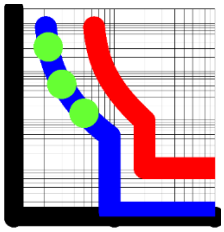
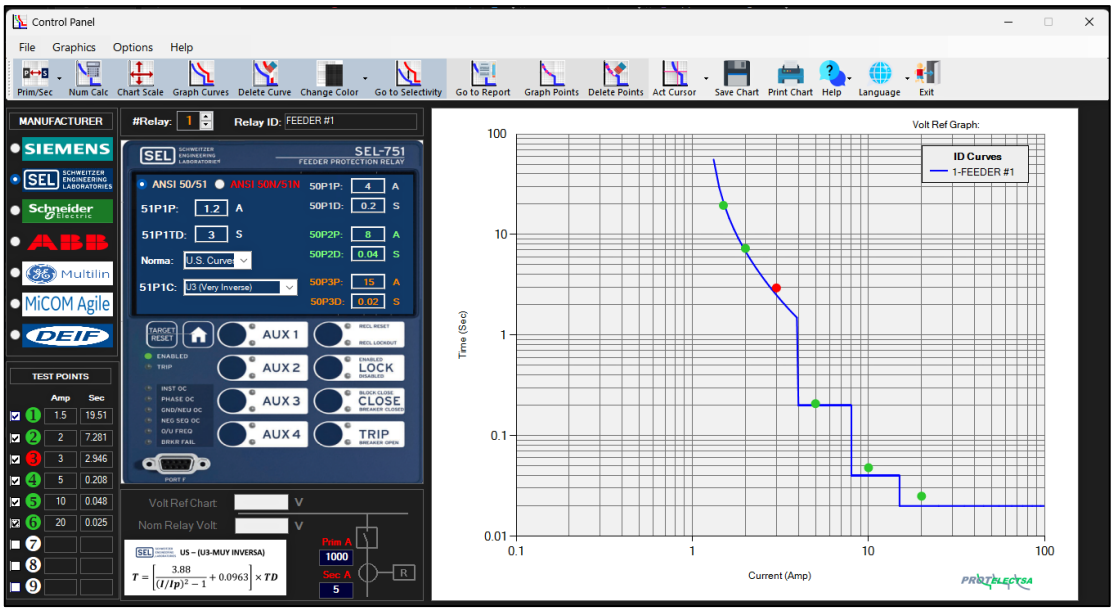
INTRODUCTION TO:
Relay Tripping Curves-PRO2©
SOFTWARE



Ver: 2.0.0



By: **Eng. Richard Mosqueda R.**

PROTELECTSA

www.protelectsa.net

info@protelectsa.net

richardmosqueda@gmail.com

Table of Contents

Introduction

Relay Tripping Curves-PRO It is a software that allows calculating, by means of mathematical equations, the characteristic curves of the protections against phase overcurrents (ANSI 50/51) and ground currents (ANSI 50N/51N), according to the different standards used by the main manufacturers of protection relays that exist in the market, as well as representing these curves on a chart with a Log-Log scale in a friendly and simple way.

This software arises from the need for engineers, technicians and electrical engineering students to have a simple tool for representing these characteristic curves, since the data for the curve graph is fed through mathematical calculations. With this software you can also represent the trip data of a protection device and compare it with the setting curve and make a test report, which includes protection relay setting data, a trip verification table and includes images. Additionally, with this software you can compare the selectivity between two inverse curves and optimize it.

In summary, with Relay Tripping Curves-PRO2 you can:

- Graph up to 30 curves of the ANSI 50/51 and ANSI 50N/51N function settings from the different manufacturers of protection relays on the market.
- Perform numerical calculations of the graphed curve and print the results.
- Graph the protection relay trip points and compare with the adjusted inverse curve.
- Activate a cursor to show the Amps vs Time values along a graphed curve.
- Create a report that includes the relay settings data, the trip verification table, the curve graph and include images.
- Calculate and optimize the selectivity between 2 graphed curves and make a report.
- Change from secondary to primary values.
- Change the scale of the log-Log chart as needed.
- Graph curves at different voltage levels.
- Change language: English to Spanish.
- Customize the Logo of the reports (Optional).

This document will explain in detail each of the features and functions of this software so that the end user becomes familiar with it.

You can download this software at: www.protelectsa.net

Who is it addressed to ?

Relay Tripping Curves-PRO2 is aimed at:

1.- Students:

1.1.- With this software, electrical engineering students will have help when learning the concepts of construction of the inverse curves used by protection relays.

1.2.- Know and work with the formulas of the mathematical equations used for the construction of the inverse curves.

1.3.- Work on the selectivity between two protection relays.

1.4.- Work on primary and/or secondary values in power systems.

1.5.- Learning the basic principles to carry out studies of protection coordination

2.- Electrical engineers and/or technicians

2.1.- Engineers and/or technicians will have a consultation tool to have first-hand how the curves of the protection device settings of their plants and/or substations are represented.

2.2.- They will be able to quickly and easily know the selectivity between two specific devices and take action in case any adjustment change is required.

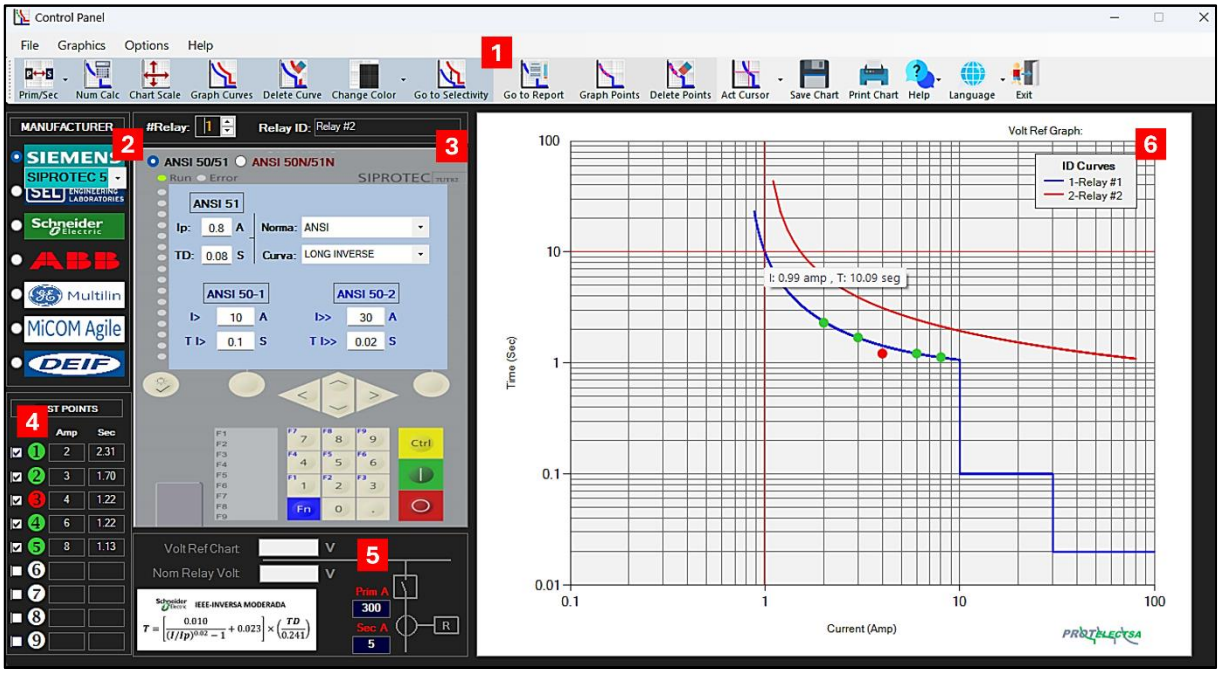
2.3.- Conduct a study of protection coordination between downstream and upstream devices.

2.3.- Observe the behavior of the adjusted curve in the event of a trip and any test performed, knowing the fault current values and trip time.

2.4.- Make a report that includes data on protection relay settings with a graph of its inverse curve.

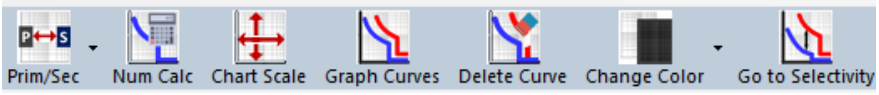
Control Panel and User Menu

The Control Panel contains the data modules and buttons necessary to carry out our tasks, although there are also some pop-up windows depending on the operation we are doing.

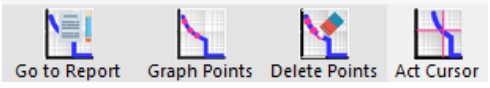


1 **Toolbar:** Contains all the buttons necessary for the program to run, and is divided into three groups:

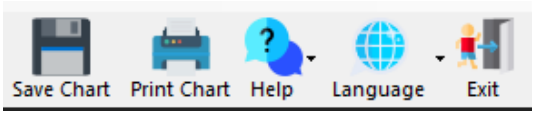
Graph menu buttons: This contains all the functions necessary to graph the curves in the Log-Log Plot, go from Secondary values to Primary values, change the scale of the Log-Log Plot, delete the curve that is graphed, change the color of background Log-Log Plot, activate the cursor and go to the windows to make the numerical calculations, calculate the selectivity between two curves and graph the starting current of the loads.



Test menu buttons: This contains all the functions necessary to graph the trip points, delete the plotted trip points and make a report.



General menu buttons: These buttons are used to graph Current/Time points, clear graphed trips points, activate the cursor to display Current/Time values along the graphed curve, and go to the report window.



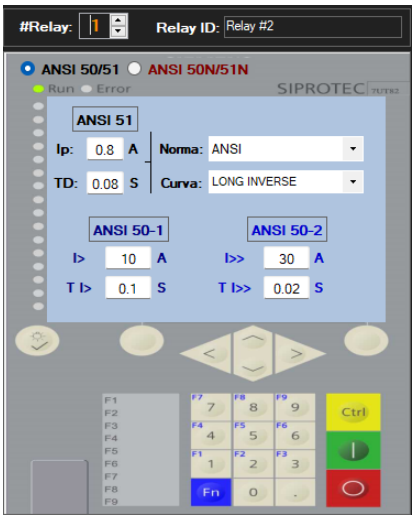
Drop-down menu: Contains the same buttons as the Toolbar, but in a drop-down way.

2 **Manufacturer Data**: This MENU contains the options for the protection relay manufacturer to choose from and for which we want to represent the settings and graph its curve. When selecting one of these manufacturers, a mimic will be displayed that simulates the front display of the protection relay.

If you select the SIEMENS option, 3 options will be displayed to choose from: SIPROTEC5, SIPROTEC4 and Reyrolle with their respective mimics of their front display.

If you select the ABB option, 2 options will be displayed to choose from: REF Series and DPU2000 with their respective mimics of their front display.

3 **Protection Relay Settings Data:** Once the manufacturer has been chosen, this is where all the data for the ANSI 50/51 or ANSI 50N/51N function settings of the protection relay are entered:



ANSI 51 or ANSI 51N data:

Ip: This is the value of the pickup current for the operation of the ANSI 51 function in Primary or Secondary Amps.

Td: Value of the time variable or Time Dial of the curve.

Standard: Here the standard used is chosen, for example: ANSI, IEC, U.S Curves or IEEE, depending on the manufacturer selected in Manufacturer Data.

Curve: Here the type of curve is selected according to the selected **STANDARD**.

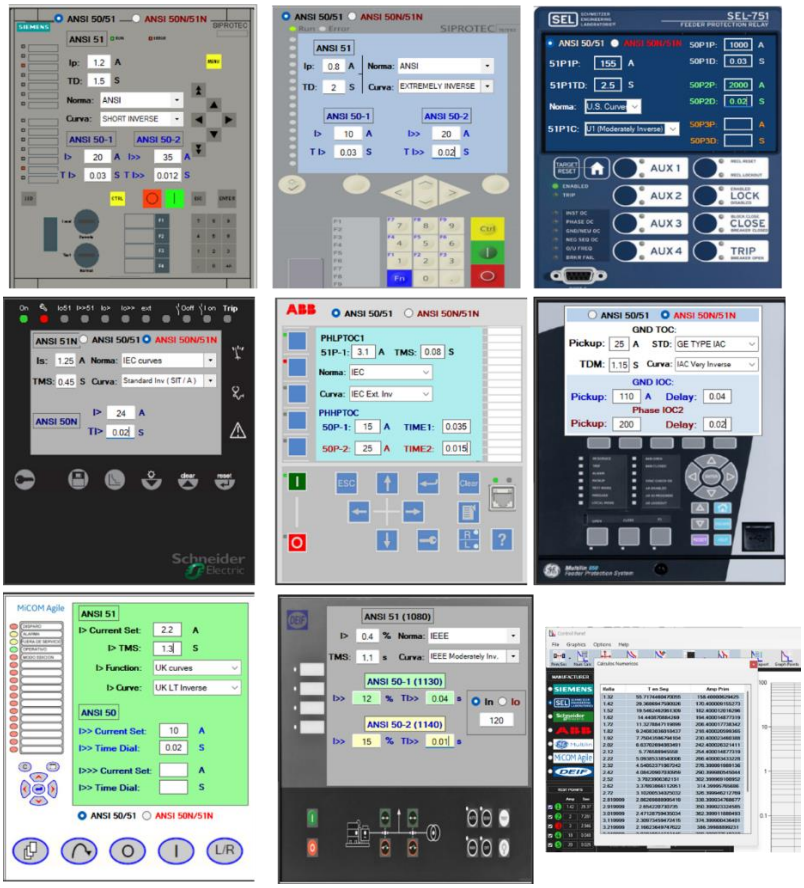
ANSI 50 or ANSI 50N data:

I>: It is the value of the instantaneous starting current or Pickup for the operation of the ANSI 50 function in Primary or Secondary Amps.

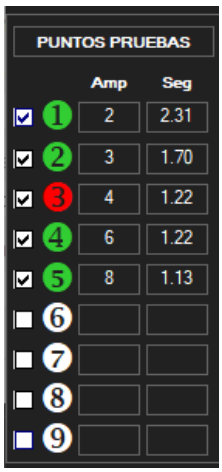
TI>: Timing value for starting the ANSI 50 protection.

Here you also select the number of the relay to which its adjustment curves will be represented and enter its respective identification. 

For greater ease when entering the protection relay setting data, this is done through the simulated image of its front panel. For each manufacturer there will be a mimic that simulates the front display and will be displayed when selecting a manufacturer:

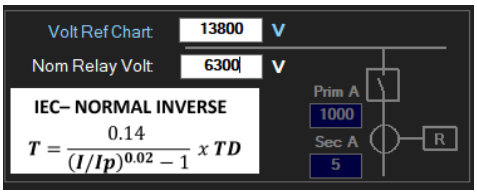


4 **Test Points**: In this menu, the values of fault currents and trip times are entered, such as the current injection values of a test case or the result of an event recorded by the protection relay.



These points are plotted on the inverse curve plotted on the Log-Log chart, in this way it is verified if the protection device acts within the range of the curve. If any point falls within a range of 10% of the curve, this point will be placed in green, but if the point falls above or is less than 10% of the curve, the point will be placed in red.

5 **Vn and Tc data box:** in this menu you can enter:



.- Values of the current transformer (CT) ratio when working with secondary values.

.- Values of the operating voltage of the protection equipment and the reference value with which the inverse curves will be plotted on the Log-Log chart (when working with primary values).

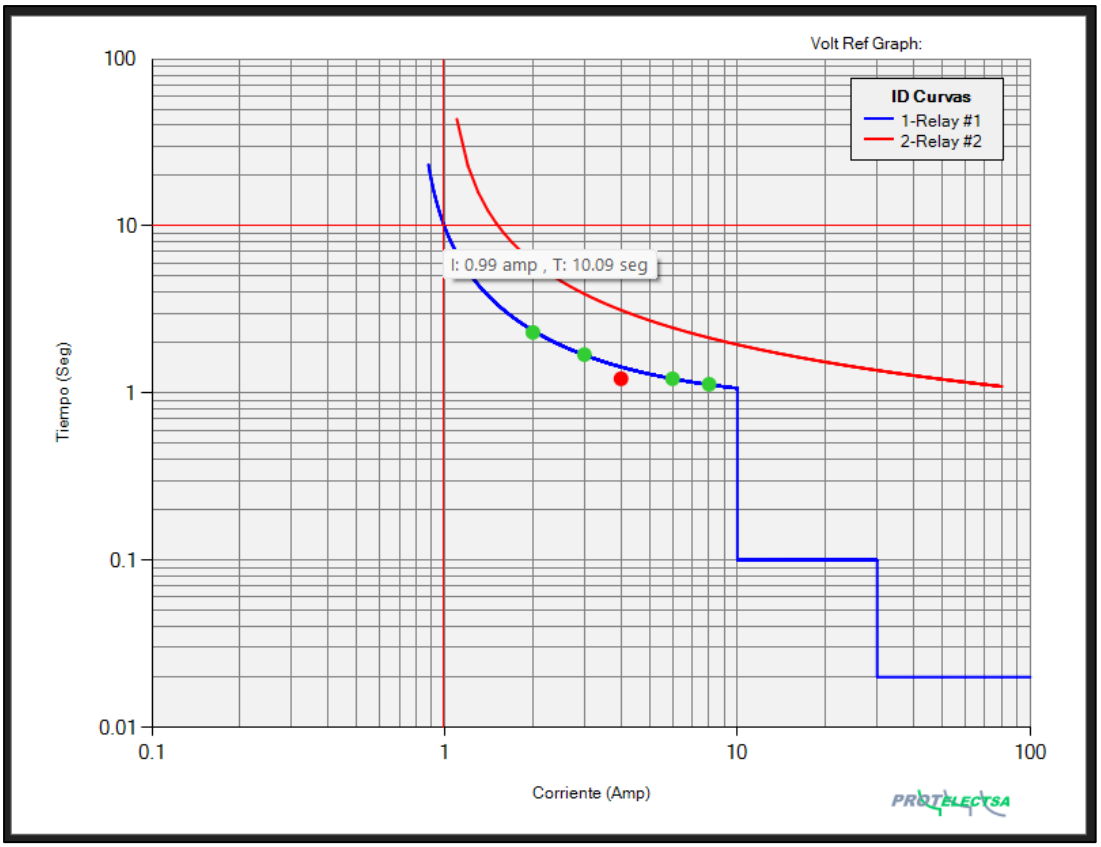
.- The equation of the curve is shown, according to the chosen standard.

6 **Log - Log Plot:** This screen shows the inverse curves of the protection relay chosen, after entering the settings data and clicking on the **"Graph Curve"** button.

The trip points can also be graphed once the data has been entered in the "Test Points" menu and the **"Graph Points"** button has been clicked.

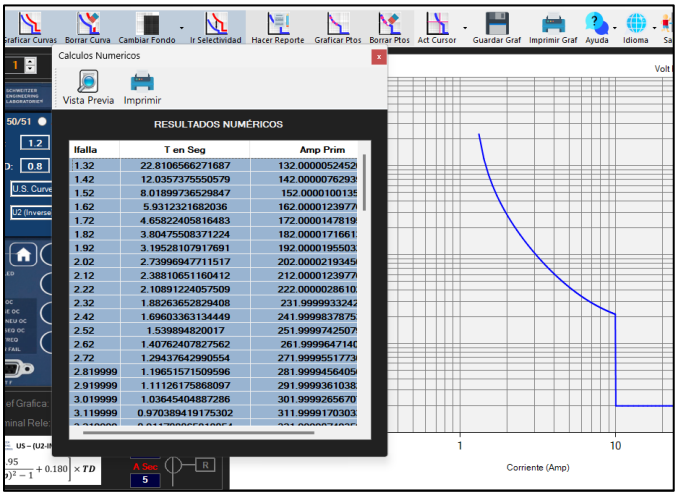
This screen shows the cursor to detail the Amp/Time values along the graphed curve. To activate/deactivate this, click on the **"Act Cursor"** button.

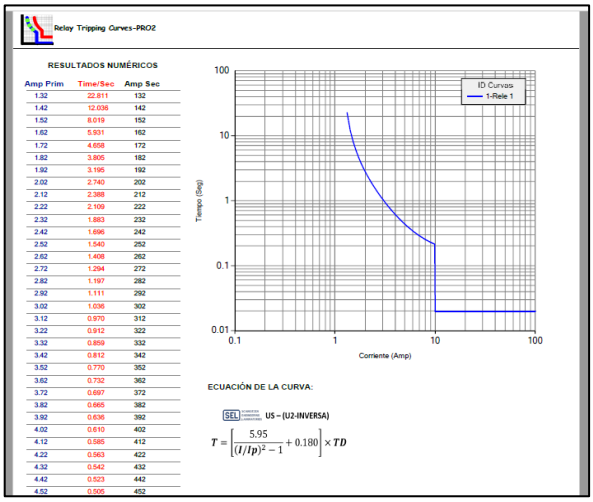
The name of the protection relay to which the graphed curves belong is also identified, as well as the reference voltage of the Log-Log chart in case of working with primary values.



Numerical Calculations

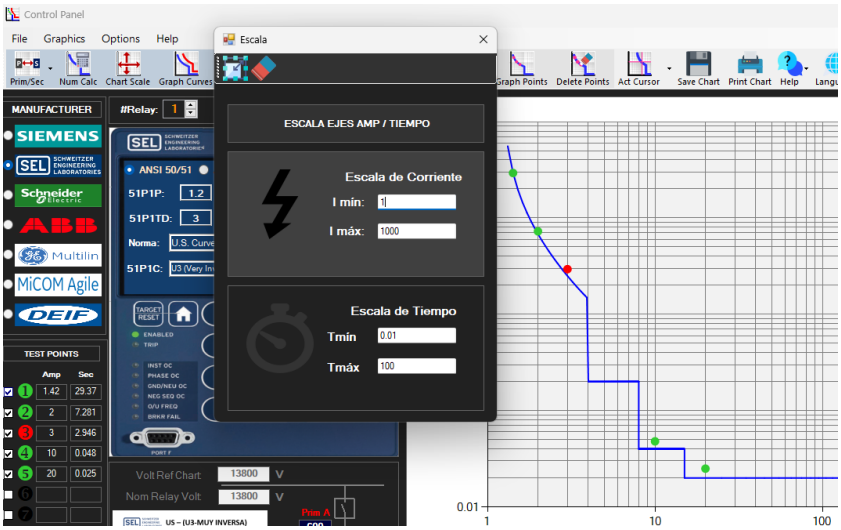
The mathematical calculations of the graphed curves can be represented by the button: this shows the results of the equations associated with the inverse curve with the data of the entered adjustments, this can be printed in a report and saved in .PDF format.





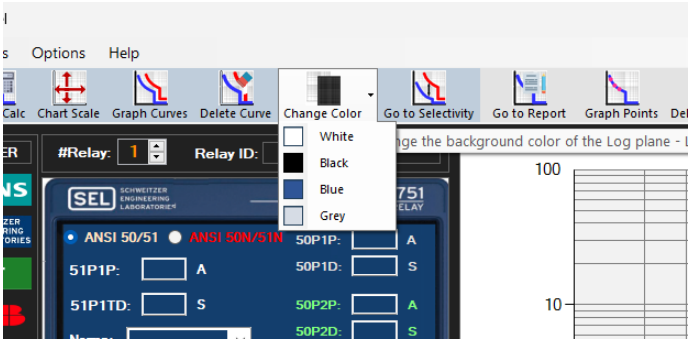
Log-Log Chart Scale

When graphing a curve, it will be graphed on a Log - Log chart on a standard scale of Imin: 0.1 / Imax: 100 and Tmin: 0.01 / Tmax: 100, this scale can be modified at the user's convenience by clicking the **Chart Scale** button:

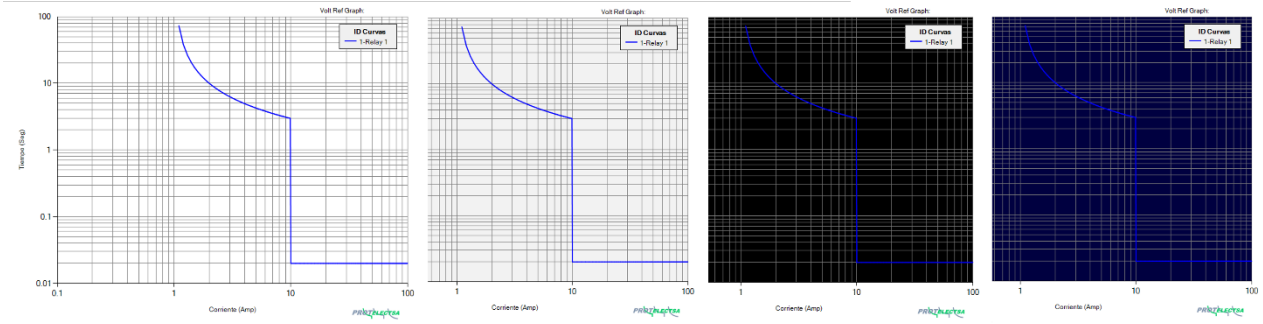


A window will be displayed with the data required to change the scale of the Log-Log chart. When entering the new values for Current and Time, click on the button: and the Log-Log chart will have a new scale. If you want to delete the data, click on:

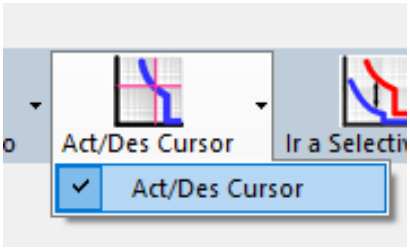
Chart area background color



You can change the background color of the Log-Log Chart from White, Black, Blue and Gray:

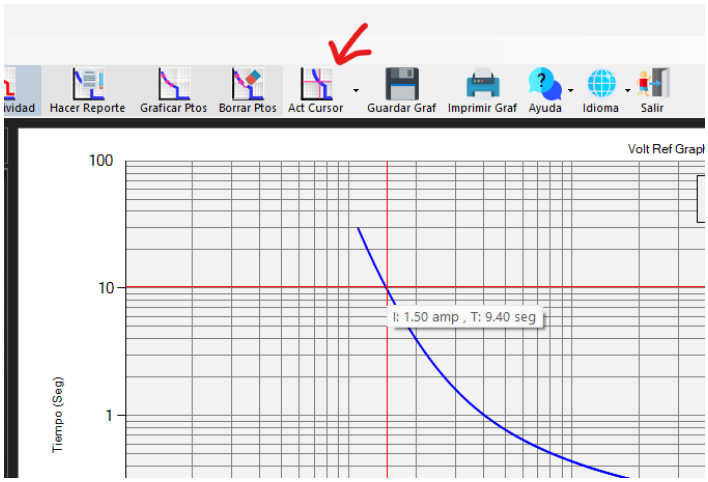


Enable/Disable Cursor



With this option, you can enable and/or disable the cursor on the Log-Log chart.

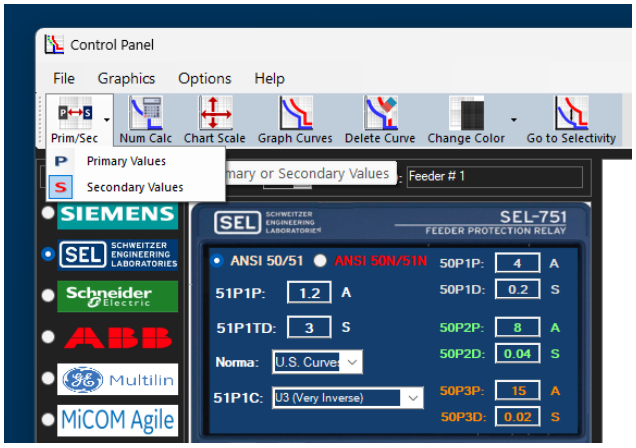
Once enabled, it allows you to position a red crosshair cursor on the Log-Log chart, and its purpose is to show the current and time value along a graphed curve.



How to graph the curves in Relay Tripping Curve – PRO2©

With **Relay Tripping Curves-PRO** all the inverse curves of the ANSI 50/51 function settings of any protection relay on the market can be graphed, taking into account the applied Standard: ANSI, IEC, IEEE, these can be graphed both in primary values as well as secondary values of the current transformers and even graphing several curves in the same Log-Log chart with different values of reference voltage, the following are the steps to follow to graph these curves with examples.

1. - Graph Curves in Secondary values: This option is the one that starts by default when opening the program in the Control Panel window. The graphed curves will refer to the secondary values of the current transformer (CT) and have the following characteristics:



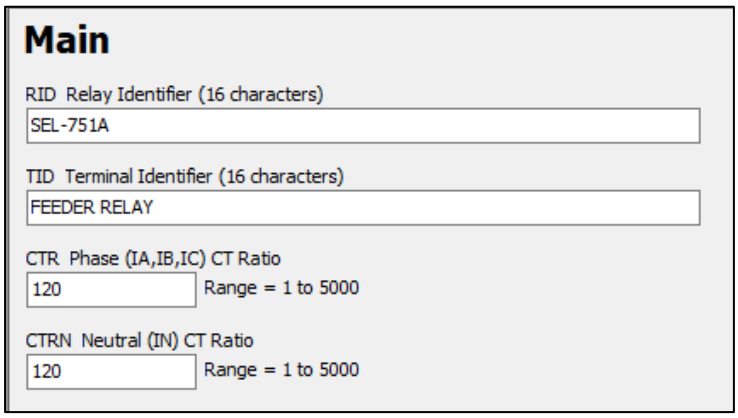
1.- The current scale will initially have a maximum value of 100 Amp (although this can be modified by means of the button: **Chart Scale**).

2.- The option to enter the CT ratio values (Primary Amp and Secondary Amp) is enabled, this is for the purpose of being used in Numerical Calculations.

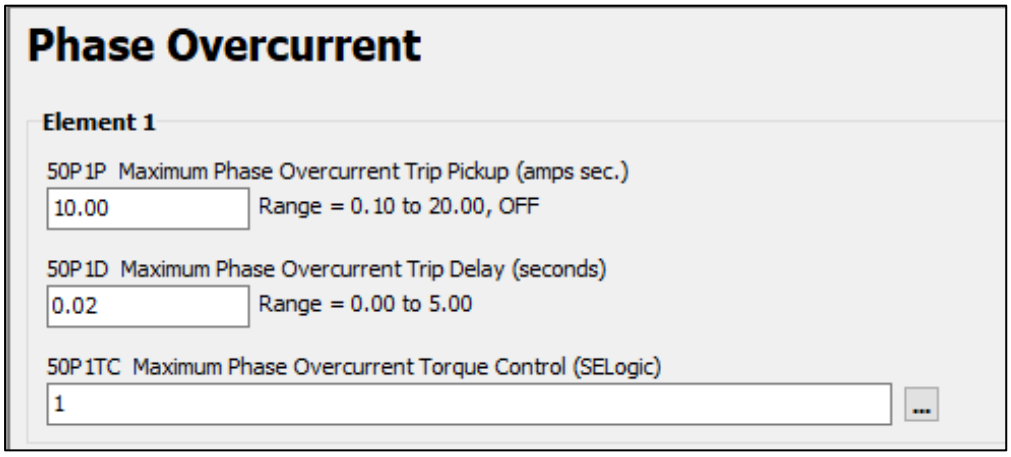
3.- The option to enter the operating voltage and reference values of the Log-Log chart is disabled, since this is enabled with the primary values option.

Example # 1: Graph the ANSI 50/51 function curve of an **SEL-751A** relay:

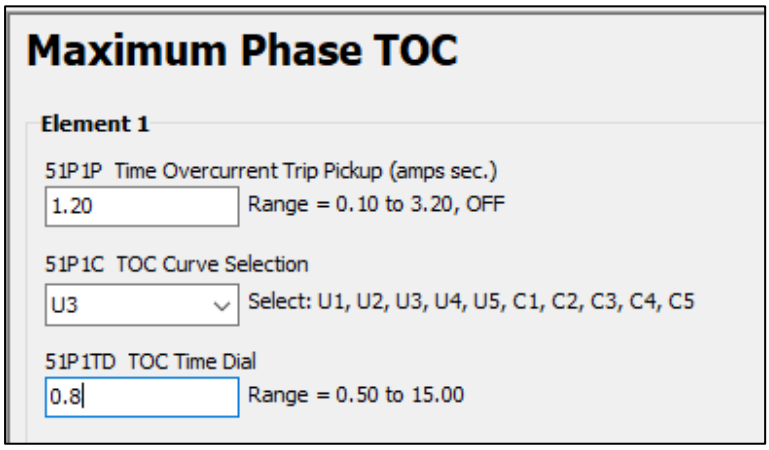
SEL-751A Relay Settings



ANSI 50 setting:



ANSI 51 setting:



In the **Control Panel** window:

.- Since it is the first curve, by default this will be Relay #1 

.- Give the relay a name in the box: "**Relay ID:"** 

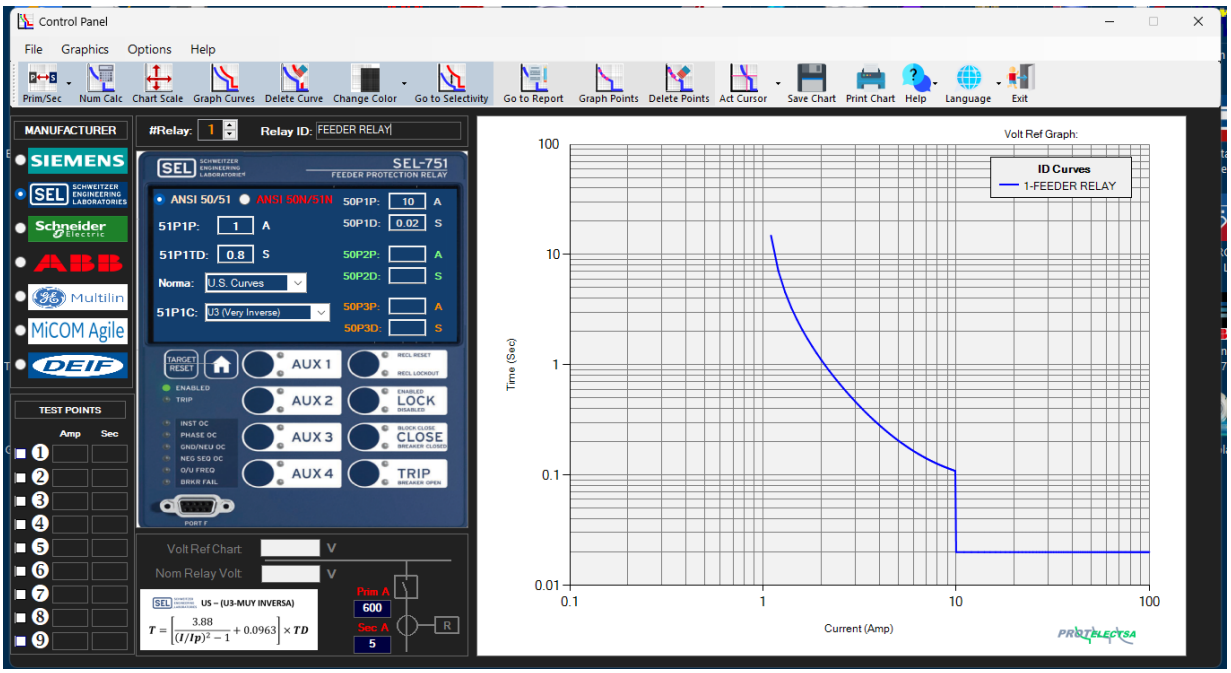
.- In the "**MANUFACTURER"** menu, select "**SEL**", the mimic of an **SEL** relay will be displayed with the settings data to be entered.

.- Enter the relay settings data for the ANSI 51 function: 51P1P, 51P1TD, Standard and 51P1C

.- Enter the relay settings data for the ANSI 50 function: 50P1P, 50P1D

.- Enter the current transformer ratio data in the **"Vn and Tc data box."**

.- After entering all the required data, click on the **Graph Curves**  button: to graph the curve in the Log – Log chart:

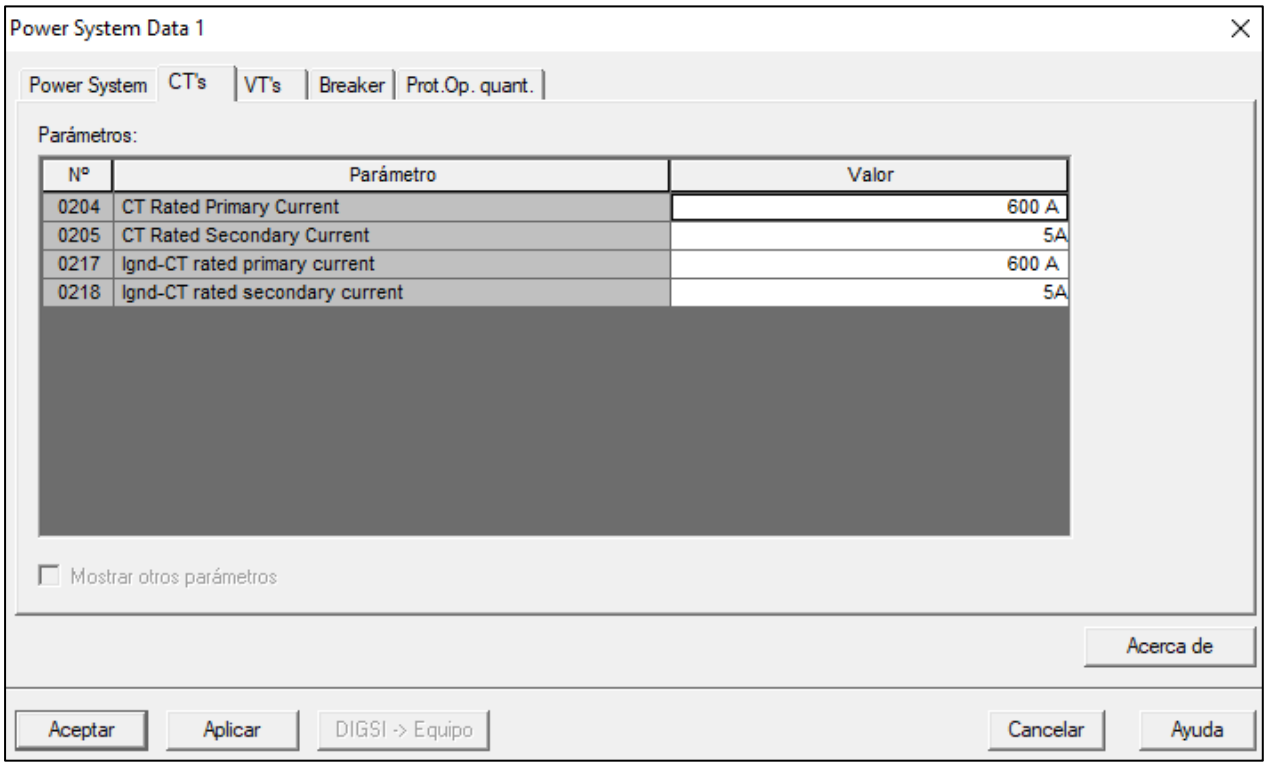


When graphing the curve, the color of the curve, the number and the name of the Relay will appear on the upper left side of the Log-Log chart.

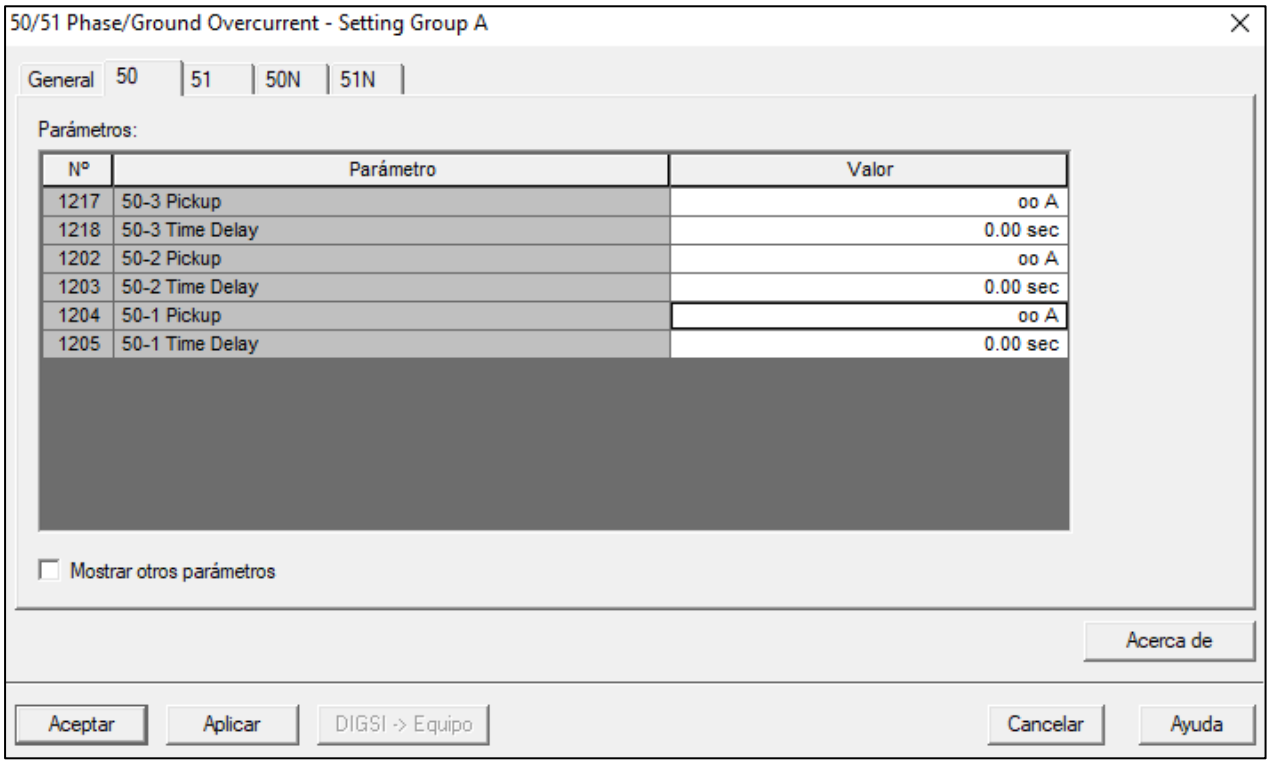
If it is necessary to indicate the voltage at which the equipment operates, you must work with primary values and enter a value in **Volt Ref Graphic** and in **Volt Nominal Relay.**

Example # 2: Graph the curve of the ANSI 50/51 function of a relay SIEMENS - 7SJ62

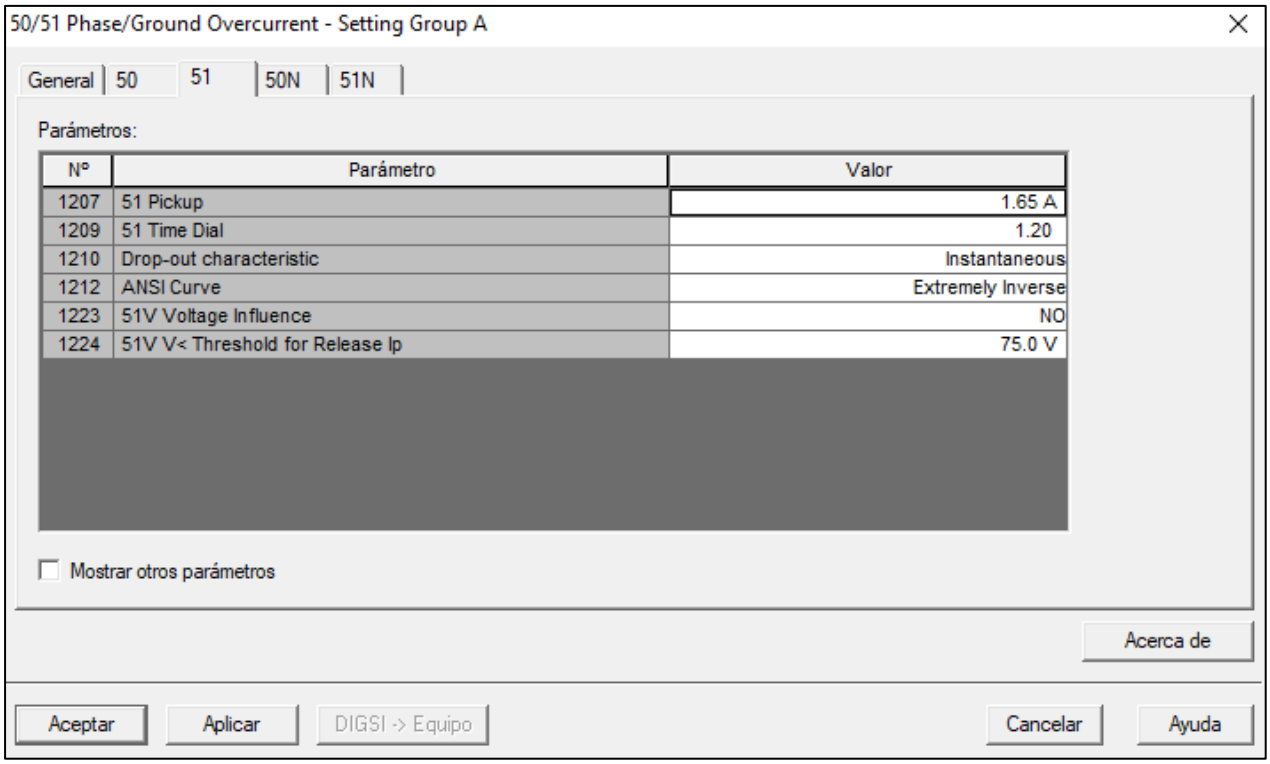
SIEMENS - 7SJ62 Relay Settings



ANSI 50 Settings:



ANSI 51 Settings:



The curve of this equipment can be graphed in a new chart, just click on the **Clear Curve** button: this eliminates the previous curve, then you can enter the data of the new curve, remaining as Relay #1, but it can also be graphed in the same previous chart, for this you have to assign the

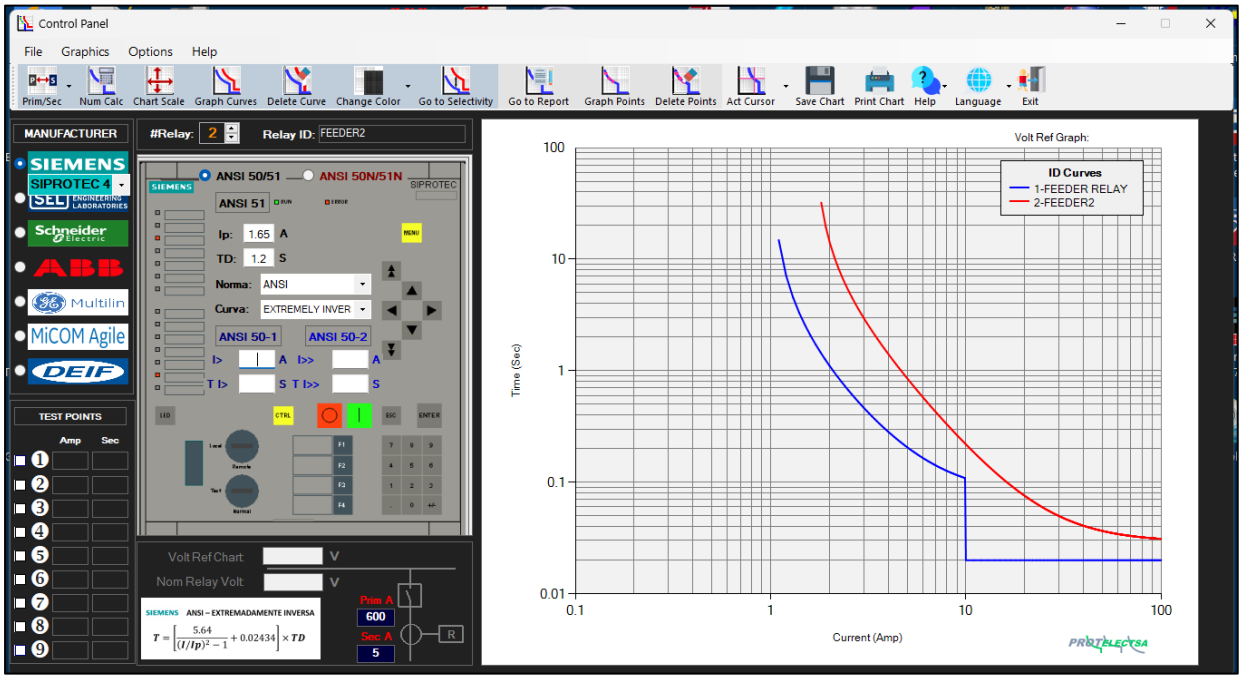
new relay number in the #Relay box and a new name in "Relay ID:", for this example, the relay will be #2  and will be called: FEEDER 2.

In the "MANUFACTURER" menu, select "SIEMENS" and then "SIPROTEC4", the mimic of a SIPROTEC4 relay will be displayed with the setting data to be entered.

.- Enter the relay adjustment data for the ANSI 51 function: Ip, TD, Standard and Curve Type.

.- Enter the current transformer ratio data in the "**Vn and Tc data box**." of

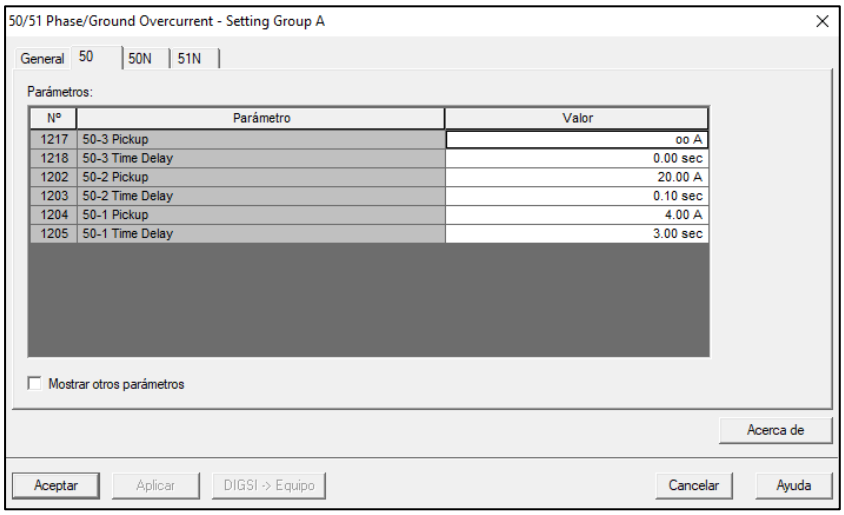
that new relay. Then click on the button: **Graph Curves**, the curve of Relay #2 (FEEDER2) will be graphed on the Log - Log chart:



Here we observe that the setting value of the ANSI 50 function or Instantaneous Current is infinite (∞), that means that the values of I> and TI> are left blank, this allows the curve to be prolonged and not have a point of cut in current and time.

Example # 3: Graph a curve but in Definite Time, which we will call FEEDER 3 and use a relay SIEMENS - 7SJ62

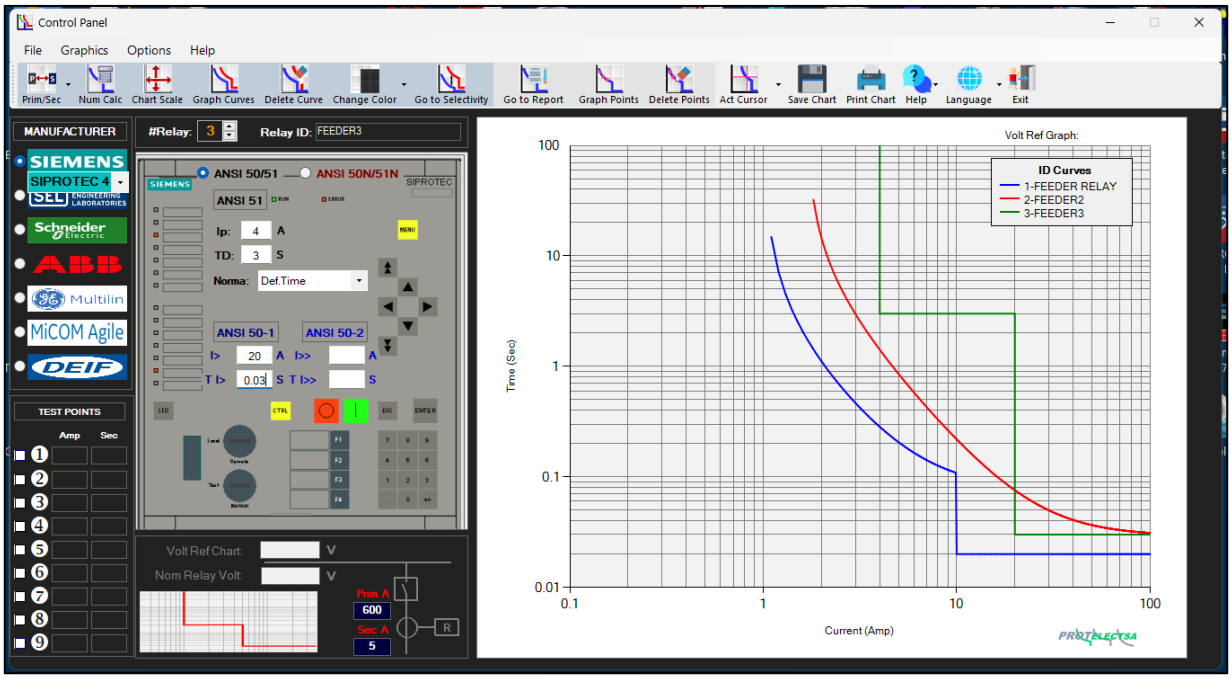
ANSI 50/51 Settings:



According to the settings, it is observed that they do not have an inverse curve, but rather a Definite Time type, therefore in the "**Standard**" drop-down list we must choose the option: "**Def. Time**" this option will be in the "**Standard**" drop-down lists of all Manufacturers.

In this example the equipment will be **#Relay: 3**, since it will be graphed in the same Log-Log chart of the previous examples, and we will call it: FEEDER 3

After entering all the data, and clicking on **Graph Curves**, the Definite Time curve of the FEEDER 3 relay appears, along with the other curves graphed previously:



2.- Graph Curves with Primary values:

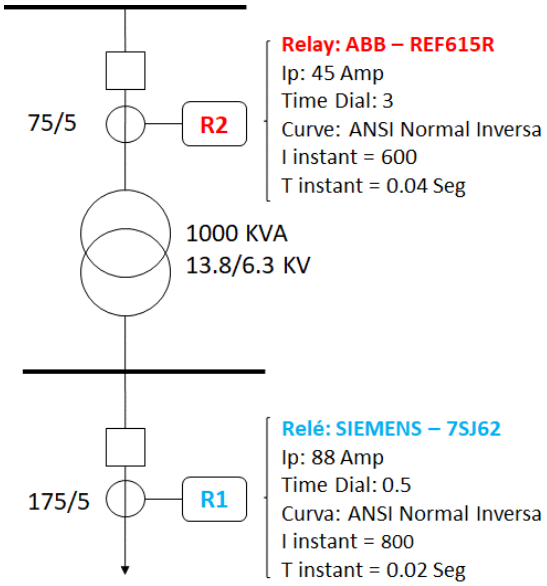
This option is selected by clicking on: **Primary/Secondary Values** , When selecting Primary Values, the graphed curves will be referred to the primary values of the current transformer (CT) and have the following properties:

1.- The current scale in the Log-Log chart will have a maximum value of 1000 Amp (although this can be modified by means of the Scale Plane option) since the adjustment values will be higher.

2.- The option of the protection relay operating voltage values and the reference voltage value of the Log-Log chart is enabled. This is very useful to compare the coordination of protections between downstream equipment and upstream equipment of a power system with different voltage levels.

3.- The option of the CT ratio values is disabled since, as it is referred to in primary values, this data is not necessary.

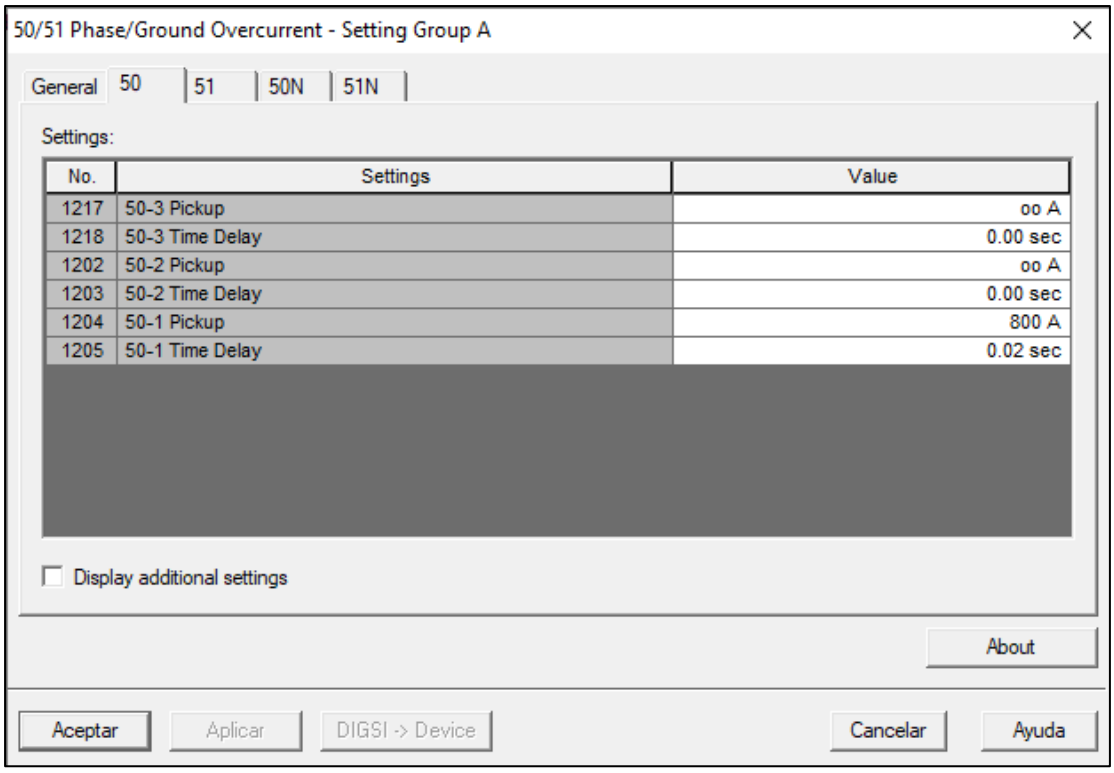
Example # 4: Graph the inverse curves of the relays in the following one-line diagram:



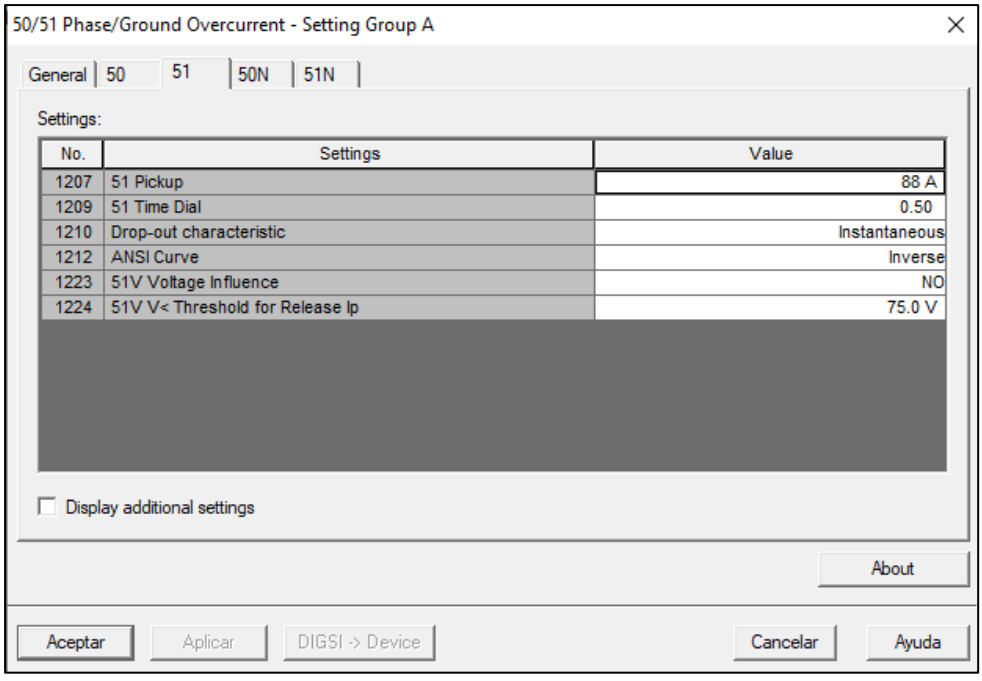
Step 1: With the primary values option activated, we enter the data required to graph the curve of Relay "**R1**"

Settings data Relay "**R1**": **SIEMENS - 7SJ62**

SIEMENS - 7SJ62: ANSI 50 Function:

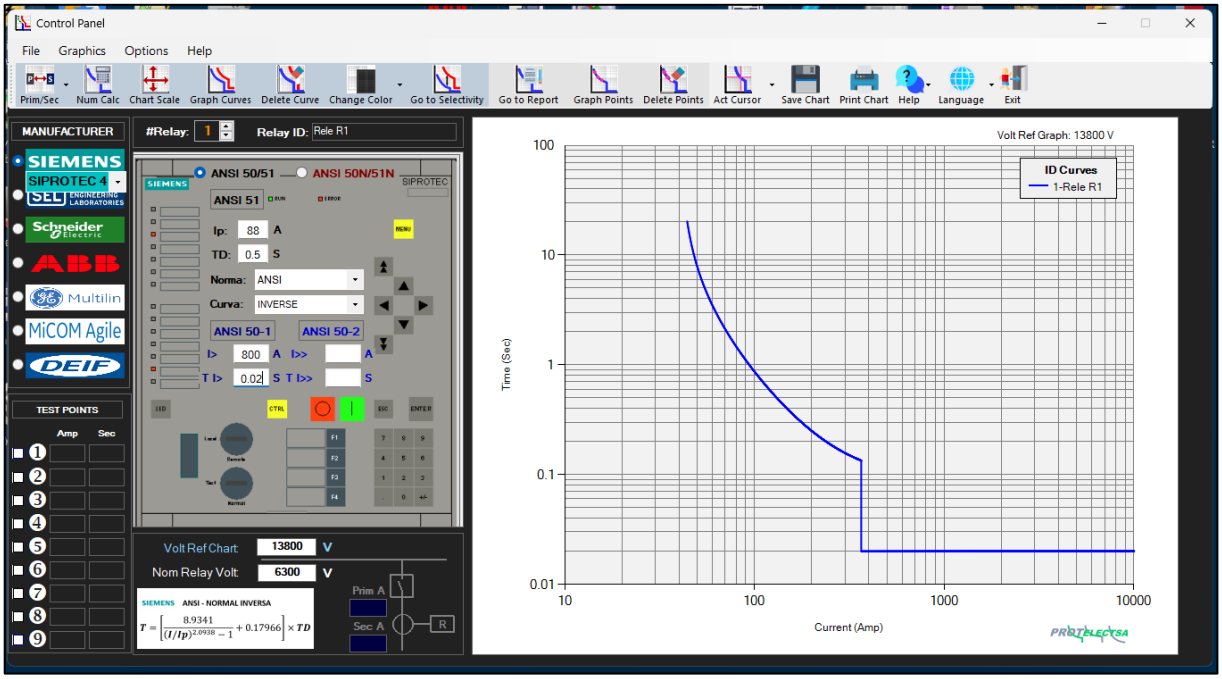


SIEMENS – 7SJ62: ANSI 51 Function:



NOTE: Remember that the system has two voltage levels: 6.3 KV (Downstream) and 13.8 KV (Upstream), therefore, it must be kept in mind at which voltage level we are going to represent the curves, generally it is performed at the level highest voltage of the system since they represent lower magnitudes of current, therefore: **Graphic Ref Volt = 13800 Volts**, the voltage value where the R1 relay operates must also be placed, in this case: **Relay nominal Volt = 6300 Volts**

After entering all the data, and clicking **Graph Curves** the curve of **R1** is shown, which is at a voltage level of 6.3 KV (Downstream) but referred to the voltage level of 13.8 KV (Upstream):



Step 2: With the primary values option activated, we enter the data required to plot the curve of Relay **R2**

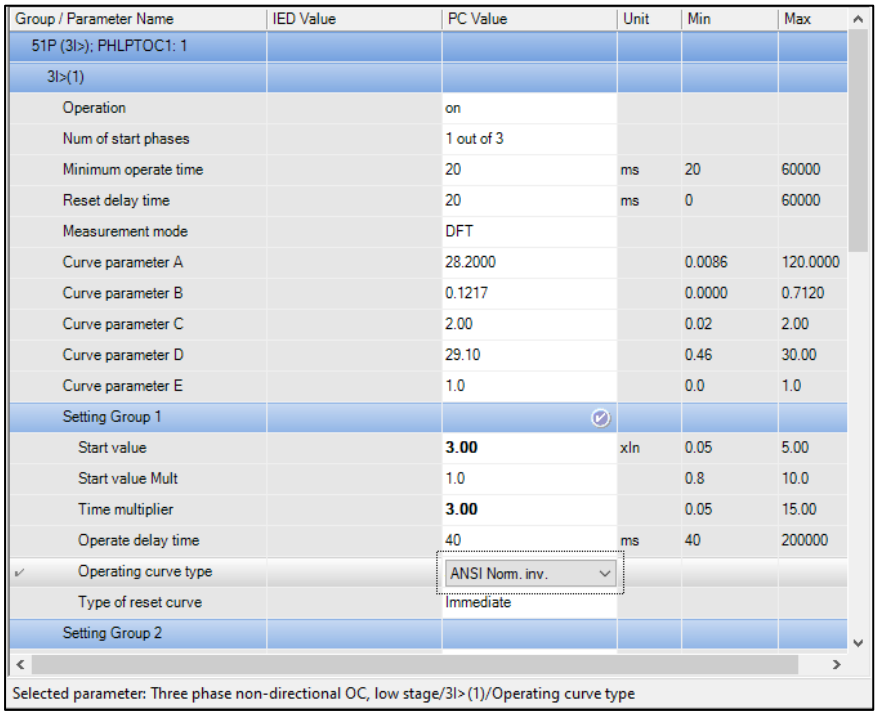
Settings data Relay "R2"- **ABB – REF615R**

ANSI 50 Function:

Group / Parameter Name	IED Value	PC Value	Unit	Min	Max
50P-1 (3I>>1): PHHPTOC1: 1					
3I>>(1)					
Operation		**on**			
Num of start phases		1 out of 3			
Minimum operate time		20	ms	20	60000
Reset delay time		20	ms	0	60000
Measurement mode		DFT			
Curve parameter A		28.2000		0.0086	120.0000
Curve parameter B		0.1217		0.0000	0.7120
Curve parameter C		2.00		0.02	2.00
Curve parameter D		29.10		0.46	30.00
Curve parameter E		1.0		0.0	1.0
Setting Group 1					
Start value		**40.00**	xIn	0.10	40.00
Start value Mult		1.0		0.8	10.0
Time multiplier		1.00		0.05	15.00
Operate delay time		**40**	ms	40	200000
Operating curve type		ANSI Def. Time			
Type of reset curve		Immediate			
Setting Group 2					

Selected parameter: Three phase non-directional OC, high stage/3I>>(1)/Operating curve type

ANSI 51 Function:



Group / Parameter Name	IED Value	PC Value	Unit	Min	Max
51P (3I>): PHLPTOC1: 1					
3I>(1)					
Operation		on			
Num of start phases		1 out of 3			
Minimum operate time		20	ms	20	60000
Reset delay time		20	ms	0	60000
Measurement mode		DFT			
Curve parameter A		28.2000		0.0086	120.0000
Curve parameter B		0.1217		0.0000	0.7120
Curve parameter C		2.00		0.02	2.00
Curve parameter D		29.10		0.46	30.00
Curve parameter E		1.0		0.0	1.0
Setting Group 1					
Start value		**3.00**	xIn	0.05	5.00
Start value Mult		1.0		0.8	10.0
Time multiplier		**3.00**		0.05	15.00
Operate delay time		40	ms	40	200000
Operating curve type		ANSI Norm. inv.			
Type of reset curve		Immediate			
Setting Group 2					

Selected parameter: Three phase non-directional OC, low stage/3I> (1)/Operating curve type

Remember that for this equipment we must place the voltage value in which it operates, since **R2** is on the 13.8 KV side we must place **Relay nominal Volt = 13800 Volts**

Another important fact to take into account in this example is that the setting values of relay **R2** are in values (x In), where "**In**" is the value of the CT ratio, in this case CT = 75/5 = 15, therefore:

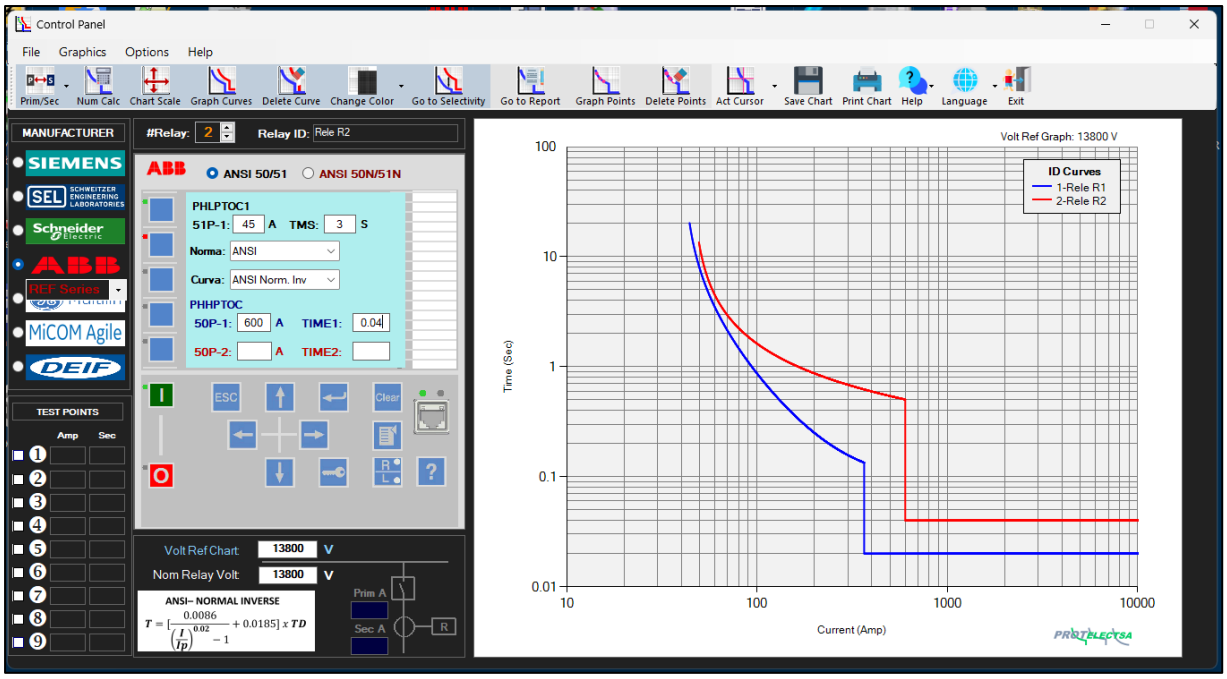
ANSI 50 Function:

Star Value (I>) = 40 x In = 40 x 15 = 600 Amp

ANSI 51 Function:

Star Value (Ip) = 3 x In = 3 x 15 = 45 Amp

Then the **R2** curve is plotted referring to the voltage level of 13.8 KV:



It should be noted the difference between the two curves, despite both being ANSI - INVERSE STANDARD (see the equations of both curves), this is due to the criteria used by each manufacturer.

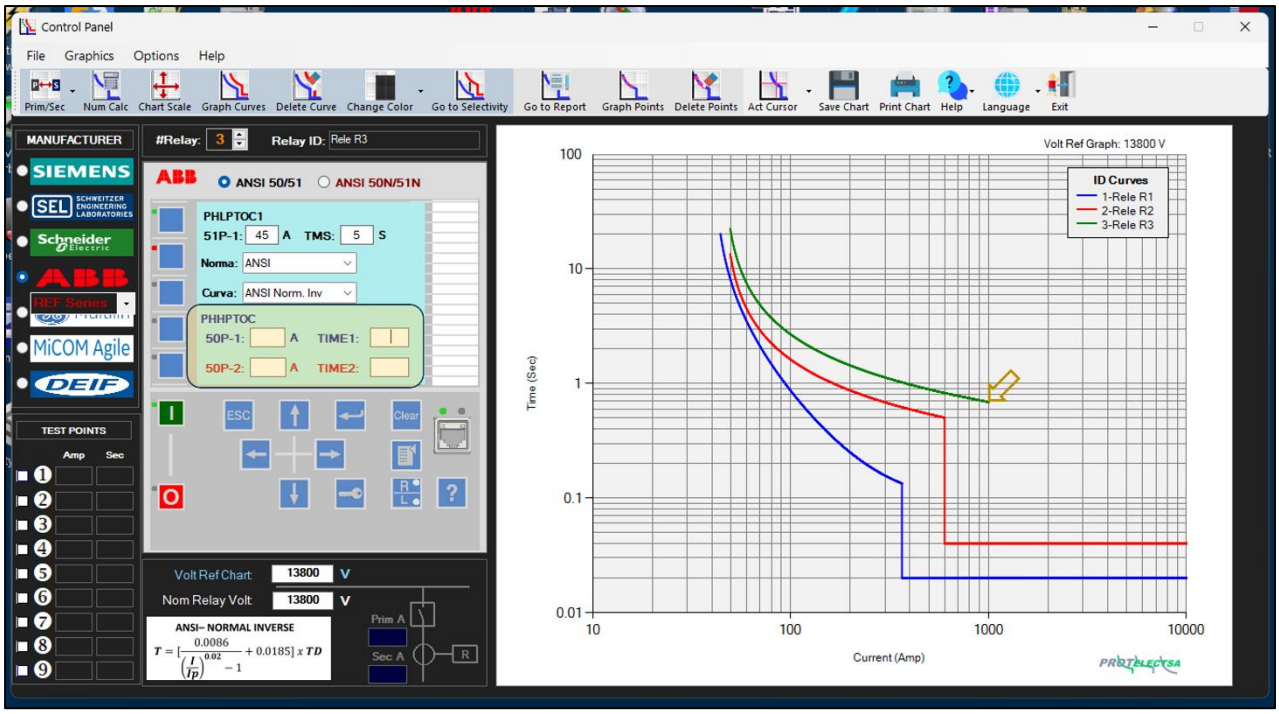
To improve the selectivity between the two graphed curves, we must do it with the **Selectivity** module: 

Example # 5: Graph an inverse curve with no instantaneous current value (I>)

Suppose that in the previous one-line diagram there is a relay called **R3 (ABB – REF615R)** at a level upstream from **R2**, also at 13.8 KV but with the following settings:

ANSI 50 setting: disabled (i.e. has no instantaneous current I>)
ANSI 51 setting: **Star Value (Ip)** = 3 x In = 3 x 15 = 45 Amp
Time multiplier (TD) = 5 Sec
Operating curve type = ANSI Norm. Inverse

After entering the necessary data, the curve would look like this:

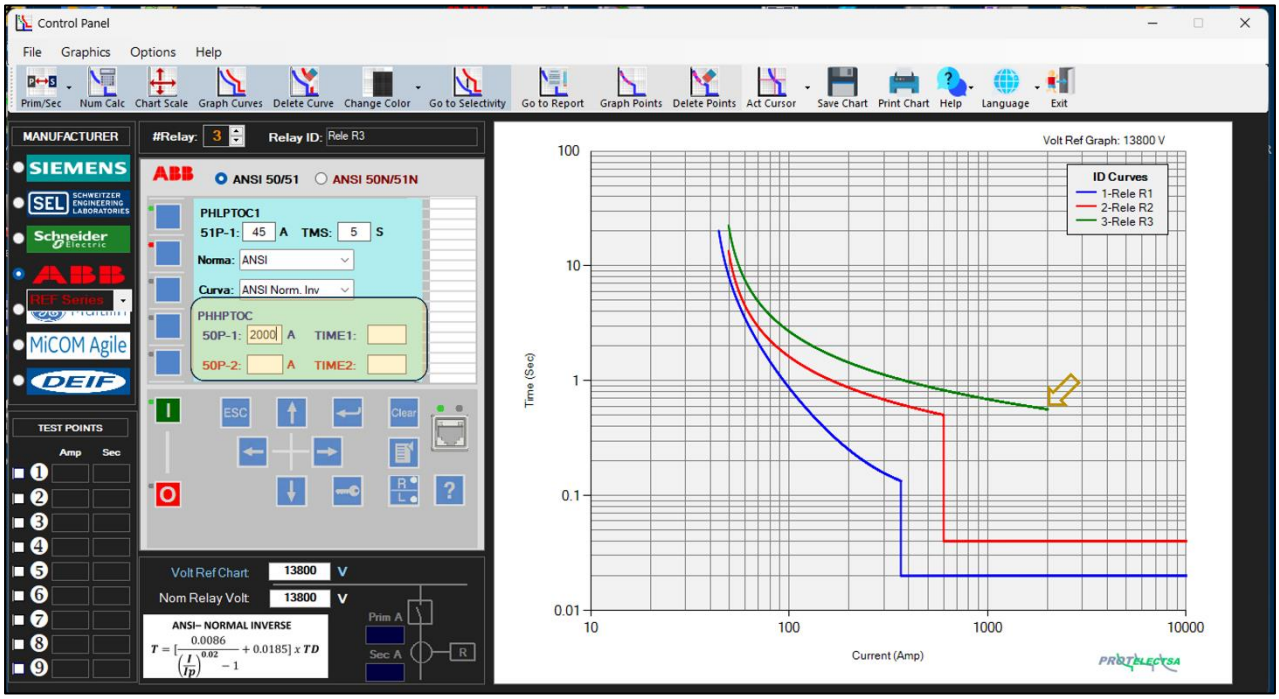


Consider that due to not having data in the **I>, Relay Tripping Curves-PRO** by default will plot the ANSI 51 curve from 1.1x Ip to 1000 Amp. As seen in the Log-Log chart.

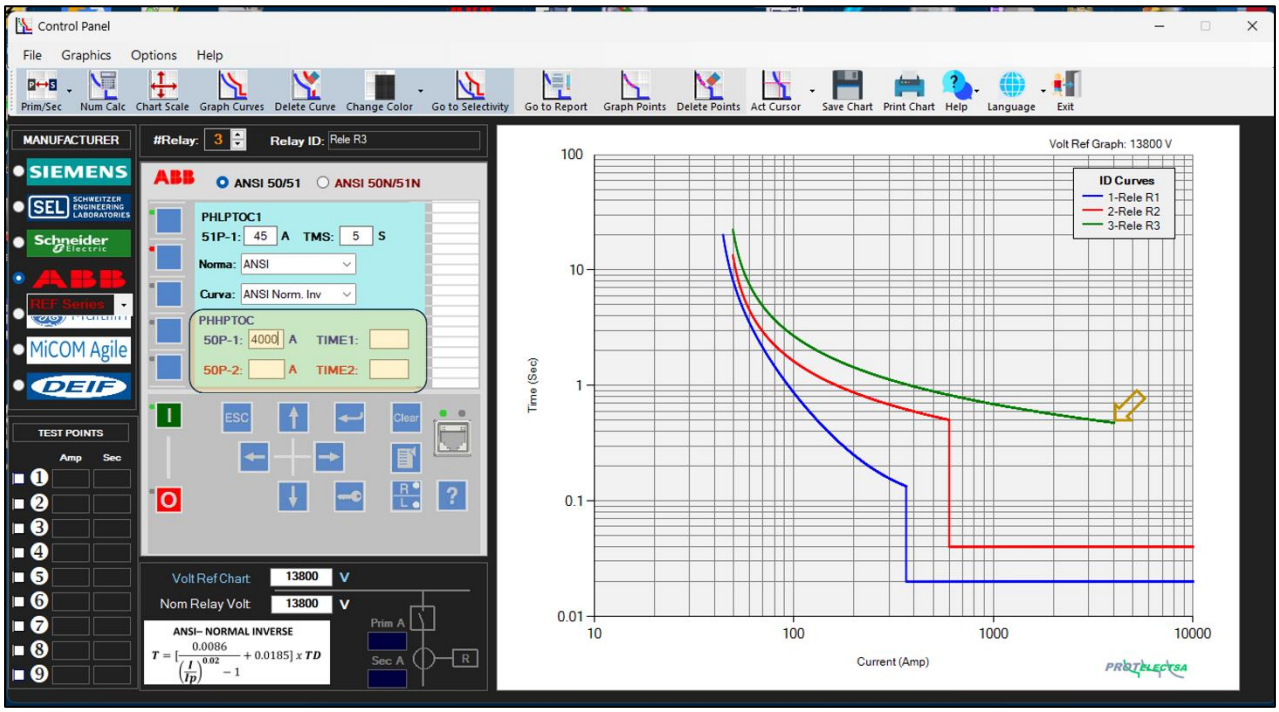
If we want the ANSI 51 curve of **R3** to be longer, we must enter a value greater than 500 Amp in the **I>** box and leave the **TI>** box blank.

Examples

. - For a Value of **I> = 2000** Amp and **TI> = "Blank"**



. - For a Value of **I> = 4000** Amp and **TI> = "Blank"**



In summary, if we leave the time value of the ANSI 50 function "blank" it is only to stretch the inverse curves (ANSI 51) in the Log-Log chart when they do not have their instantaneous adjusted.

Selectivity between two curves in Relay Tripping Curve – PRO2©

Relay Tripping Curves-PRO allows you to check the chronometric selectivity between two graphed curves and even improve it. To do so, you must follow the following procedure:

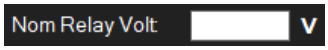
Step 1.- In the **Control Panel**, we go from Secondary values to Primary values. This is because, as we are going to work based on system voltage levels, with primary values, mathematical calculations become easier.

Step 2.- In the **Control Panel**, in **"Manufacturer Data",** we select the protection equipment to which the "Downstream" Relay belongs, which by default will always be: 

and enter the setting data.

Step 3.- Enter or name the "Downstream" Relay (#Relay:1) in the box: 

Step 4.- In **"Vn and Tc data box."** Enter in: 

the value of the reference voltage in which the "Downstream" Relay curve will be represented in the Log-Log chart, and in: 

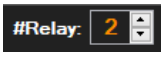
enter the nominal voltage of the circuit where the "Downstream" Relay operates. *Consider that, for circuits with different voltage levels, the curves must be represented in the Log-Log plane at the highest voltage level of the system.*

Step 5.- Then follow steps 1 to 4, click on the **Graph Curves** button, the adjustment curve of the "Downstream" Relay (#Relay:1) will be graphed in the Log-Log plane at the reference voltage of the system.

Step 6.- Once the "Downstream" Relay curve (#Relay:1) is graphed, click on the **Go to Selectivity** button to open the selectivity pop-up window.

Step 7.- In the **Selectivity** window, we must enter the **ImaxF** value, which is the highest fault current that the "Downstream" Relay (#Relay:1) sees.

Step 8.- With the **ImaxF** value already entered, we click on the **Calculate ΔT** button, so that it shows us the **T1** time of the "Downstream" Relay (#Relay:1) for a value of **ImaxF**.

Step 9.- Without closing the **Selectivity** window, we return to the **Control Panel** window to select the protection equipment to which the "Upstream" Relay curve belongs, but first we must select: 

and enter its name in: 

and follow Step 2 above.

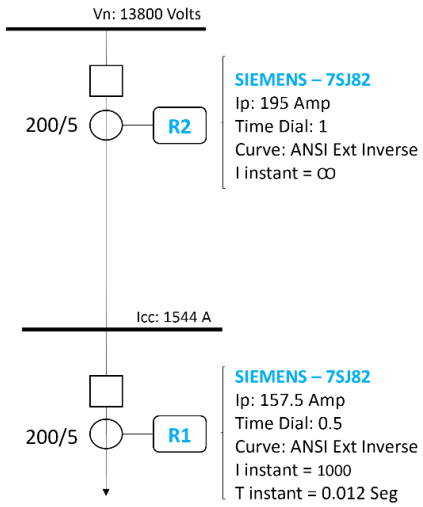
Step 10.- Same as **Step 4** above, we must enter the value of the reference voltage Volt Ref Chart V in which the "Upstream" Relay curve will be represented in the Log-Log chart and enter Nom Relay Volt V the nominal voltage of the circuit where the "Upstream" Relay operates.

Step 11.- Once the curve of the "Upstream" Relay (#Relay:2) has been graphed, we go back to the **Selectivity** window and click on the **Calculate ΔT** button to calculate and show us the time **T2** for a value of **ImaxF** and the **ΔT** that represents the time difference between the Downstream equipment and the Upstream equipment.

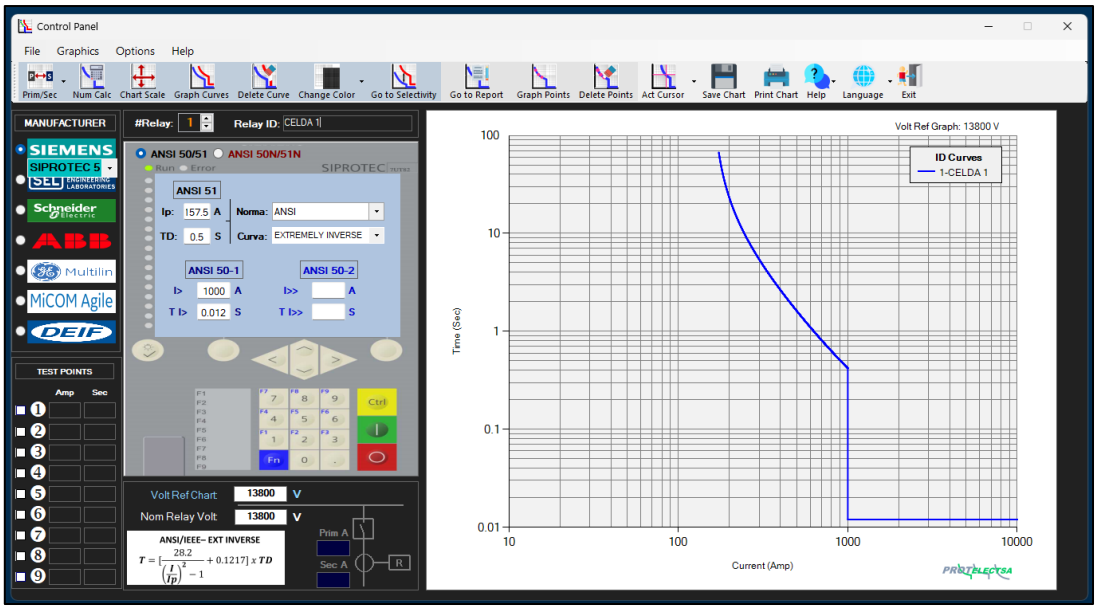
NOTE. The **ΔT** value must be between 0.2 and 0.4 Seg and will be represented in GREEN between these values, it will be represented in RED with values above 0.4 Seg and below 0.2 Seg.

Step 12.- In case we want to achieve an optimal **ΔT** value, we must go again to the **Control Panel** window (without closing the Selectivity window) and modify the **TD** (Time Dial) value in the "Upstream" Relay curve (Relay:2), graph that curve again with the Graph Curves button and then in the Selectivity window we click again on the Calculate **ΔT** button, follow this step again in case the **ΔT** value is not between 0.2 and 0.4 Seg.

Example # 1: Calculation of selectivity between two curves at the same voltage level



Steps 1 to Step 5.- We select and graph the curve of the "Downstream" Relay (#Relay:1) with its settings, remember not to skip **Step 4**, for this example the Reference voltage and the Nominal voltage are the same, according to the single-line diagram.

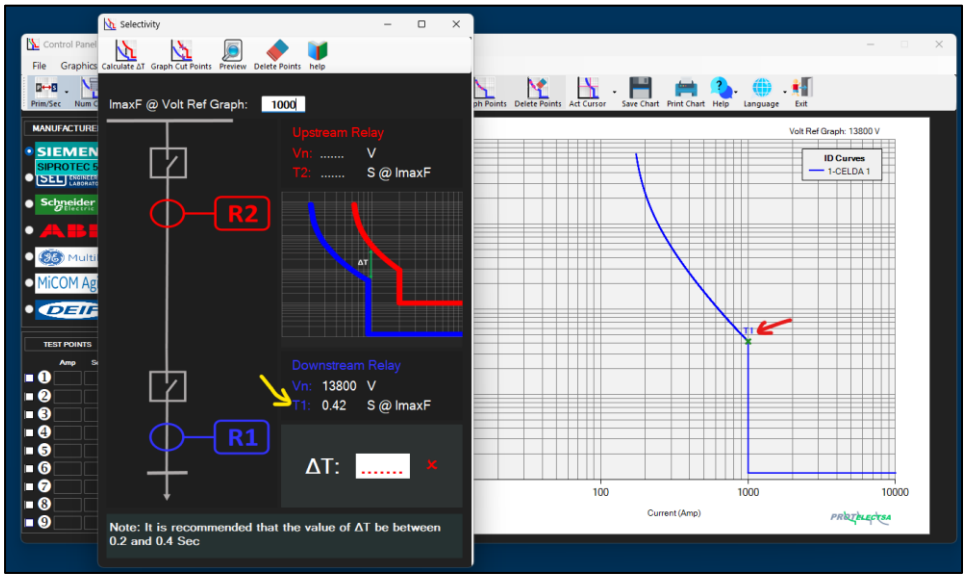


Step 6. - Click on the **Go to Selectivity** button to open the selectivity pop-up window.

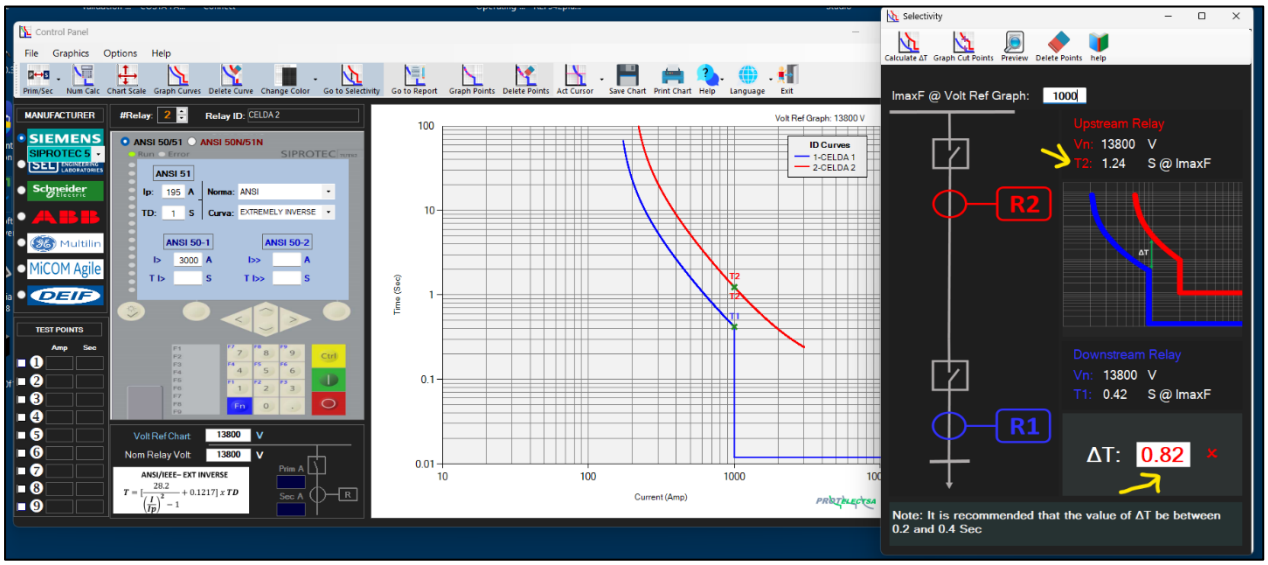
Step 7. - In the Selectivity window, we must enter the value of **ImaxF**, which is the highest fault current that the "Downstream" Relay sees.

Step 8. - With the **ImaxF** value (For this example this value will be 1000 Amp, since it is the maximum fault current) we click the **Calculate ΔT** button, then we observe the value of **T1** in 0.42 Sec, for an **ImaxF** of 1000 Amp. of the downstream equipment: CELL 1

NOTE: If we want to mark the point of **T1** on the Log-Log plane, we must click on: **Graph Cut Points** , after Calculating **ΔT,** do the same procedure for **T2**

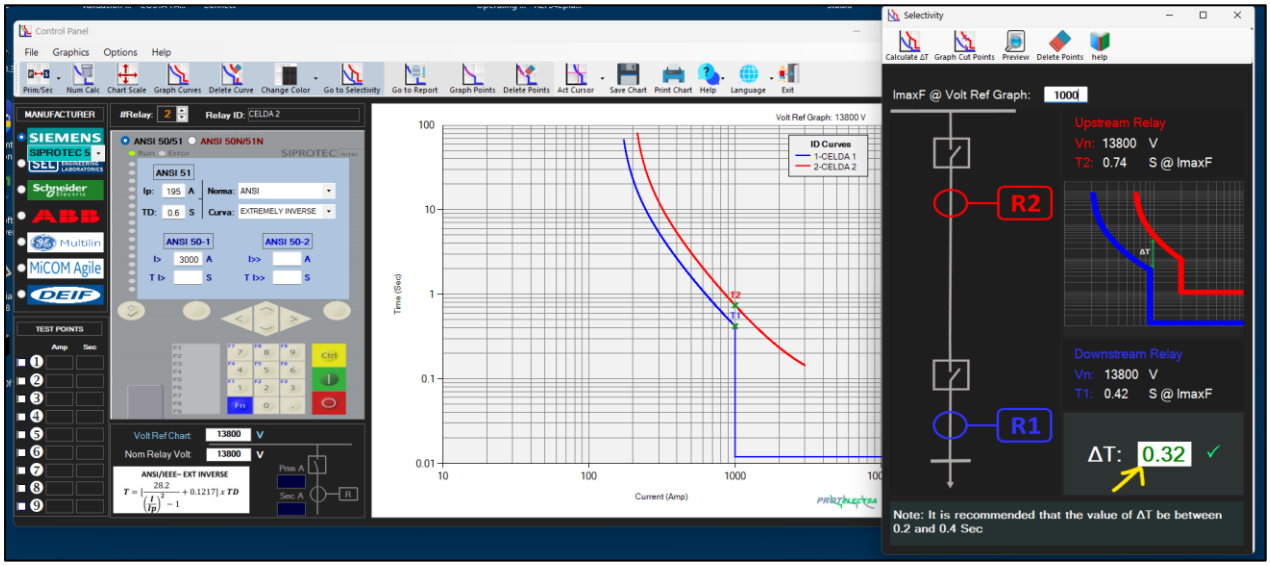


Step 9 to Step 11.- Without closing the **Selectivity** window, we go to the **Control Panel** window and do the same steps above to graph the "Upstream" Relay (#Relay:2), Then, we go back to the **Selectivity** window and click the **Calculate ΔT** button:



Here we see that the value of **T2** is 1.24 Seg for an **ImaxF** of 1000 Amp and the **ΔT** is **0.82** Seg and highlighted in red, that is, above the recommended range.

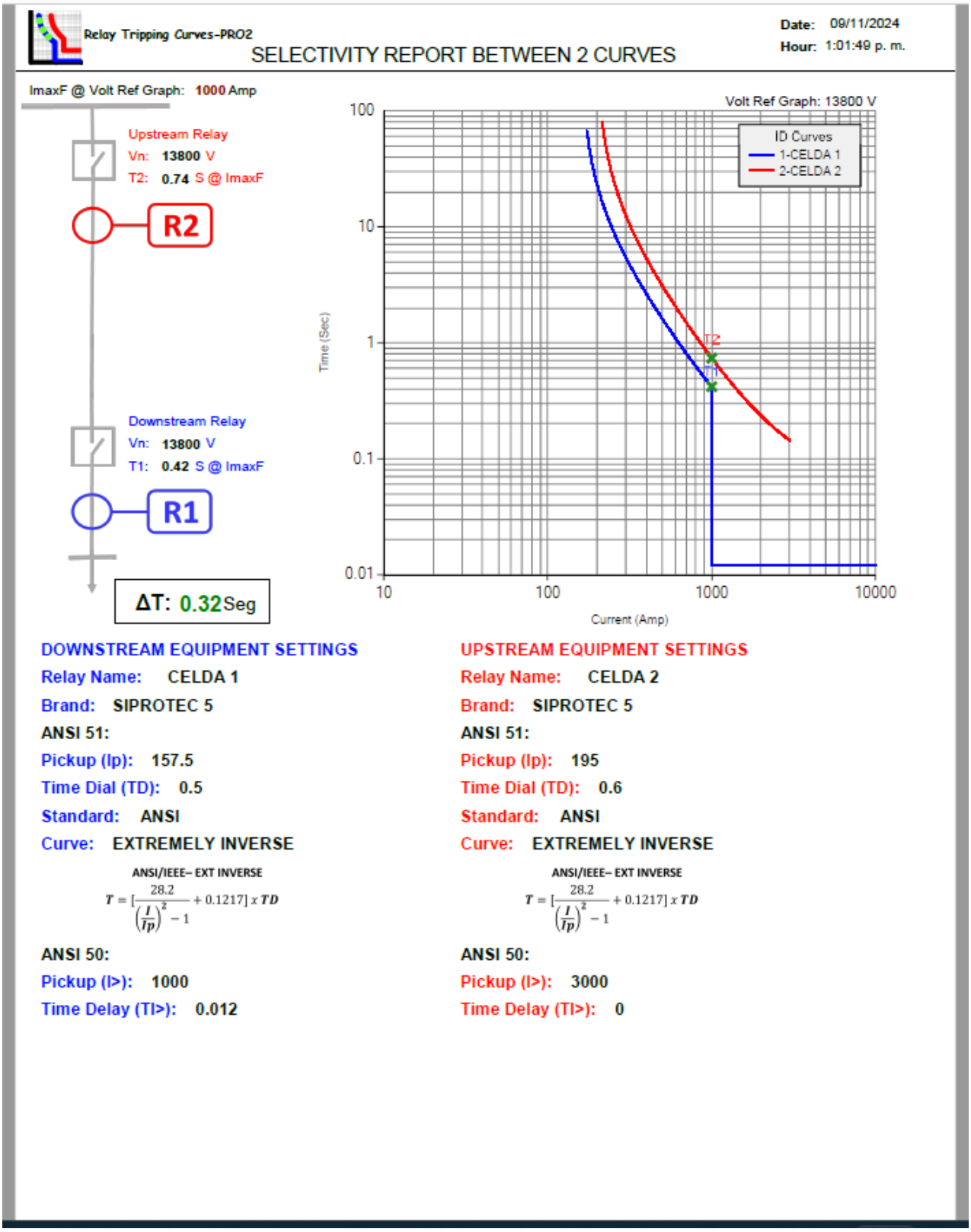
If we want to optimize the value of **ΔT** , we must follow **Step 12**. In the **Control Panel** window, we modify the **TD** value of the "Upstream" Relay (#Relay:2) from 1 Seg to 0.6 Seg, and we graph the curve again and calculate the ΔT:



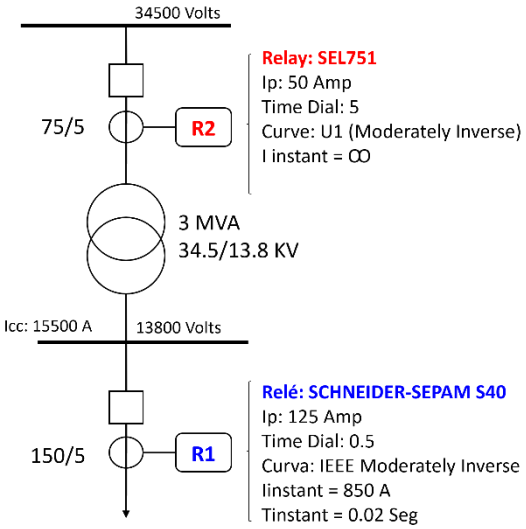
Here we see that the value of **ΔT** is within the allowed range.

To make a report of this study and to serve as support and history, what we do is click on: and save in .PDF format

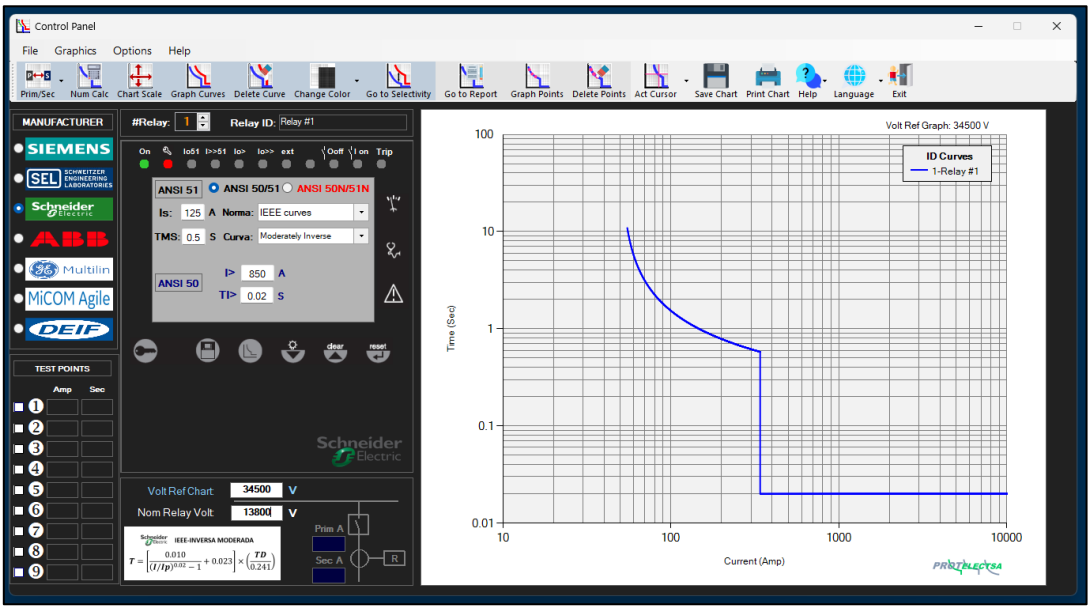
The Report for Example #1 will look like this:



Example # 2: Calculation of selectivity between two curves with different voltage levels, according to the following one-line diagram



Steps 1 to Step 5.- We select and graph the curve of the "Downstream" Relay (#Relay:1) with its settings, remember not to skip **Step 4**, For this example the Reference voltage is 34500 Volts since it is the highest voltage of the system and the Nominal voltage where the "Downstream" Relay operates is 13800 Volts



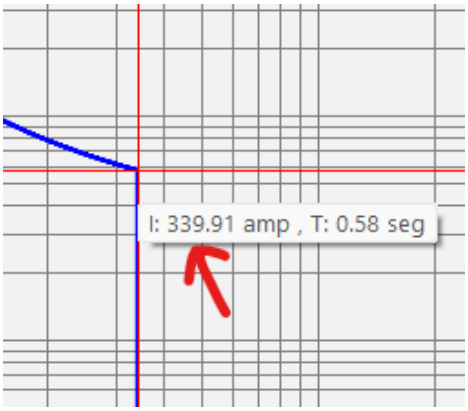
Step 6. - Click on the **Go to Selectivity** button to open the selectivity pop-up window.

Step 7. - In the Selectivity window, we must enter the value of **ImaxF** referred to the Volt Ref of the Log-Log chart, as the Icc of the associated bar is 15400 Amp @ 13.8 kV and the I> setting value (Instantaneous current): 850 Amp @ 13.8 kV, in this case the **ImaxF** must be the same as the I>

setting, but referred to a voltage level of 34.5 kV, we have two ways to calculate this value:

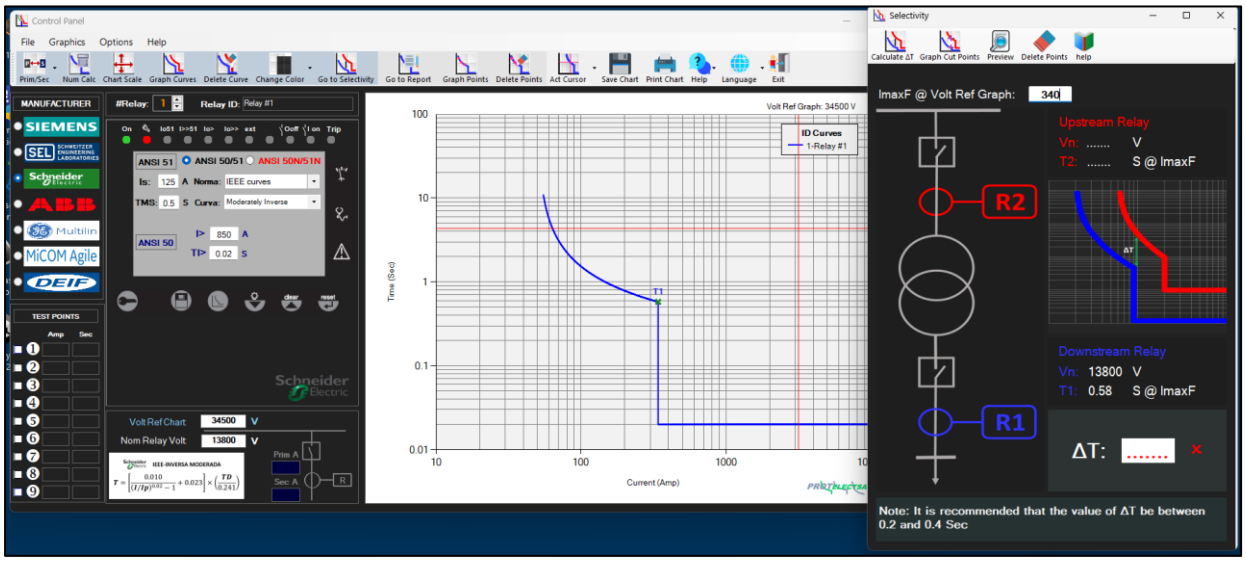
1.- Doing the calculation: 850 A x (13.8/34.5) = 340 A

2.- In the Control Panel, we enable the cursor, by means of the button: **ACT Cursor**, then we place ourselves on the curve, exactly where the value of the I> or instantaneous current begins, and we observe at once the value of **ImaxF** since the curve is referred to a voltage level of 34.5 kV.

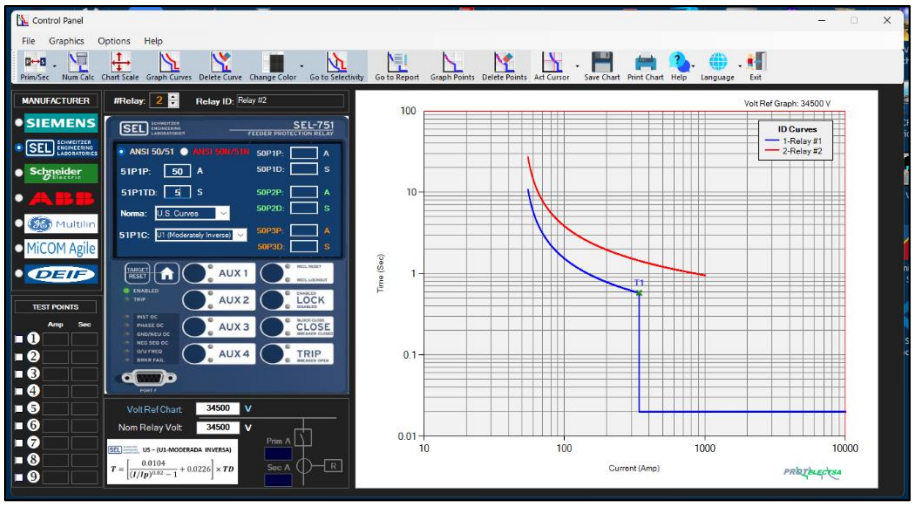


Step 8. - Now with the value of **ImaxF** (340 A, for this example), we click the button: **Calculate ΔT** Then, the value of **T1** is observed in 0.58 Sec, for an **ImaxF** of 340 A @ 34.5 kV of the equipment

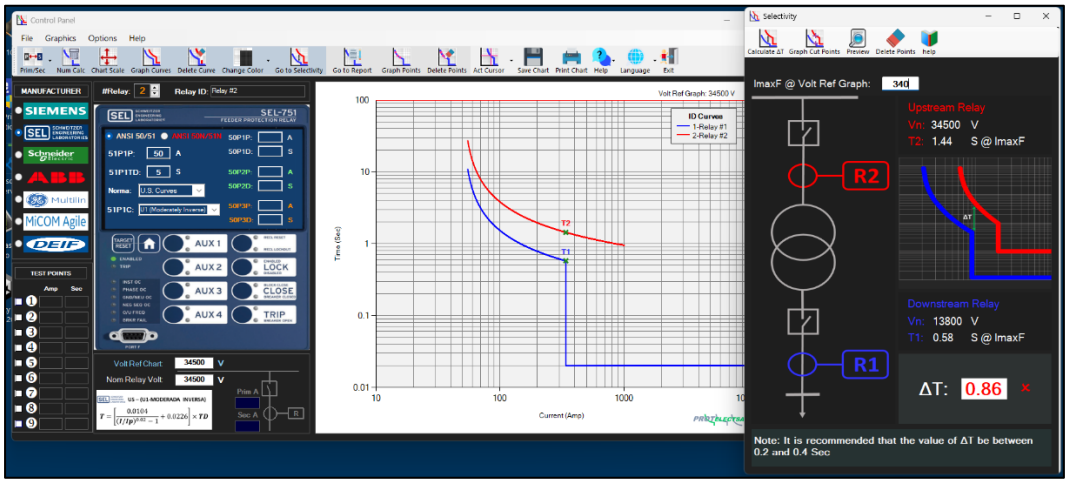
NOTE: If we want to mark the point of **T1** on the Log-Log plane, we must click on: **Graph Cut Points** , after Calculating **ΔT,** do the same procedure for **T2**



Step 9 to Step 11.- Without closing the **Selectivity** window, we go to the **Control Panel** window and do the same steps above to graph the "Upstream" Relay (#Relay:2), Then, we go back to the **Selectivity** window and click the **Calculate ΔT** button:

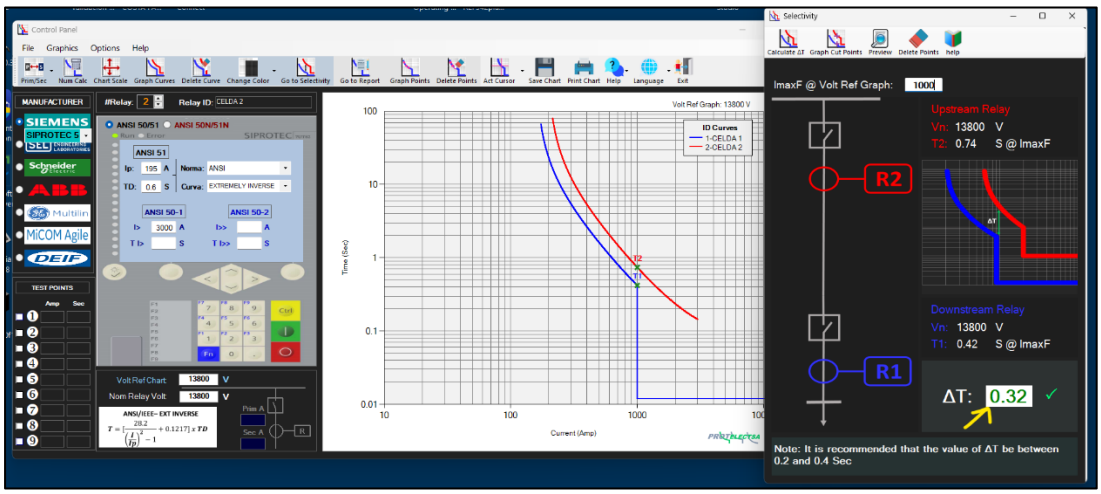


Then, we go back to the **Selectivity** window and click the **Calculate ΔT** button:



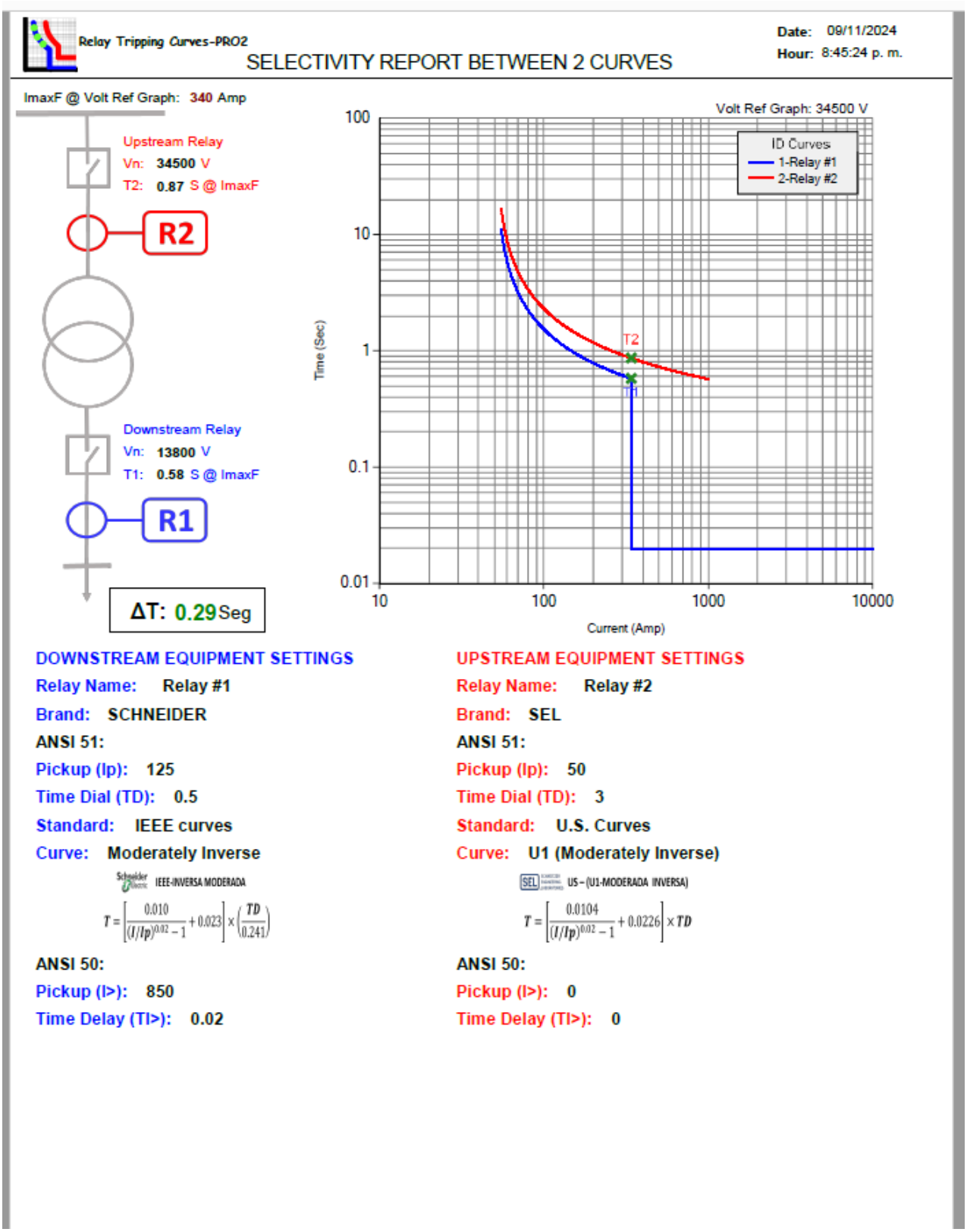
Here we see that the value of **T2** is 1.24 Sec for an **ImaxF** of 340 Amp and the **ΔT** is **0.86** Sec and highlighted in **red**, that is above the recommended range.

If we want to optimize the value of **ΔT**, we must follow **Step 12.** In the Control Panel window, we modify the **TD** value of the "Upstream" Relay (#Relay:2) from 5 Sec to 3 Sec, and we graph the curve again and calculate the **ΔT:**



Here we see that the value of **ΔT** is within the allowed range.

To make a report of this study and to serve as support and history, what we do is click on: and save in .PDF format

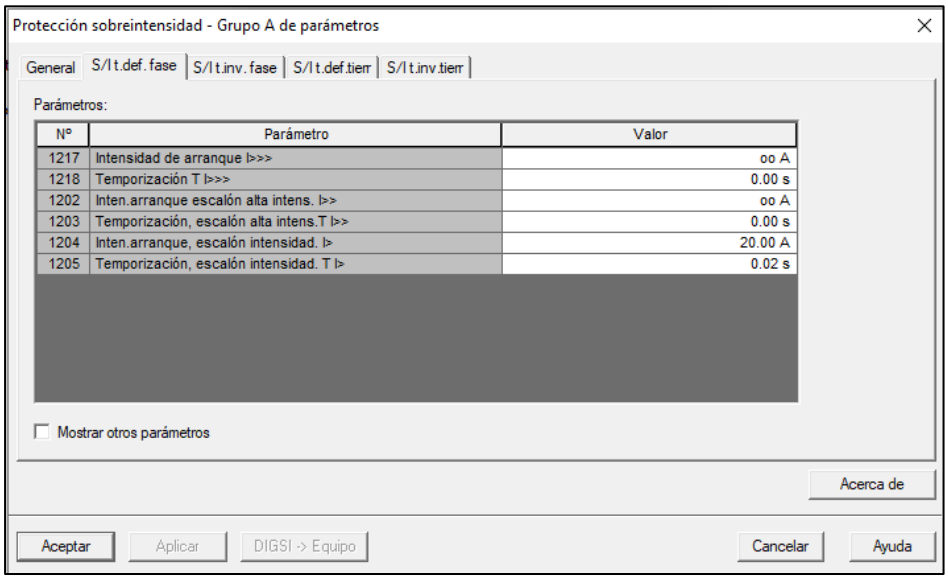


Graph test points on Relay Tripping Curve – PRO2©

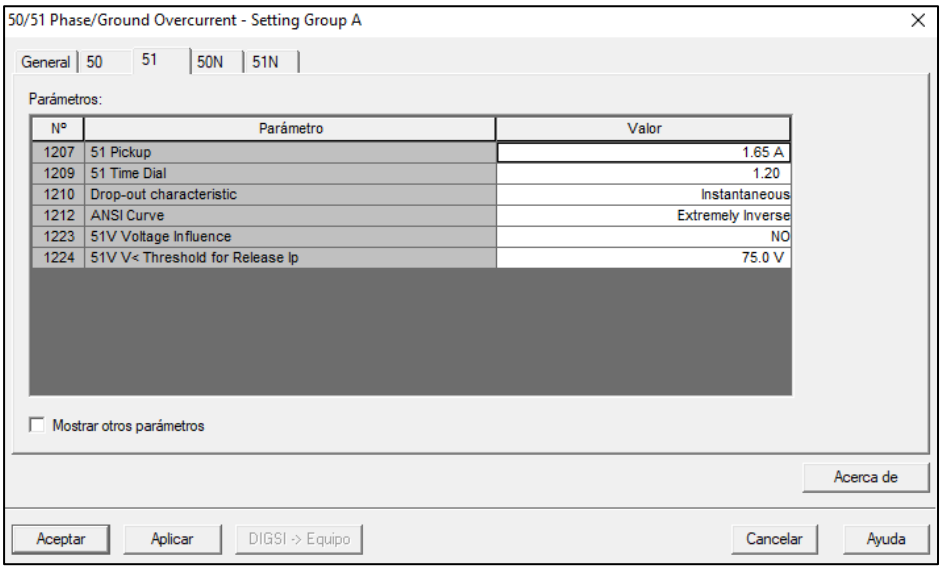
One of the advantages of **Relay Tripping Curves-PRO** is the possibility of graphing the trip points of the protection relay and comparing it with the adjusted inverse curve, this is done by entering the current and time values in the **TEST POINTS** module.

Example: There is a SIEMENS protection relay, model 7SJ635, which requires current injection tests to verify trips. A FREJA 300 relay testing system is used. At the time of the tests, the protection team does not execute the automatic reset, therefore, the tests must be done manually by injecting a certain current value and noting the value of the protection relay trip time, in order to verify with the curve set for the ANSI 50/51 function.

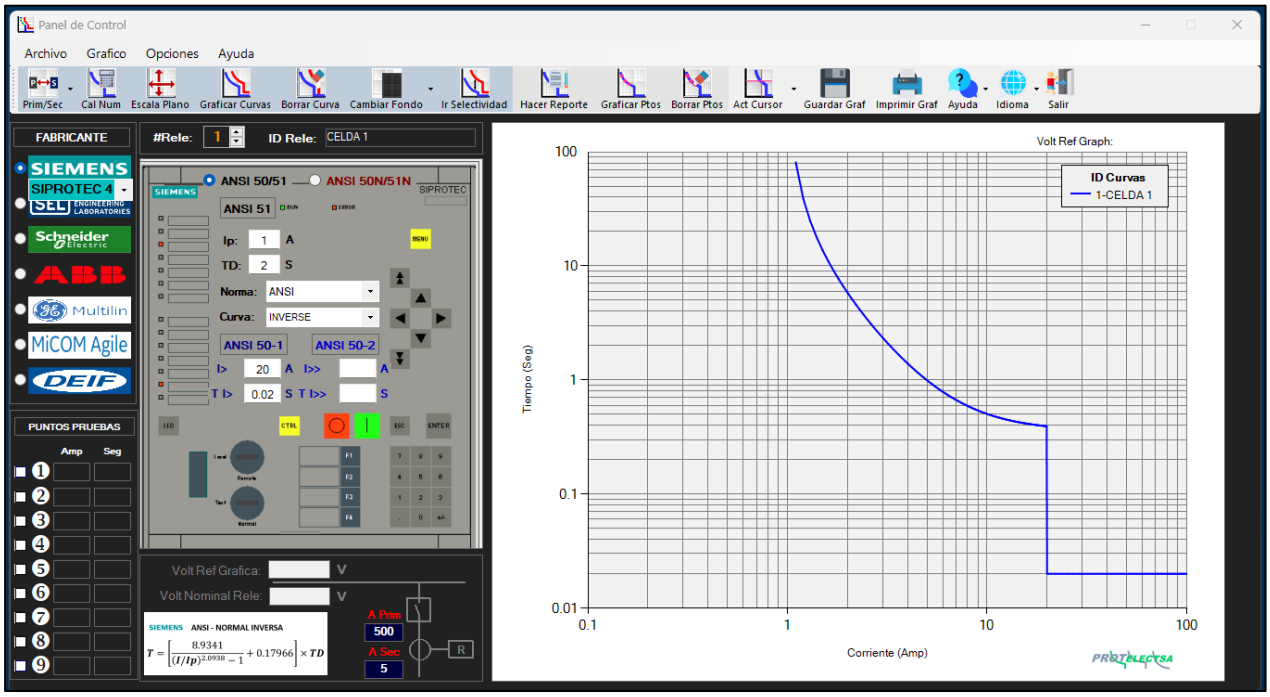
ANSI 50 function settings



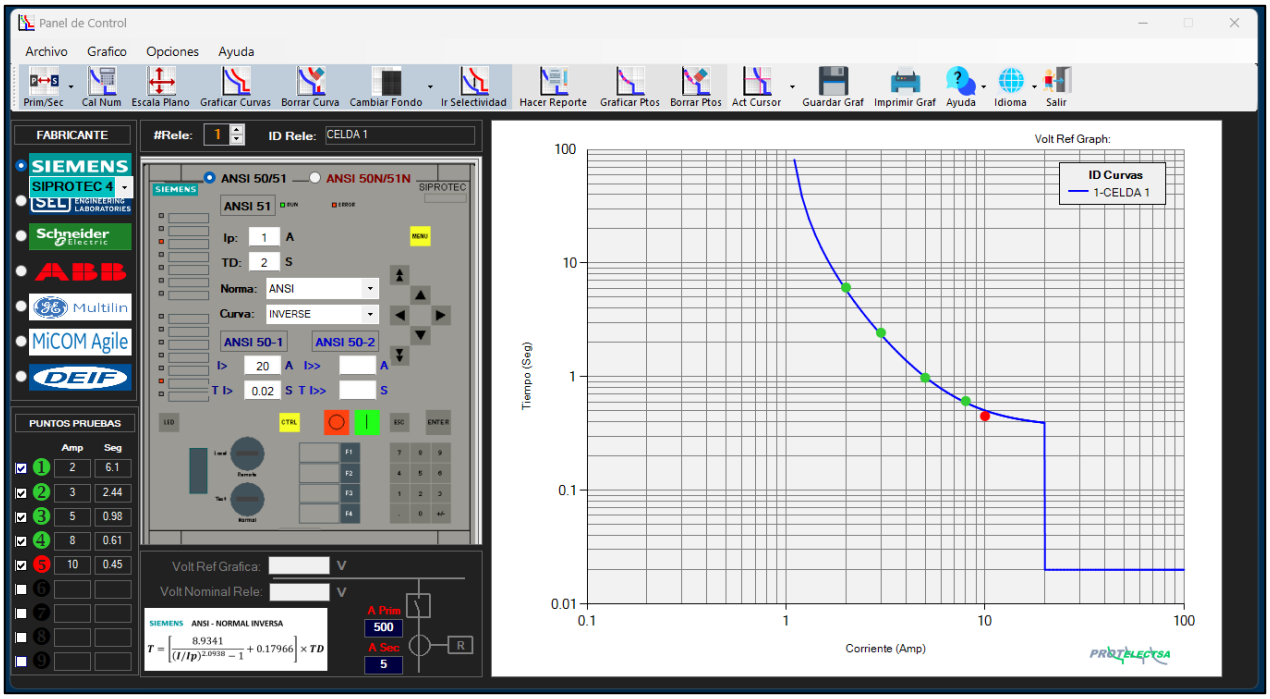
ANSI 51 function settings:



1.- Using the protection relay data, graph the ANSI 50/51 function setting curve:



2.- In the **TEST POINTS** module, the values of the current injection points must be entered, but first the number of tests performed must be selected. In the example, 5 points were injected, the current injection values and the results of the protection relay tripping time are entered, then click on **Graph Points**. 



These points are plotted on the inverse curve plotted on the Log-Log chart, in this way it is

verified if the protection equipment acts within the range of the curve. If any point falls within a range of 10% of the curve, this point will be placed in green, but if the point falls above or below 10% of the curve, the point will be placed in red.

Then, we can make a report that includes the relay data, the trip verification table and the cure graph by clicking on: **Go to Report** 

Make a Report with Relay Tripping Curve - PRO©

With Relay **Tripping Curves-PRO** We can also make a report by clicking on the Make Report button: this takes us to a pop-up window that includes:

- TEST RESULTS: This is a table with the results of the comparison between the test points and the graphed curve. For each point, the fault current injected with the relay tripping time is indicated, as well as the theoretical time for the specific point of the fault current, the maximum tolerance and the % difference between the relay tripping time and the theoretical time, as well as the value of the fault current in primary values and finally the status of the test. The TEST RESULTS TABLE also shows the Status. This indicates when a test is within the tolerance range of ±10% with a mark (√) and with an (X) when it is out of range.

.- INSTALLATION DATA, PROTECTION EQUIPMENT DATA and TEST EQUIPMENT DATA: Here we enter the relevant data of the Relay under study, its location, as well as the data of the equipment used for the tests.

.- TYPE OF FAULT: Here we select the type of fault we are testing.

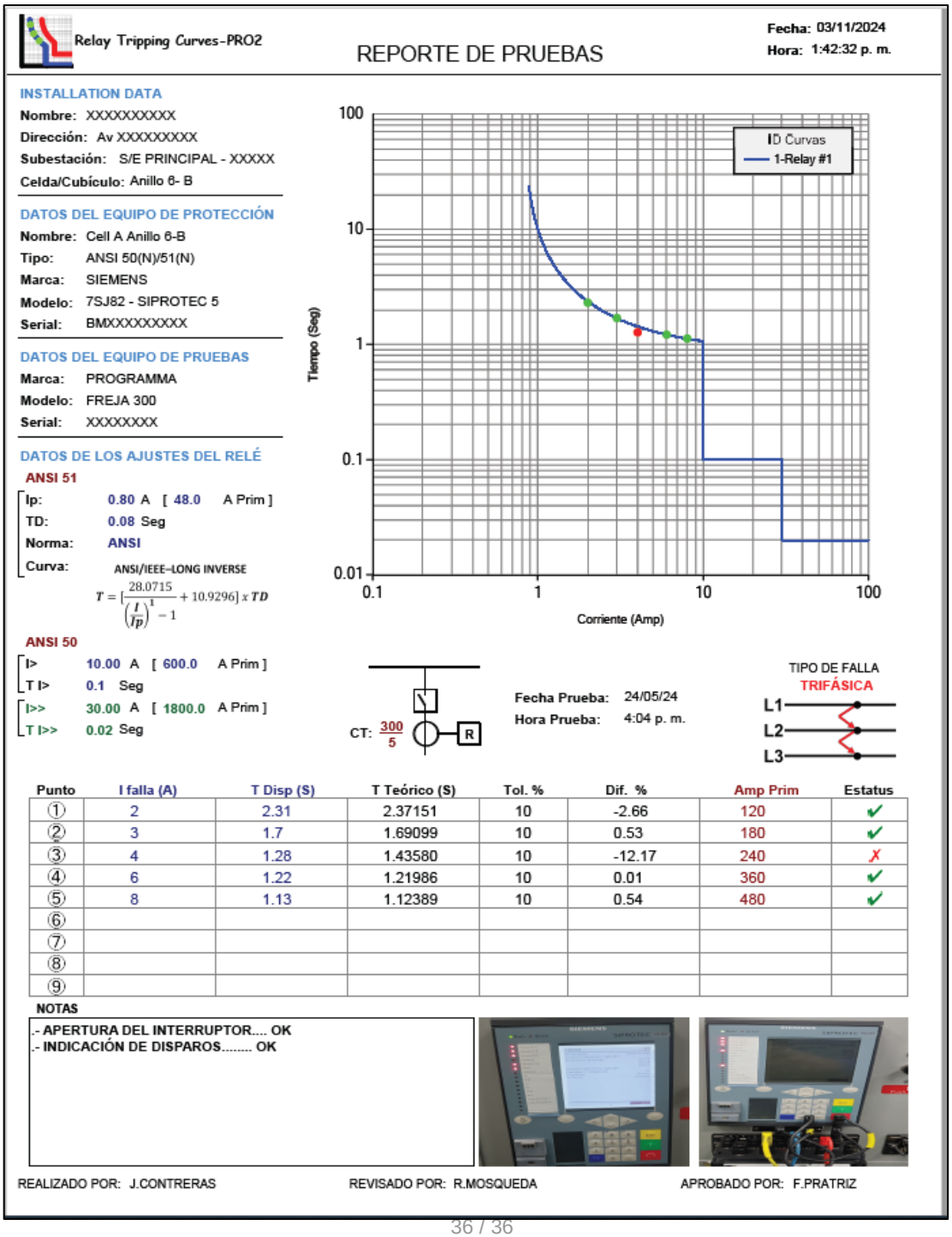
.- NOTES: We can add any relevant comments.

.- By clicking on the IMAGE boxes we can select any photo relevant to the test.

After entering all the protection relay data, installation data and test equipment data, we click on **Preview** button, the report is created which we can then save in PDF format.

The Report includes:

1. - All the data entered in the Report window (DATA OF THE INSTALLATION, DATA OF THE TESTING EQUIPMENT, NOTES and Time / Date of the Tests).
2. - Time and Date the report is printed.
3. - DATA OF THE PROTECTIVE EQUIPMENT (this comes from the data entered in the Control Panel, before graphing the curve)
4. - TESTS RESULTS TABLE (This will indicate the verification of Trip-Time, that is, the results of the test points vs. the theoretical values of the plotted inverse curve).
5. - Graph of the inverse curve in the Log-Log Plot.
6. - The Current Transformer Ratio (Value Entered in the Control Panel).



Relay Tripping Curves-PRO2

REPORTE DE PRUEBAS

Fecha: 03/11/2024
Hora: 1:42:32 p. m.

INSTALLATION DATA
Nombre: XXXXXXXXXX
Dirección: Av XXXXXXXXX
Subestación: S/E PRINCIPAL - XXXXX
Celda/Cubículo: Anillo 6- B

DATOS DEL EQUIPO DE PROTECCIÓN
Nombre: Cell A Anillo 6-B
Tipo: ANSI 50(N)/51(N)
Marca: SIEMENS
Modelo: 7SJ82 - SIPROTEC 5
Serial: BMXXXXXXXXX

DATOS DEL EQUIPO DE PRUEBAS
Marca: PROGRAMMA
Modelo: FREJA 300
Serial: XXXXXXXX

DATOS DE LOS AJUSTES DEL RELÉ

ANSI 51
Ip: 0.80 A [48.0 A Prim]
TD: 0.08 Seg
Norma: ANSI
Curva: ANSI/IEEE–LONG INVERSE

$$T = [\frac{28.0715}{\left(\frac{I}{Ip}\right)^1 - 1} + 10.9296]\, x\, TD$$

ANSI 50
I> 10.00 A [600.0 A Prim]
T I> 0.1 Seg
I>> 30.00 A [1800.0 A Prim]
T I>> 0.02 Seg

CT: 300/5

Fecha Prueba: 24/05/24
Hora Prueba: 4:04 p. m.

TIPO DE FALLA
TRIFÁSICA
L1
L2
L3

Punto	I falla (A)	T Disp (S)	T Teórico (S)	Tol. %	Dif. %	Amp Prim	Estatus
①	2	2.31	2.37151	10	-2.66	120	✔
②	3	1.7	1.69099	10	0.53	180	✔
③	4	1.28	1.43580	10	-12.17	240	✗
④	6	1.22	1.21986	10	0.01	360	✔
⑤	8	1.13	1.12389	10	0.54	480	✔
⑥							
⑦							
⑧							
⑨							

NOTAS
.- APERTURA DEL INTERRUPTOR.... OK
.- INDICACIÓN DE DISPAROS..... OK

REALIZADO POR: J.CONTRERAS
REVISADO POR: R.MOSQUEDA
APROBADO POR: F.PRATRIZ