INSTRUMENTOS PARA TESTES ELÉTRICOS

Test Tutorial

Equipment Type: Protection Relay

Brand: SCHWEITZER (SEL)

Model: 451

Function: 67 or PTOC - Directional Overcurrent

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

Objective: Perform tests on the directional overcurrent function to prove the operating time and its directionality

Version control:

Version	Descriptions	Date	Author	Reviewer
1.0	Initial release	01/06/2022	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 SEL 451 Relay in the Quick Software

1. Relay connection to CE-6710

Appendix A shows the relay terminal designations.

1.1 *Auxiliary Source*

Connect the positive (red terminal) of the Aux Source. Vdc to pin *"Z29 (Power +)"* of the relay connect the negative (black terminal) of the Aux Vdc Source to pin *"Z30 (Power -)"* of the relay.

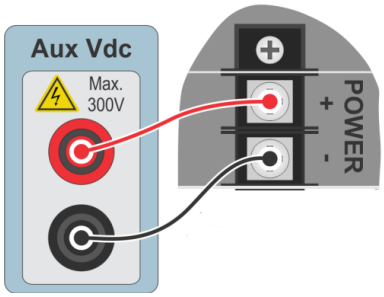

Figure 1

1.2 *Current and Voltage Coils*

To establish the connection of voltage coils, connect voltage channels V1 and V2, V3 to pins Z13, Z15 and Z17 of the Z terminal of the relay and connect the commons of the voltage channels to pins Z14, Z16 and Z18 of the relay terminal. To establish the connection of the current coils, connect the current channels I1 and I2, I3 to pins Z01, Z03 and Z05 of the Z terminal of the relay and connect the commons of the current channels to the pins Z02, Z04 and Z06 of the relay terminal as shown below:

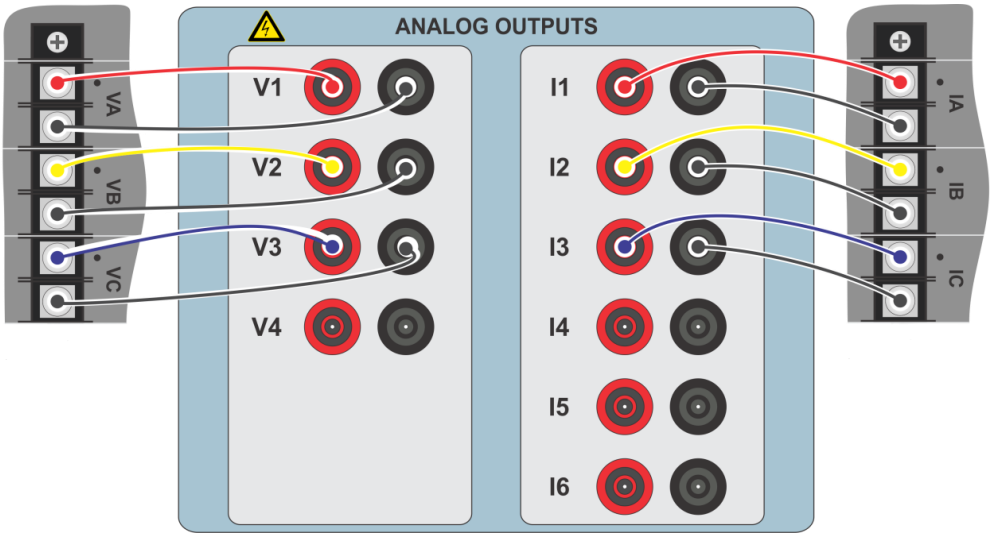

Figure 2

1.3 *Binary Inputs*

Connect the binary input of the CE-6710 to the binary output of the relay.

- BI1 to pin B01 and its common to pin B02 of the relay.

The following figure shows the details of the connection.

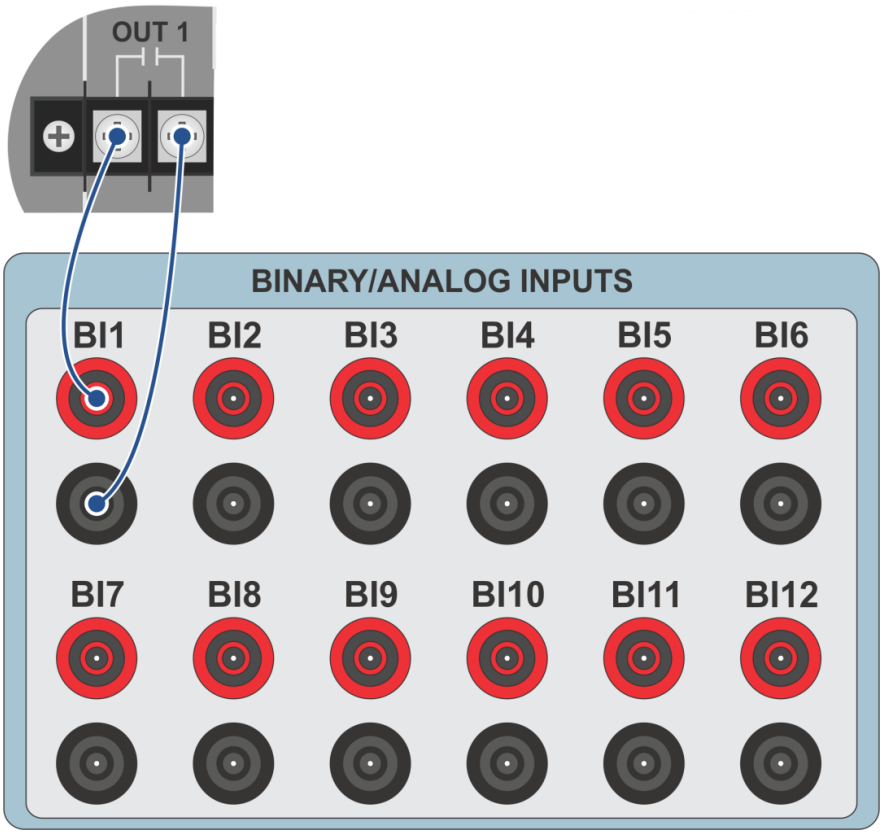

Figure 3

2. Communication with the 451 relay

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

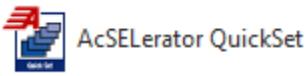

Figure 4

When opening the program, the relay file is selected if the communication has already been carried out. Otherwise click on *"Novo"*.

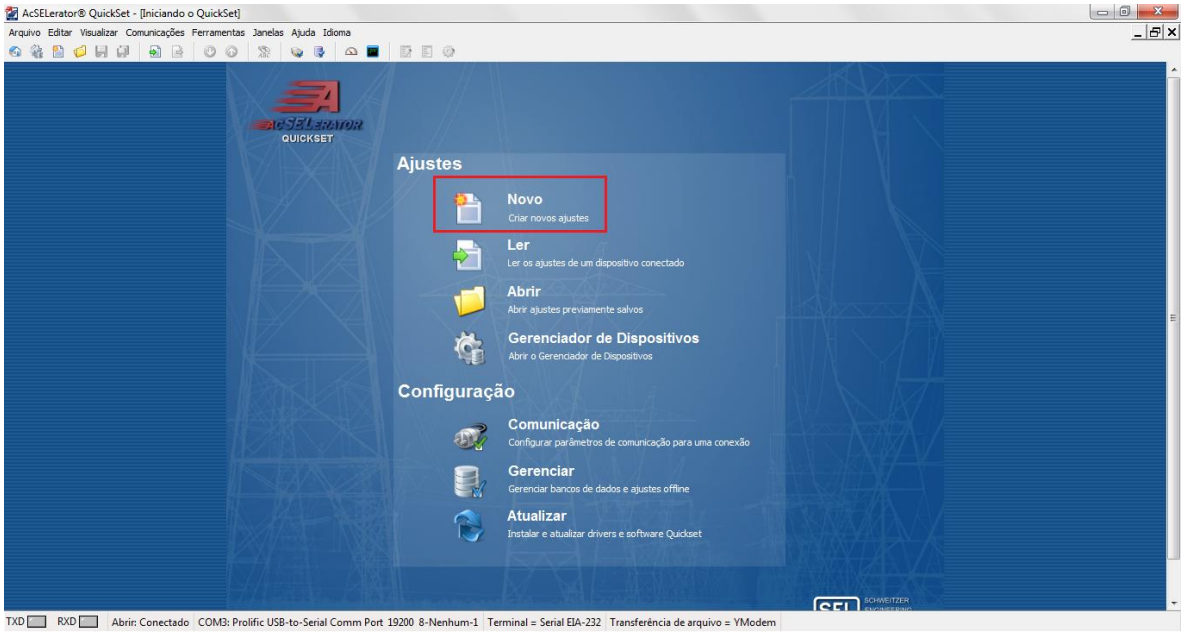

Figure 5

In the next screen, the model and version of the tested relay are set. Check on the front panel through the following path *"Main Menu > View Configuration"*.

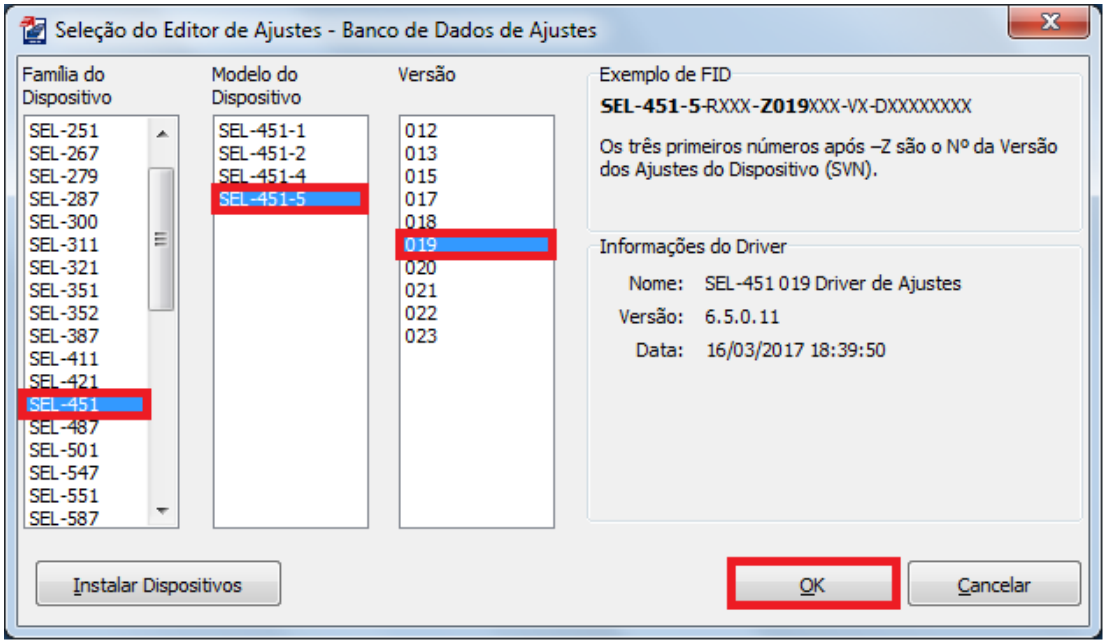

Figure 6

Then the *"Part Number"* must be set. Use the following path to view *"Main Menu > View Configuration"*.

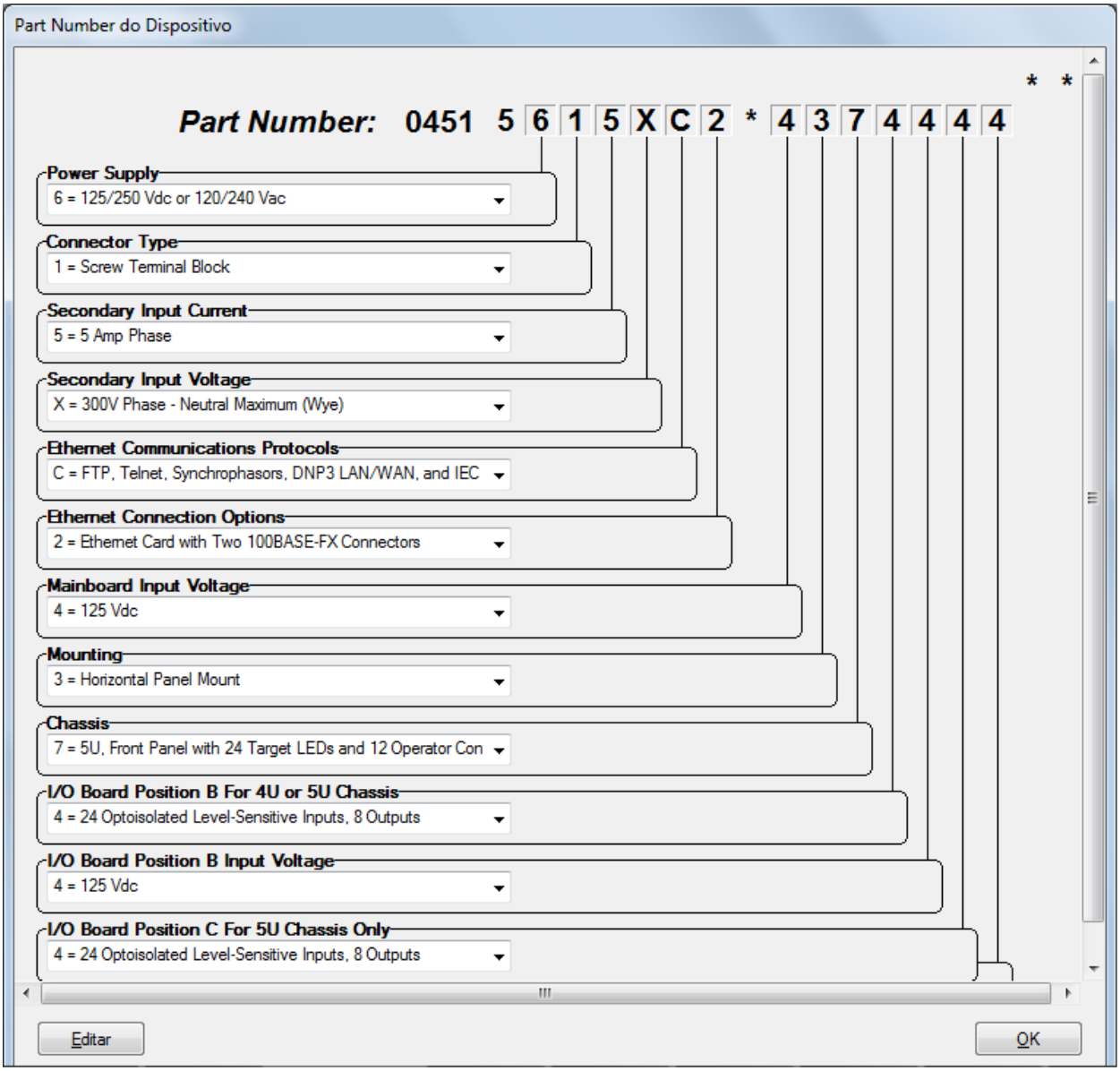

Figure 7

Then click on the highlighted icon according to the figure below:

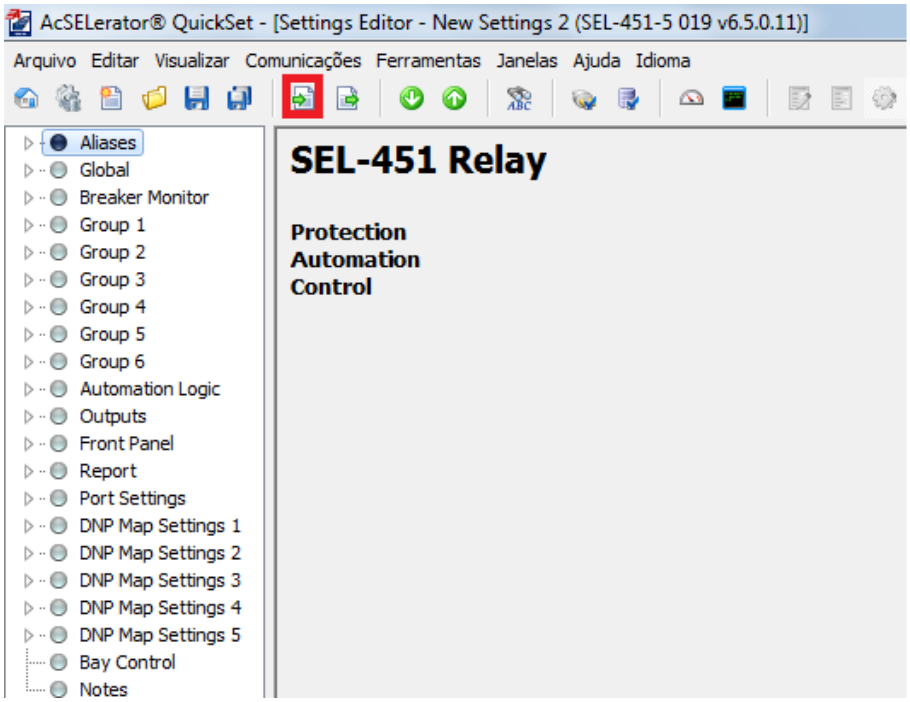

Figure 8

3. Parameterization of the SEL 451 relay

3.1. *General Global Settings*

After the connection has been established, click next to *"Global"* and *"General Global Settings"* and adjust the value of the phase sequence and frequency.

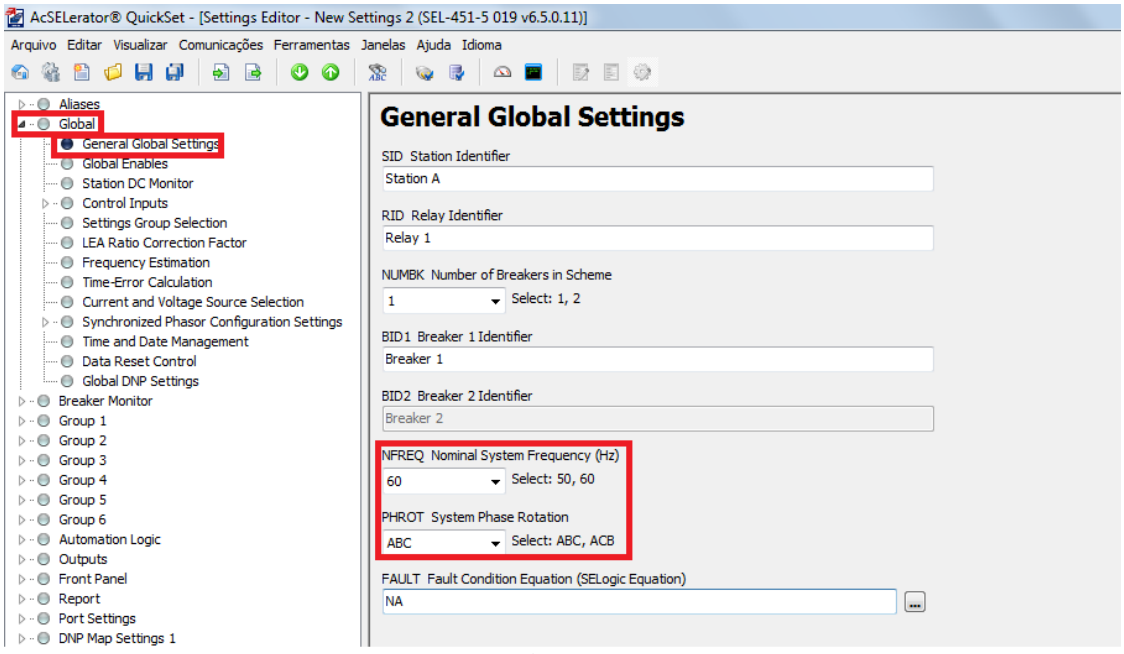

Figure 9

3.2. *Line Configuration*

Click on *"Group 1"*, then *"Set 1"* and finally select *"Line Configuration"*. In the figure below, configure all the characteristics of the feeder or line that this relay protects. Note that the voltage and current transformation ratios of the two relay inputs are parameterized (W and X for current, Y and Z for voltage), the positive sequence impedances in magnitude and angle, as well as the zero sequence impedances, also in module and angle and finally the length of the line.

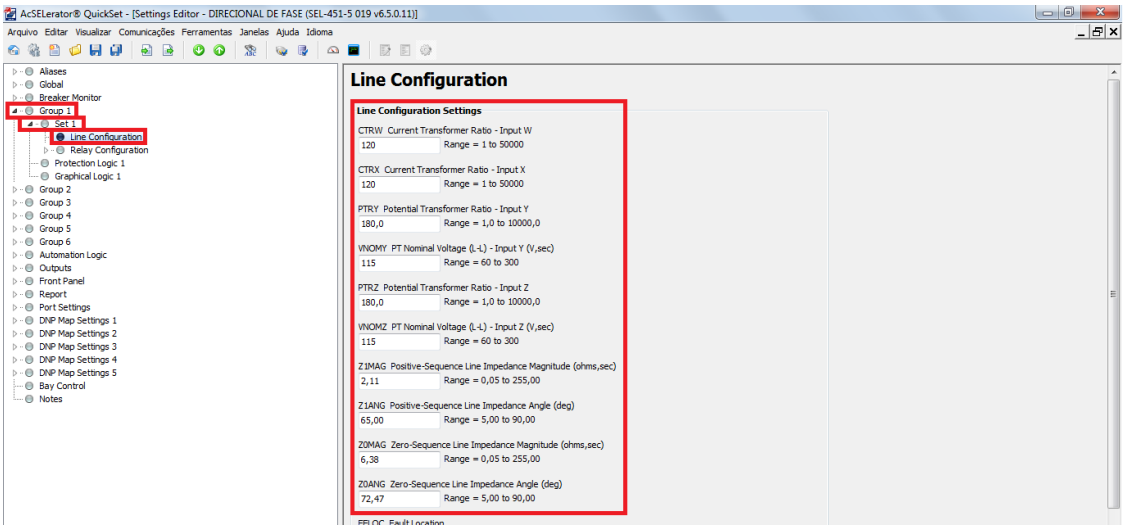

Figure 10

From the figure above, the adjustment that matters most in this test is the positive sequence angle. In the case of this relay, this angle is adopted as the maximum torque angle. Both for three-phase faults and for two-phase faults. Note in the figure below that for a two-phase fault, the negative-sequence current leads the negative-sequence voltage by 180-Z1ANG, while for a three-phase short-circuit, where there are only positive-sequence components, the positive-sequence current lags behind the voltage positive sequence by Z1ANG.

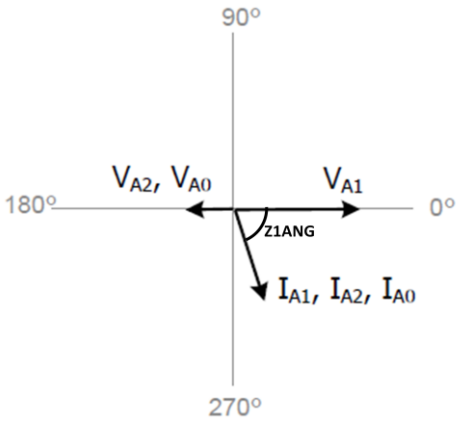

Figure 11

3.3. *Relay Configuration Enables*

Click on *"Group 1"*, then *"Set 1"* and finally select *"Relay configuration"* (do not open the settings tree). If there is a possibility in order to increase the reliability of the tests, **it is recommended to enableonly the function that will be tested**. In the figure below, only the *"E50P"* function is highlighted with an adjustment level.

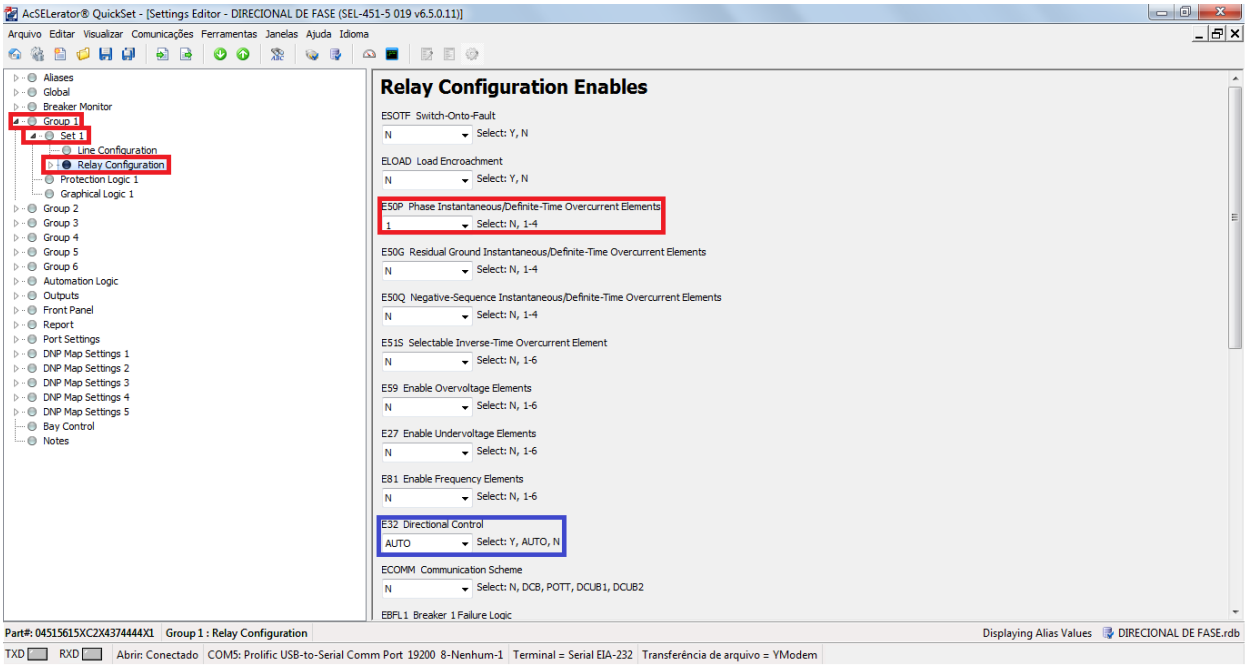

Figure 12

The setting highlighted in blue in the figure above must be selected as *"AUTO"*, because in this case the relay automatically calculates the forward and reverse region of function 67, according to the equations in the RELAY MANUAL. **It is essential that the user has an advanced knowledge of this function**. This knowledge can come from the equipment manual and mainly by consulting the following article:

Fleming B., "Negative Sequence Impedance Directional Element", Schweitzer Engineering Laboratories, Inc., Pullman, Washington, USA.

3.4. *Load Encroachment*

Load compensation will not be used for this test. Note in the figure below that as it had already been blocked, the adjustments below had no effect:

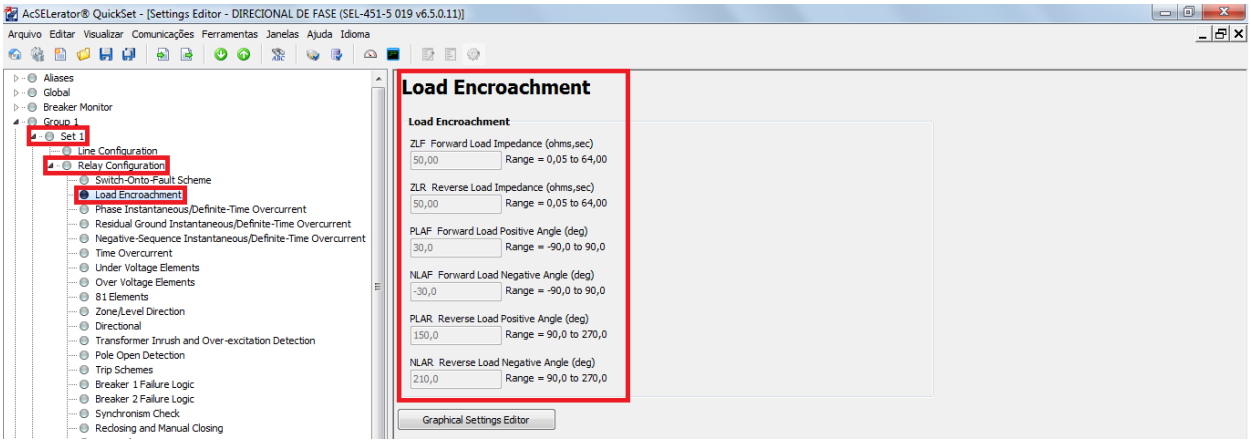

Figure 13

3.5. *Phase Instantaneous/Definite Time Overcurrent*

Click next to *"Group1 > Set 1 > Relay Configuration"* then "*Phase Instantaneous/Definite-Time Overcurrent"*. In this field, the value of element 1 is adjusted to 10A with an actuation time of 300 ms (18 cycles). Also note that the torque control is associated with the *"Relay Word Bit > F32P"*. Therefore, the 50P function will only be activated when a fault is declared to be direct.

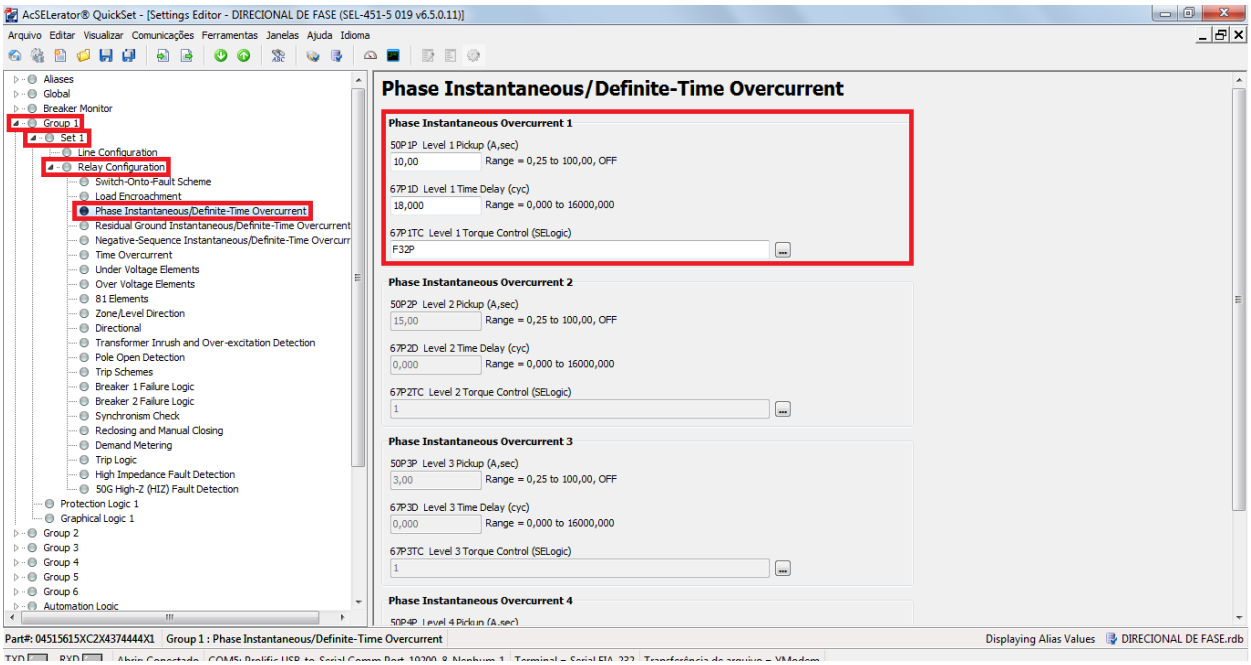

Figure 14

3.6. *Zone/Level Directional*

The first two overcurrent settings are fixed for direct directionality, if the user wants to choose, he must do for the third and fourth overcurrent settings. In this case it is possible to opt for reverse directionality. It is disabled in the figure below, as the test is performed with the first overcurrent setting enabled and the rest disabled.

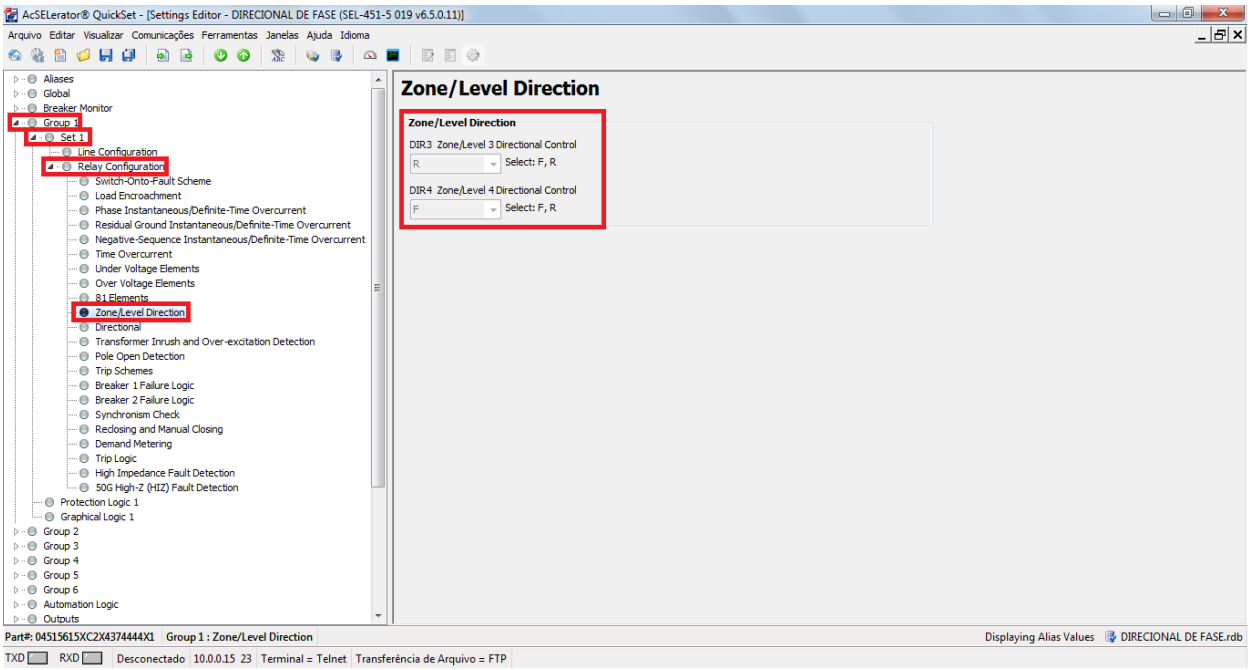

Figure 15

3.7. *Directional*

Click next to *"Group1 > Set 1 > Relay Configuration"* then *"Directional"*. Note that the parameters are locked as they have already been calculated *("Directional Control = AUTO")*.

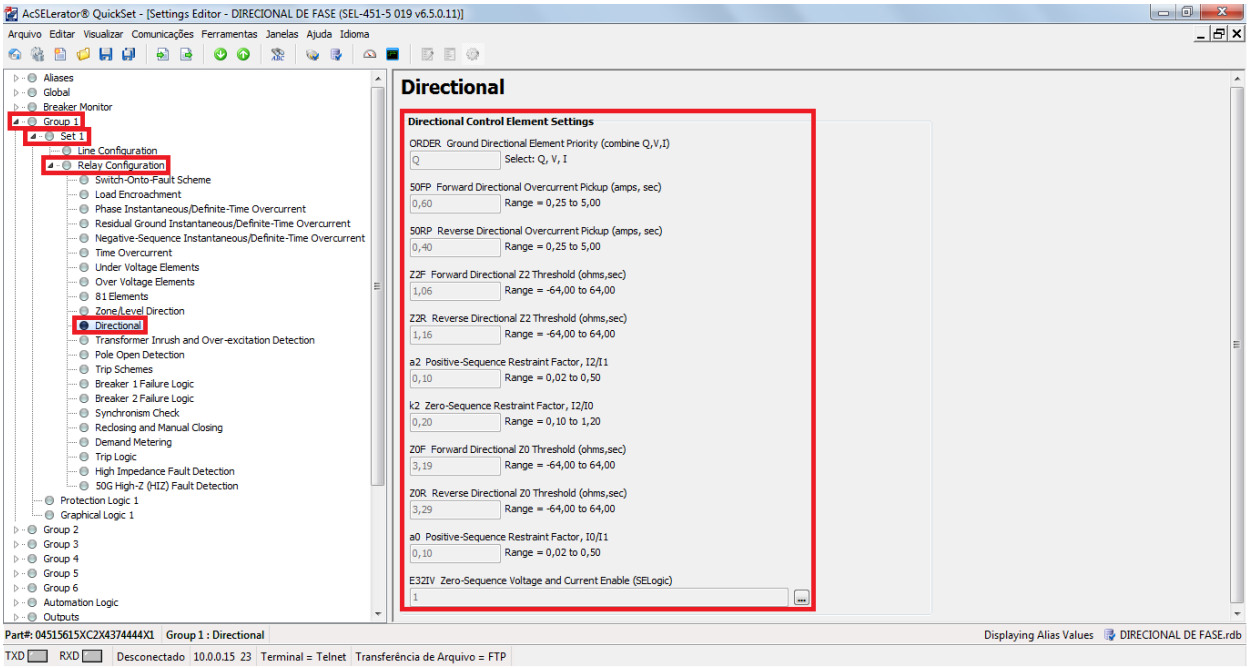

Figure 16

3.8. *Pole Open Detection*

Here, the open pole detection method is parameterized (if it is by the auxiliary contact of the circuit breaker or by undervoltage).

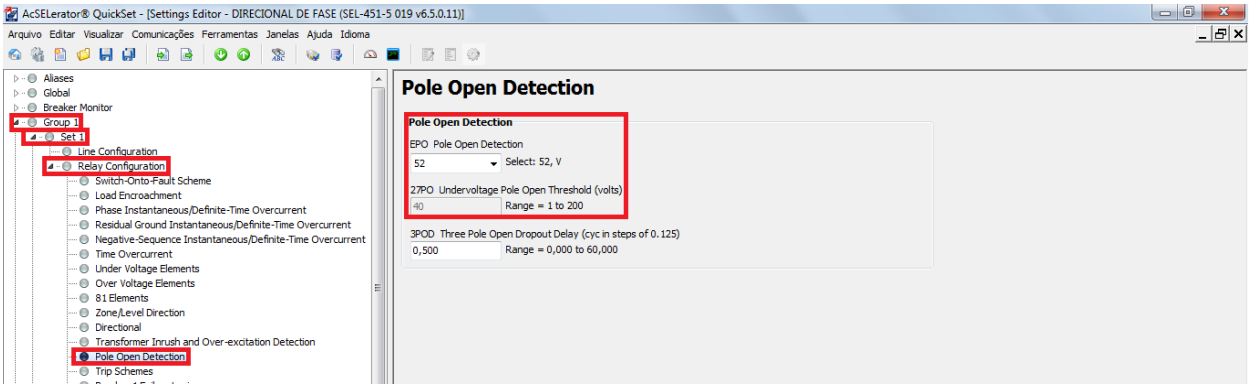

Figure 17

4. Binary Output Adjustments

4.1. *Interface Board Output*

Click next to *"Output"* and then select the option *"Interface Board Output"* and make the following adjustments: on output 201, set the tripping of the 50P function through the signal *"67P1T"*.

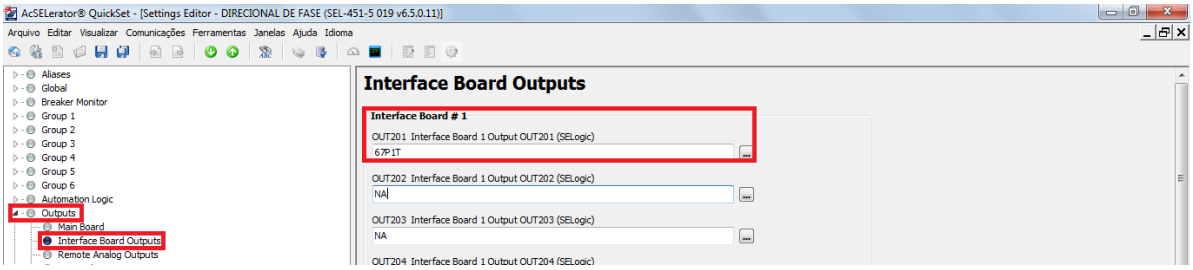

Figure 18

A very important observation must be made. The test will be done by applying only negative sequence, thus characterizing biphasic faults. This is because **the negative sequence element has priority over the positive sequence element**, according to the logic taken from the manual:

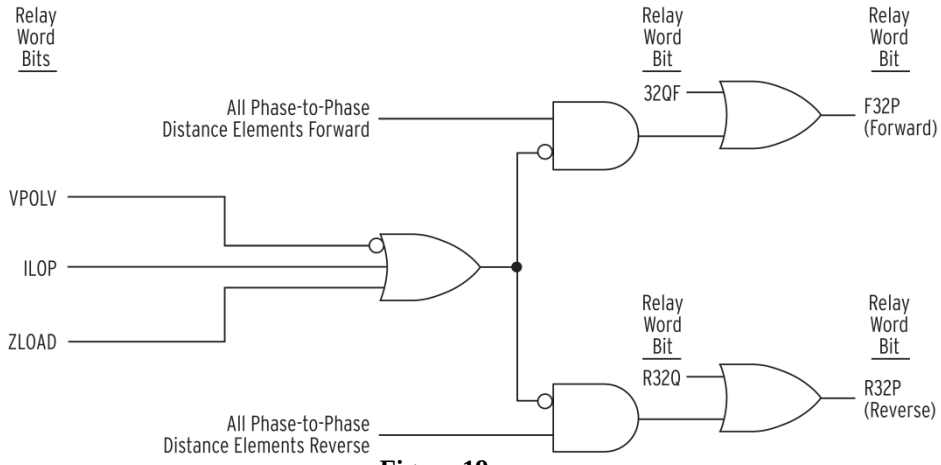

Figure 19

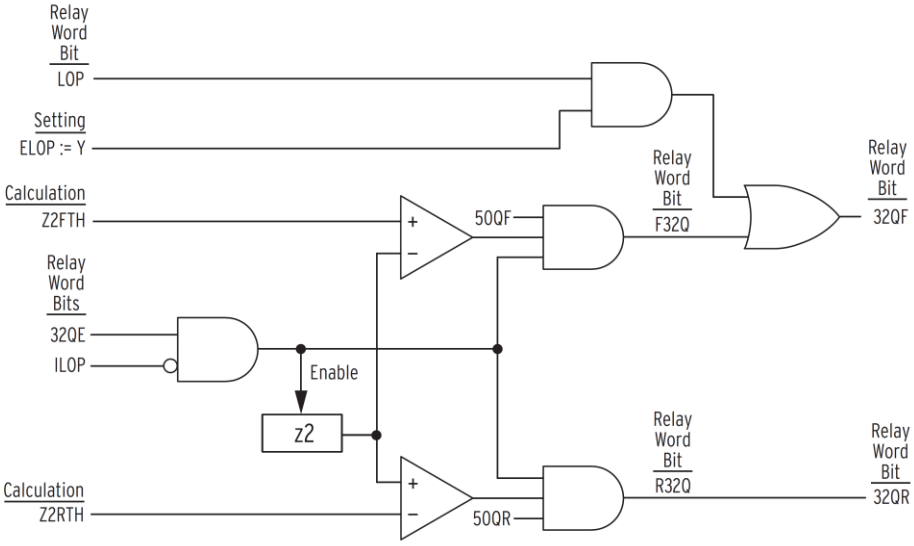

Figure 20

4.2. *Submitting the Settings*

Click the selected icon and submit at least the following adjustments.

Figure 21

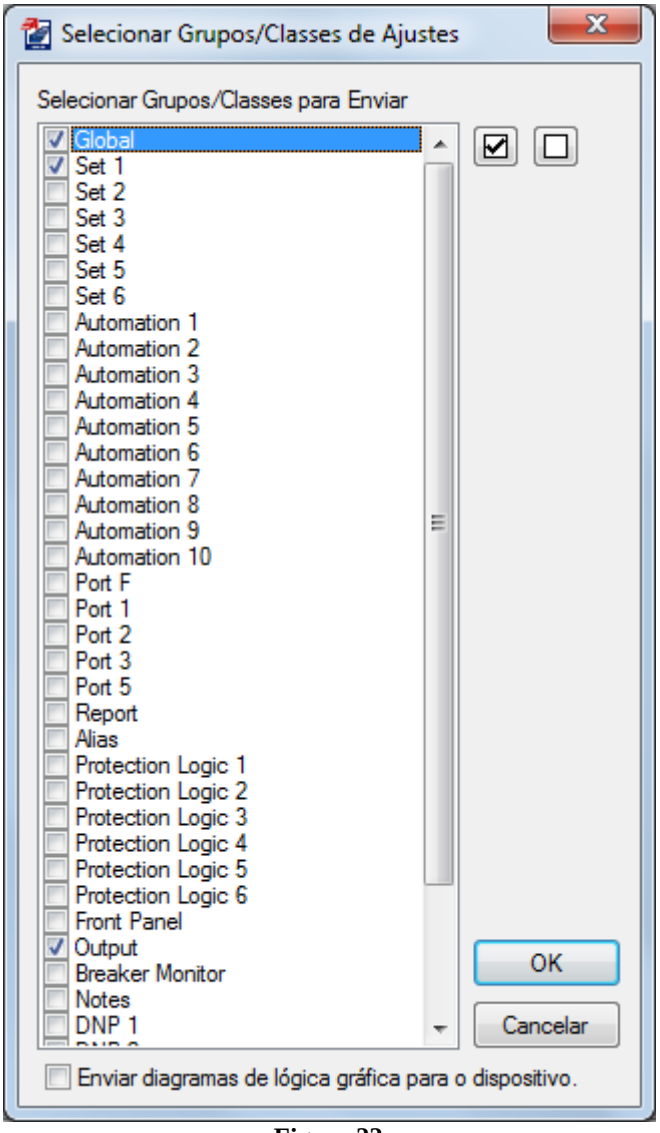

Figure 22

5. Quick software adjustments

5.1 *Opening the Quick*

Click on the *"Conprove Test Center"* application manager icon.

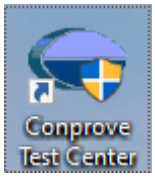

Figure 23

Click on the *"Quick"* software icon.

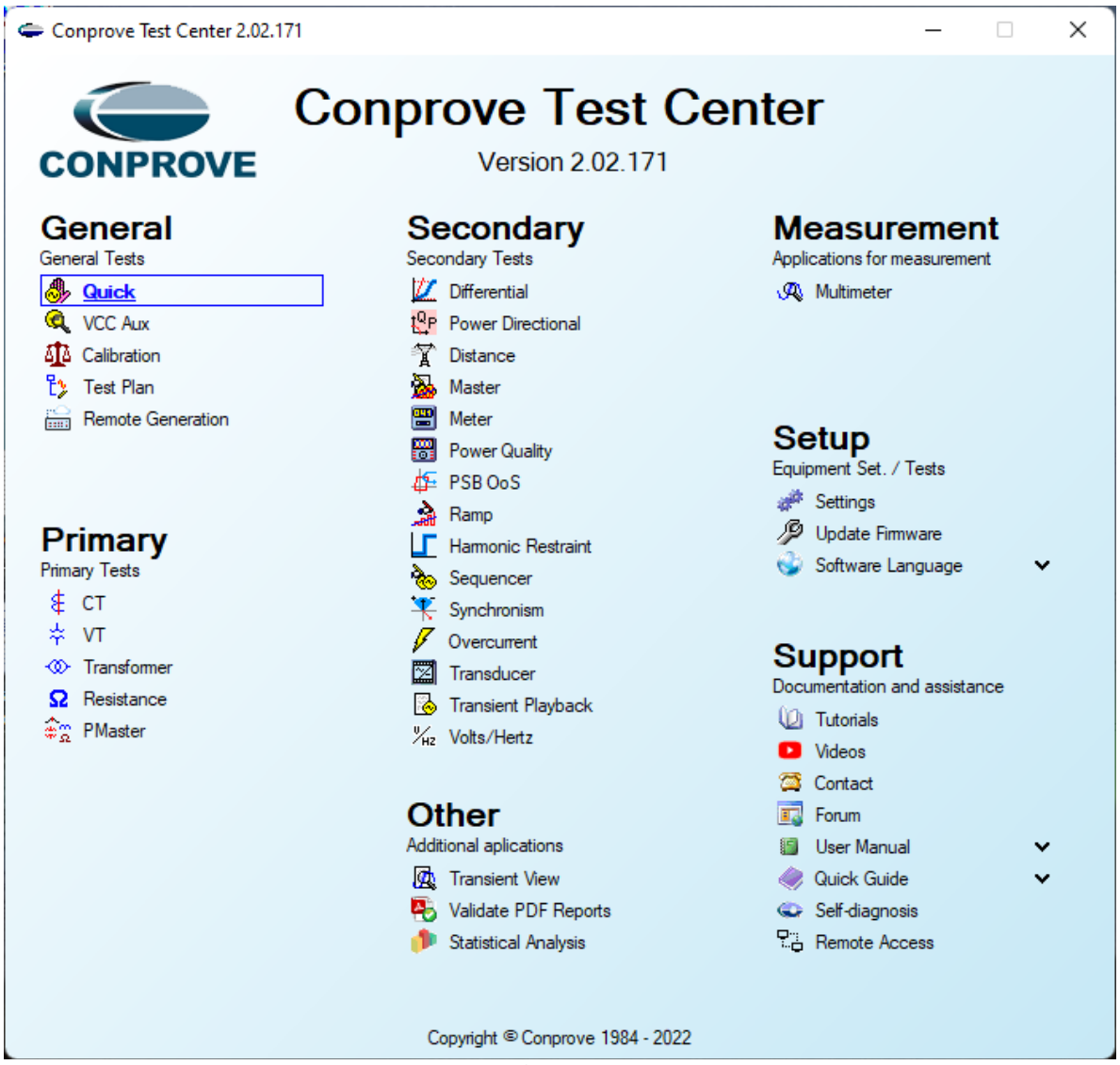

Figure 24

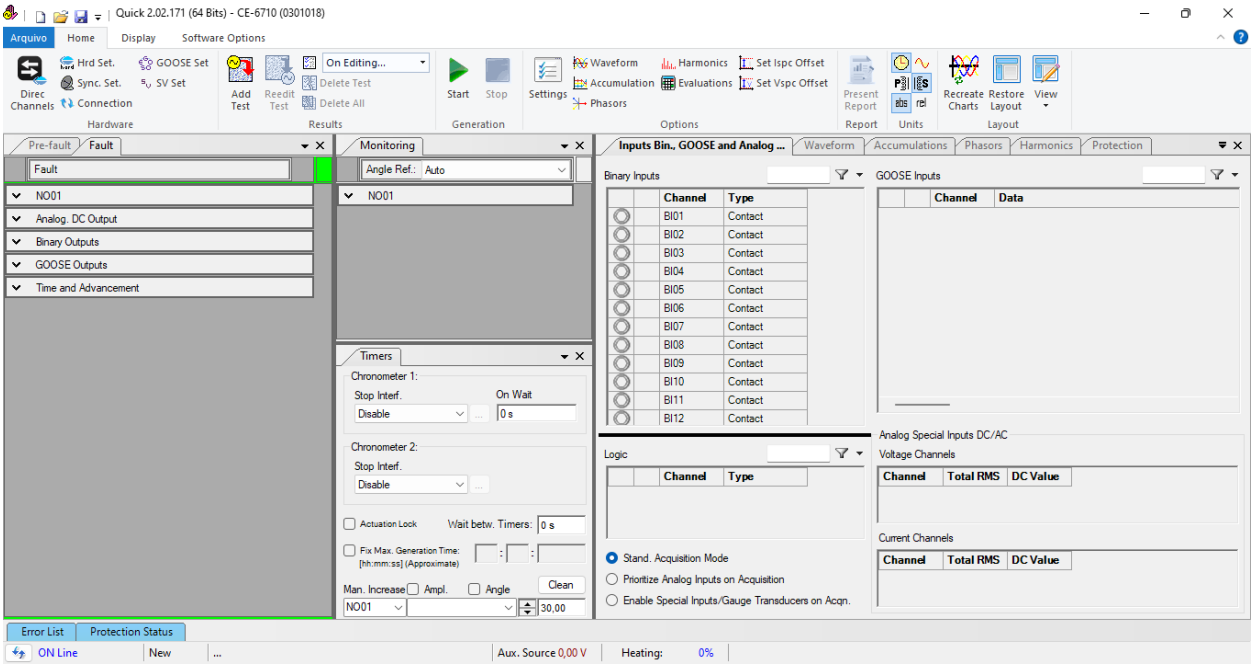

Figure 25

5.2 *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.

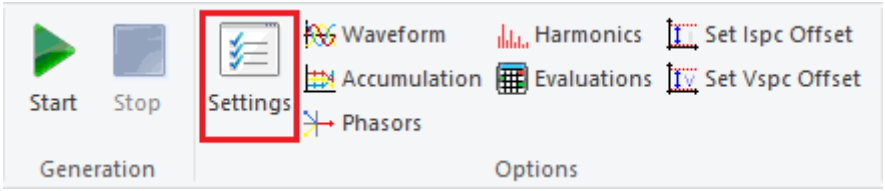

Figure 26

Inside the *"Settings"* screen, fill in the *"General Inform."* 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.

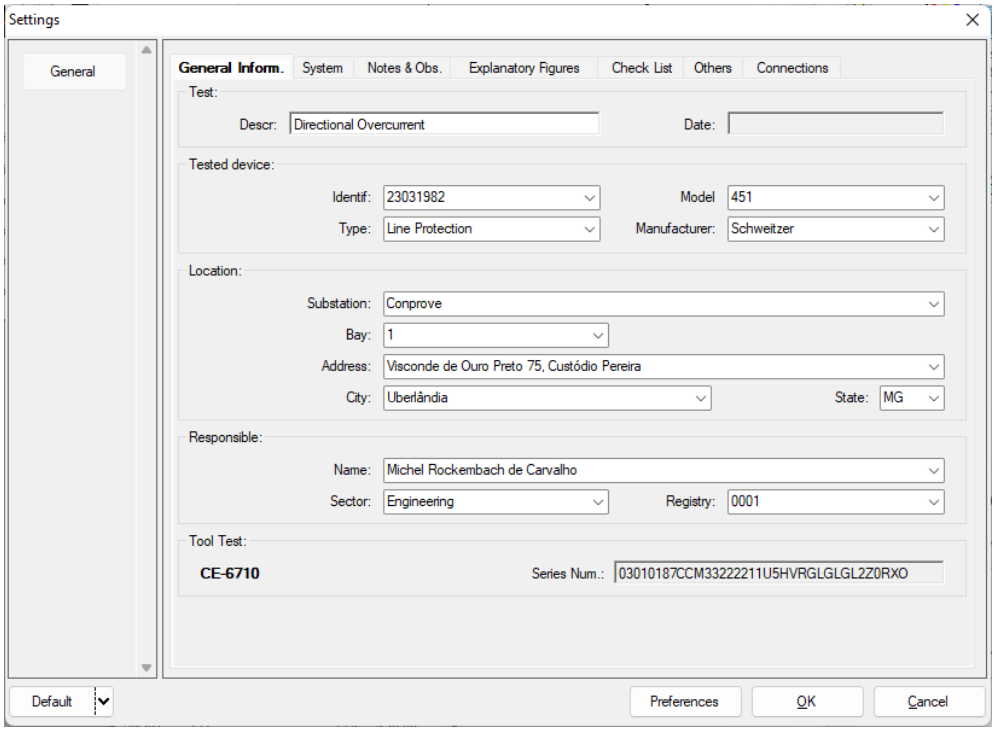

Figure 27

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.

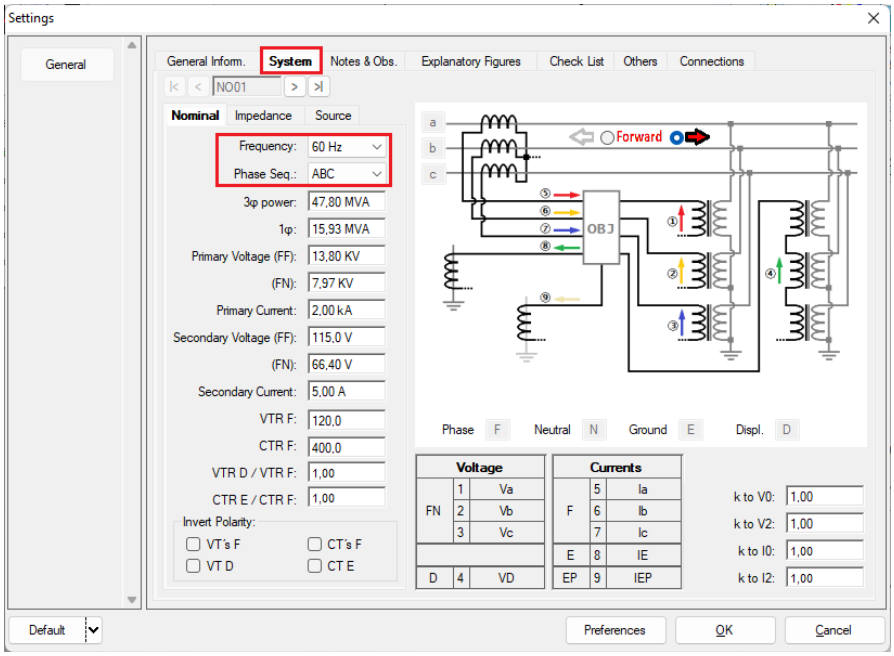

Figure 28

There are other tabs where the user can insert *"Notes & Obs."*, *Explanatory Figures*, *and "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 Direction

Click on the icon highlighted in green to associate created channels with nodes automatically. Choose the option *"Advanced"* highlighted in red. In the "*Output: Analog. and SV"* create a node and name it *"NO01"*. Create five Voltage Channels. Associate the first three to the 3 voltage hardware *"V1", "V2" and "V3",* with the created node *"NO01"* and with the points *"Va", "Vb"* and *"Vc"*. The fifth voltage channel will be dummy and will not have associated hardware, however it will belong to *"NO01"* and will be point *"kV2"*.. Create seven Current Channels. Associate the first three with the 3 current hardware *"I1", "I2"* and *"I3",* with the created node *"NO01"* and with the points *"Ia", "Ib"* and *"Ic"*. The seventh current channel will be dummy and will not have associated hardware, however it will belong to *"NO01"* and will be point *"kI2"*. Click the confirm button as highlighted below.

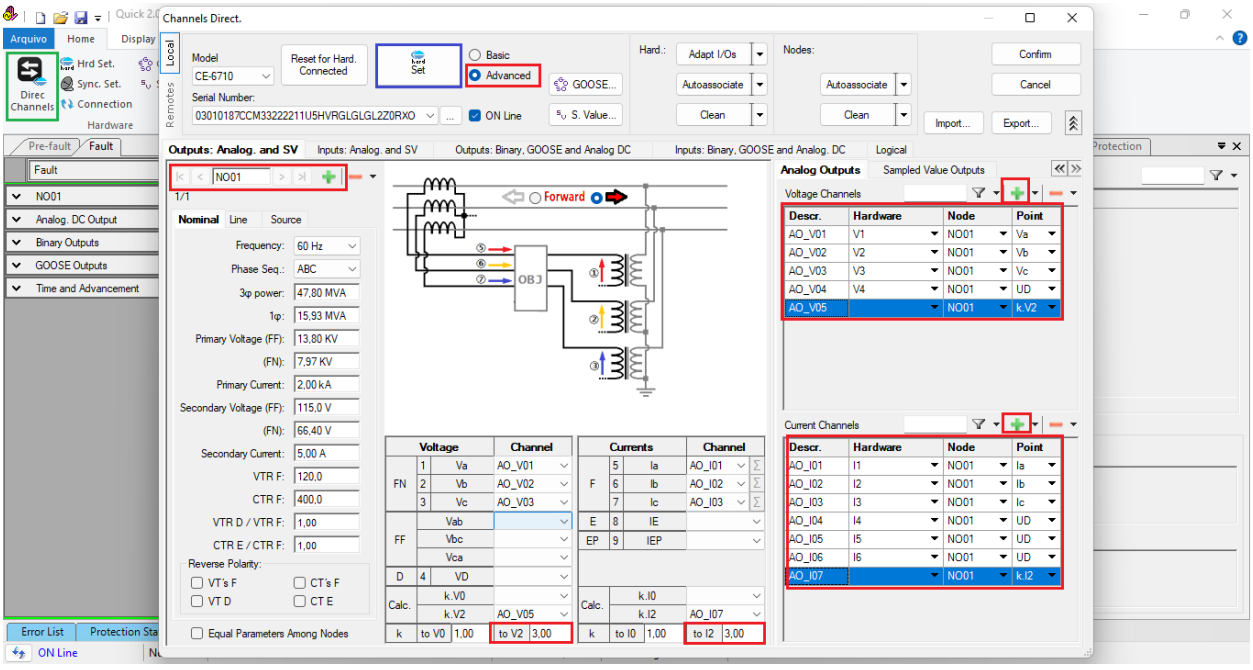

Figure 29

Note: It is essential to use the multiplied of *"Seq. Negative"* equal to 3, if you choose the value equal to 1, the pick-up settings must be divided by 3. This is due to the fact that the relay works with the magnitude 3I2 and 3V2. Choosing the first option, the software already performs the division automatically.

Then configure the hardware by clicking the blue highlighted button.

7. Hardware Configurations

Click the *"Hard Set"* button to configure the power supply, stipulate the configuration of the generation channels and the method of stopping the binary inputs.

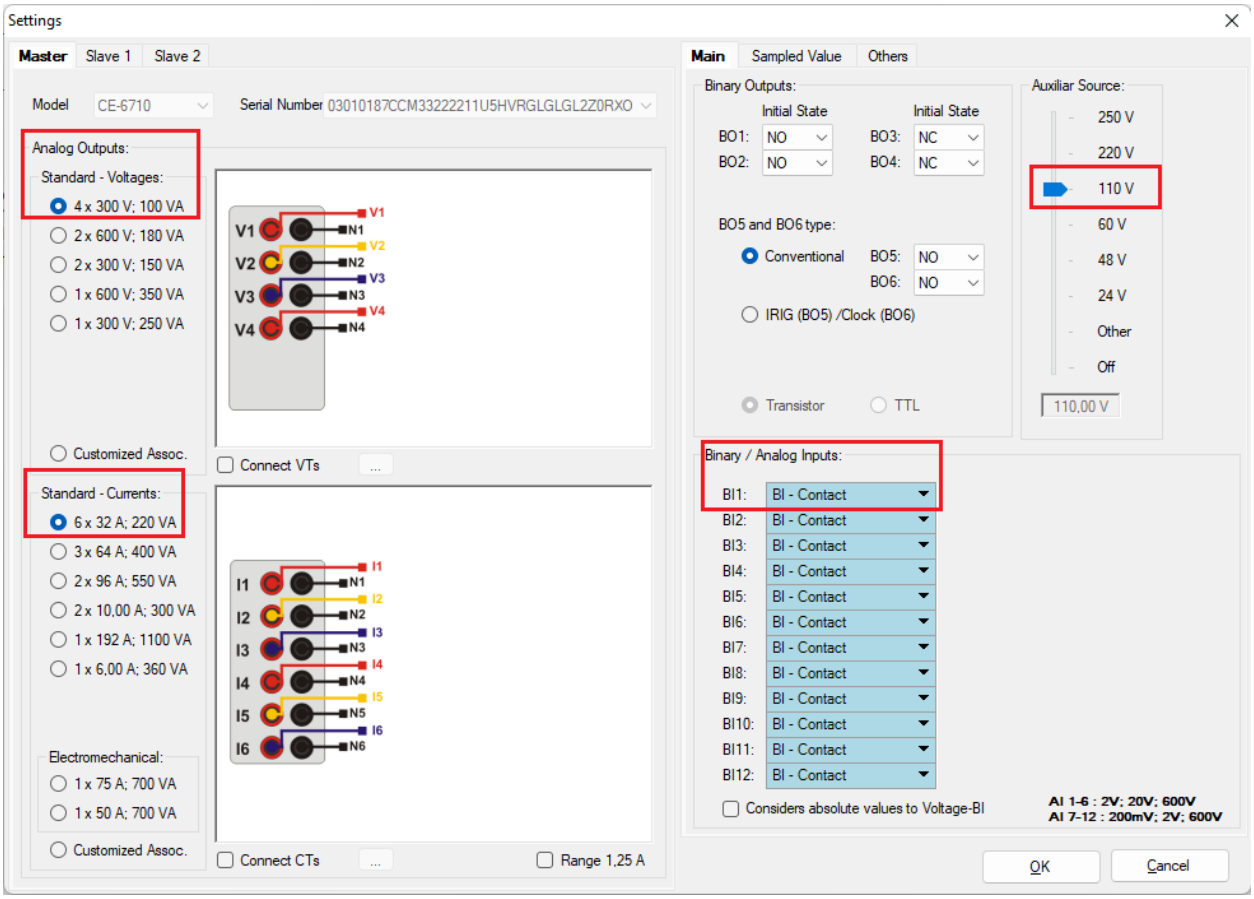

Figure 30

8. Phase Overcurrent Directional Adjustment

8.1 *Protection Tab > Directional Tab > Overcurrent Tab*

Due to the great complexity of this function, noted in the equation exposed in the RELAY MANUAL, CONPROVE developed an exclusive tool that allows knowing the directionality characteristic, based on the adjustments that are collected in the relay and on the values applied by the case. To access the feature, click on the green highlighted *"SEL Directionality"* tab.

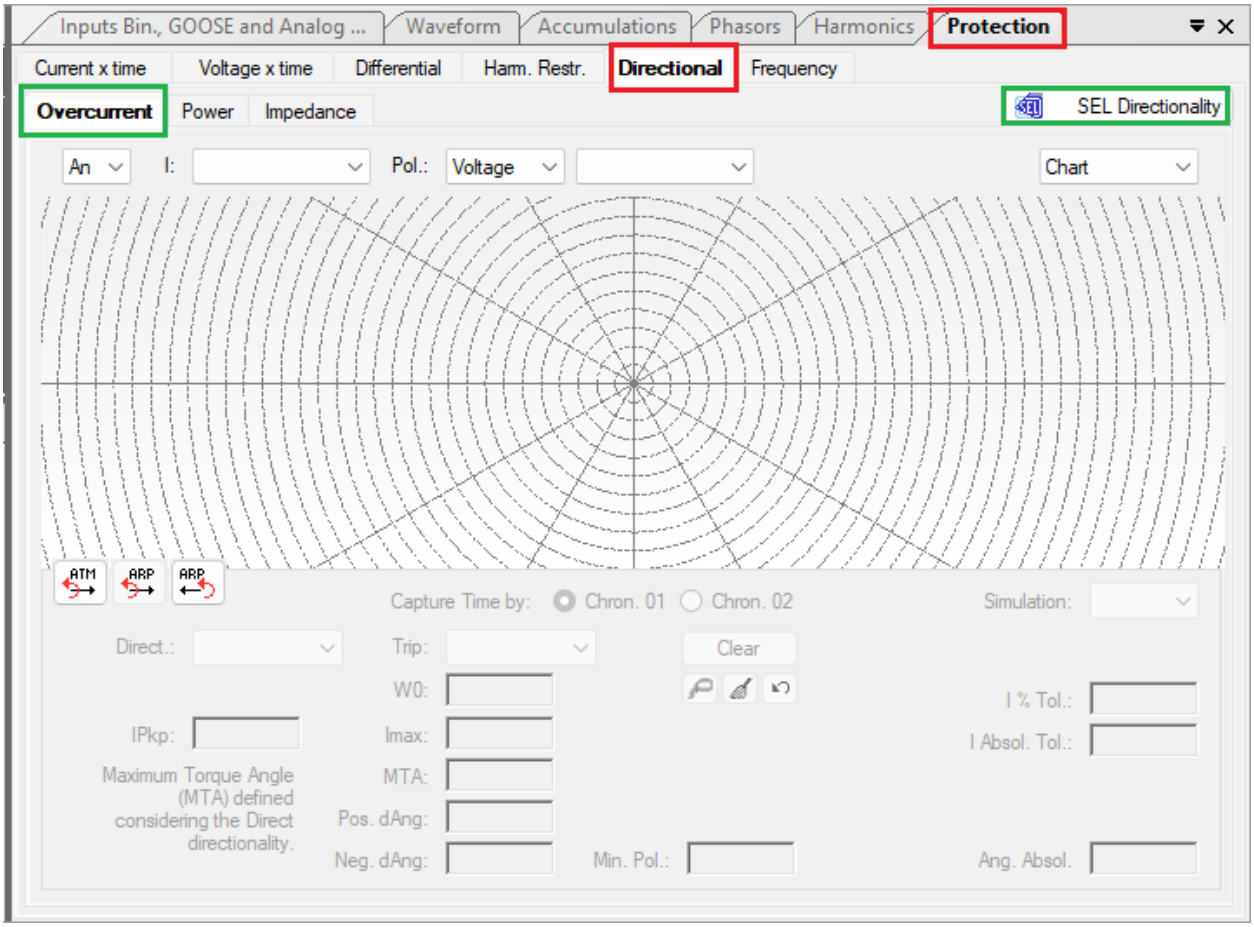

Figure 31

Note in the figure below that the requested data are the same as those parameterized in the relay. The user must complete the fields below as carefully as possible, as each of them directly influences the final test result.

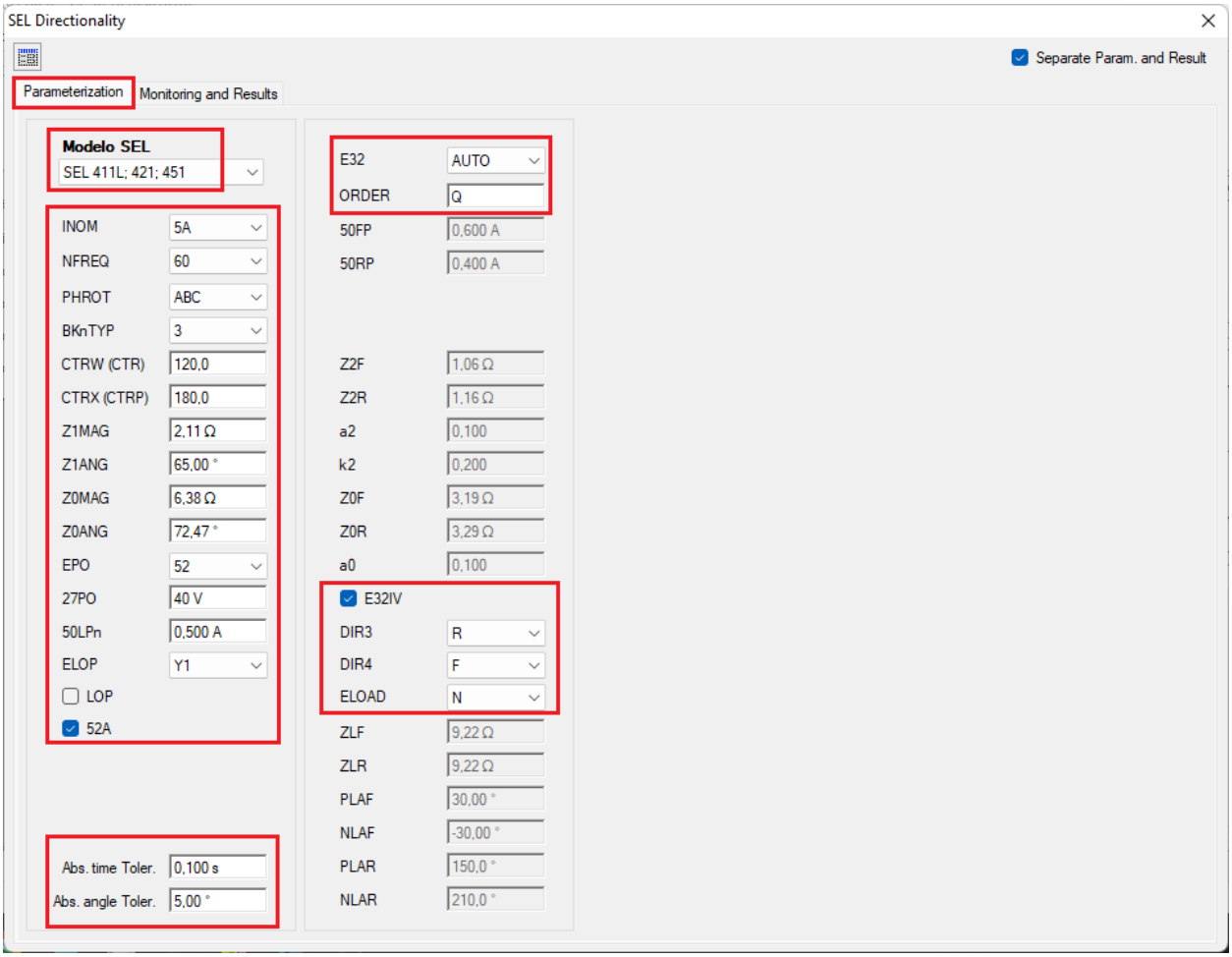

Figure 32

Note the figure below, that although we use the *"Relay Word Bit" "67P1T"* in the relay adjustment, here in the test set, to be correctly evaluated, *the "Relay Word Bit"* used is the *"67Q1T"*. This is possible since in the previously discussed logics, directionality by elements of negative sequence acts directly on the positive sequence. Even in the pickup and delay fields 50Q1P, 67Q1D are parameterized with the phase data *"50P1P"* and *"67P1D"*. Thus, generating purely negative-sequence faults (evidencing phase-to-phase faults) it is possible to evaluate the tripping by phase directional overcurrent. Also note the use of the negative sequence characteristic to evaluate a positive sequence trip.

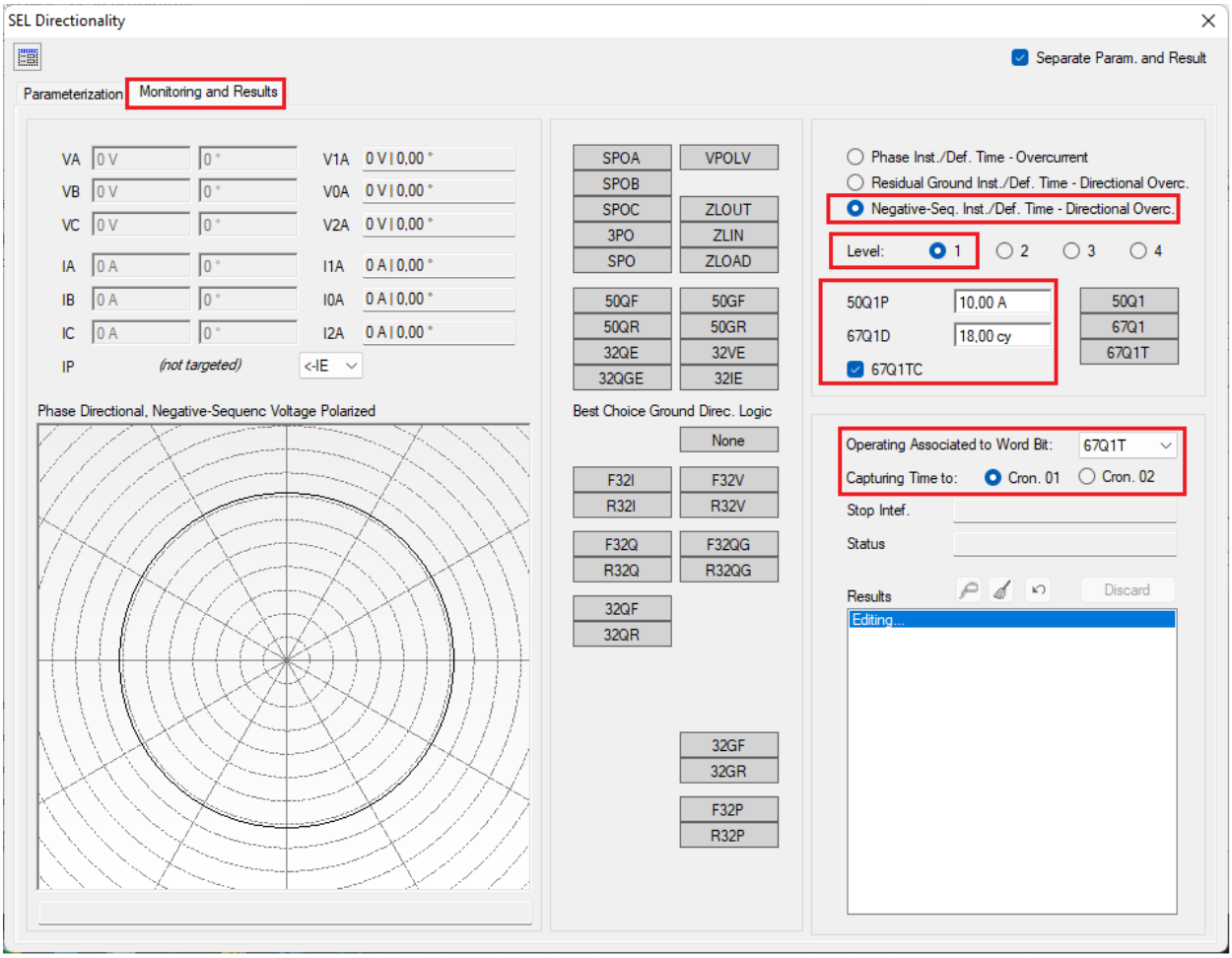

Figure 33

8.2 *Directionality Test*

The 67P function directionality test will be performed. Close the *"SEL Directionality"* window. In the missing tab, choose the definition as *"Simet. Comp."* as shown below. Then access the *"Chronometer"* tab, select the stop interface as BI01.

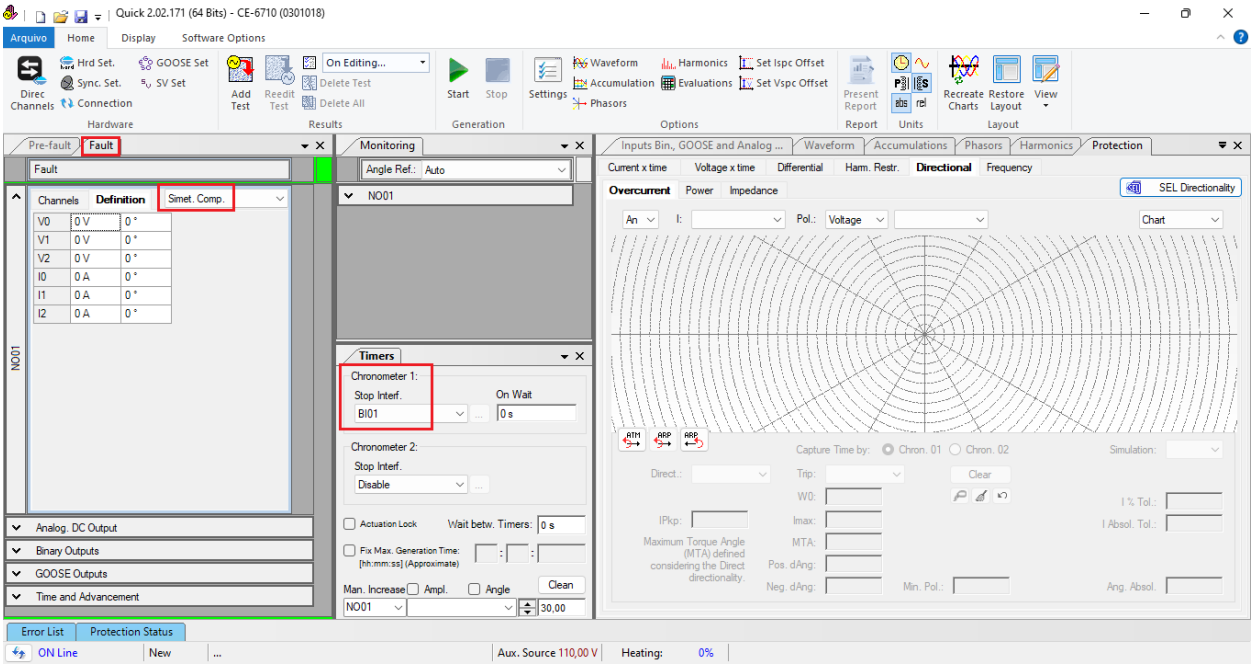

Figure 34

After clicking on the button mentioned above, click again on the *"SEL Directionality"* feature, located in the *"Protection > Directional > Overcurrent"* tab. Enter the fault as negative sequence voltage and current values, by selecting the option *"Simet. Comp."*.

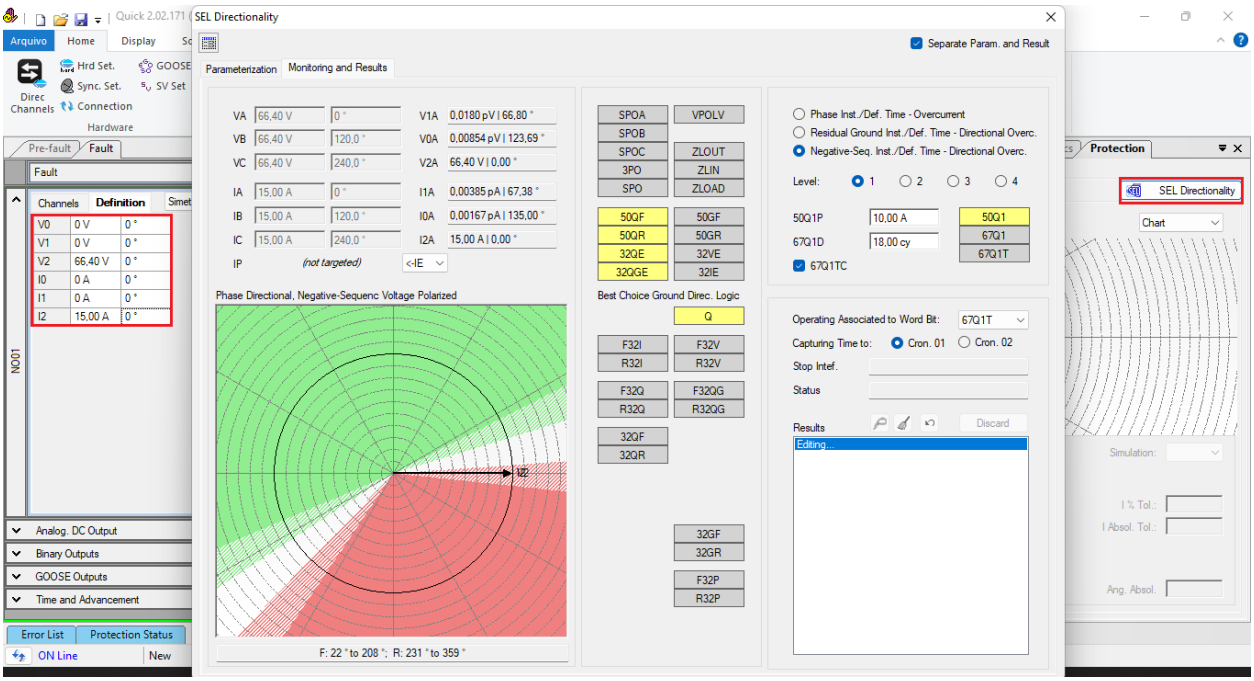

Figure 35

Start the generation by clicking on the icon highlighted below or using the command *"Alt +G"*. If the relay does not stop generating, use the *"Alt+P"* command.

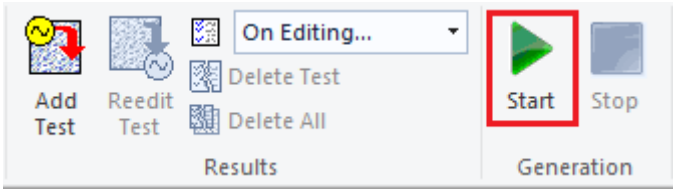

Figure 36

After the relay actuation or not actuation, capture the tested point by clicking on the icon highlighted in red (capture loop). Note that it is shown in the *"Stop interf."* if the tested point had actuation or not, if this point is within the operating or non-operating region and within the tolerances, the feedback in the *"Status"* field *"OK"* is shown.

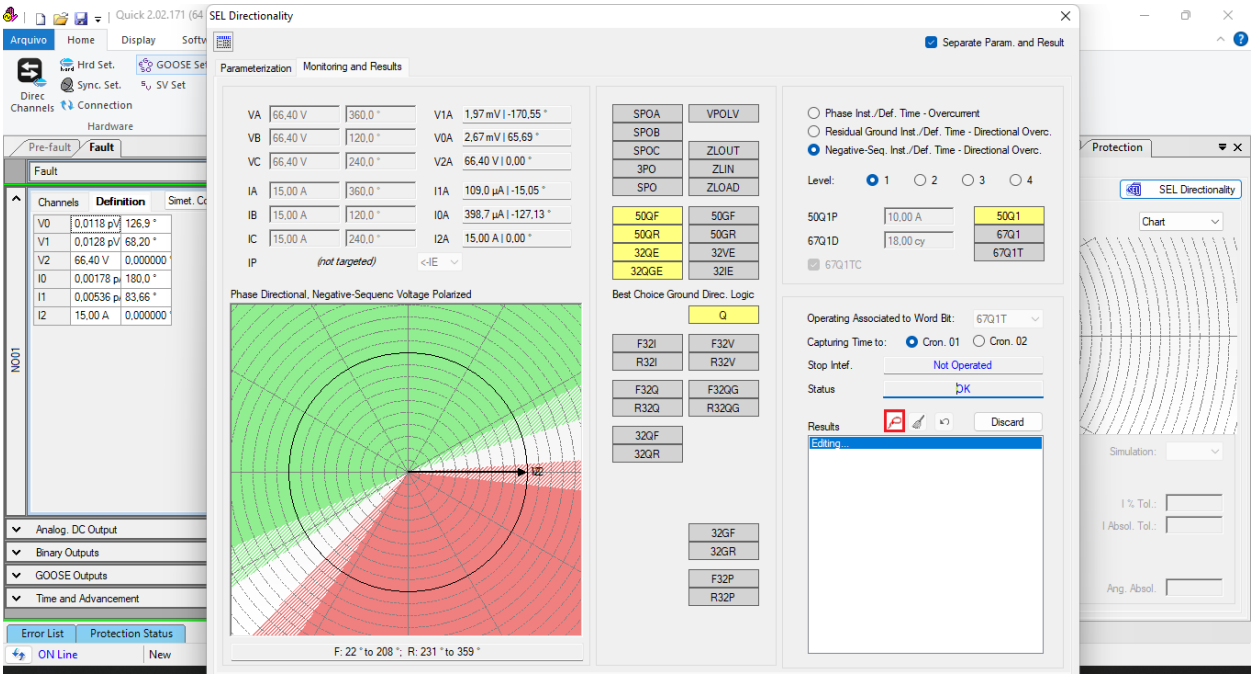

Figure 37

Only vary the angle of the negative sequence current by 30° and capture all points.

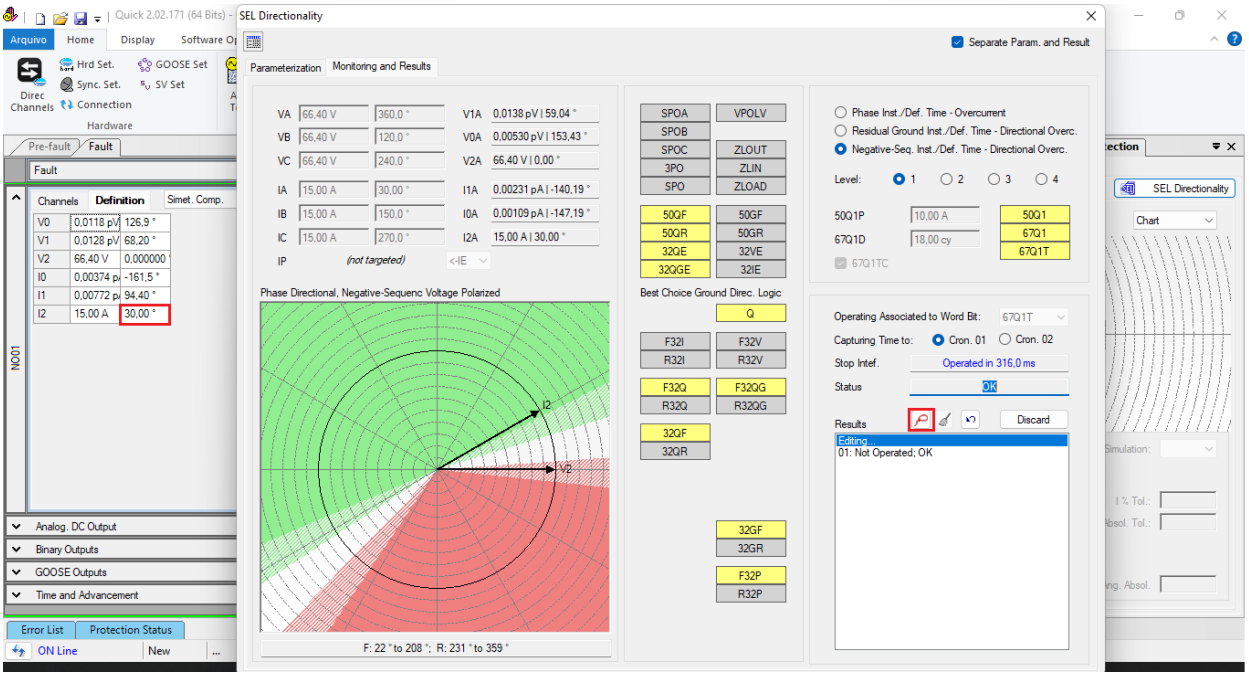

Figure 38

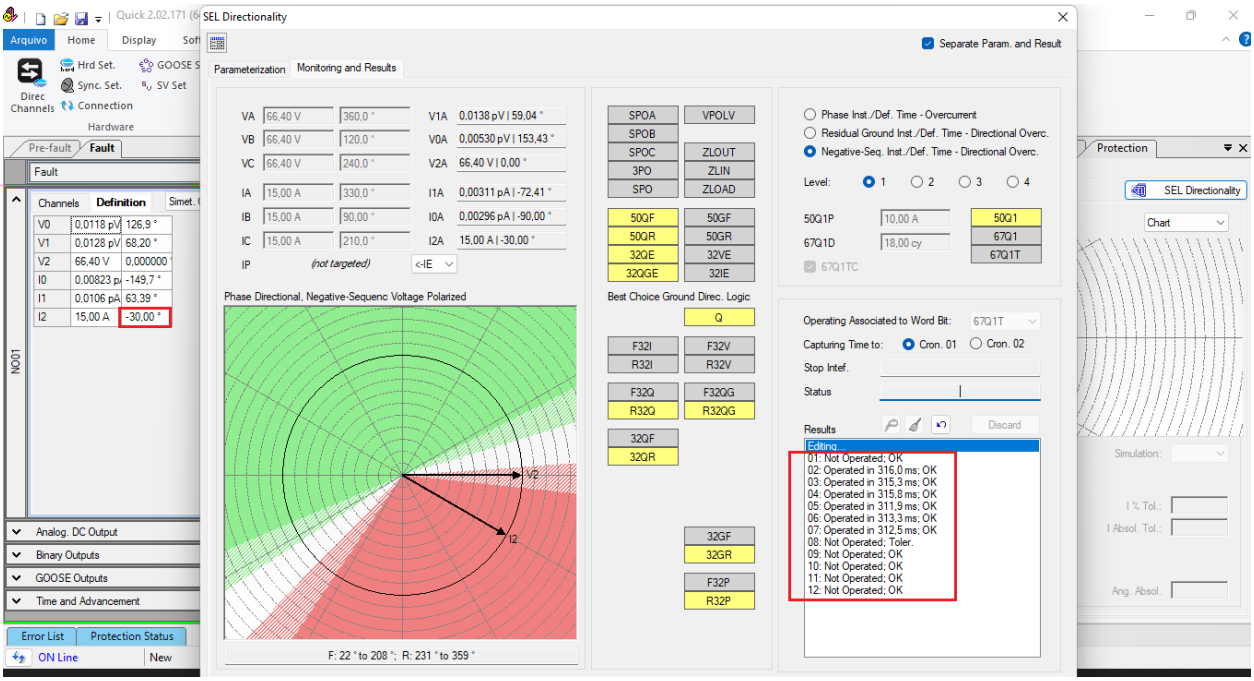

Figure 39

An important observation is that the user must keep the negative sequence voltage and current modules constant, because if they change the entire characteristic changes (Observe the equation in the relay manual). Compare the figure above with the figure below:

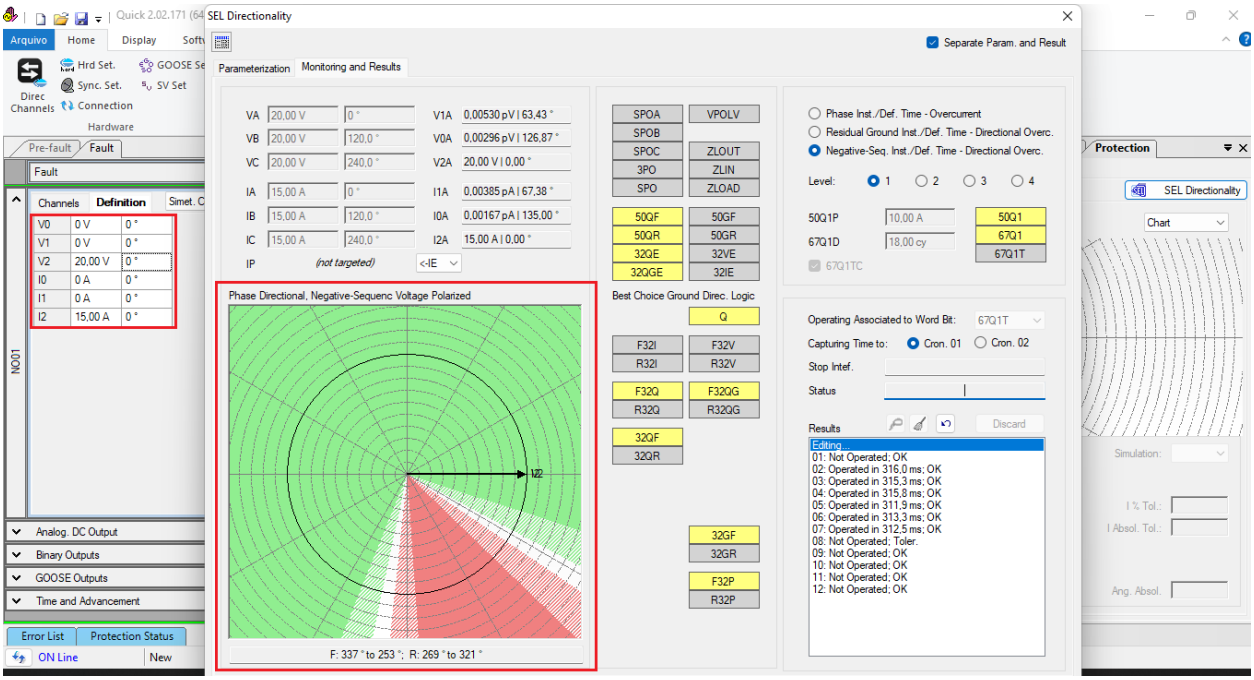

Figure 40

9. Report

After finishing the test, click on the *"Present Report"* icon 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.

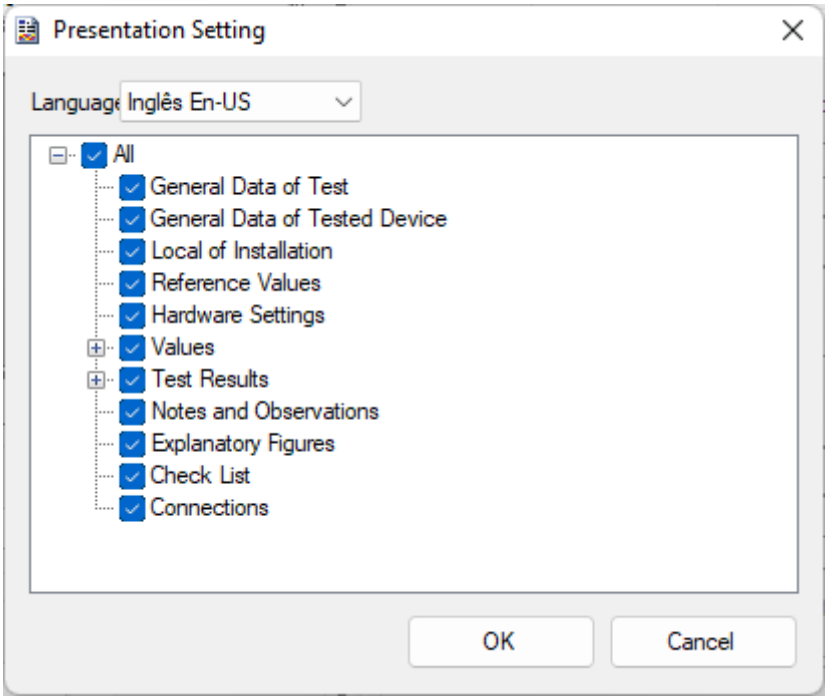

Figure 41

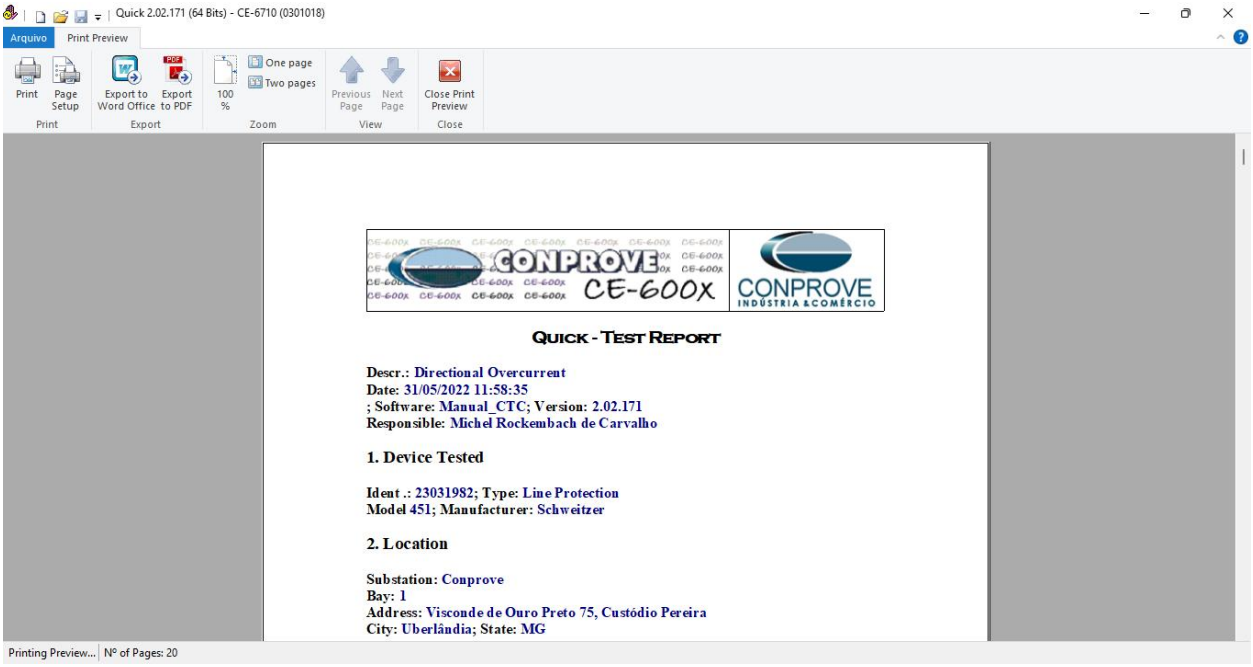
Quick 2.02.171 (64 Bits) - CE-6710 (0301018)
Arquivo
Print Preview
Print
Page Setup
Export to Word Office
Export to PDF
100 %
One page
Two pages
Previous Page
Next Page
Close Print Preview
Zoom
View
Close
CONPROVE
CE-600X
CONPROVE
INDÚSTRIA &COMÉRCIO
QUICK - TEST REPORT
Descr.: Directional Overcurrent
Date: 31/05/2022 11:58:35
; Software: Manual_CTC; Version: 2.02.171
Responsible: Michel Rockembach de Carvalho
1. Device Tested
Ident .: 23031982; Type: Line Protection
Model 451; Manufacturer: Schweitzer
2. Location
Substation: Conprove
Bay: 1
Address: Visconde de Ouro Preto 75, Custódio Pereira
City: Uberlândia; State: MG
Printing Preview...
Nº of Pages: 20

Figure 42

APPENDIX A

A.1 Terminal Designations

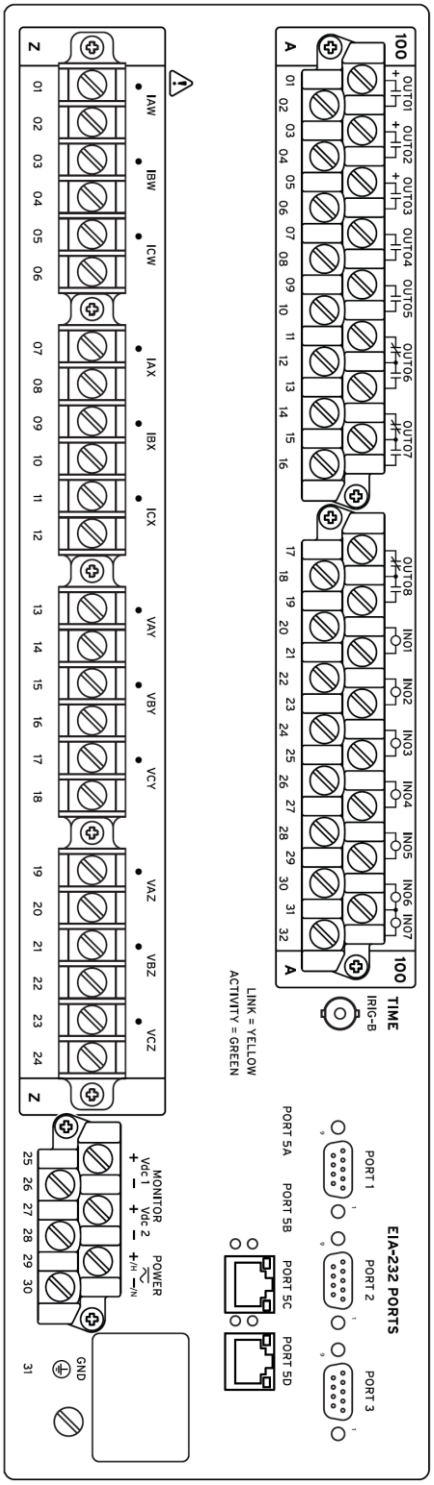

Figure 43

A.2 Technical Data

Relay Element Pickup Ranges and Accuracies

Instantaneous/Definite-Time Overcurrent Elements

Phase, Residual Ground, and Negative-Sequence

Pickup Range	
5 A Model:	OFF, 0.25–100.00 A secondary, 0.01 A steps
1 A Model:	OFF, 0.05–20.00 A secondary, 0.01 A steps
Accuracy (Steady State)	
5 A Model:	±0.05 A plus ±3% of setting
1 A Model:	±0.01 A plus ±3% of setting
Transient Overreach:	< 5% of pickup
Time Delay:	0.000–16000 cycles, 0.125 cycle steps
Timer Accuracy:	±0.125 cycle plus ±0.1% of setting
Maximum Operating Time:	1.5 cycles

Time-Overcurrent Elements

Pickup Range	
5 A Model:	0.25–16.00 A secondary, 0.01 A steps
1 A Model:	0.05–3.20 A secondary, 0.01 A steps
Accuracy (Steady State)	
5 A Model:	±0.05 A plus ±3% of setting
1 A Model:	±0.01 A plus ±3% of setting
Time-Dial Range	
U.S.:	0.50–15.00, 0.01 steps
IEC:	0.05–1.00, 0.01 steps
Curve Timing Accuracy:	±1.50 cycles plus ±4% of curve time (for current between 2 and 30 multiples of pickup)
Reset:	1 power cycle or Electromechanical Reset Emulation time

APPENDIX B

Equivalence of software parameters and the relay under test.

Table 1

Quick Software		SEL 451 Relay	
Parameter	**Figure**	**Parameter**	**Figure**
INOM	32	Secondary Input Current	07
NFREQ	32	NFREQ	09
PHROT	32	PHROT	09
CTRW (CTR)	32	CTR	10
CTRX (CTRP)	32	PTR	10
Z1MAG	32	Z1MAG	10
Z1ANG	32	Z1ANG	10
Z0MAG	32	Z0MAG	10
Z0ANG	32	Z0ANG	10
EPO	32	EPO	17
27PO	32	27PO	17
50LPn	32	----	--
ELOP	32	ELOP	12
52A	32	----	--
E32	32	E32	16
ORDER	32	ORDER	16
50FP	32	50FP	16
50RP	32	50RP	16
Z2F	32	Z2F	16
Z2R	32	Z2R	16
a2	32	a2	16
k2	32	k2	16
Z0F	32	Z0F	16
Z0R	32	Z0R	16
a0	32	a0	16
E32IV	32	E32IV	16
DIR3	32	DIR3	15
DIR4	32	DIR4	15
ELOAD	32	ELOAD	12
ZLF	32	ZLF	13
ZLR	32	ZLR	13
PLAF	32	PLAF	13
NLAF	32	NLAF	13
PLAR	32	PLAR	13
NLAR	32	NLAR	13

Quick Software		SEL 451 Relay	
Parameter	Figure	Parameter	Figure
50Q1P	33	50Q1P	14
67Q1D	33	67Q1D	14
67Q1TC	33	67Q1TC	14

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