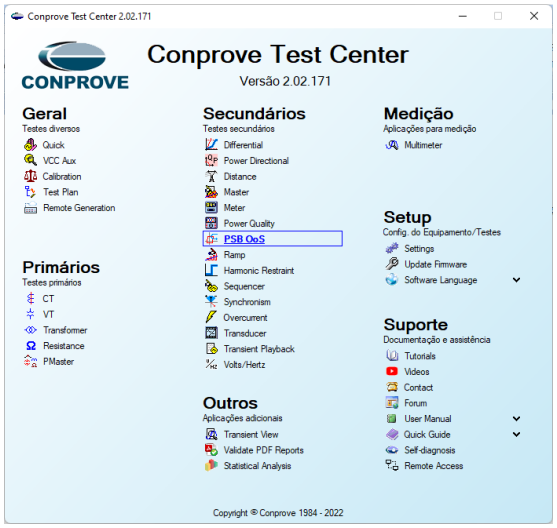


Figure 16

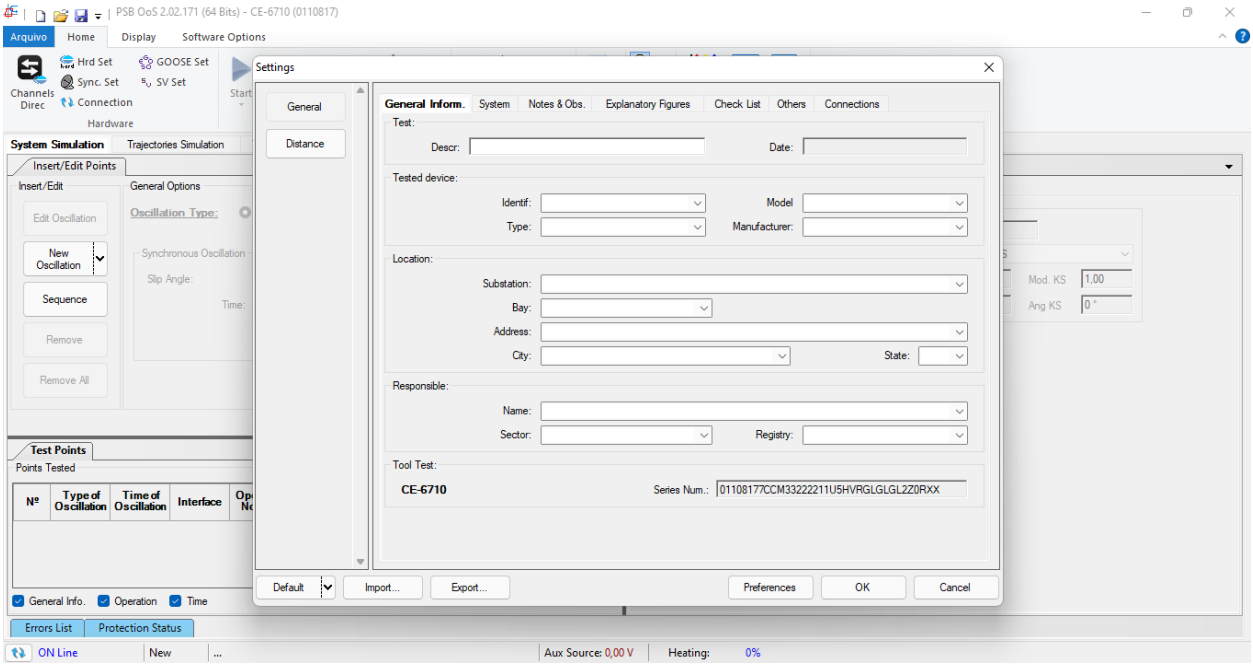


Figure 17

5.2 *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.

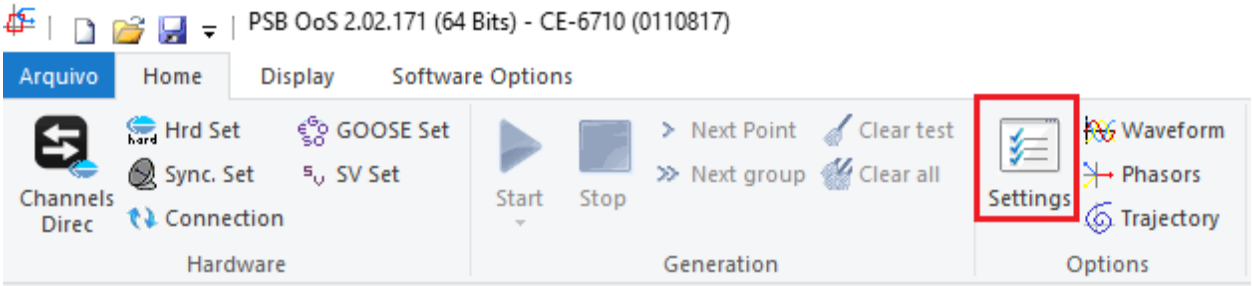


Figure 18

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 in it.

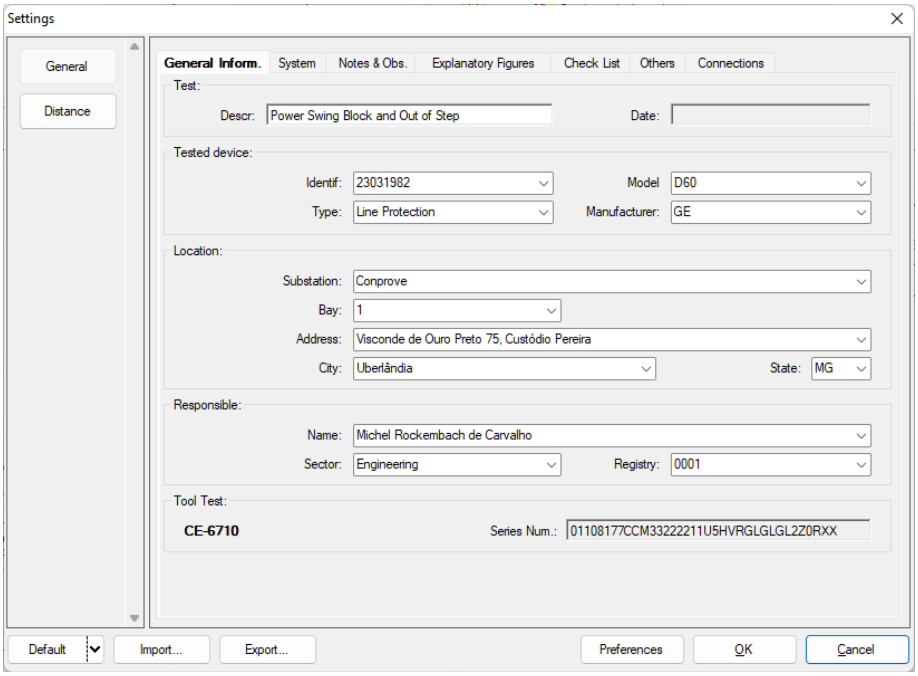


Figure 19

5.3 *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.

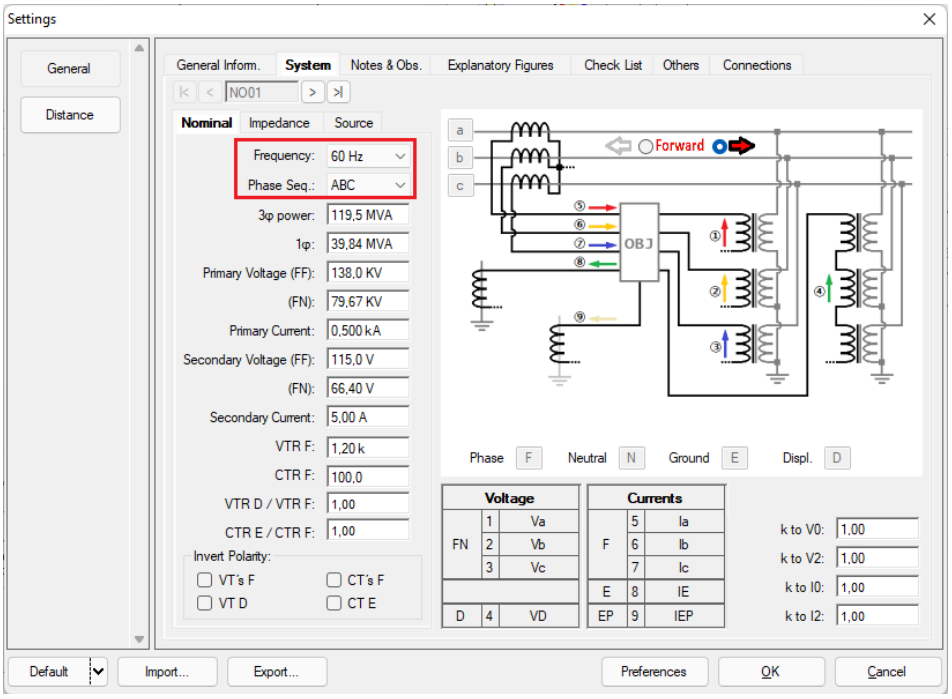


Figure 20

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.

6. Channel Targeting and Hardware Configuration

Click on the icon pointed out below.

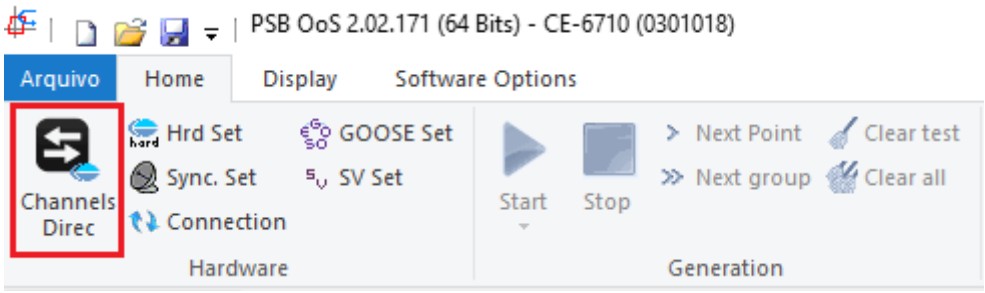


Figure 21

Then click on the highlighted icon to configure the hardware.

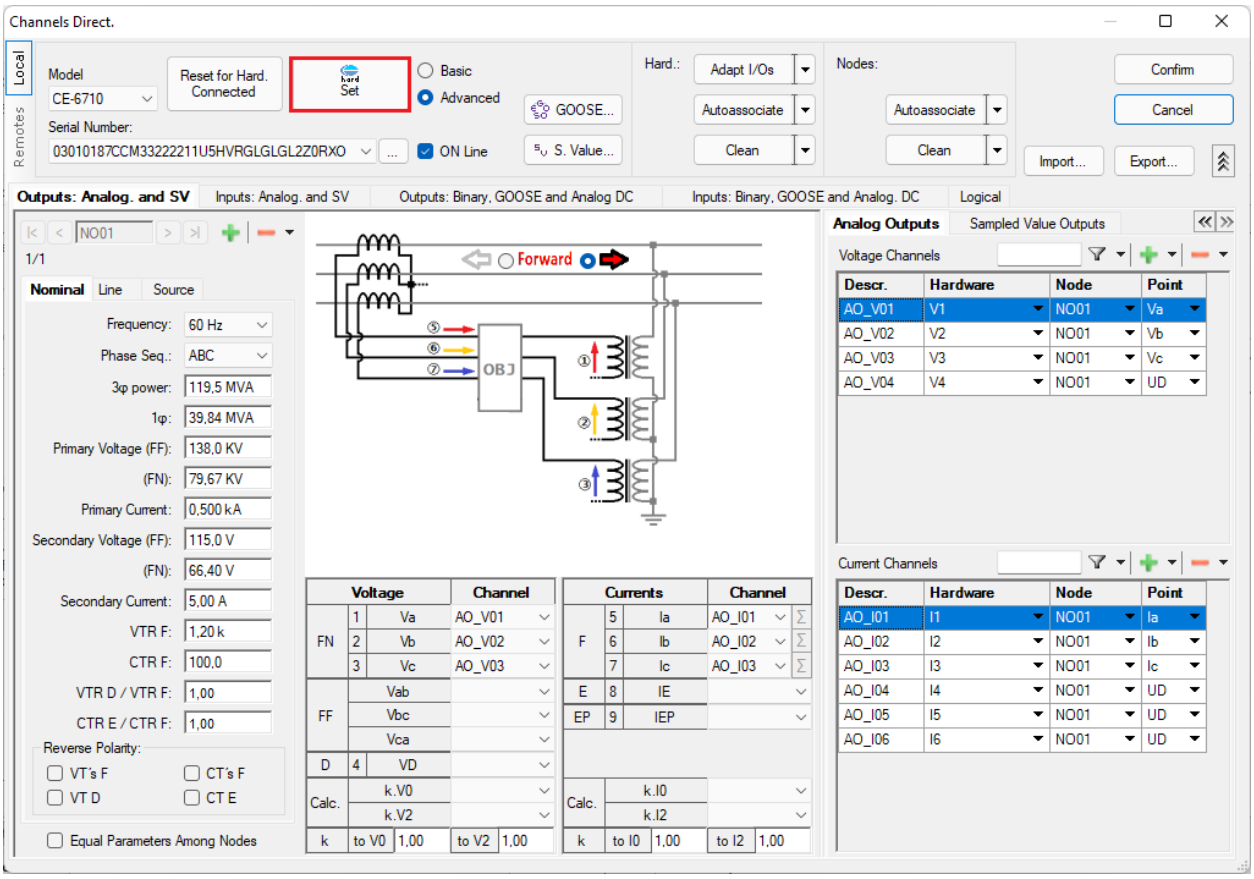


Figure 22

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

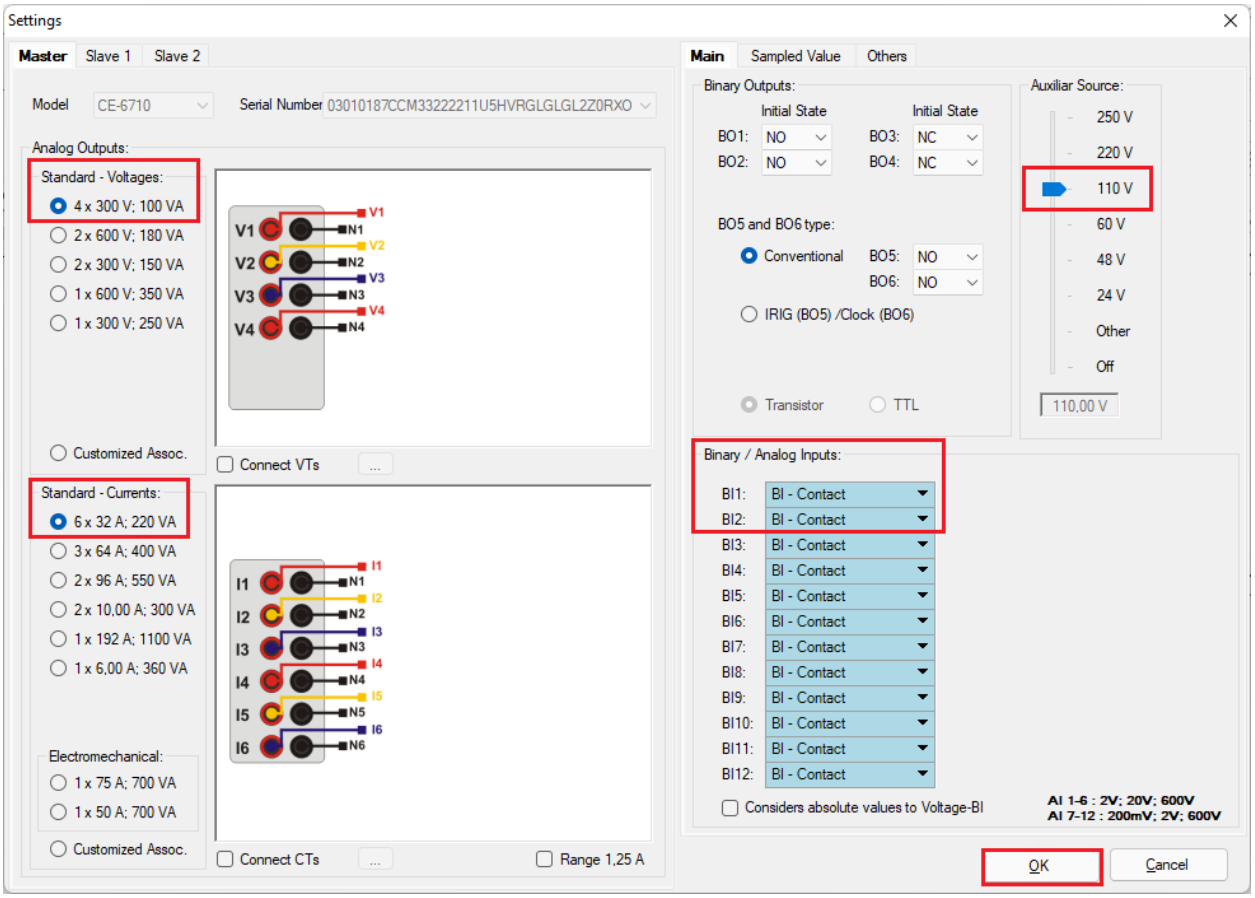


Figure 23

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

Figure 24

7. Distance Adjustments

7.1 *Distance screen > Distance Prot. Settings*

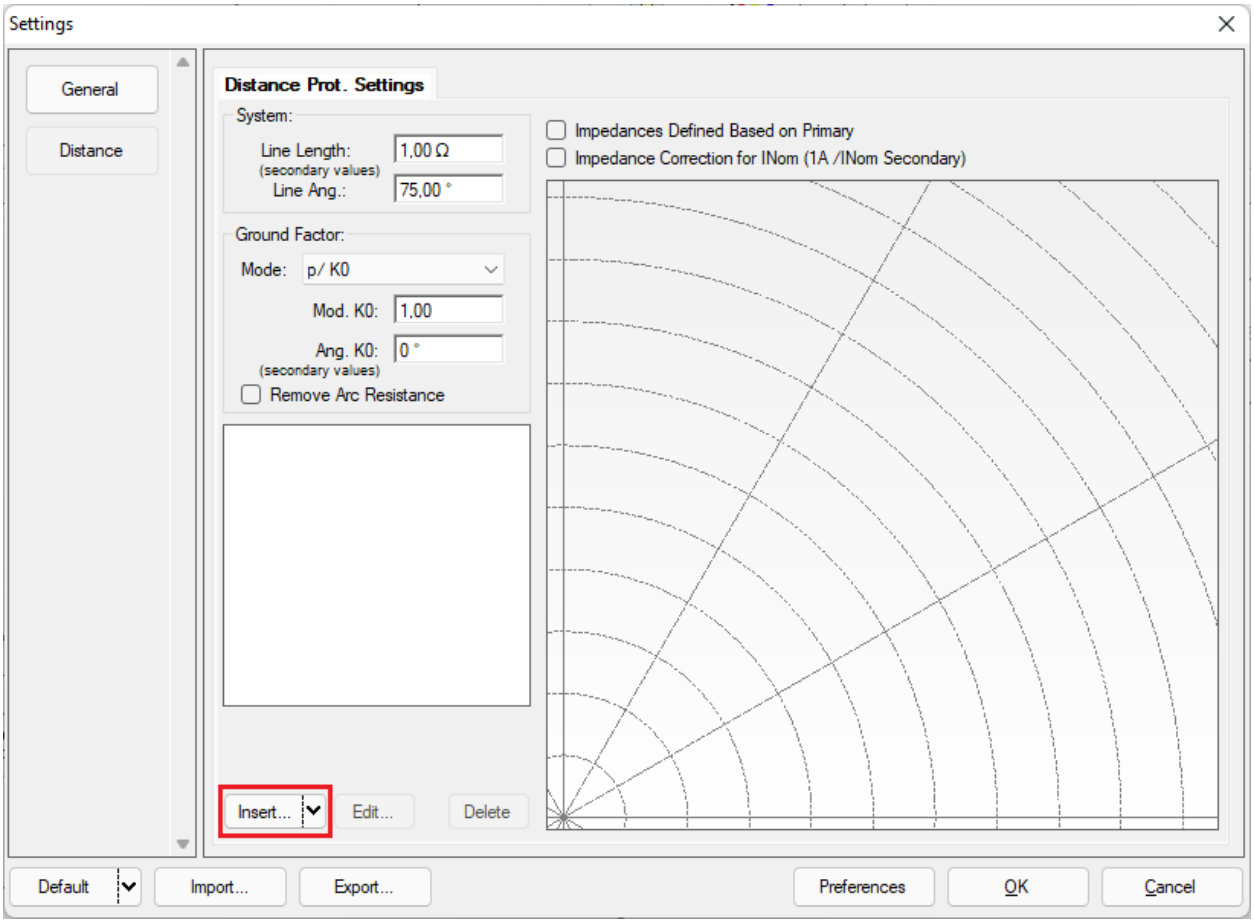


Figure 25

7.2 *Entering the Phase Zone*

The first zone to be entered will be zone-1 (Phase). Click on the *"Insert"* field highlighted in red in the previous figure. On the settings screen, first choose the relay mask *"GE D60- 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"*.

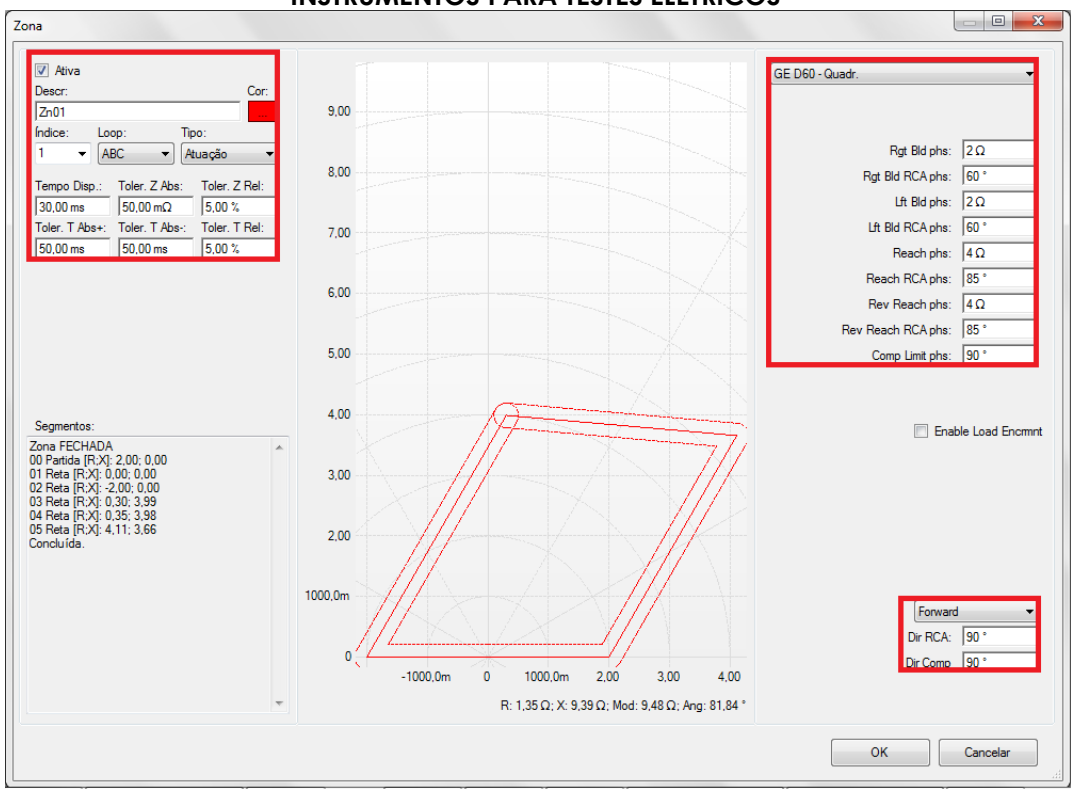


Figure 26

7.3 *Inserting the blinders*

By clicking on *"Insert"* again, set the values of two zones with quadrilateral characteristics to represent the blinders being an internal and an external one. Depending on the time the impedance path takes to pass between the two blinders, the relay decides which action to take.

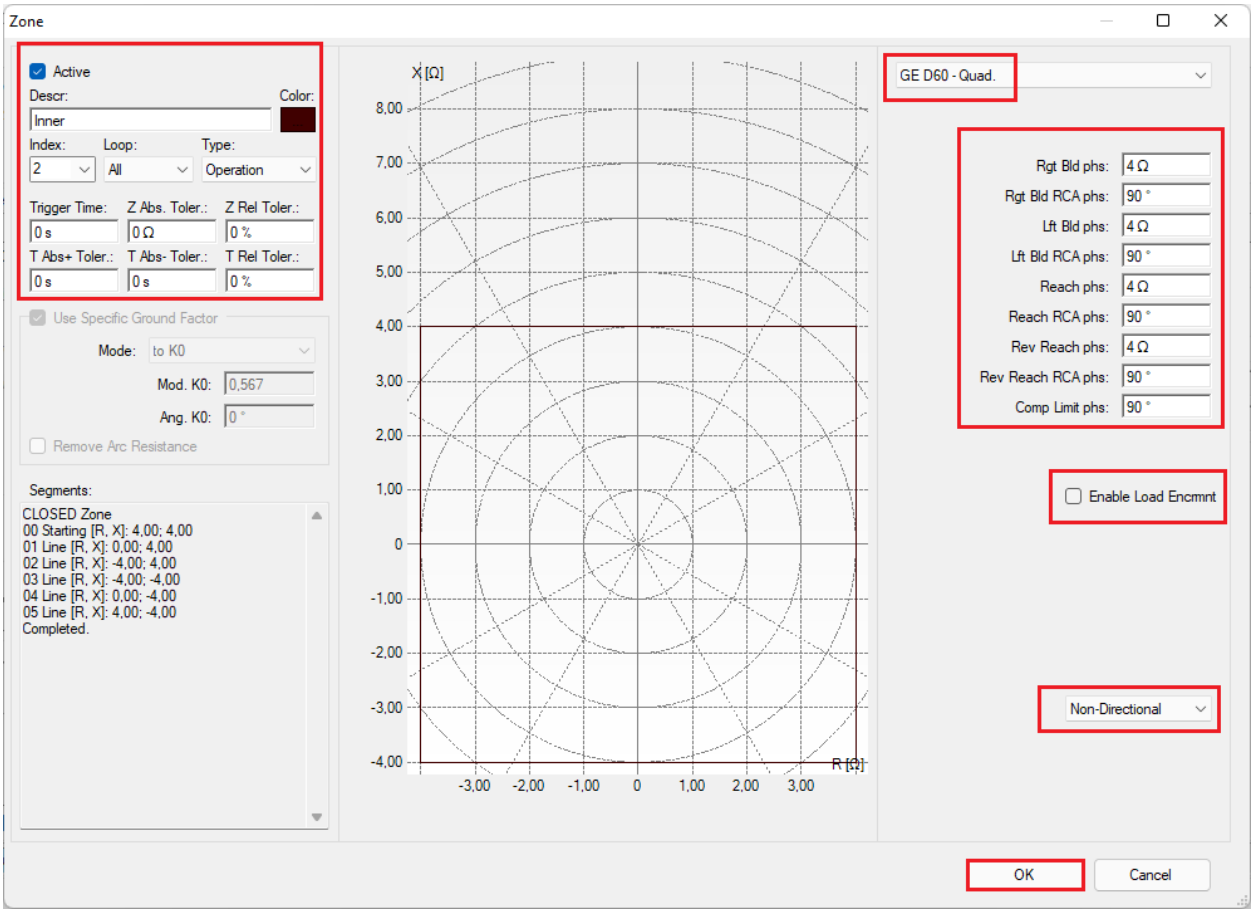


Figure 27

By clicking on *"Insert"*once again, set the values for Outer zone.

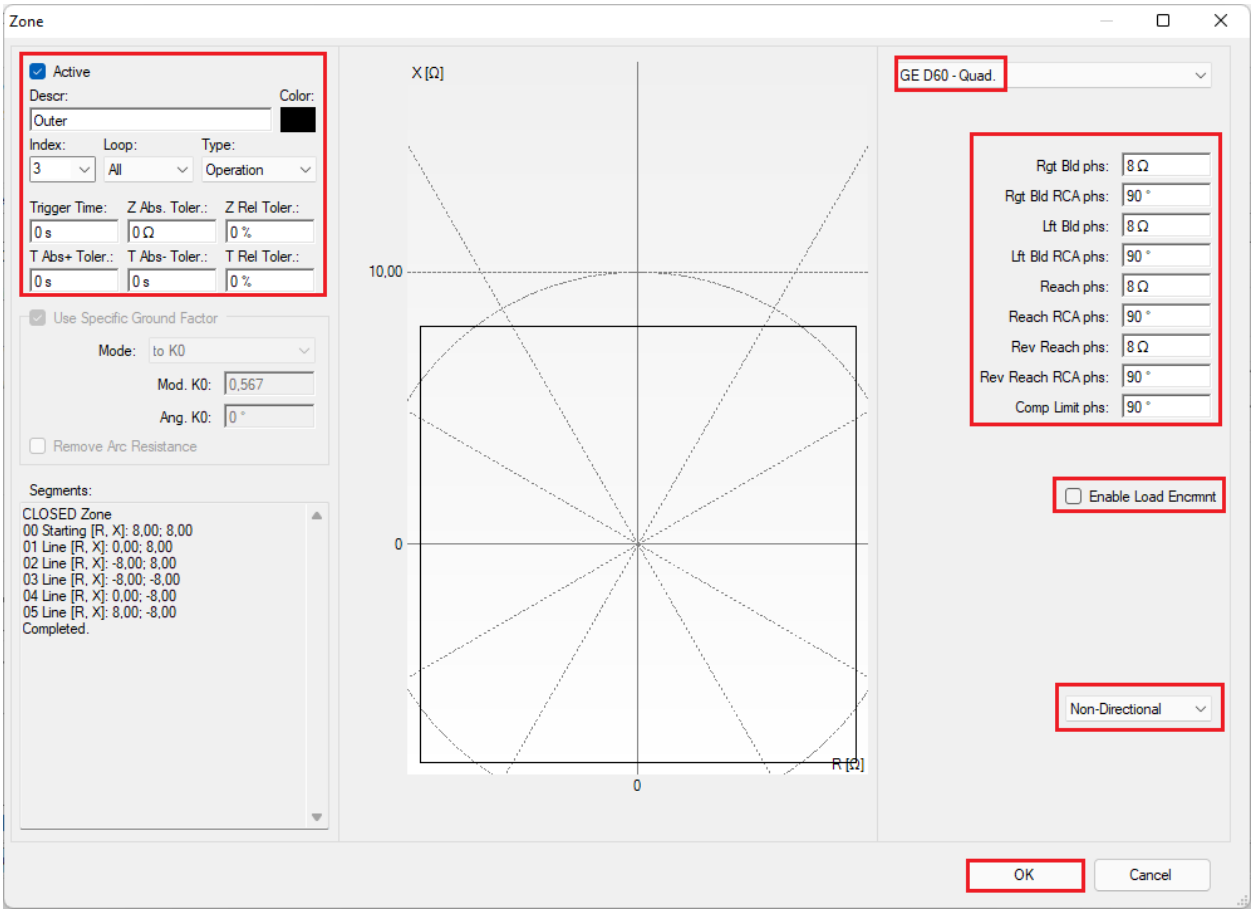


Figure 28

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 = "*OoS Trip*".

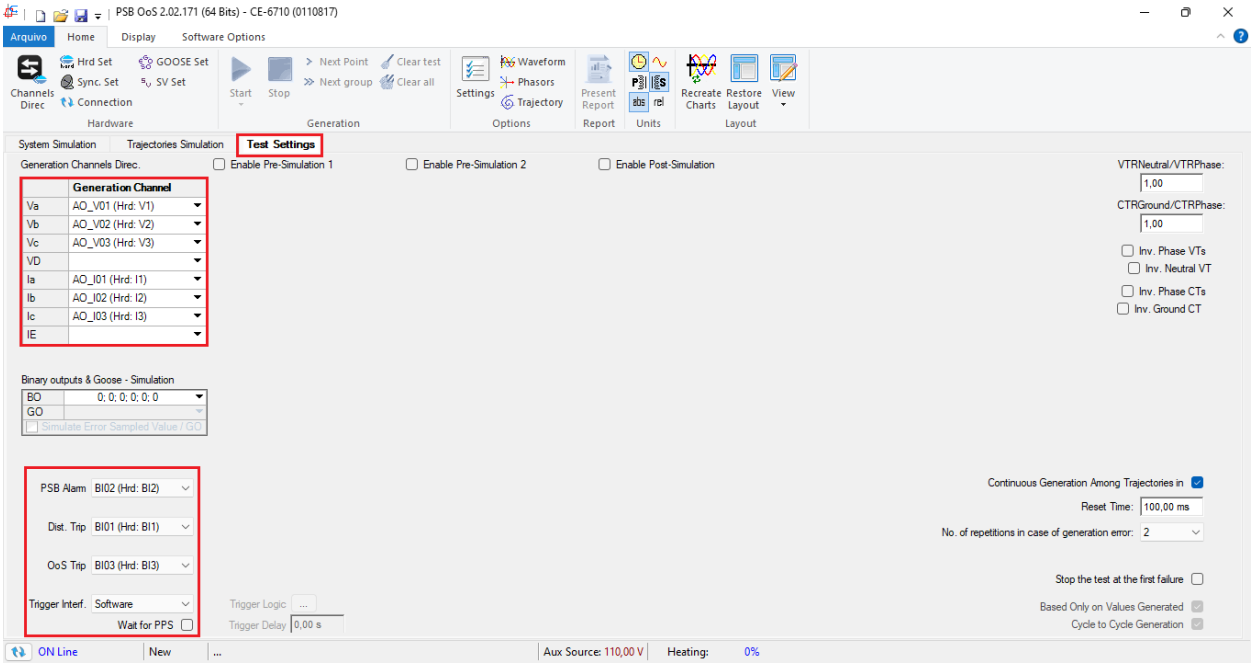


Figure 29

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 *Trajectories Simulation*

The Trajectory Simulation test makes it possible to create the same tests as the System Simulation, however it has the great advantage of not being tied to the real system settings, so that the user has complete freedom to control the impedance trajectory (dZ/dt). The key factor in detecting the types of oscillation is in the time settings of the *"Delay Pickup (from 1 to 4)"* parameters inserted into the relay. Depending on the time the trajectory takes to pass from the external to the internal blinder, the following situations arise:

1. Time greater than *"Delay 1 Pickup"* set to 0.03 seconds to cross the two blinders regardless of the side (right or left). Power Swing Block tripping.
2. The time set in *"Delay 2 Pickup"* is not used in this case. This parameter must be considered when using 3 blinders.
3. When the *"Trip mode"* option is set to *"Early"*, a time greater than the *"Delay 3 Pickup"* set to 0.02 seconds to cross the inner zone causes the relay to perform the Out-of-Step trip..

4. When the *"Trip mode"* option is set to *"Delay"*, a time greater than the *"Delay 4 Pickup"* set to 0.05 seconds to cross the two blinders on both sides causes the Out-of-Step trip to be triggered. That happens if the trajectory leaves the outer zone.
5. Time shorter than *"Delay 1 Pickup"*, longer than the distance setting, the Distance function trips.

Note: The difference between the external and internal blinder is 4 Ω, provided that a trajectory parallel to the abscissa axis is adopted.

8.4 *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 50.00Ω/s this ensures that the time to cross the two blinders is 0.08 seconds, sufficiently greater than the one set.

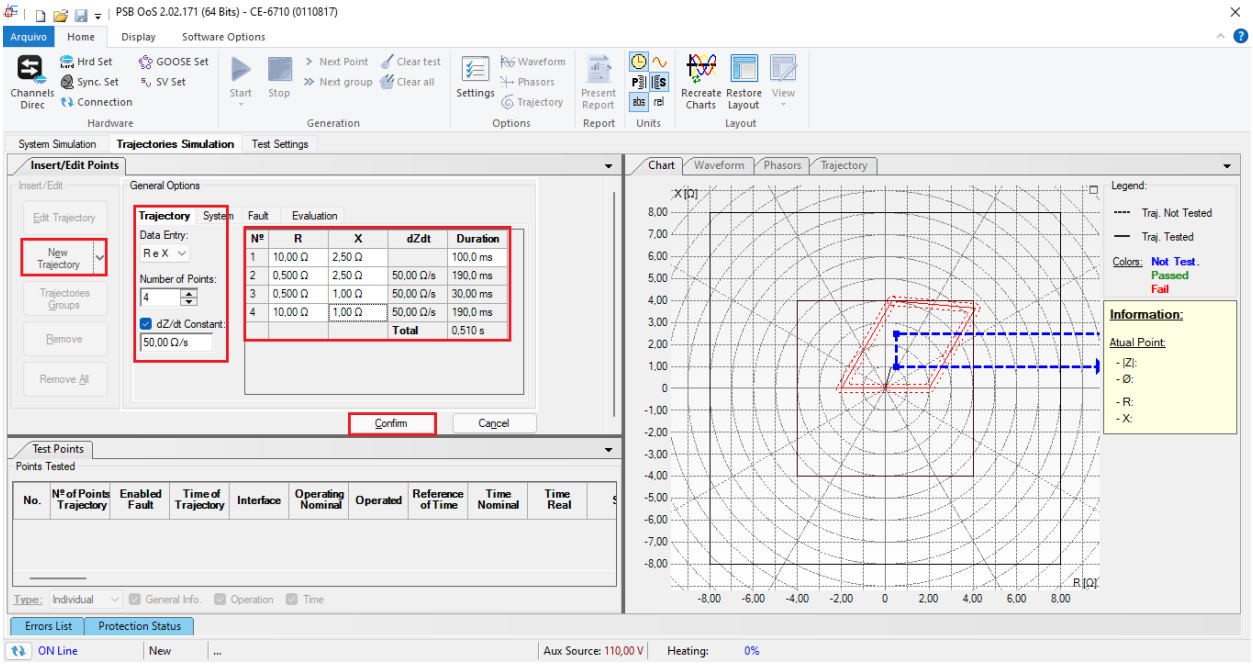


Figure 30

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

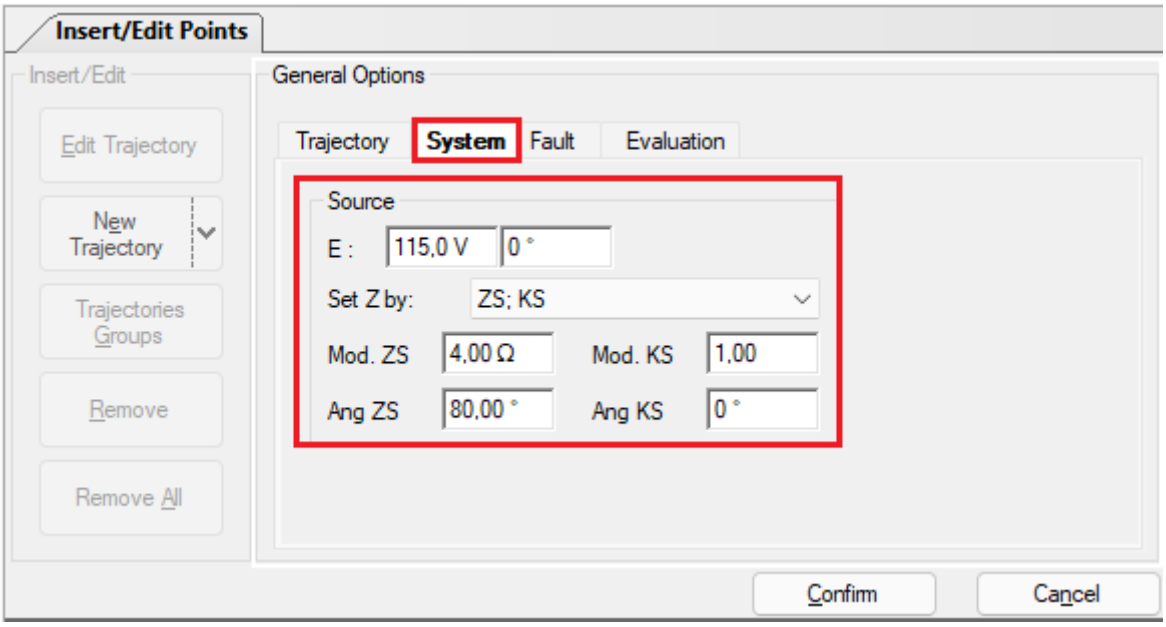


Figure 31

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"*.

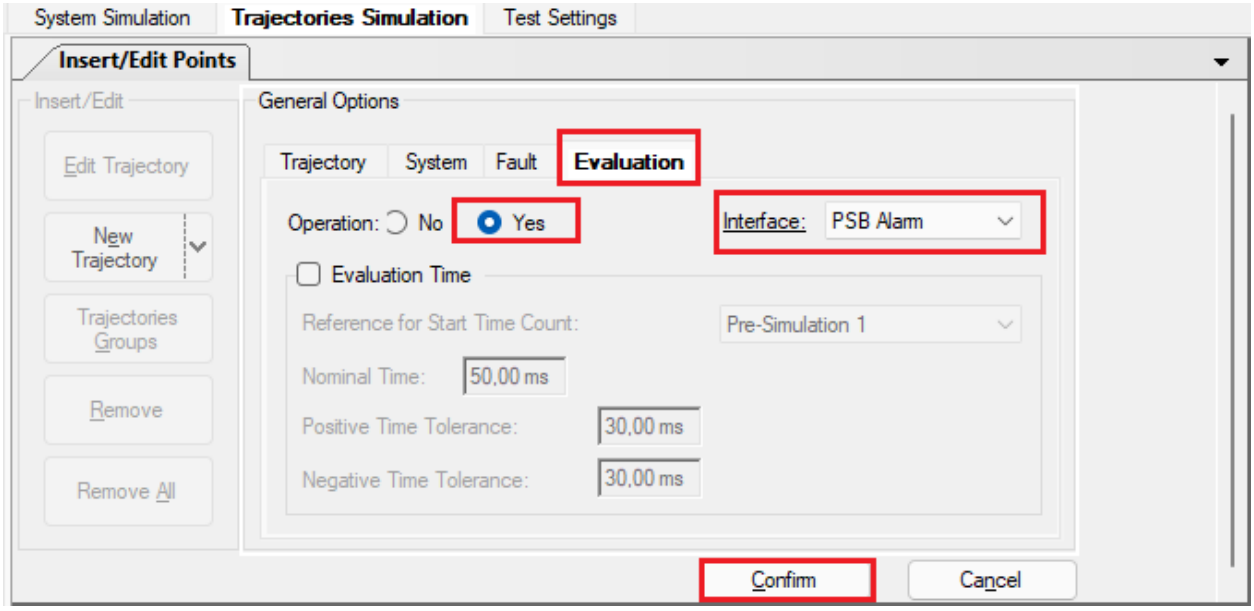


Figure 32

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

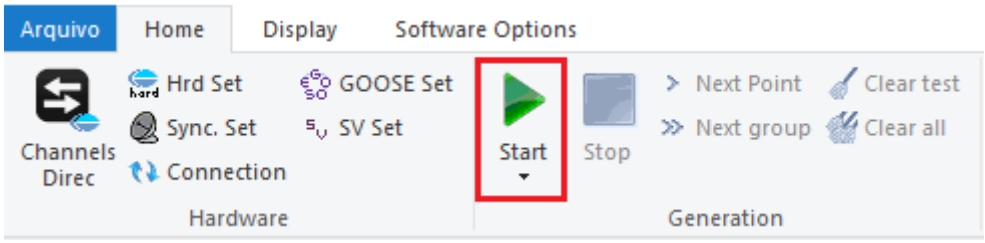


Figure 33

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

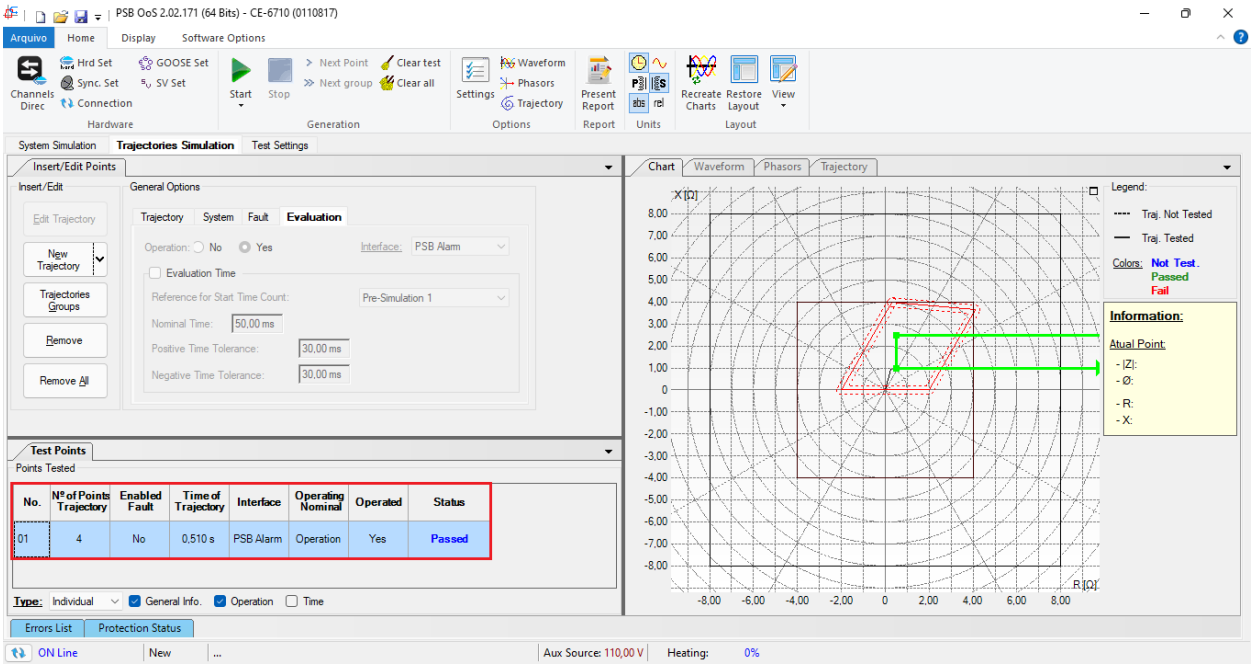


Figure 34

8.5 *Asynchronous Oscillation Trajectory Simulation (Delay Mode)*

To verify the performance of the OoS trip, the following trajectory is used. To do so, click on the *"New Oscillation"* icon, use the highlighted points and keep the impedance variation of the previous test.

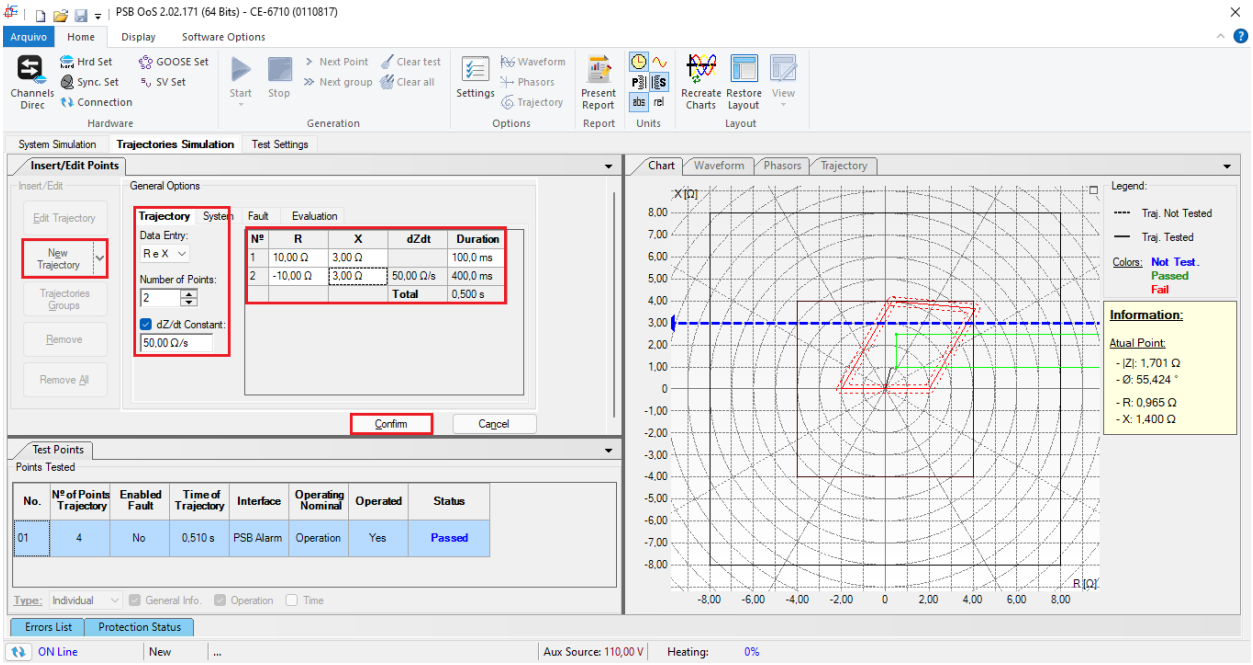


Figure 35

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

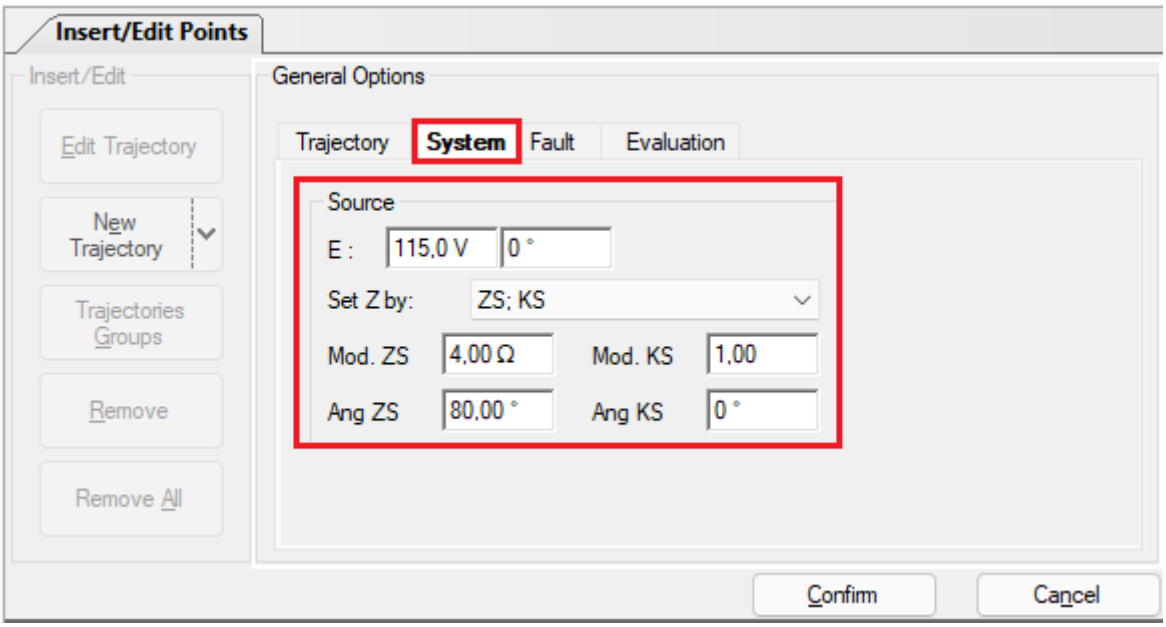


Figure 36

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

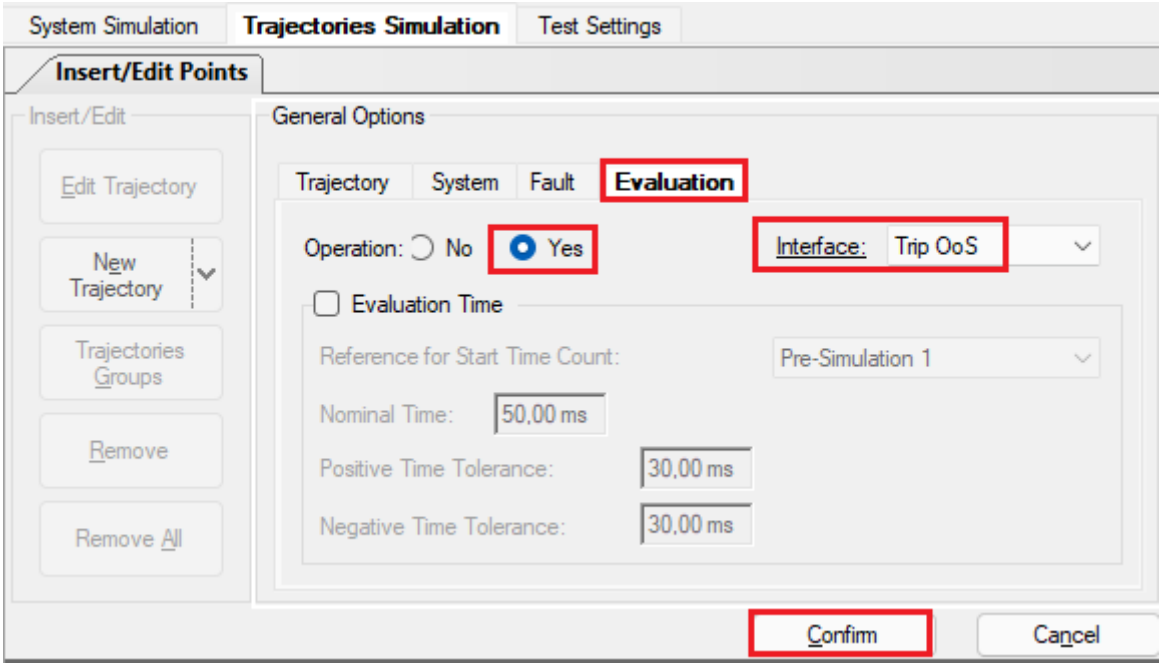


Figure 37

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.

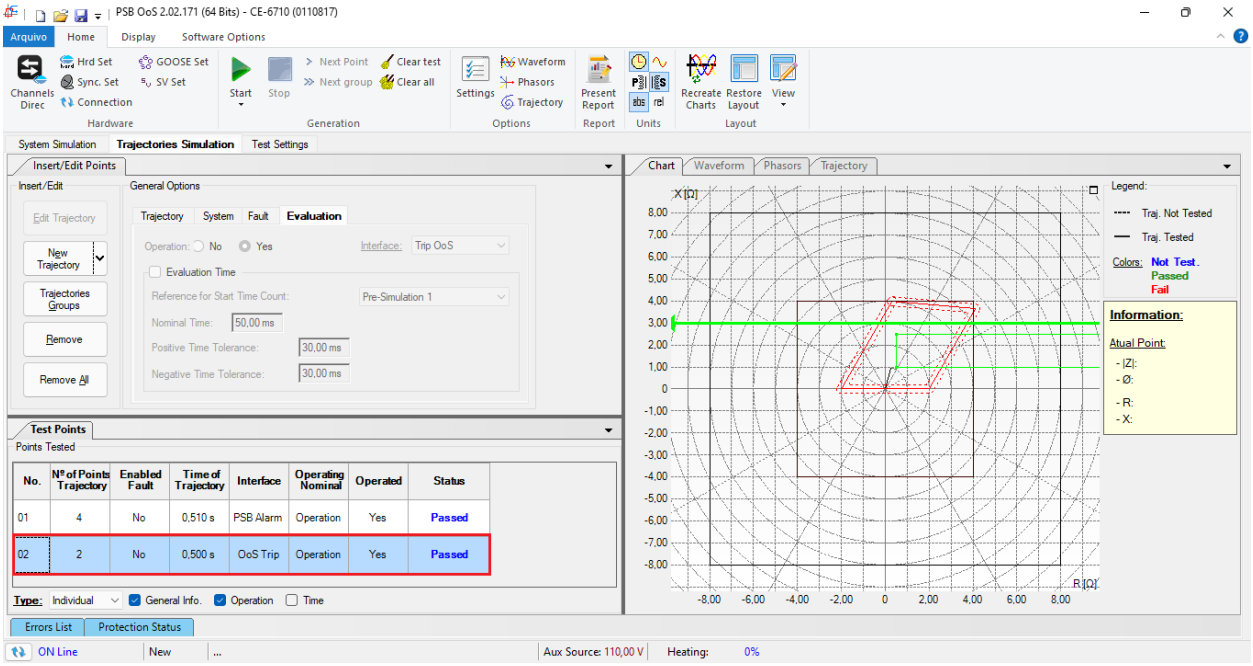


Figure 38

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.

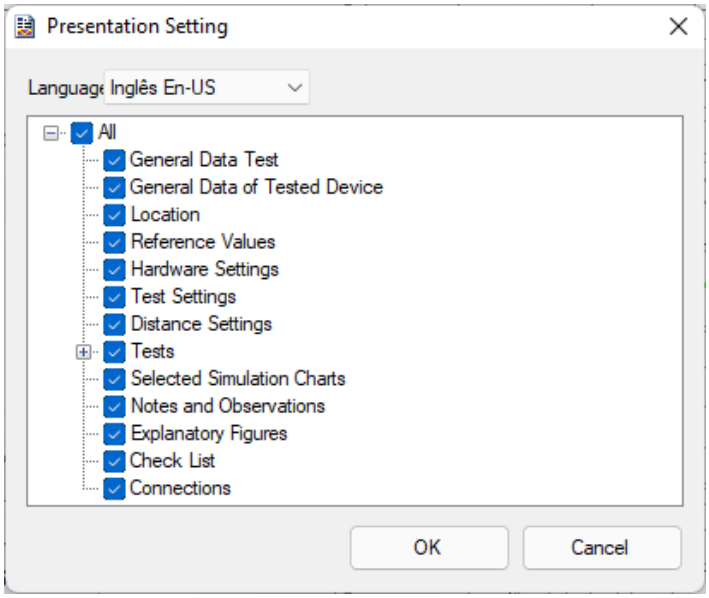


Figure 39

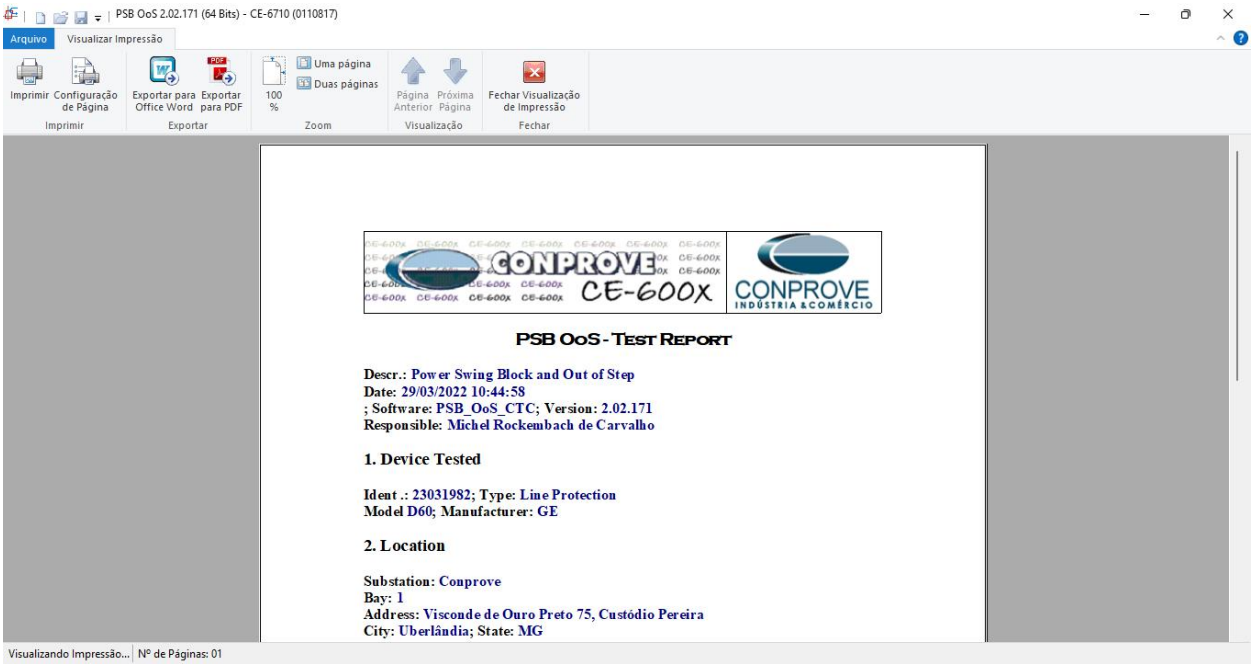


Figure 40

APPENDIX A

A.1 Terminal Designations

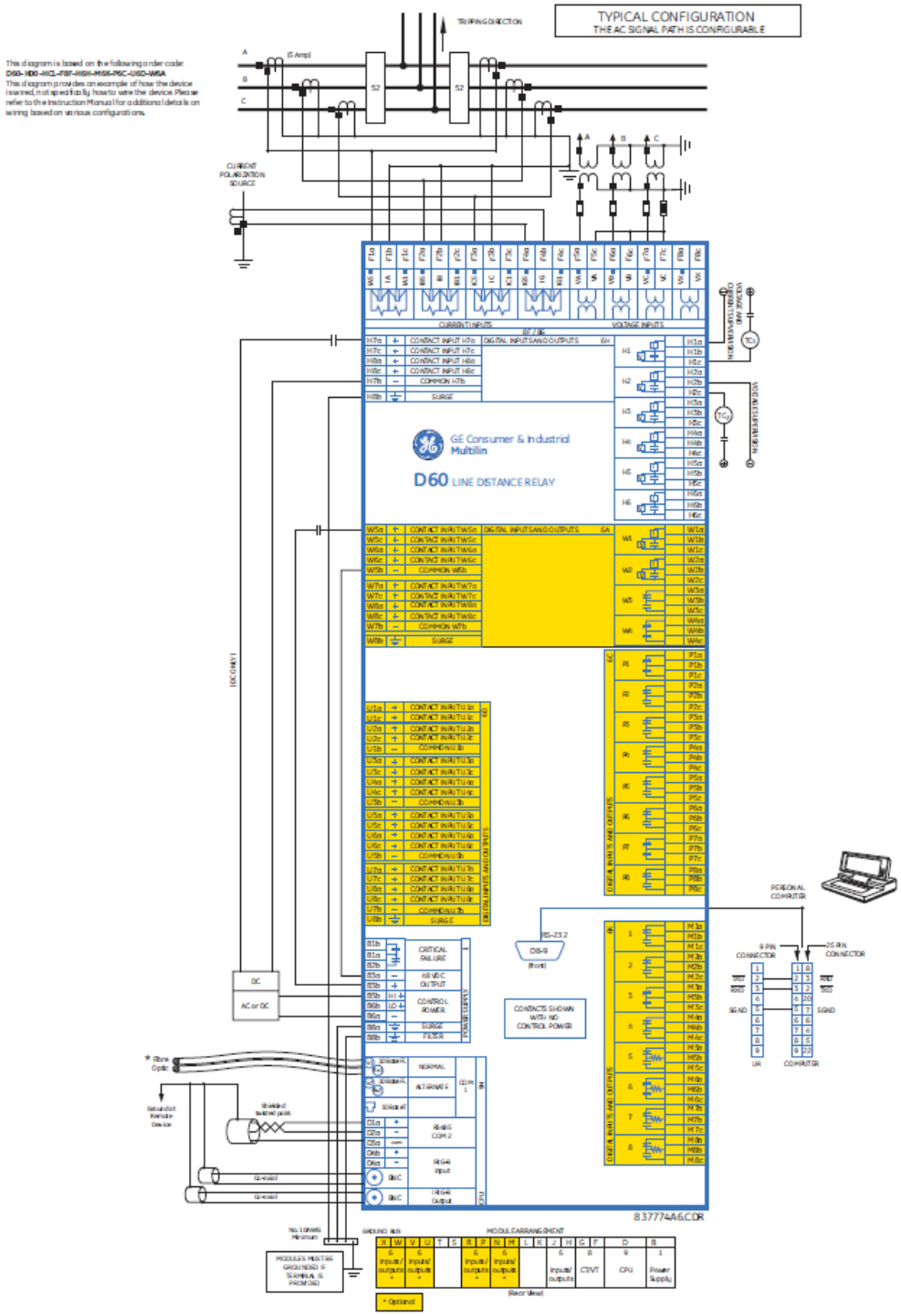


Figure 3–12: TYPICAL WIRING DIAGRAM

Figure 41

A.2 Technical data

POWER SWING DETECT

Functions:	Power swing block, Out-of-step trip
Characteristic:	Mho or Quad
Measured impedance:	Positive-sequence
Blocking / tripping modes:	2-step or 3-step
Tripping mode:	Early or Delayed
Current supervision:	
Pickup level:	0.050 to 30.000 pu in steps of 0.001
Dropout level:	97 to 98% of pickup
Fwd / reverse reach (sec. Ω):	0.10 to 500.00 Ω in steps of 0.01
Left and right blinders (sec. Ω):	0.10 to 500.00 Ω in steps of 0.01
Impedance accuracy:	±5%
Fwd / reverse angle impedances:	40 to 90° in steps of 1
Angle accuracy:	±2°
Characteristic limit angles:	40 to 140° in steps of 1
Timers:	0.000 to 65.535 s in steps of 0.001
Timing accuracy:	±3% or 4 ms, whichever is greater

APPENDIX B

Equivalence of software parameters and the relay under test.

Table 1

Software PSB_OoS		D60 Relay		
Parameter	**Figure**	**Parameter**	**Screen ID**	**Figure**
Zn1_Fase		**Phase Distance Z1**		
Rgt Bld phs	26	Quad Right Blinder	13	12
Rgt Bld RCA phs	26	Quad Right Blinder RCA	13	12
Lft Bld phs	26	Quad Left Blinder	13	12
Lft Bld RCA phs	26	Quad Left Blinder RCA	13	12
Reach phs	26	Reach	13	12
Reach RCA phs	26	RCA	13	12
Rev Reach phs	26	Rev Reach	13	12
Rev Reach RCA phs	26	Rev Reach RCA	13	12
Comp Limit phs	26	Comp Limit	13	12
Dir RCA	26	Dir RCA	13	12
Dir Comp	26	Dir Comp Limit	13	12
Inner		**Power Swing Detect**		
Rgt Bld phs	27	Inner Rgt Bld	218	13
Rgt Bld RCA phs	27	Fwd RCA	218	13
Lft Bld phs	27	Inner Lft Bld	218	13
Lft Bld RCA phs	27	Fwd RCA	218	13
Reach phs	27	Fwd Reach	218	13
Reach RCA phs	27	Fwd RCA	218	13
Rev Reach phs	27	Rev Reach	218	13
Rev Reach RCA phs	27	Rev Rca	218	13
Comp Limit phs	27	Fwd RCA	218	13
Dir RCA	27	Fwd RCA	218	13
Dir Comp	27	Fwd RCA	218	13
Outer		**Power Swing Detect**		
Rgt Bld phs	28	Outer Rgt Bld	218	13
Rgt Bld RCA phs	28	Fwd RCA	218	13
Lft Bld phs	28	Outer Lft Bld	218	13
Lft Bld RCA phs	28	Fwd RCA	218	13
Reach phs	28	Quad Fwd Out	218	13
Reach RCA phs	28	Fwd RCA	218	13
Rev Reach phs	28	Quad Rev Out	218	13
Rev Reach RCA phs	28	Rev Rca	218	13
Comp Limit phs	28	Fwd RCA	218	13
Dir RCA	28	Fwd RCA	218	13
Dir Comp	28	Fwd RCA	218	13