KINGSINE

KRT V3 Universal Relay Test

User Manual

Version: V3.11

KINGSINE ELECTRIC AUTOMATION CO.,LTD

Revision History

Date	Version	Description	Auth.
2024/01/25	V3.10	All modules updated.	Jin
2024/02/27	V3.11	Chapter 5: Test Center. Chapter 6: Test Object	Jin

1. KRT Introduction

1.1 Basic Overview

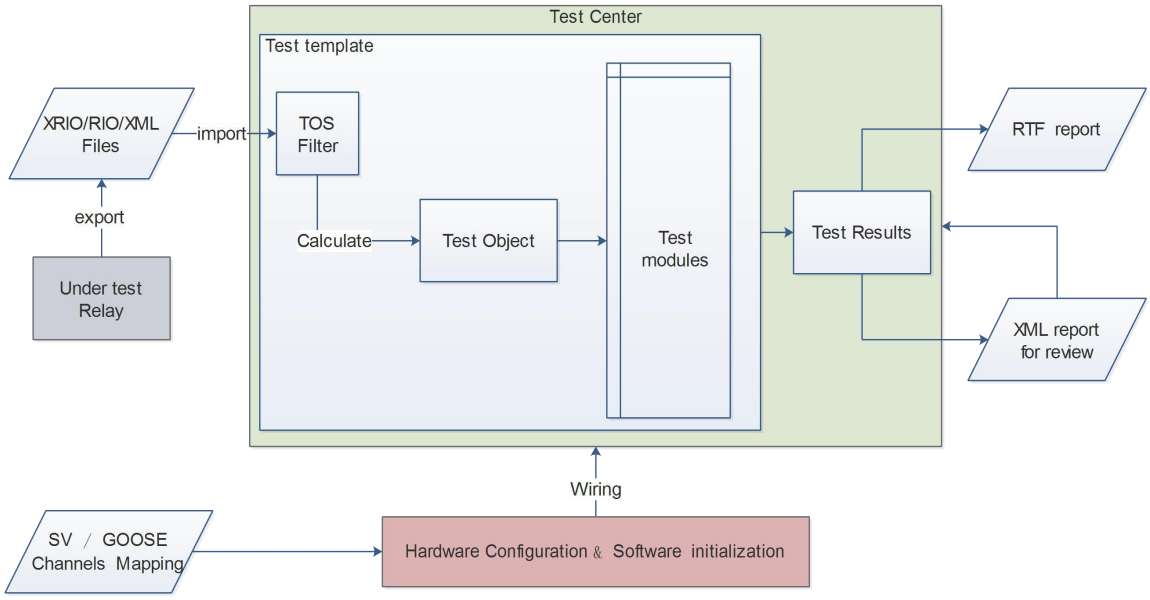
KRT software, as a simple yet powerful application, provides great convenience to power companies, relay protection manufacturers, and other users. It is capable of performing various types of tests and calibrations for protection devices, energy meters, transducers, and more. It offers users a comprehensive, feature-rich, and user-friendly testing solution. Our goal is to provide customers with a powerful integrated software. The "Test Center" feature of our software enables one-click automation of testing and calibration for most typical relay protection devices.

The success of KRT software is greatly attributed to the valuable opinions and feedback received from our customers and partners across various industries. To date, we have incorporated these suggestions into our software, making it more robust and user-friendly. We firmly believe that "perfect products come from continuous improvement," and your feedback serves as a strong support for our progress.

Users can perform the following tests using KRT software:

- Test various relays using the AC/DC test module
- Test complex relays using the advanced module
- Test multifunctional relays using the Test Center
- Test protection/IED devices (including IEC61850 GOOSE and sampled values), as well as merging units etc.
- Test energy meters
- Test transducers

KRT Software Flowchart

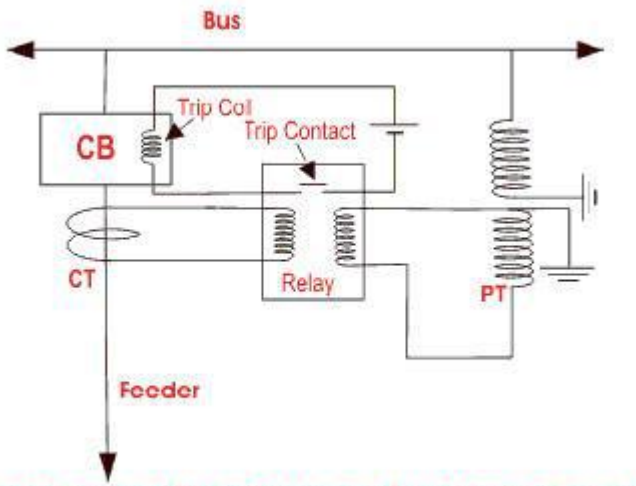


Eagle Eye View - Relay Testing

A relay is a switching device that sends a trip command to a circuit breaker in case of abnormal faults.

The relay receives input signals from CT/PT, at the same time, the program calculates the fault status. It sends a trip command to the circuit breaker when a fault condition is detected.

The relay trip time (dT) is the time difference between the fault status "arrival" and the issuance of the trip command.



Basic connection diagram of protection relay

Relay Protection Testing (Typical Steps)

Step 1: The relay protection tester inputs current, voltage, and simulated fault parameters at the CT and PT terminals corresponding to the relay being tested. At the same time, the timer starts counting when the fault parameters are generated.

Step 2: The protection device receives the fault and delays sending the trip command. The delay trip time of the protection device depends on the time setting of the protection parameters.

Step 3: The relay protection tester receives the trip command from the protection device and stops the timer.

Step 4: The engineer compares the actual measured trip time with the set trip time of the protection device to determine if the test result passes.

The term "COM" in KRT software refers to...

To quickly start running and effectively using the KRT software, users only need to remember this simple "COM" term:

- **C** - (**C**onnection & **C**onfiguration)
- **O** - (Define Test **O**bject)
- **M** - (Set Test **M**odules)

Eagle Eye

1. Connection & Configuration

The first step, "Connect," refers to the user establishing a connection between the tester and the computer software. Once the connection is successfully established, the user can see the display of "Connected" in the top right corner of the software.

The second step is "Configure," where users set the following variables:

- Rated values and parameters for analog input/output (system variables)
- Parameters for Binary input/output (system variables)
- GOOSE and sampled value channels (system variables)
- Terminology for analog signals and binary input/output (software variables)
- Selection of rated voltage for auxiliary DC source (auxiliary DC variable)

2. Define Test **O**bject

Each tested device (most protection devices) has its corresponding "Test Settings", and all these test object settings are located within the "Test Objects" section. The Test Objects section is used for:

a) Define normal/fault conditions for the protection device.

b) Define the test results (software calculated values) for the protection device under different fault conditions. After the test is completed, the actual test results are compared to the software calculated values based on the set error range. Then, a pass or fail result is determined.

c) Based on the parameter values of the test object, the software generates a visual representation that simulates the test object. This can assist users in:

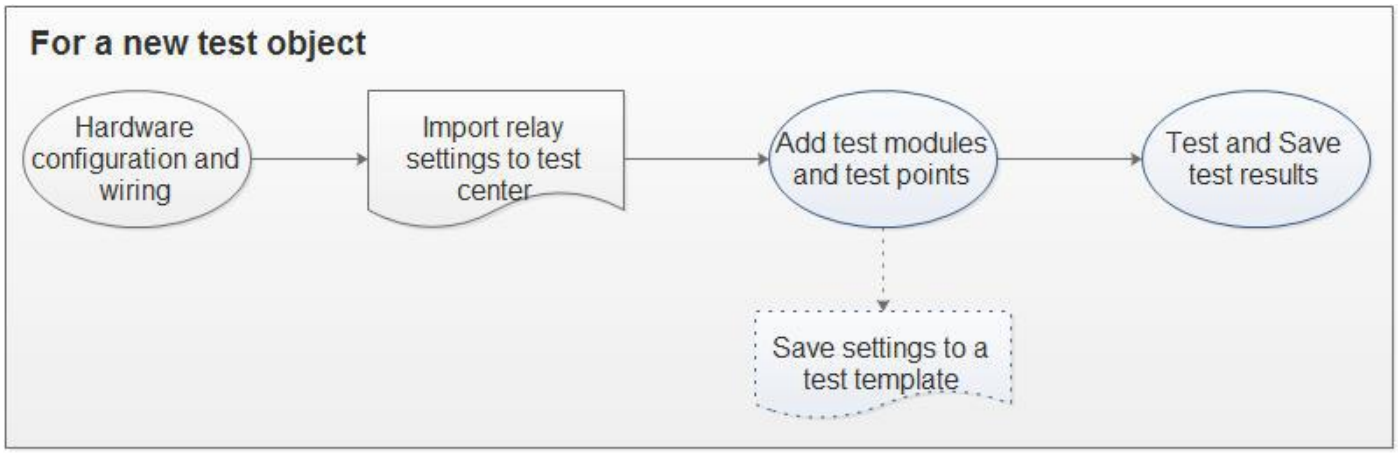
- Triggering faults directly by clicking on the graphical representation.
- Viewing the status of the test results (Pass/Fail) directly on the graphical representation.

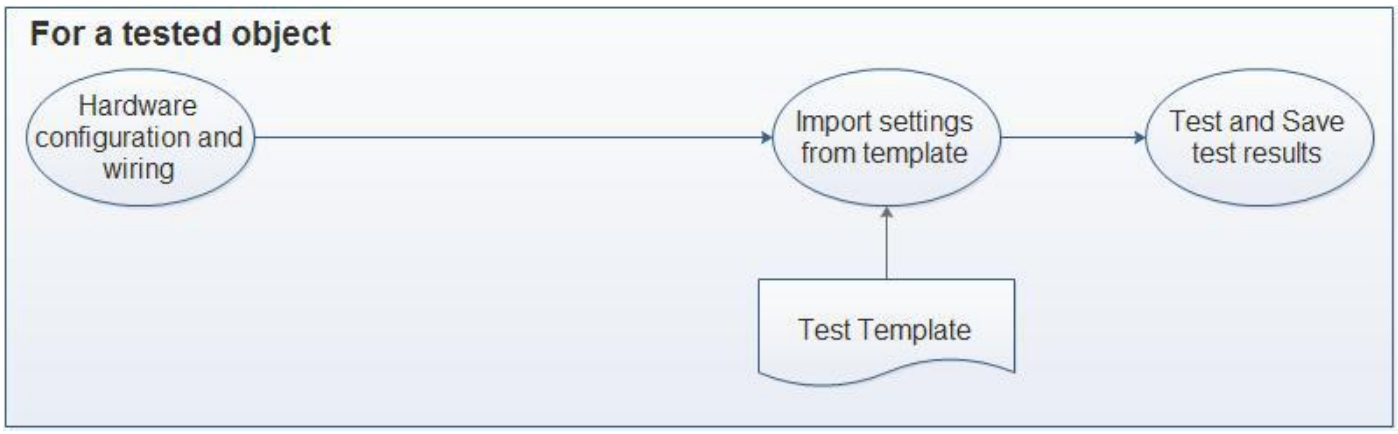
3. Set Test **M**odules

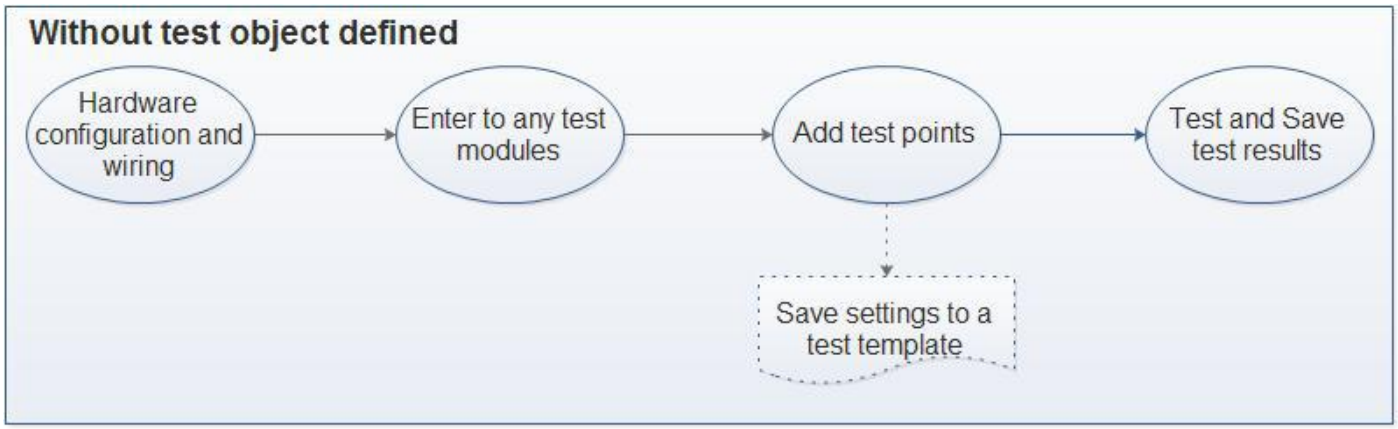
The final step of the test is for the user to enter the corresponding test module and configure the fault value output. This section typically involves setting the following parameters:

- Fault characteristics
- Delay time (pre-fault time, fault output time, and post-fault time)
- Trigger logic for binary input and output
- Virtual view of the fault under test
- Various types of views, such as vector views, report views, wiring diagrams, time signal views, etc.

There are three simple ways to quickly start and complete a test:







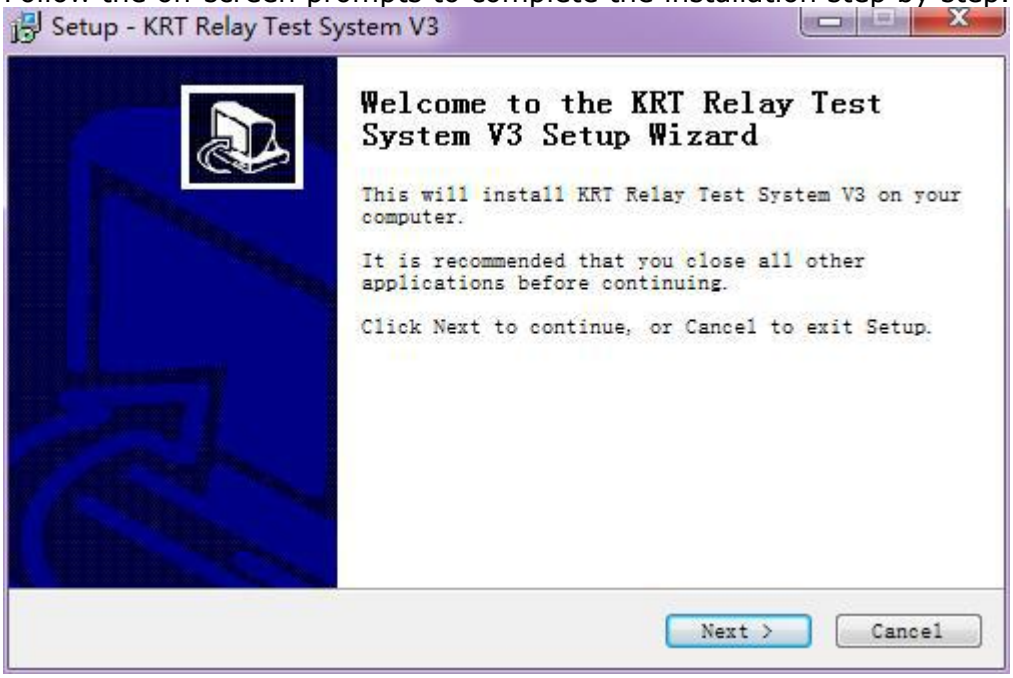
1.2 Software installation

System requirements:

Windows 7 SP1 + .net framework V4.0
Windows 8 or 8.1(64bit), any SP
Windows 10
Windows 11
System administrator privileges are required during software installation.
Screen resolution should be 1024 x 768 or higher.

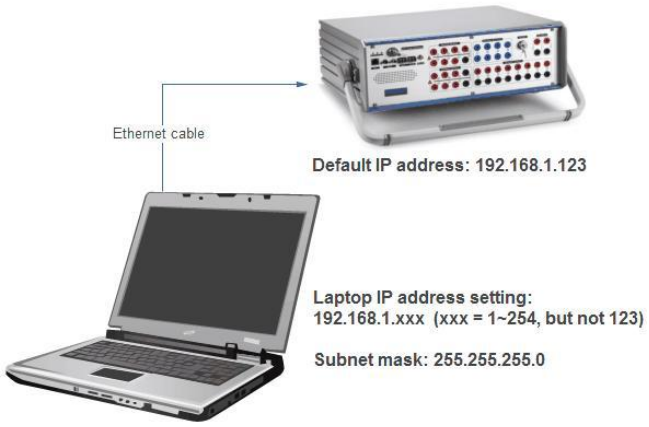
KRT software installation:

1. Confirm that the system requirements mentioned above are met.
2. Run "KRT Vx.x.xx.exe" with administrator privileges.
   Note: Right-click on the installation file and select "Run as administrator."
3. Choose the appropriate language environment for installation.
4. Follow the on-screen prompts to complete the installation step by step.

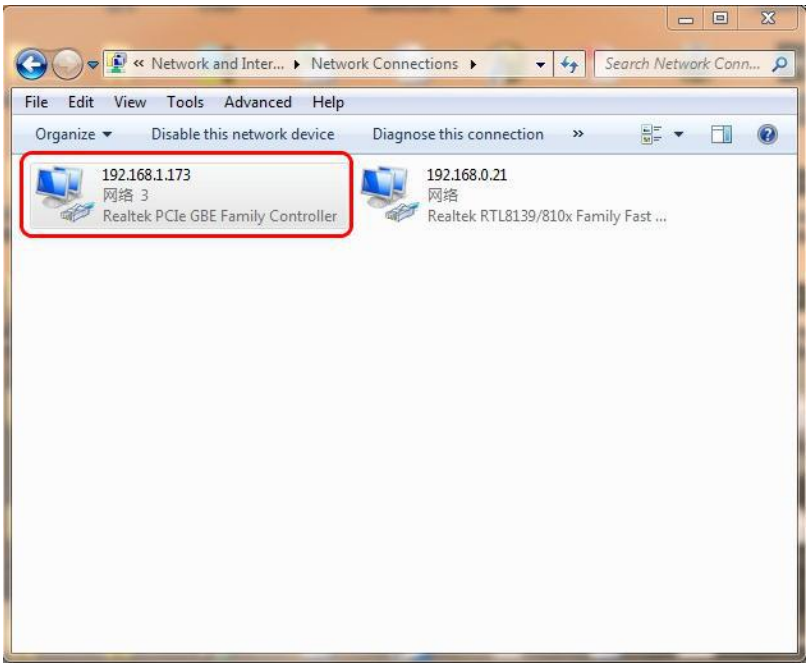


1.3 Communication Setting

IP address:



1.	The default IP address out of the factory is 192.168.1.123.
2.	Set the computer's IP address to the network segment 192.168.1.XXX (XXX can be any value between 1 and 254, but it should not be the same as the address of the tester to avoid IP conflicts. For example, if the factory default address of the tester is 192.168.1.123, then the computer's IP address should not be set to this IP address). Set the computer's gateway to 255.255.255.0.
3.	Connect the computer and the tester using an Ethernet cable.



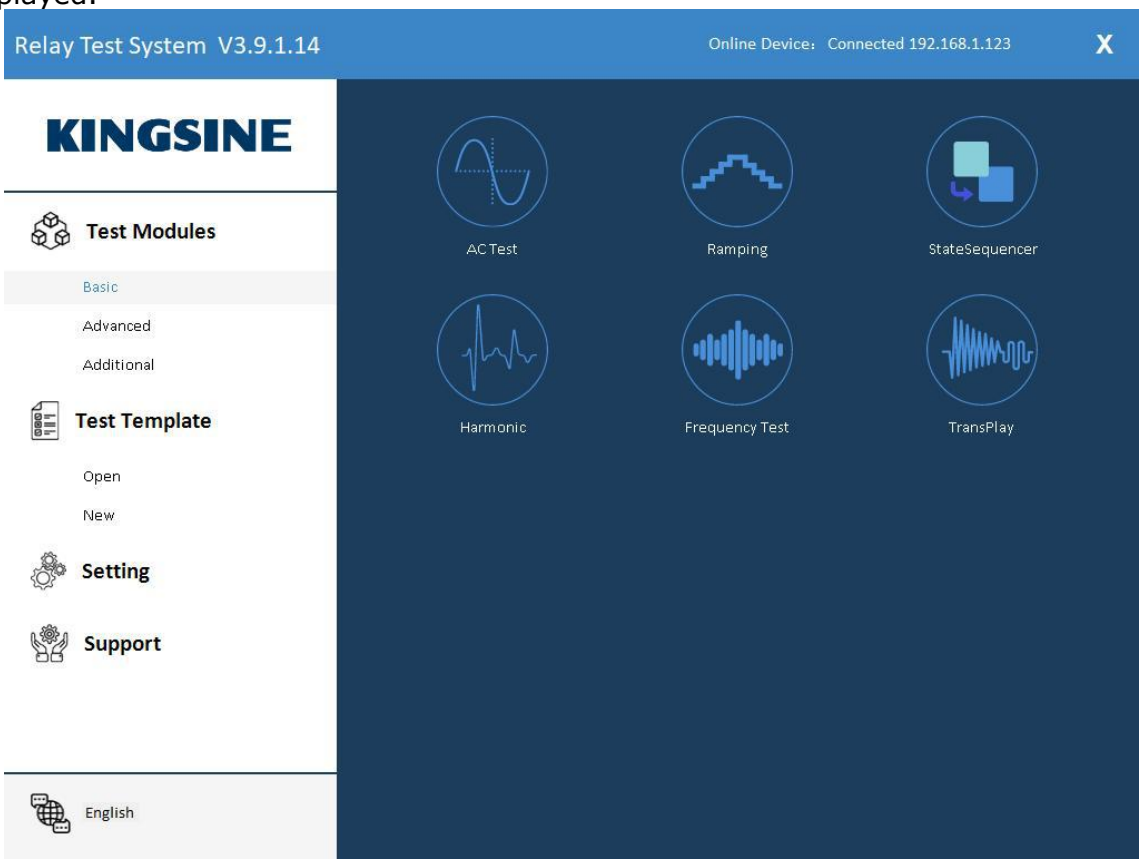
TCP/IP Refer to the hardware manual for information regarding the Ethernet port and TCP/IP configuration.

At the top right corner of our KRT software startup page, the connection status will be automatically displayed, indicating whether it is "Connected" or "Not connected"

Note: If the IP address of our tester and the IP address of the computer are not in the same network segment, the KRT software will display the IP address of the tester but will not be able to establish a successful connection. It will keep attempting to connect. Users need to check if the IP address of the computer's local network is correct and verify the firewall settings to ensure that the firewall is not blocking the connection between KRT and the tester.

2. Startup Page

On the left side, there is a test category navigation which includes Test Modules, Test Templates, Settings, Support, and Language Switch.
In the top right corner, the connection status and the IP address of the connected tester are displayed.



See: System Setting, Support

2.1 Introduction to Test Modules

Within the Test Modules, there are sections such as "Basic," "Advanced," "Fixed Value," "MU Test," and "Additional." Each section contains a varying number of test function units. By clicking on the respective function unit icon, you can access the corresponding functional test unit.

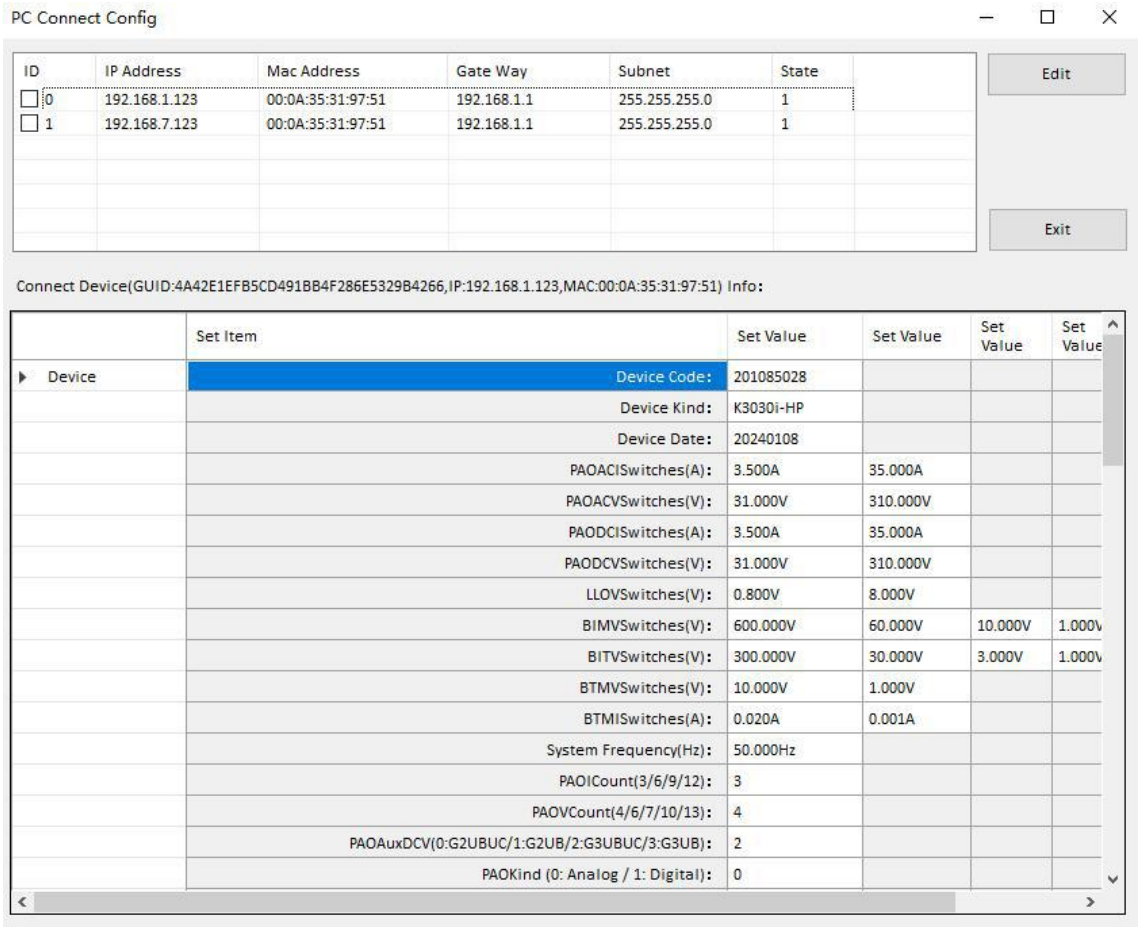
2.2 Test Templates

The Test Templates provide two functionalities: creating new templates and opening existing templates. It allows for easy management, creation, and editing of user-defined test templates. Users can also modify existing modules and generate new templates based on them.

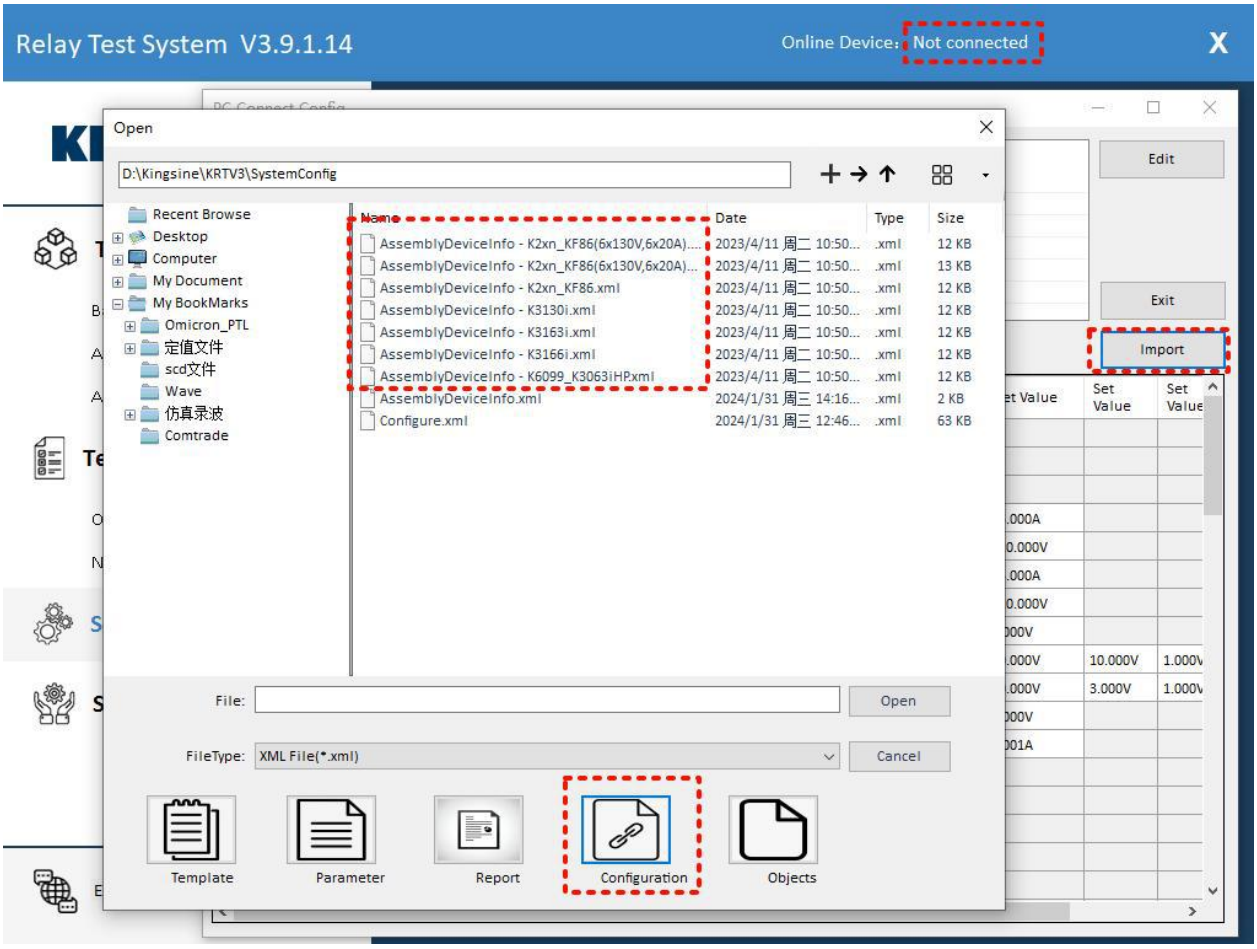
2.3 Setting

2.3.1 Hardware Setting

Configure and edit the online tester's IP address for testing. It will also display basic parameter information of the connected tester.



See: [Communication Setting]



When the device is in an offline state, opening the "System Settings" dialog allows you to import offline device configuration files, making it convenient to explore software features and create offline test templates.

2.3.2 Software Setting

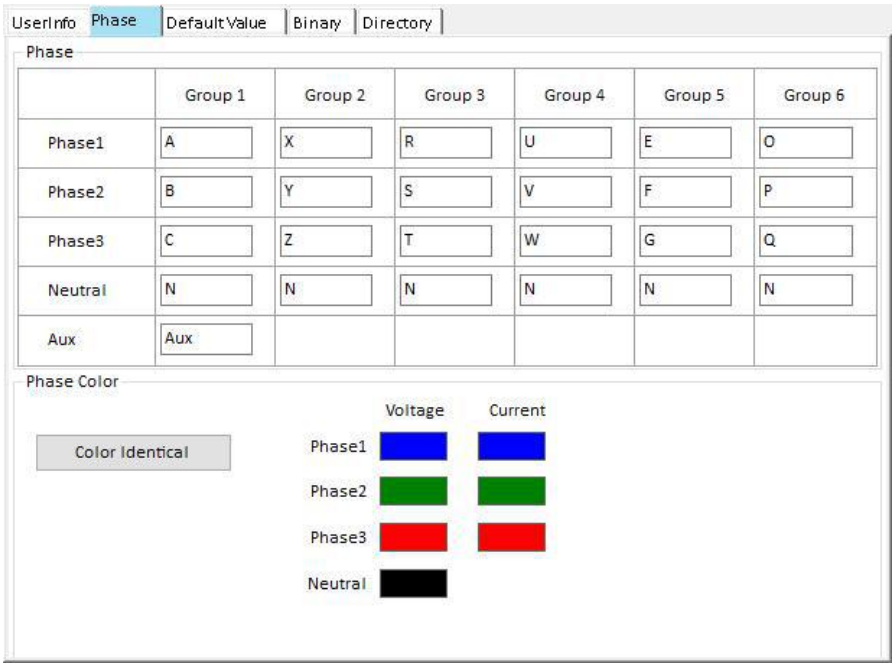
The software configuration defines the global parameter settings required for testing.

1. Test Info:

Defining the name of the test personnel and the company name, which will be required for report output.

2. Phase:

Users can customize the display colors and phase label names for each phasor channel in the software.

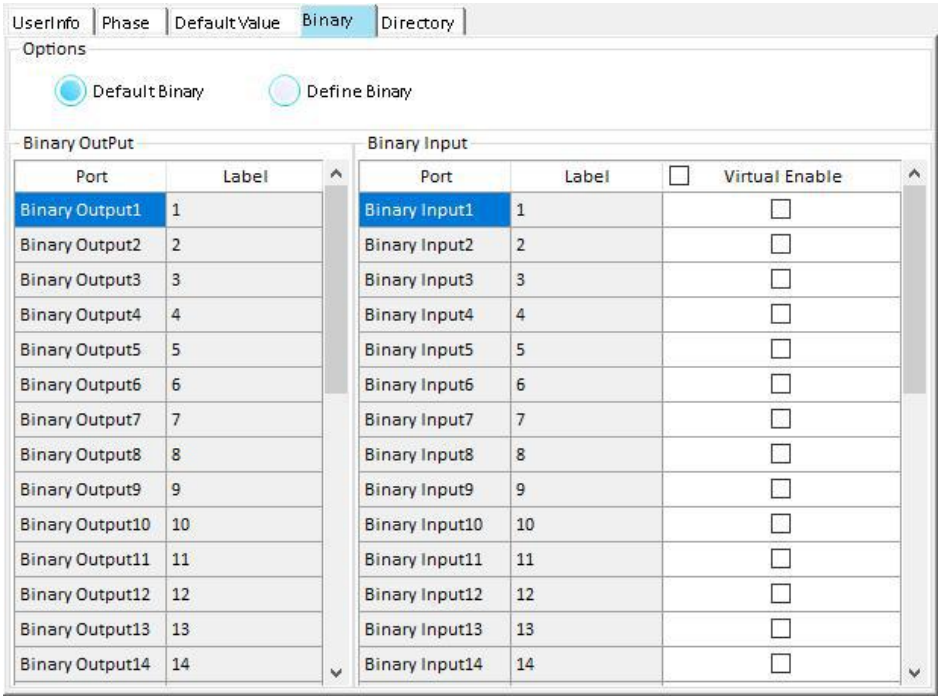


3. Default Value:

Defining default values for rated voltage, rated current, and rated frequency, which are used to initialize default values for the test object.

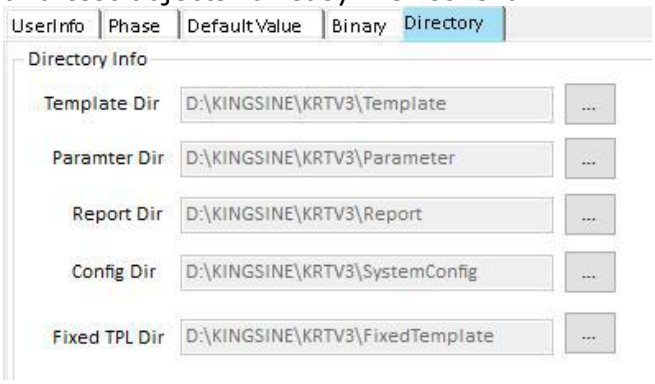
4. Binary:

Defining the display names for binary inputs and outputs, as well as the virtual enable and channel settings for binary inputs. (The software buttons can simulate external input signals for binary inputs, and related settings can be found in the "Virtual Digital Inputs" section in the System Setting)



5. Directory:

Defining the save directory for test templates, test parameters, reports, configuration information, and test objects for easy file retrieval.

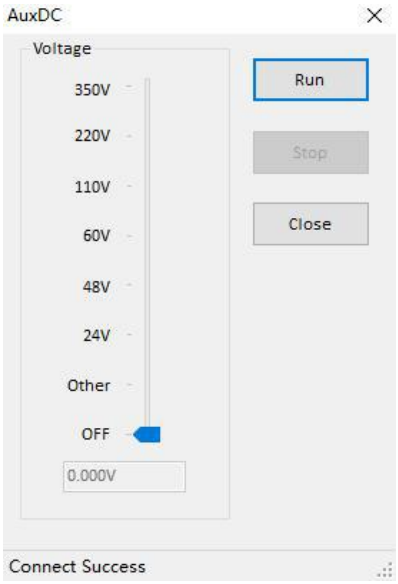


2.3.3 Aux DC

Auxiliary DC output is used to power protective devices. The auxiliary DC output is not affected by any other test module.

You can also enable the auxiliary DC output by clicking on the auxiliary DC icon in the status bar of any test module, and then enabling it in the pop-up dialog box.

Refer to the "Auxiliary DC Source" section in the hardware manual for more information.



When the auxiliary DC output starts to be active, on the startup page and in the status bar of all modules, the auxiliary DC indicator will display as **green**, indicating that the auxiliary DC is operational.

2.4 Support

2.4.1 Calibration

This feature is used for calibrating testing equipment and should be used by authorized personnel.

2.4.2 Upgrade

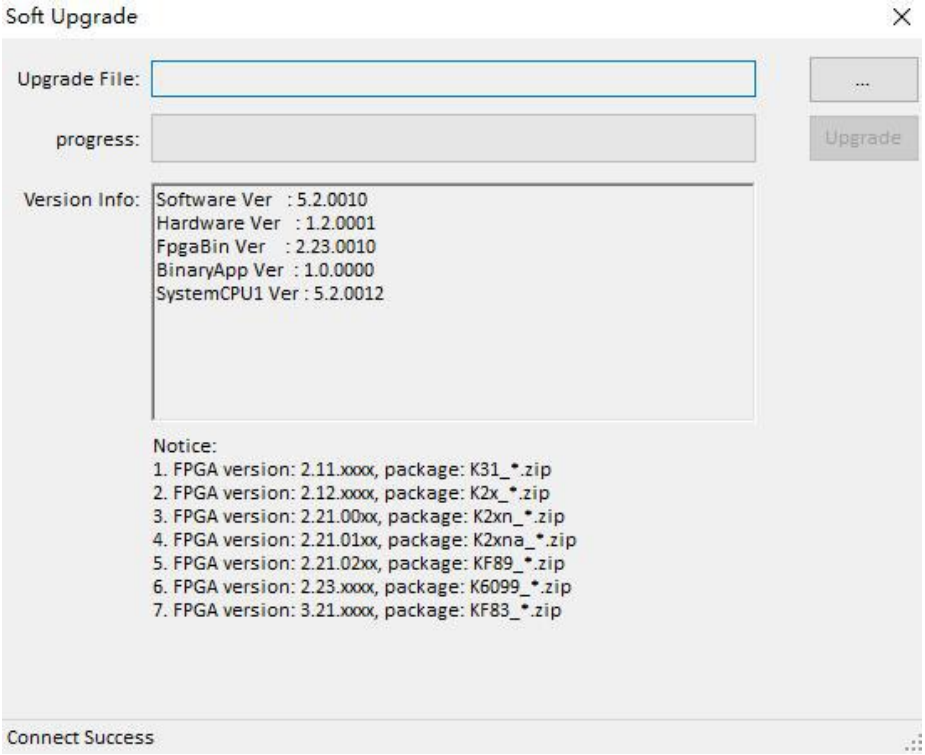
Firmware upgrade process

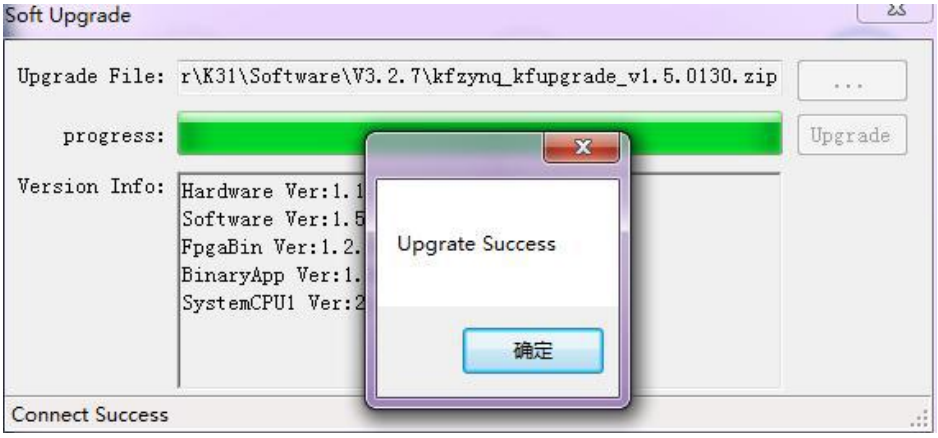
1. Power on the tester and successfully establish a connection with the computer software.

2. Run the KRT software and navigate to the "Upgrade" window. Locate and load the corresponding new firmware program "xxxx_vx.x.x.x.zip." Then, click on the "Upgrade" button. (**During the upgrade process, please do not disconnect the power or communication connection of the tester.**)

   The software will automatically verify the upgrade package based on the currently connected tester model. Upgrade packages with incompatible versions will not be executed for the upgrade.

3. Wait for the upgrade process to complete until a dialog box pops up indicating "Upgrade Success." After the upgrade is completed, the device will automatically restart.

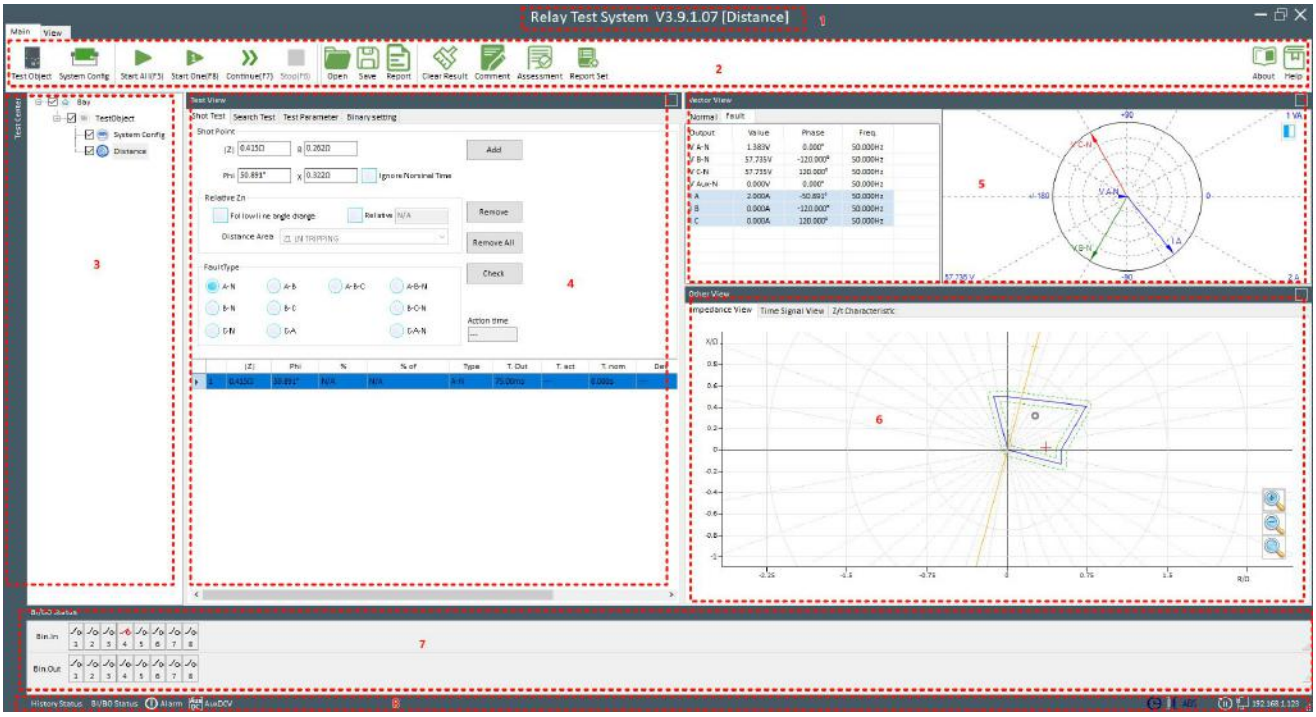




2.4.3 License

The license agreement allows you to view the current authorized feature licenses and import new license certificates to add optional features (when customers purchase optional modules, they will receive a new license certificate that can be imported to activate the new feature licenses).

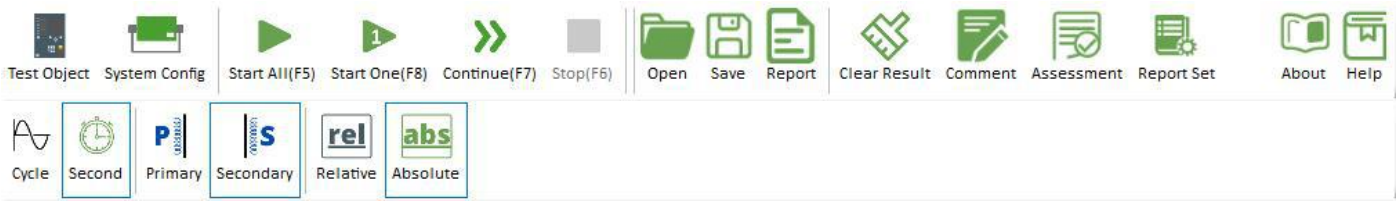
3. Overview of Interface and Toolbar



1. Title
2. Menu & Toolbar
3. Test Center view
4. Main Test View
5. Vector View
6. Characteristics
7. Dock Area: History Status、Binary status、Alarm、AuxDC
8. Status Bar

3.1 Menu & Status Bar

Menu:



Button	Description
Test Object	Provide editing/importing/exporting of test object parameters. These parameters can be used in all test modules for testing. Each test template file corresponds to a specific test object. Refer to:Test Object
System Config	Refer to: System Config
SMV abnormal 、GOOSE abnormal	Used for IEC61850 SV and GOOSE abnormal test.
Start All(F5) Start One(F8)	Start All(F5): This button automatically runs from the first activated module in the test center until the last activated module is finished running, and

Continue(F7) Stop(F6)	then stops. Start One(F8)：This button only runs the module in the test center where the cursor is currently positioned. Continue(F7)：This button runs from the module in the test center where the cursor is currently positioned until the last module is finished running, and then stops. Stop(F6): Force to stop running.
Open	Open an XML format test result for viewing.
Save	Save an XML format test result file for viewing and reproducing test scenarios.
Report	Save the test results as an RTF or PDF report format, following the predefined report format settings.
Export Report	Used for the one-click testing feature, it can export the results in a custom report format based on user requirements.
Clear Result	Clear the current test results.
Comment	You can add comments to the current module. When generating and exporting reports, this information will be automatically included after the test results of the current module.
Assessment	The user can modify the evaluation conclusion of the current test.
Report Set	Users can configure which data blocks will be displayed and included in the report.
View	
Primary、Secondary	Display primary or secondary values and automatically convert them based on the ratio parameters set in the test object.
Absolute、Relative	Relative values and absolute values, calculated as multiples of the rated value.
Second、Cycle	Seconds/Cycle: Display time format as seconds or Cycle.

Status Bar:

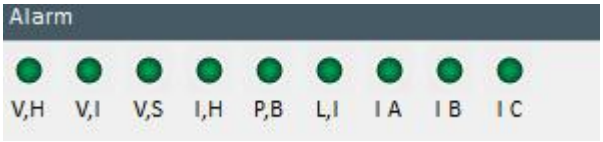
History Status：

Record the main state transition information and logs.

BI/BO Status：

Display the status of binary inputs and binary outputs.
The status of binary outputs is updated only during runtime.
The number of binary inputs and binary outputs is automatically matched based on the device configuration.

Alarm：

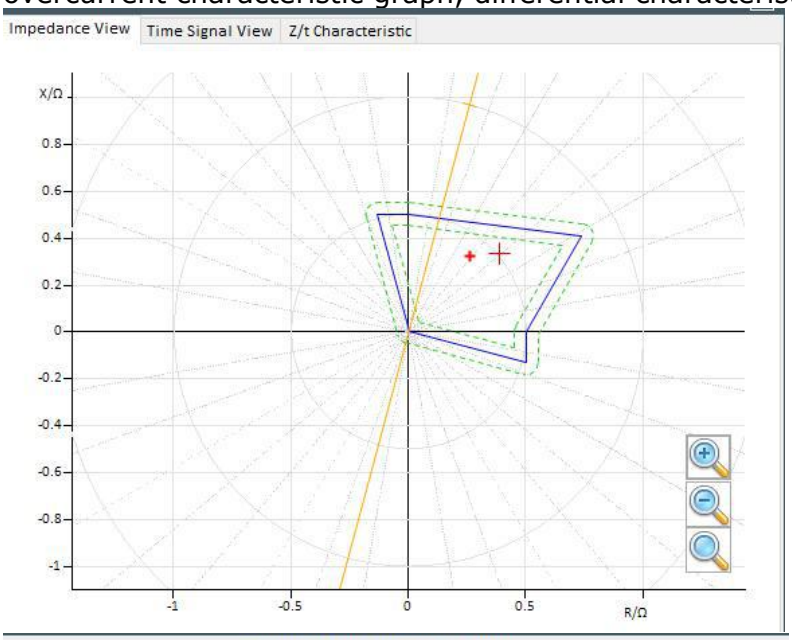


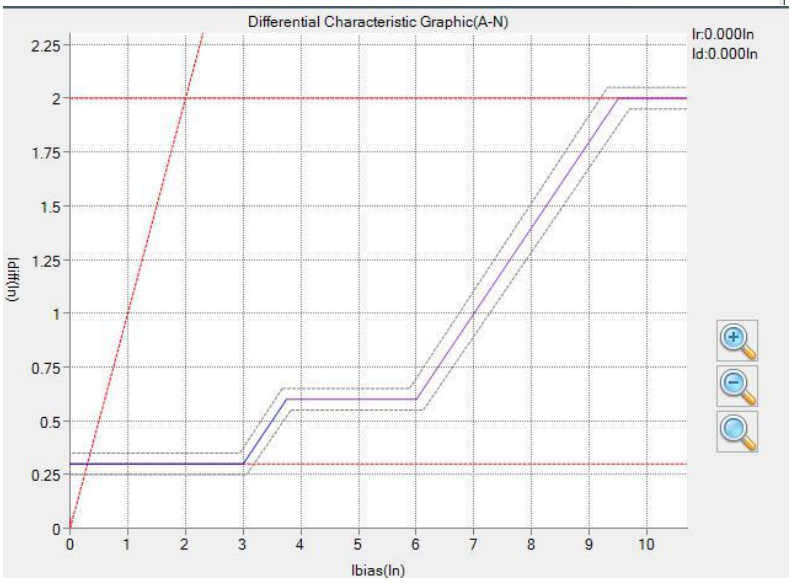
When the indicator light is **red**, it indicates an abnormal alarm state.

V,H	Voltage amplifier overheating
V,I	Voltage amplifier wrong connected to external H.V source.
V,S	Voltage outputs is short circuit
I,H	Current amplifier is overheating
P,B	The power imbalance
L,I	Low-level outputs wrong connected to external H.V source
IA,IB,IC,IX,IY,IZ	Current outputs open circuit indicator (The detection sensitivity is related to the open circuit alarm threshold for current in the system configuration. Current outputs below the threshold for open circuit will not trigger an alarm.)

3.2 Test View, Vector View, Characteristic View

The test view may have multiple tab bars, and different test modules may use different tabs. These tab bars include: result view, wiring view, report view, time signal view, impedance view, overcurrent characteristic graph, differential characteristic graph, and so on.

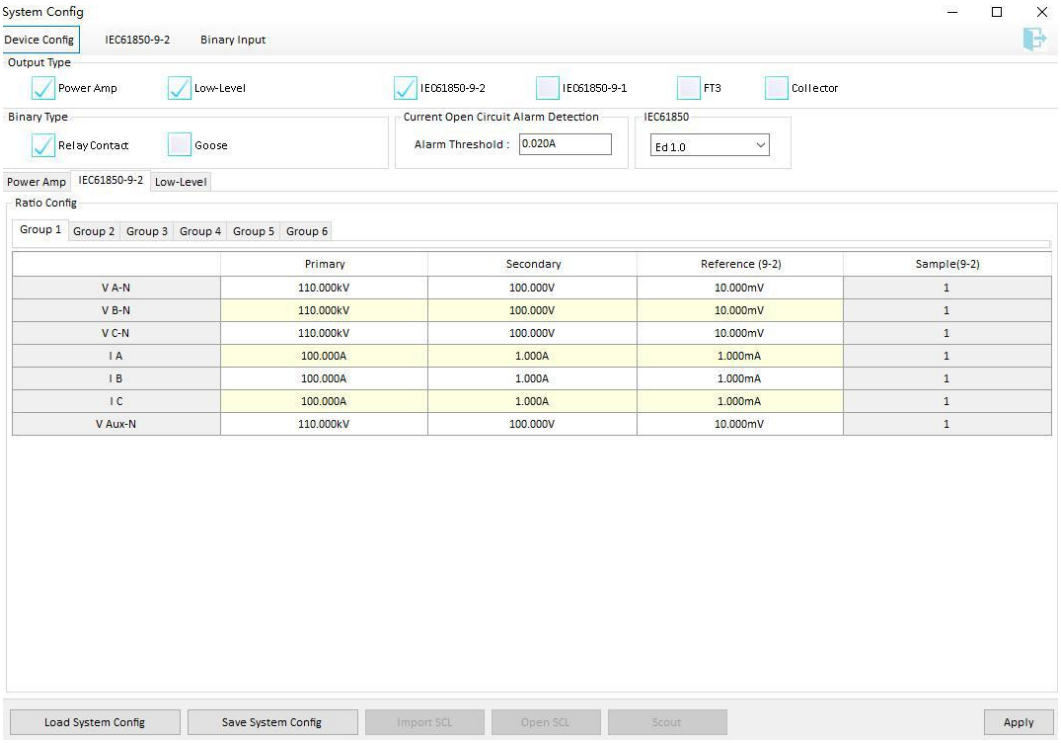




4. System Config

Clicking on "System Config" will take you to the system settings interface.
Here, you can configure the operating mode of the tester, including:

Output Type	Power Amp
	Low-Level output
	IEC-61850-9-2
	IEC-61850-9-1
	FT3
	Collector
Binary Type	Relay Contact (Dry/Wet)
	GOOSE
	Virtual Binary Input （You can use software buttons to simulate external binary input signals to trigger software state transitions. To use this feature, you need to first map the software button to a binary input channel in the "Binary" setting under Software setting）
Ratio Config	Group 1 - Group 6, valid for IEC61850 types Group 1 - Group 2, valid for Low-level output



After completing the configuration, it is necessary to click the "Apply" button to save the settings. If the tester is not connected, a dialog box will pop up with the message "Failed to send configuration."

4.1 Output Type Setting

In the "Output Type" interface, users can choose to set the output mode of the tester, including analog power amplifier output, Low-level signal output, IEC61850 SV output mode, etc.

Output Type	
Power Amp	If you want the tester output voltage or current analog signal, you need to select this option. Refer to: Amplifier output wiring

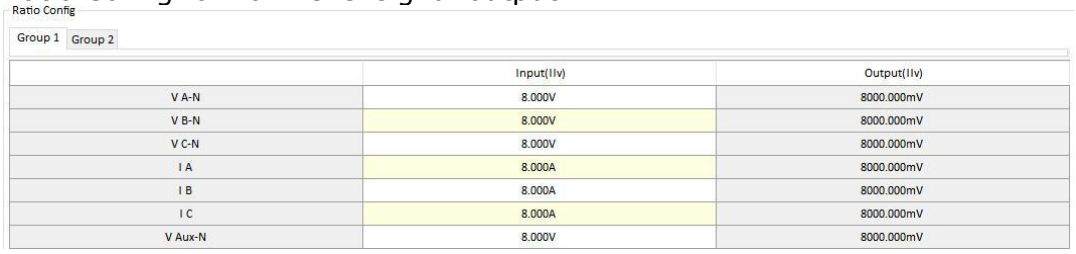
Output Type	
Low-level signal output	If you need to output a low-level analog signal, you need to select this option.
IEC61850-9-1 IEC61850-9-2 FT3 Collector	The tester outputs digital signals according to the corresponding protocol.

Binary Type

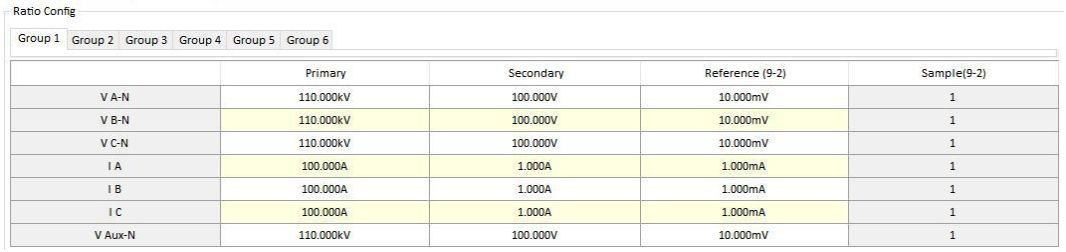
Relay Contact	The tester uses binary input/output ports (banana plugs or combination interfaces) to send/receive binary signals for binary inputs and outputs.
GOOSE	The tester sends/receives binary input signals through the mapped GOOSE channels.

Ratio Config

Ratio Config for Low-level signal output:



Ratio Config for IEC61850 type output:



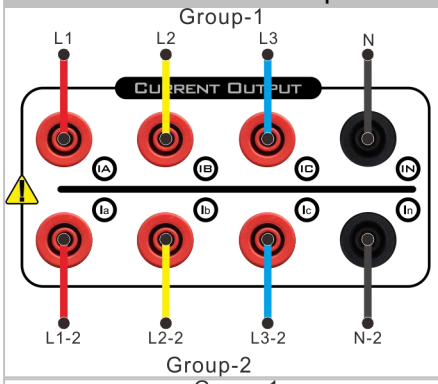
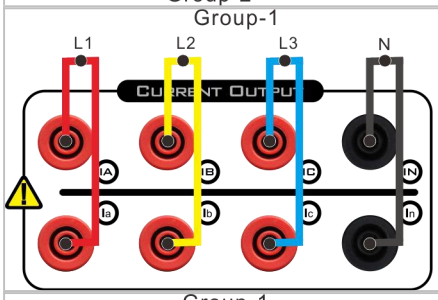
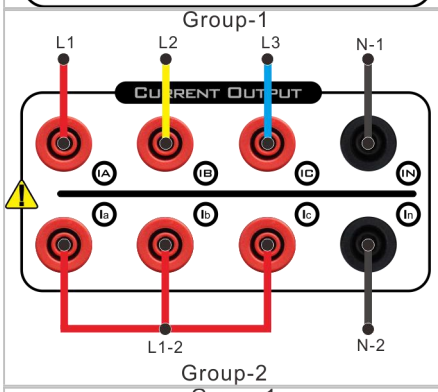
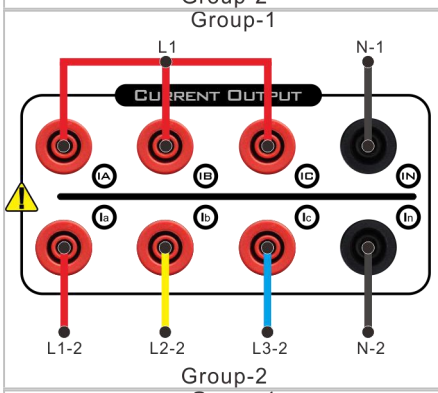
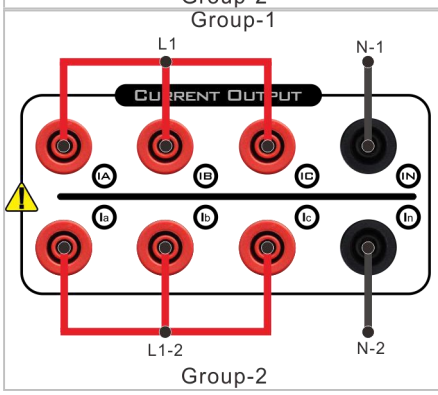
The "Ratio Config" for the power amplifier output mode are not configured in this interface. They are set within the Test Object section.

4.2 Amplifier Output Wiring

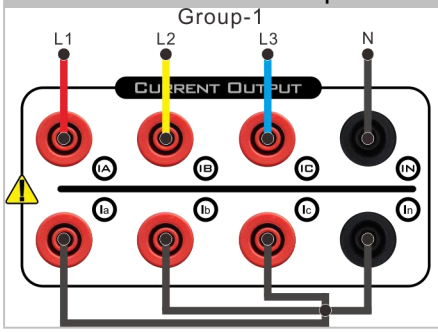
The available analog output channels for the current hardware are automatically detected by the software.

Current output wiring method

Model of 6 Current output channels

Model of 6 Current output channels	
	6 Current channels output independently
	3 current channels output mode Group 1 & Group 2 parallel output
	3 current (group 1) + 1 current (group 2) Group 1 is set to independently output each phase, and Group 2 is set to three-phase parallel output mode.
	1 current (group 1) + 3 current (group 2) Group 1 is set to three-phase parallel output mode, and Group 2 is set to independently output each phase. This output mode is only effective in certain specific test modules, such as AC test, ramp test, and state sequence test.
	1 current (group 1) + 1 current (group 2) Both Group 1 and Group 2 are set to three-phase parallel output mode. This output mode is only effective in certain specific test modules, such as AC test, ramp test, and state sequence test.

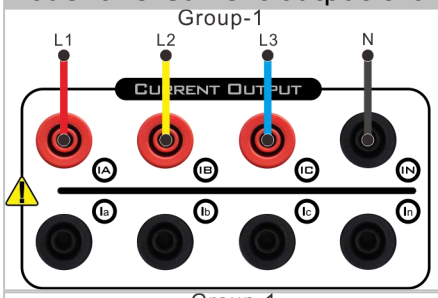
Model of 6 Current output channels



3 DC current output mode

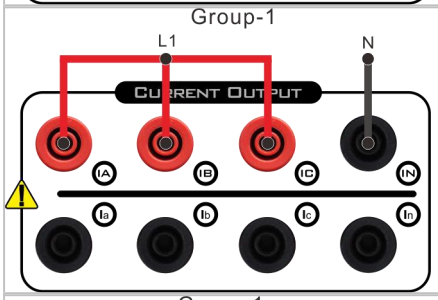
Group 1 ports are used for output, while Group 2 ports are shorted to ground.

Model of 3 Current output channels



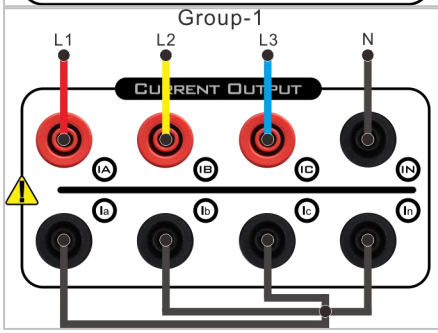
3 current output mode

Independent output each phase



1 current output mode

Group 1 is set to three-phase parallel output

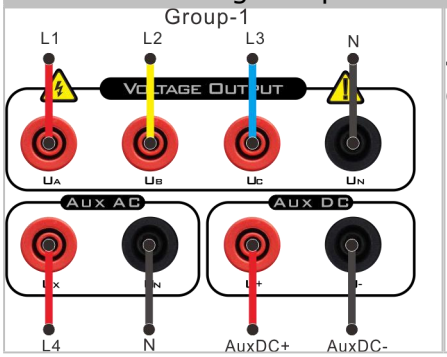


3 DC current output mode

Group 1 ports are used for output, while Group 2 ports are shorted to ground.

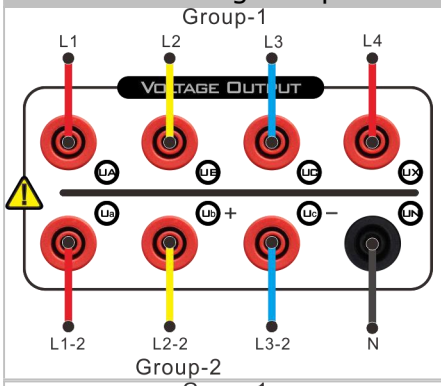
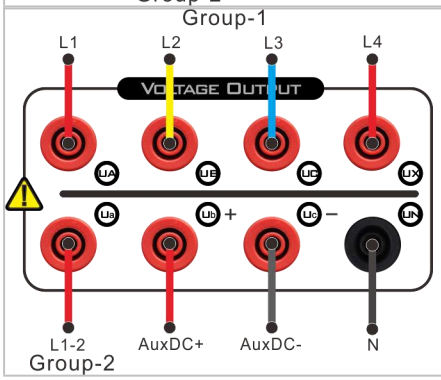
Voltage output wiring method

Model of 4 Voltage output channels



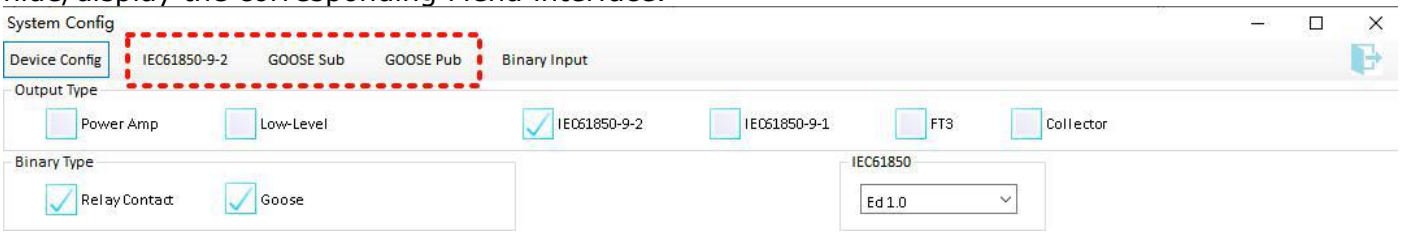
4-phase voltage output + auxiliary DC output (or no auxiliary DC output).

Model of 7 Voltage output channels

Model of 7 Voltage output channels	
	7-phase voltage with independent output for each phase (auxiliary DC output is not available).
	5-phase voltage output + auxiliary DC output When auxiliary DC output is enabled, the Ib and Ic voltages of Group 2 will become unavailable for use.

4.3 IEC61850 mode

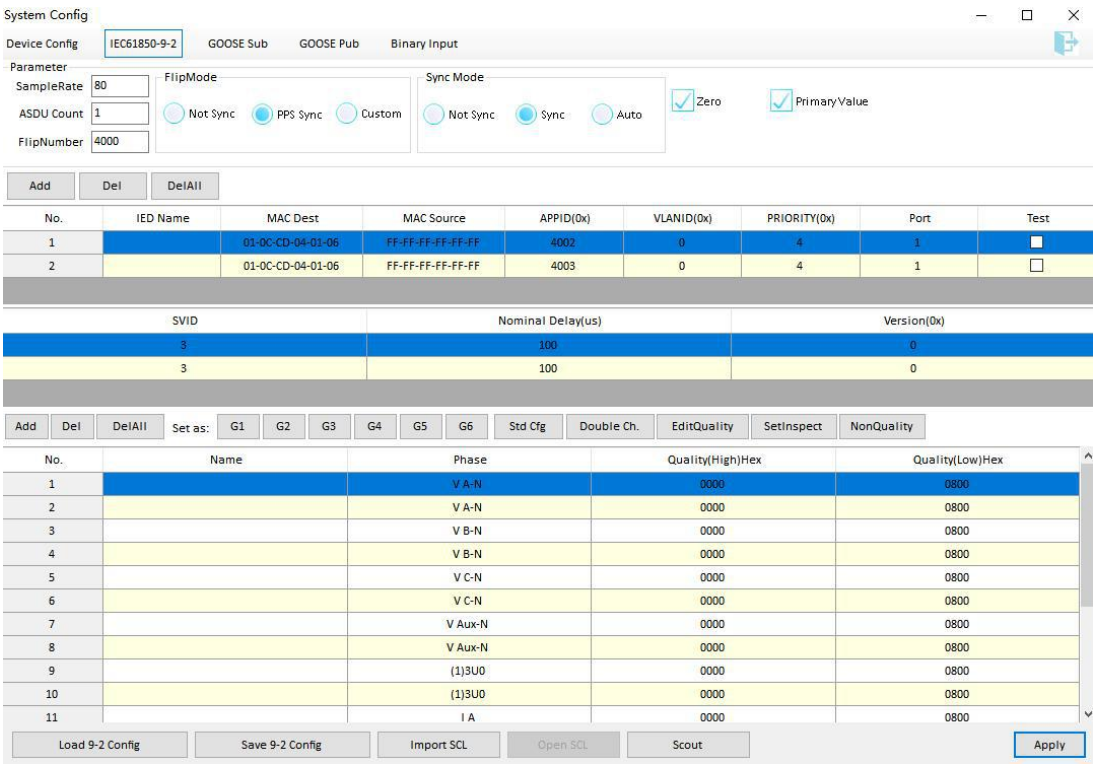
When selecting IEC61850-9-1/IEC61850-9-2/FT3/Collector, the top menu bar will automatically hide/display the corresponding Menu interface.



Refer to: IEC61850-9-1/2

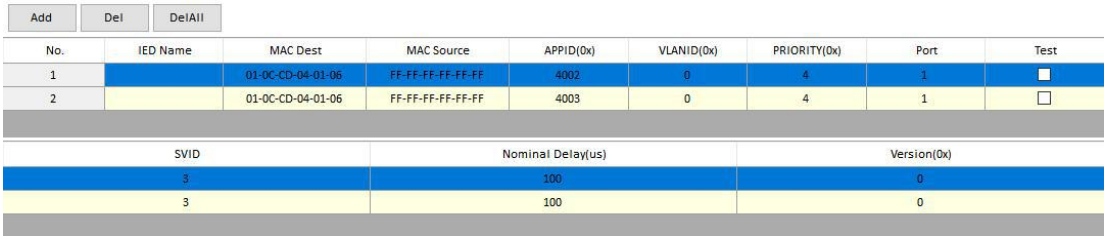
IEC61850-9-1 /2

IEC61850-9-1 and IEC61850-9-2 are two different protocols within the IEC61850 standard. Users need to select the appropriate protocol based on the one used by their actual IEDs (Intelligent Electronic Devices).



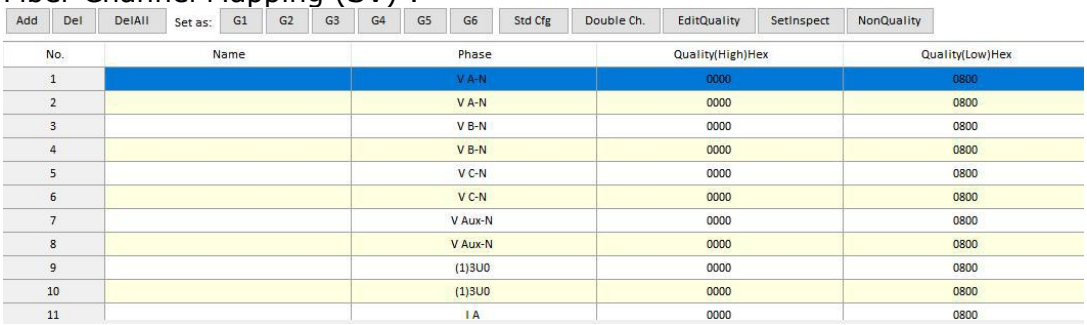
Users can import SCD/CID/ICD files from the station or previous saved configuration files to quickly complete SV or GOOSE channel configurations.

IED select:



This area allows for the selection of IED devices.

Fiber Channel Mapping (SV) :

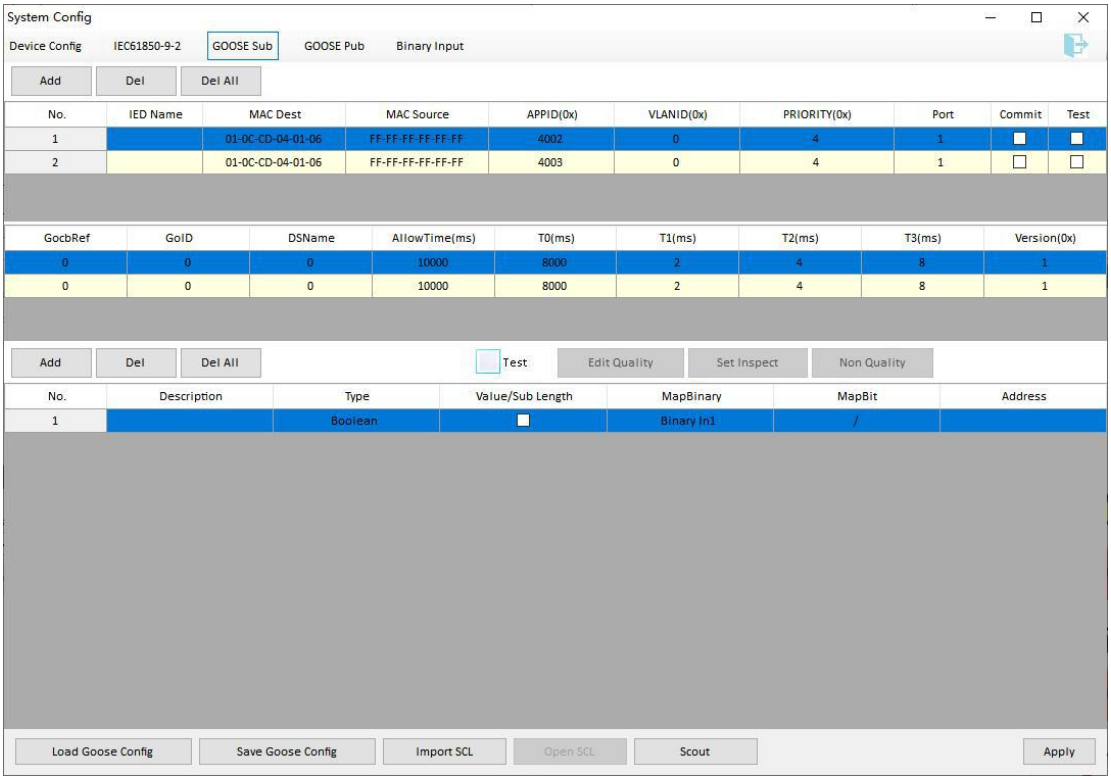


This area allows for editing or mapping of SV channels, and once mapped, these channels will be effective across all test modules. Users can utilize the quick buttons "Configure as Group 1 - Group 6" to fast complete the configuration process.

4.4 Binary Type

4.4.1 GOOSE mode

GOOSE publishing and GOOSE subscribing will be enabled based on the type of switch status GOOSE. For example, we can map binary output 1 to a GOOSE publisher and binary input 1 to a GOOSE subscriber.



Users can import SCD/CID/ICD files from the local station, or they can import previously saved configuration files to quickly complete SV or GOOSE channel configurations.

The "Message Detection" button allows the test set to automatically detect connected GOOSE signals.

4.4.2 Relay Contact

Users can further define input parameter types for binary inputs on the "Binary Inputs" page.

Input	Contact Type	Nominal Voltage
1	Potential free	15.000V
2	Potential free	15.000V
3	Potential free	15.000V
4	Potential free	15.000V
5	Potential free	15.000V
6	Potential free	15.000V
7	Potential free	15.000V
8	Potential free	15.000V

Any flip condition for a binary input must satisfy the Deglitch time, For example, with a deglitch time of 15 ms, a binary input will only be recorded if its flipping time is longer than this duration.

Input	The port of Binary input
Contact Type	1. Potential free (Wet/Dry contact) 2. Trigger on threshold (Only applicable to certain models)
Nominal Voltage	Set the threshold voltage V for DC trigger flip in threshold triggering mode

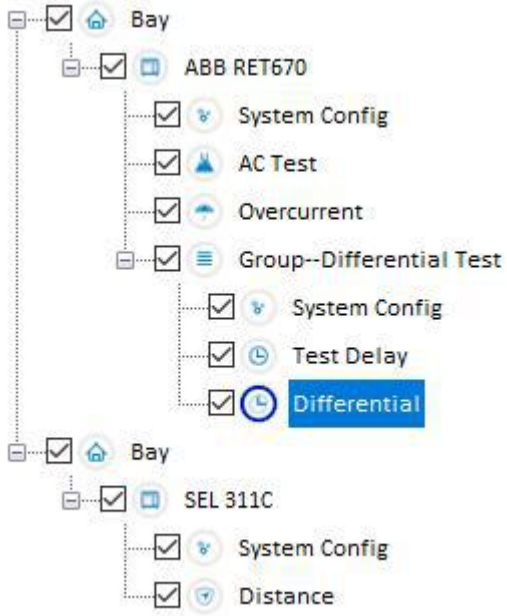
Reaction’s threshold(%)	Threshold triggering coefficient, controlled by the user to set the accuracy of the trigger threshold, applies to all contacts set for threshold triggering.

5. Test Center

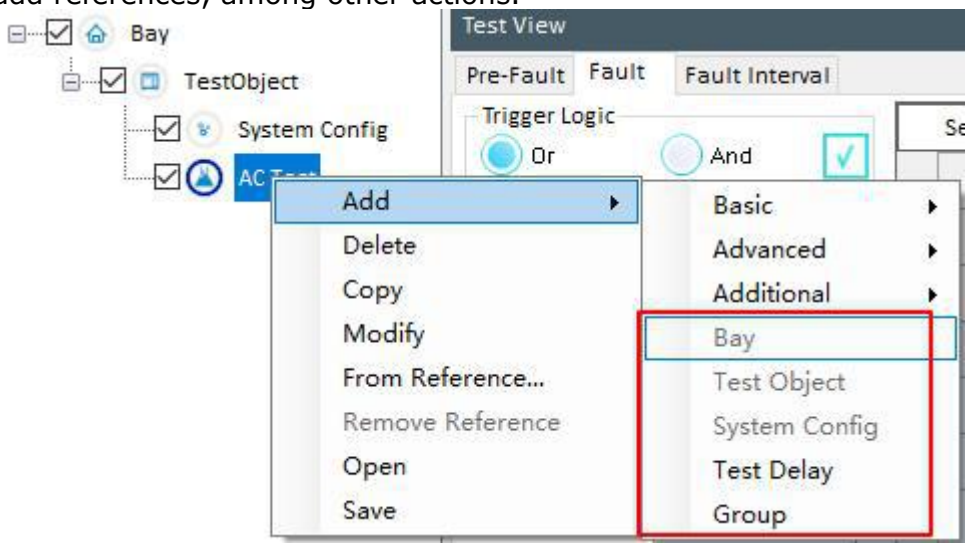
In the KRT software, all testing parameters are managed through test templates. Users can add test modules via the "Test Center" or directly access any individual test module; if accessing from a single test module, the software reads the default test template.

The template file contains information about the test object, all relevant test modules, and user-defined test points. Users have the convenience to create and modify test templates easily.

At the top of the "Test Center" view, the user-named test template is displayed. By default, a test template does not have a name.



Users can right-click on a module node in the Test Center to add new test modules. They can also hold and drag already-added modules for reordering. Additionally, they have the option to rename, add references, among other actions.



Add	Add a test module after current selected node.
Delete	Delete current selected node.
Copy	Append a selected node at the last.
Modify	Rename or change the settings of current selected node.

From Reference...	Link a binary reference parameter from the data of test object. This data will binding and active/deactive to current node.
	A linked node will appear as blue ground color and disable user operate the active/deactive selection until remove the link reference.
Remove Reference	Remove the linked reference.
Open	Open an exist template.
Save	Save the present settings to a template file.

Note:

- After organizing the test modules for a test object, it can be saved as a .krt test template, enabling direct loading and testing of the same type of protective device in future tests, thus saving steps and time.
- Upon completing a test, the template along with the test results can be stored as an .xml report. This report can later be loaded to view test results and template parameters, or even used interchangeably with .krt templates.

5.1 Bay

The Bay layer is used to organize and manage multiple test objects, and it is located at the first level of the test center. Multiple Bay layers can be added to the test center to manage multiple test objects, but the more objects are added, the higher the performance requirements for the computer. Therefore, it is generally not recommended to add multiple Bay layers within the test center.

5.2 Test Object

Test objects are used to organize and manage all test function modules, and they are located under the Bay layer. Multiple test objects can be added within an Bay layer, corresponding to multiple devices within the Bay or different set value parameter configurations for a single device.

Just like "Bay," adding too many "Test Objects" also places higher demands on computer hardware performance. Otherwise, it may result in slow software operation.

Under the "Test object," various test modules can be added for protection functions, and different test functions can be organized in groups, grouping together functions of the same type.

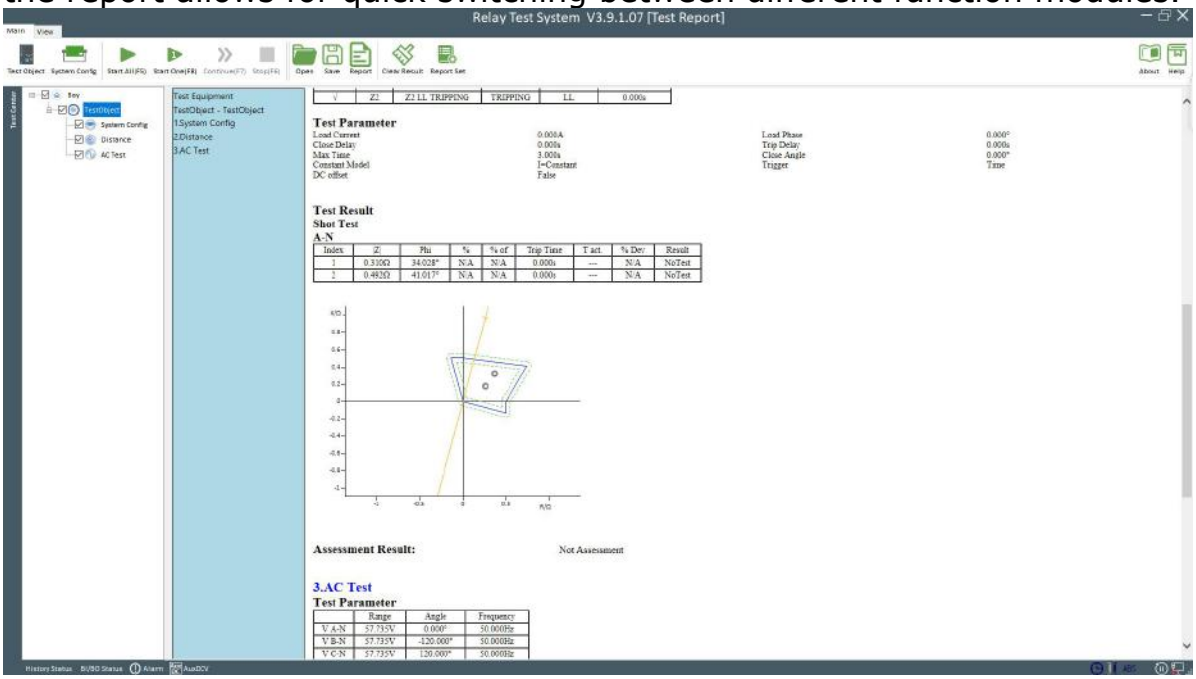
During automated testing, the test center will automatically complete all tests based on the currently selected "Test object." In the case of multiple "Test objects" testing will not cross over between the objects. Users need to manually select different "Test objects" before running the test.

Both the Bay layer and all modules managed beneath it have an activation checkbox. Only modules and objects that have the activation checkbox selected will be used during testing, while modules and objects without the activation checkbox selected will be ignored during testing.

Except for the default system configuration, the activation checkboxes for all modules and objects managed under other test objects can be linked to a boolean parameter value of the test object through the "From Reference..." option in the right-click menu. This allows for automatic control of the effectiveness of test modules within the test center by changing the data of the test object. (This has significant implications for

editing general test templates; when the protection set values change, the test modules can automatically adapt to the changes.)

By moving the cursor over the "Test object" and clicking on it, a quick preview of the test report can be displayed, as shown in the figure below. Additionally, the navigation bar in the report allows for quick switching between different function modules.



5.3 System Config

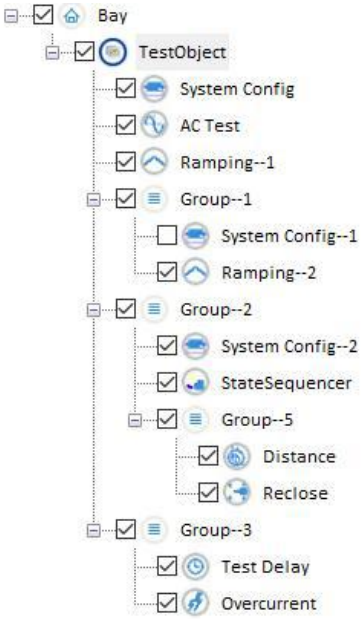
The "System config" primarily manages settings related to the test instrument hardware, such as power amplifier output configuration, IEC61850 SV and GOOSE configuration, and so on.

Within each test object, there must be at least one "System config" module. The software automatically adds a default "System config" module in the first module position under each test object.

The effective scope of "System config":
"System config" only applies to the test modules at the same level or lower levels that come after it, which is referred to as the effective scope of the "System config". It does not affect the test modules located before it or at higher levels.

In cases where there is overlapping effective scope among multiple "System config", the principle of proximity is applied. The "System config" closest to the module takes priority in setting.

As shown in the diagram below:

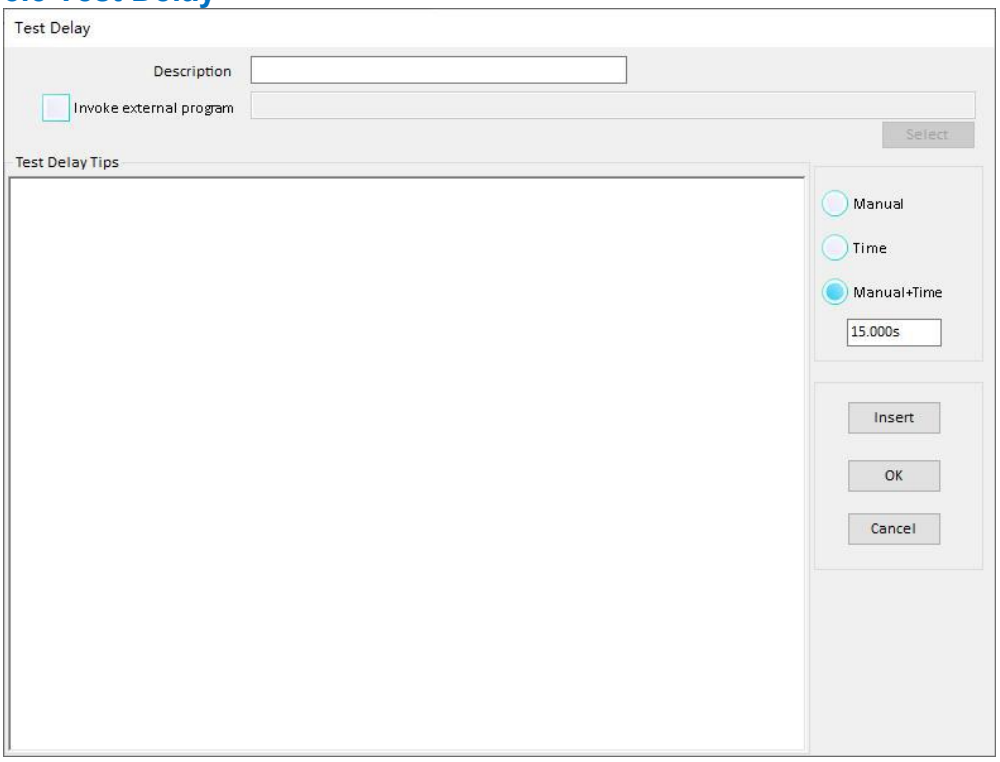


1. The first "System config" under the test object is the default "System config", and it applies to all subsequent modules.
2. The effective scope of "System config-1" should have been the "Ramping-2" module under "Group-1". However, since its activation checkbox is not selected, its effective scope does not take effect. According to the principle of proximity, the "Ramping-2" module still uses the default "System config".
3. The effective scope of "System config-2" includes the "State Sequencer" under "Group-2" and all modules under "Group-5".
4. "Group-3" is not included in the effective scope of "System config-1" and "System config-2". Therefore, following the principle of proximity, it still uses the default "System config".

5.4 Group

Groups do not have any specific testing functions; they are primarily used to organize and manage multiple different testing function modules. Users can group together multiple modules of the same type or with high relevance according to their preferences for easier viewing and management. Additionally, "System config" can be combined with groups to manage modules that require different "System config" by placing them within the same group.

5.5 Test Delay



The "Test Delay" module can be used to prompt users for additional confirmation actions during the testing process. It can provide reminders in the form of text, images, or a combination of text and images. The waiting method can be set as "Manual," "Time," or "Manual" + "Time" to confirm the completion of the test delay module.

In addition to displaying prompt information, the "Test Delay" module can also invoke external applications.

Note: KRT is only responsible for calling external programs and does not manage the execution results of external programs.

6. Test Object

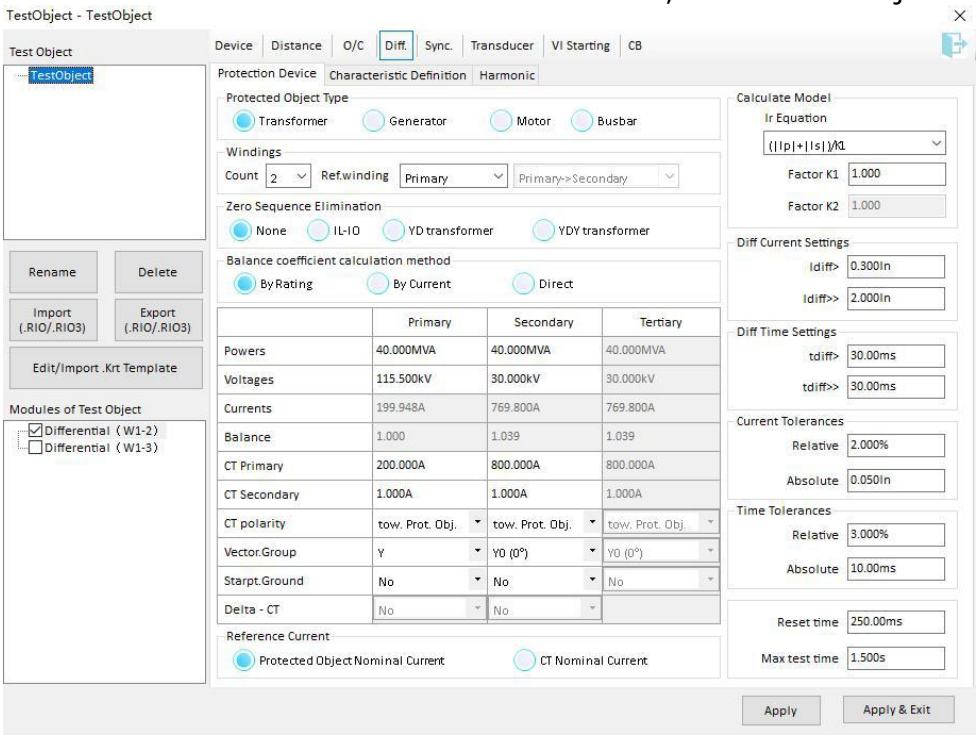
Within the KRT software, the test object parameters are embedded within the test template (.KRT). More information, refer to: Basic Overview

A test object contains multiple object types, such as Device, Distance, Overcurrent, Differential, Synchronization, Transducer, VI starting, and CB configuration.

Except for the "Device" object type, the other types can have multiple data instances (with at least one instance by default).

Test Object View:

From the menu "Parameters" or via the toolbar, select "Test Object" to enter the Test Object View.



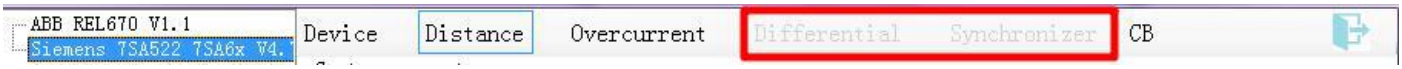
The upper part of the left border is for managing the test objects. Users can delete and rename the test objects, and they can also quickly reference new data using the import and export function buttons.

Import (.RIO/.RIO3) Export (.RIO/.RIO3)	Import a .RIO/.RIO3 format file to Over Write current test object settings; or Export present active test object settings to a .RIO/.RIO3 format file; .RIO format is used compatibility for KRT Version 2.x and 3.x; but not all features able to export to .RIO format file such as more than 3 elements in each Overcurrent element type. .RIO3 format only compatibility for KRT V3.x; During import, it is also possible to select a .XRIO file that includes

	RIO object data. If the file does not contain RIO object data, a prompt will appear indicating that the .XRIO file is invalid.
Edit / Import .Krt Template	Entry to Test Object Converter will enable editing of the a .Krt template, import settings from relay parameters, etc.

The lower part of the left border displays the data instances of the currently selected object type. Operations such as adding, deleting, copying, and renaming data instances can be performed through the right-click menu. When there are multiple data instances, only one data instance can be tested at a time for a test module.

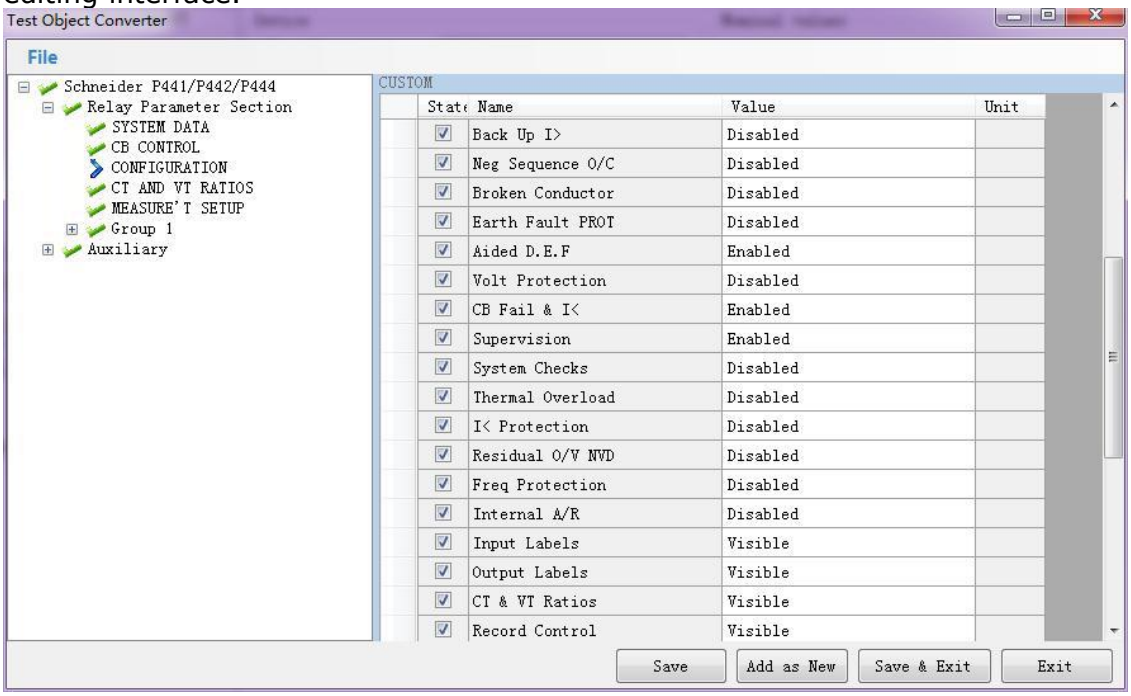
The majority of the right side of the interface consists of parameters for various types of test objects. These parameters are imported from the Test Object Converter (TOS) filter. Any modifications made in the test object view will not be reflected back to the TOS filter. Additionally, all parameters in this window will only affect the current test.



After importing .KRT template data, the object types displayed in gray on the top navigation page of the test object indicate that the parameters for these object types have not been defined in the Test Object Converter. All parameters in these modules will be the default parameters of the software.

6.1 Test Object Converter

Clicking the "Edit/Import Template" button within the test object leads to the test object converter's editing interface.



The test object converter employs a TOS (Test Object System) filter to display protection relay data. Its data structure mirrors that of the relay manufacturer, encompassing all data relevant to the relay under test. The TOS filter permits users to manually input parameters or utilize an import function to copy relay data from relay setting software. It automatically translates the protection relay data into KRT (Relay Test Parameters).

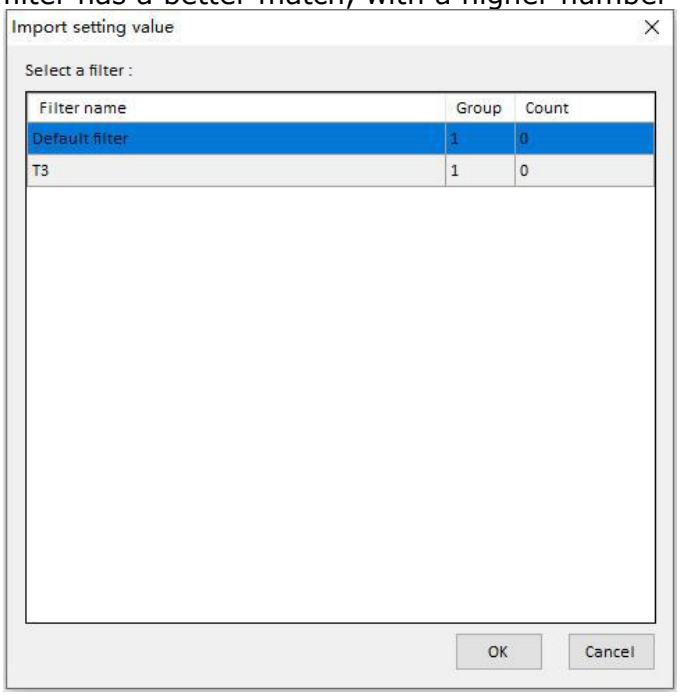
3 steps to complete the parameter setup of the converter:

1. Open the .KRT template file of a protective device currently requiring testing, then navigate to "Test Object" - "Edit".

2. Manually enter the protection parameter setting interface, or "Import" the protective device data into the filter.
3. Confirm and save these data into the test object within our KRT software.

Import function

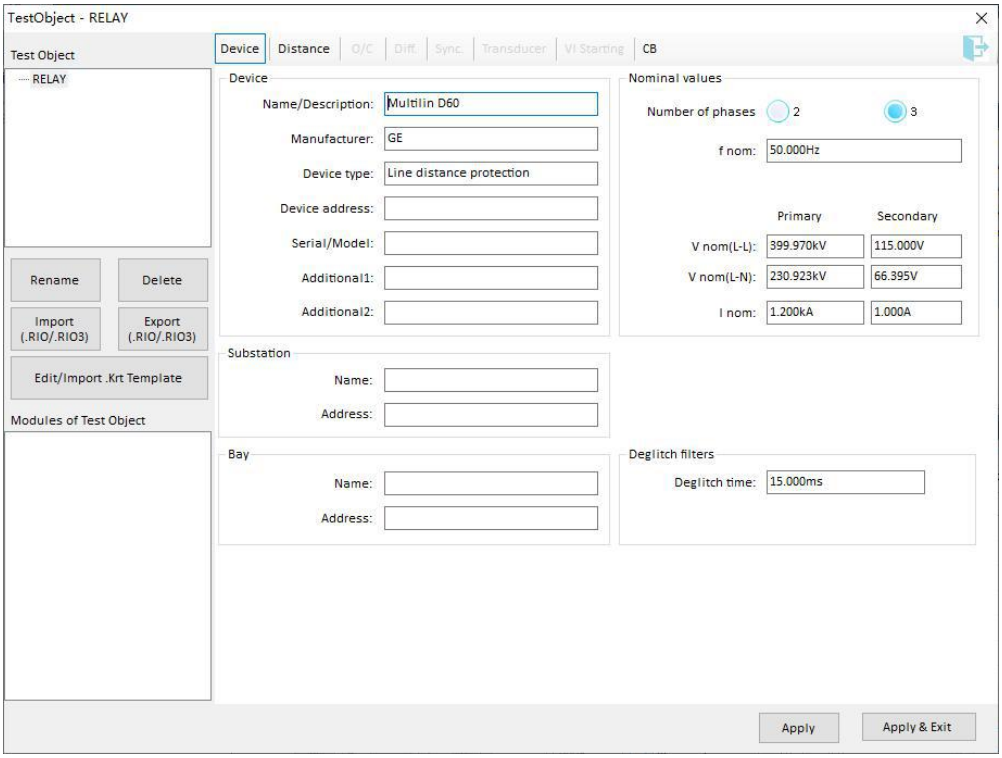
KRT template files can incorporate multiple distinct filters, and users need to select the corresponding filter to import data. (One can refer to the number of matches to determine which filter has a better match, with a higher number of matches generally indicating a better fit.)



Test Object Converter Button Key:

Save	Replace the test object currently in use in the Test Center with the edited object from the current converter.
Add as New	Add the edited object from the current converter to the Test Center as a new test object.
Save & Exit	Replace the currently used test object in the Test Center with the edited object from the current converter, and then exit the converter interface.
Exit	Exit the test object converter.

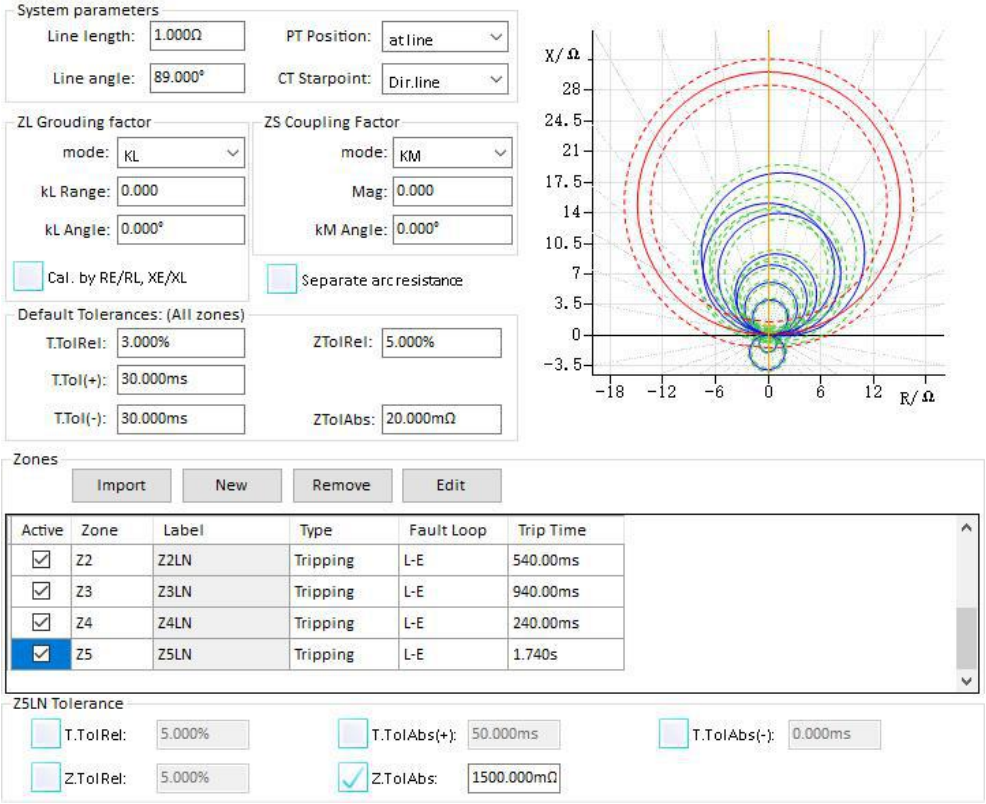
6.2 Device



Device Label Description:

Device/substation/Bay	The information of the test object. This information is primarily used in the output report.
Nominal Values	Number of phases (2 / 3 phases); In the testing module's view, when switching between "primary" for primary and secondary CT/PT parameters, the actual displayed values depend on the set ratio value on this side. ● The ratio setting for the Low-level signal mode can be found in "Output Type Setting".
F.nom	The default output frequency of each module is the same as the rated frequency value of the protective device under test.
Deglitch filters	Filtering out transient trip spike signals, with a setting range of 0 to 25 ms.

6.3 Distance



PT Position:

At line:	Vpost-fault = 0V
At busbar:	Vpost-fault = Vnom

CT starpoint:

Dir. line:	The current flow direction is: from the test instrument to the test object.
Dir. busbar:	The current flow direction is: from the test object to the test instrument.
In general, the "forward direction" is defined as the flow from the busbar side to the protected line side. If the Starpoint of the CT (Current Transformer) is connected on the line side, then in this case, the so-called "forward direction" aligns with the "positive direction" within the software. When the CT's Starpoint is connected towards the busbar side, it can be accounted for by selecting CT Starpoint Towards Busbar in the settings of the test object. This will result in a 180° phase shift of the generated output current, and the actual phase change can be observed in the vector view on the test interface.	

ZL Grounding factor:

The grounding factor is applicable for single phase ground faults impedance measured in response to the relay.
ZL grounding factor is used for constant current or constant voltage fault mode.
ZS grounding factor is used for constant system impedance mode. ZS impedance settings see: Test Parameter of distance module.

There are 3 modes for the ZL grounding factor setting:

KL, RE/RL & XE/XL, Z_0/Z_1

KL uses Magnitude and Angle mode to calculate:

$$KL = \frac{Z_0 - Z_1}{3 * Z_1} = \mathrm{Re}(KL) + j\,\mathrm{Im}(KL) = |KL| \angle \theta$$

RE/RL & XE/XL use resistance and reactance mode to calculate:

$$\frac{RE}{RL} = \frac{R_{Z0} - R_{Z1}}{3 * R_{Z1}} = KR \quad \& \quad \frac{XE}{XL} = \frac{X_{Z0} - X_{Z1}}{3 * X_{Z1}} = KX$$

Note: KR & KX *does not represent the real and imaginary parts of the grounding compensation coefficient K, and the conversion from* KR & KX *to K as below:*

$$K = \frac{K_R R_{Z1}^{\ 2} + K_X X_{Z1}^{\ 2}}{R_{Z1}^{\ 2} + X_{Z1}^{\ 2}}$$

Z0/Z1 is polar coordinate that represents the magnitude and angle of KL.
"Z0" represents the zero-sequence impedance while "Z1" represents the positive-sequence impedance of the line protected.

For ZS grounding factor input: **KM, RE/RL & XE/XL, Z_0M/Z_1M**

The ZS grounding factor is equivalent to the line equivalent impedance (positive sequence impedance) from the power supply source of the system to the protected object, and it only comes into effect when the fault mode is set to "ZS Constant". All formula representations refer to the ZL grounding factor.

Default Tolerances (All zones) :

For the evaluation and comparison of time and impedance error ranges, this parameter serves as a global setting applicable to all impedance intervals, except in specific intervals where custom error ranges are defined.
The final error is taken as the greater value between the relative error and the absolute error calculation.

Zones

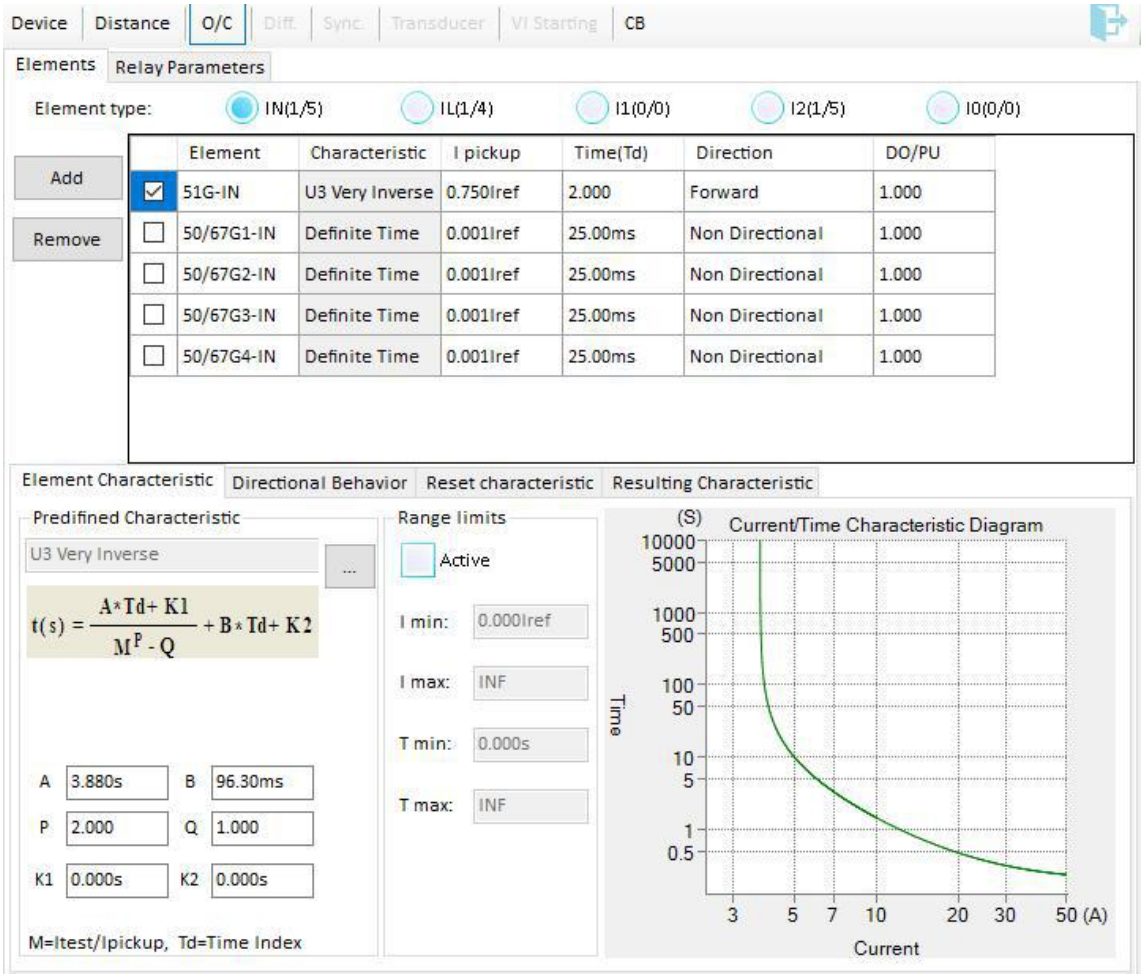
The zone list contains a listing of all specified zones for all fault loops.

A graphical editor allows the user to define the nominal relay characteristics and settings easily.

"New","Remove" and "Edit" buttons enable adding or deleting a zone, as well as modifying the characteristic of the selected zone.

Active	Only the zones for which the activation checkbox is checked are effective for the test module.
Zone	The name of zones.
Label	For individual zone identification.
Type	Tripping: tripping zone has a corresponding trip time associated with it.
	Extended Zone: Similar to the trip zone, during testing, users can still define whether this zone should be activated for testing at the distance and overall group interfaces. Typically, when testing the extend zone, a corresponding synchronizing voltage signal is also required.
	Non-tripping: this zone has no tripping allowed (e.g. load encroachment area)
Fault Loop	Specifies the fault types for which the settings are valid.
Trip Time	Tripping time for each zone.

6.4 Overcurrent



PT Position:	
On line:	Vpost-fault = 0V
On busbar:	Vpost-fault = Vnom

CT Starpoint:	
Towards line:	Phase shift between the currents and voltages = fault angle.
Towards busbar:	Phase shift between the currents and voltages = fault angle + 180°.

PT and CT connections setting will be no use while "Directional behavior" of the relay is set as "Non-Directional".

Elements of overcurrent

The elements contains:

IL	Phase element
IN	Residual element
I1	Positive sequence element
I2	Negative sequence element
I0	Zero sequence element

Element list:

Active	only activated elements are in-use when a test is being performed.
Element name	Unique name for each element; double-click the cell to rename it.
Characteristic	Name of the tripping characteristic
I pick-up	Pick-up current of the element, specified as a multiple of the Inom
Time	It gives the trip time in seconds for a definite time characteristics and a time index for inverse characteristics.
Direction	It can be Forward, Reverse or Non-directional

Notice: All checked elements operate in a parallel combination, and their final combined curve characteristics can be viewed on the "Results Characteristics" tab.

Predefined Characteristic

To those definite time elements, the parameters area are of no use.

- Parameters A, B, P, Q, K1 and K2 used for IDMT characteristics.
- Parameters A, Q, P used for I2T characteristics.
- Parameters A, B, C, D, E used for IAC characteristics.

Through the "New" - "Custom" pathway, users can create custom tabular format characteristic curves where a table for current time values is contained, enabling the definition and editing of the desired characteristic curves. Entries in the table are sorted in ascending order according to their values.

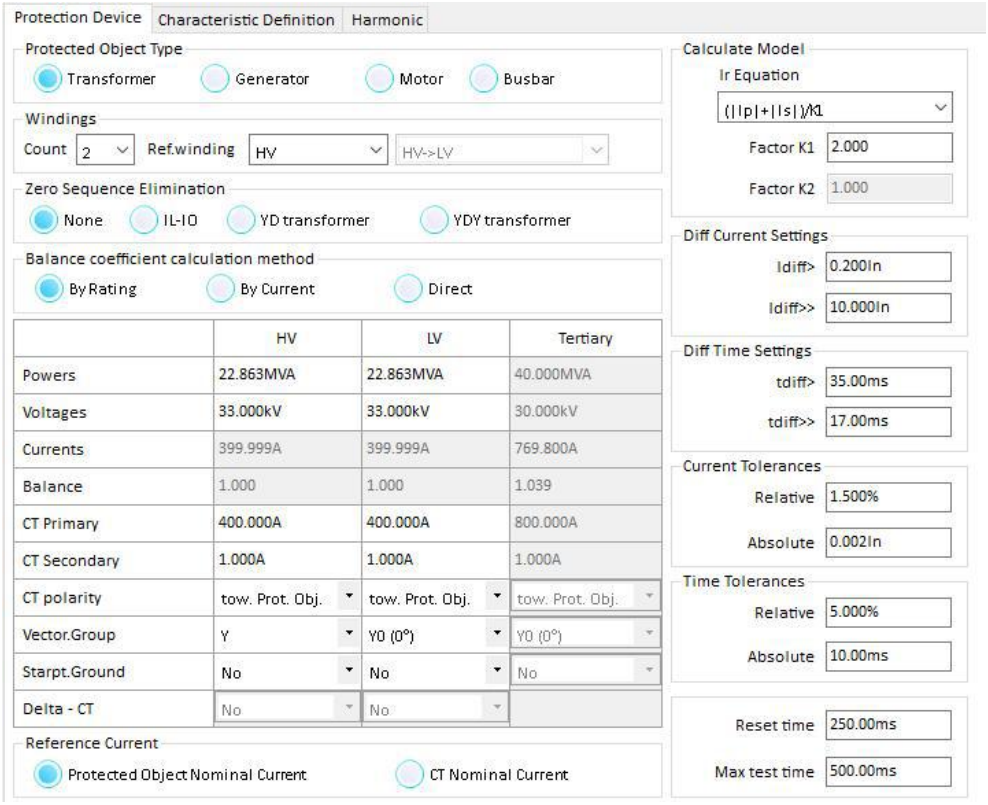
Reset Characteristic :

Off	No reset time defined
Definite time	fixed reset time for all shot points.
Inverse time	Automatically calculating the reset time tr(s) in seconds tr(s) = R*Td R: definable constant Td: Time index scaling the time axis of the curve.

View Resulting Characteristic

This tab displays the combined characteristic curves for all the final checked elements.

6.5 Differential



6.5.1 Protection Device

Protected Object Type

Define the type of protection device.
Available options include: Transformer / Generator / Motor / Busbar.

Windings

Count	Number of windings
Ref.winding	Select the measurement reference winding; for ratio and harmonic restraint, simulate a fault occurring on this selected side. For a three-winding transformer, if the primary side is chosen as the reference, the other side(s) need to be defined according to the testing method employed. The three-winding configuration is only applicable for transformer object types. When selecting a three-winding configuration, in the differential protection module parameter setup interface, different test windings can also be chosen based on actual requirements.

Balance coefficient calculation method

Select the calculation method or direct setting for balanced coefficient.

Test object parameters setting

Powers	Nominal power per winding.

Voltages	Nominal voltage per winding
Currents	Show the line current calculated from power and voltage ratings.
Balance	Show the balance calculated from power, voltage and CT ratings.
CT Primary	Nominal primary current per winding
CT Secondary	Nominal secondary current per winding
CT polarity	Define a direction for the CT Starpoint (towards line or towards protected object)
Vector Group	Define the vector group of connection of the protected object. possible connection are: Y(star connection) or D(delta connection)
Starpt.Ground	Set the Starpoint grounded or not of the corresponding winding. This setting influences the current flow for single-phase faults.
Delta - CT	Set whether there is a delta-connection of the CTs While the corresponding vector group is set to Y type.

Reference Current

The absolute values of the measured currents transformed to the reference winding through vector group adjustment or zero-sequence elimination are different, which is due to variations in CT ratios and the discrepancies when converted to I.nom using Protected Object Nominal Current values.

Therefore, whether to use "Protected Object Nominal Current" or "CT Nominal current" for the test current is a choice that varies among relay protection manufacturers. These parameters are essential, and it is necessary to refer to the manufacturer's definitions for the tested protection object when making the settings.

Zero Sequence Elimination

Zero-sequence elimination is solely related to single-phase faults.

- No: Absolute values are recalculated by the protection device; no zero-sequence elimination is performed.
- IL - I0: Line current minus zero-sequence current
- YD: YD type auxiliary CT
- YDY: YDY type auxiliary CT

Calculate Model

Ibias(Ir) is determined based on the protection model provided by the manufacturer.

$(|Ip|+|Is|)/K_1$

$(Ip-Is)/K_1$

$(|Ip|+|Is|\times K_2)/K_1$

$\max(Ip,Is)$

$\min(Ip,Is)$

$sqrt(Ip\times Is\times\cos(a))$

$(|Ip|+|Is|-|Idiff|)/K1$

Diff Current Settings, Diff Time Settings, Current Tolerances, Time Tolerances

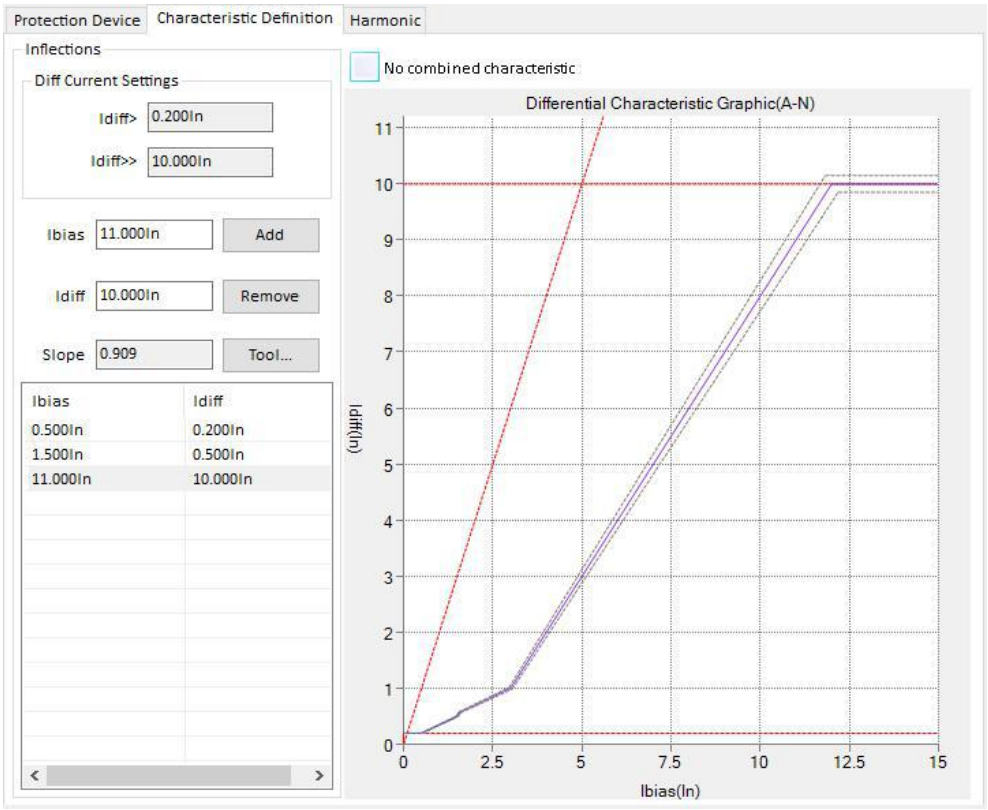
The settings are made according to the protection relay's setting sheet or hardware parameters.

If parameters are imported from a template, these parameters have already been predefined based on the specific protection model being tested and generally do not require manual modification.

In the assessment of test outcomes, the criterion for Passed or Failed the measurements involves taking the maximum between the relative tolerance and the absolute tolerance for both current deviation and time deviation.

6.5.2 Characteristic Definition

This tab is used to define the differential characteristics of the test object.



Diff Current Settings

The Idiff> & Idiff>> values are taken from the settings on the "Protection Device" tab.

Buttons

Add	Adds the segment defined by the Ibias & Idiff pairs.
Remove	Deletes the currently selected segment
Tool...	Auxiliary tools for segments generate

No combined characteristic

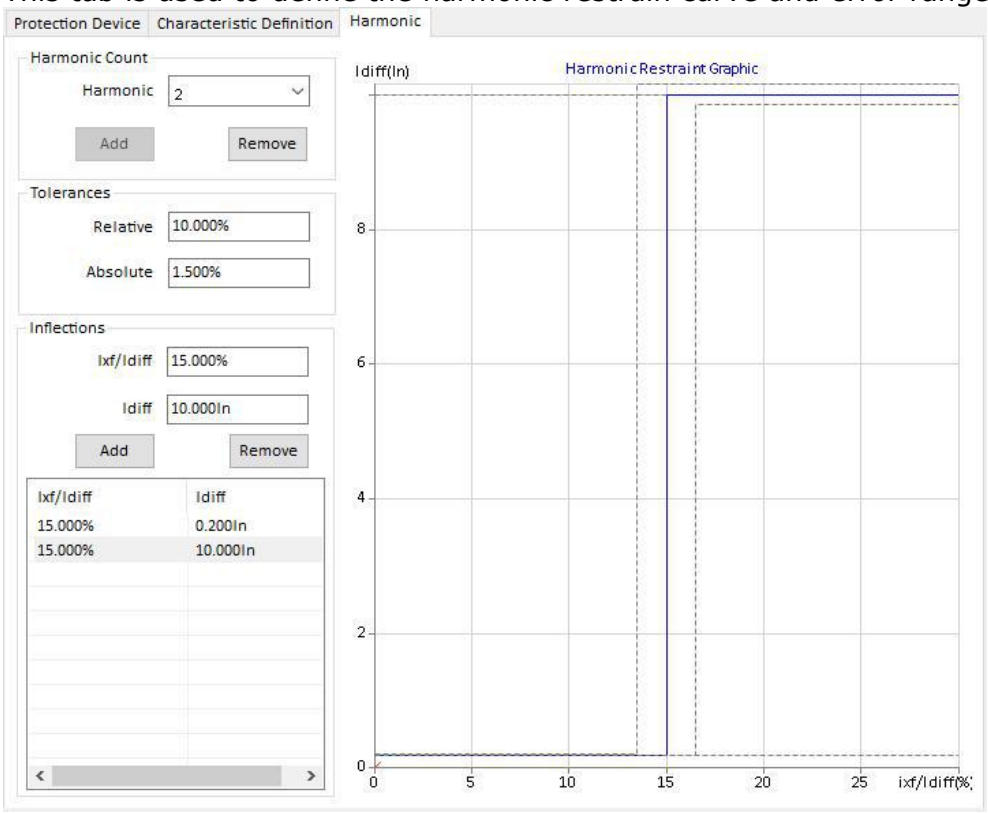
If the relay measures Ibias and Idiff phase selectively, then the measurement of one phase has a Idiff/Istab current twice as high as the other two phases may occur for certain test objects, vector groups and zero-sequence eliminations.

In the healthy phases, the relays can filter out the currents with high deviation, so activate the "No combined characteristic" option to disable the use of combined characteristic. This will allow for testing relays to block the trip decision in the healthy phases.

Enabling the "No combined Characteristic" option affects only the testing of single-phase fault types.

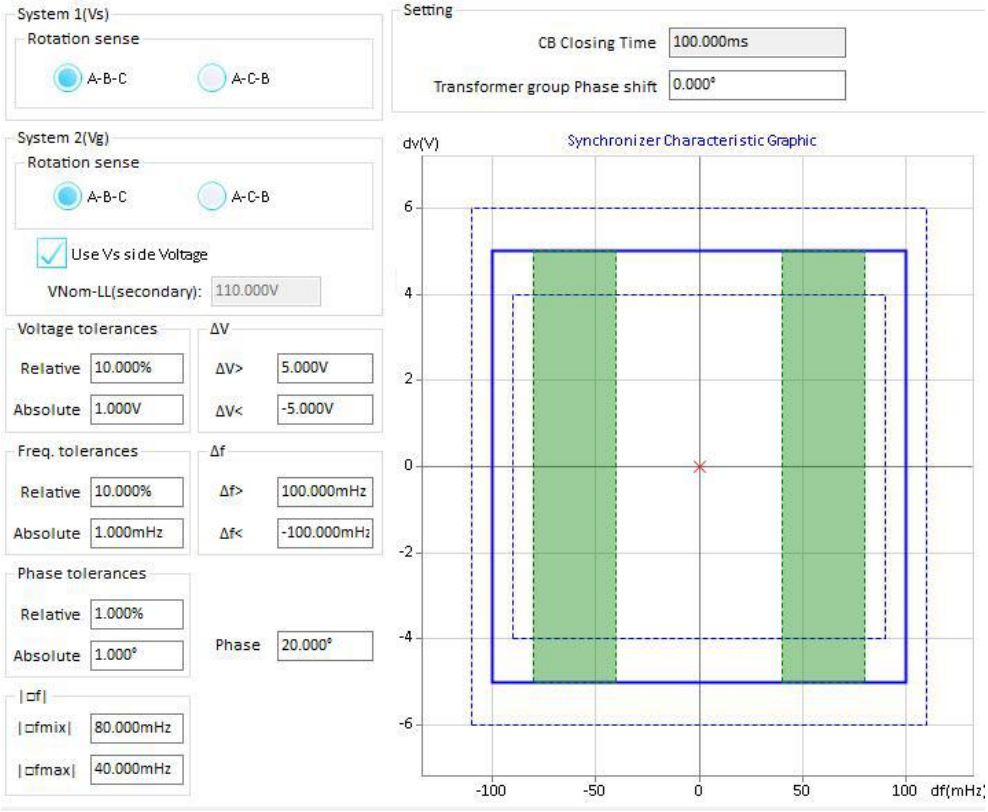
6.5.3 Harmonic

This tab is used to define the harmonic restrain curve and error range within the test object.



Buttons	
Add	Adds the inflection segment defined by the Ixf/Idiff & Idiff pairs
Remove	Deletes the currently selected segment

6.6 Synchronizer



System 1 - Vs

This side simulates the grid-side, serving as the condition for synchronous reference.
Rotation Direction(Vs): Set the phase sequence of the system side.

System 2 - Vg

This side simulates the generator-side, which will be synchronized and connected to the system side.
Rotation Direction(Vg): Set the phase sequence of the side to be paralleled.

Use Vs side voltage

Enable this option to automatically set the voltage on the generator side to match that of the system side; otherwise, it allows the user to manually define the rated voltage value for the generator side.

Setting

CB Closing Time	Display the circuit breaker closing time, which defaults to the setting from the"CB" object page and can be manually adjusted by the user.
Transformer group phase shift	This value is defined by the characteristics of the coupling transformer, representing the inherent phase difference between the system side and the side awaiting synchronization.

Synchronizer Characteristic

Voltage tolerance △v	Set maximum tolerance of △v> and △v<, Obtain the maximum value between the relative and the absolute values.
Freq. tolerance △f	Set maximum tolerance of △f> and △f<, Obtain the maximum value between the relative and the absolute tolerances.
Phase tolerance	Determine the phase shift between the Vs and Vg sides through the circuit

	breaker closing delay and the coupling transformer, and ascertain their maximum allowable error; take the larger value between the relative tolerance and the absolute tolerance.
Dead Zones △fmin & △fmax	The dead zone refers to the range within which a synchronizing relay does not output any voltage or frequency control commands.

6.7 CB (Circuit Breaker)

The Circuit Breaker Object configures the CB trip and closes the command delay time while simulates the real connection from CB auxiliary contacting 52a and 52b during trip and closing.

7. Test Modules

7.1 AC Test

The AC test module implements basic functions, allowing users to manually or automatically set parameters such as voltage, current, and frequency for static or ramping output.

Prerequisites for testing

This module does not require a pre-defined test object, but defining a distance object can greatly assist in selecting test points when using the Z-x mode.
Define hardware configurations, wiring, and trip signal settings.
In the test parameter interface, define set mode, variables, Quantity, and pre-fault conditions.

Button and Options

 F2	In manual mode, increase the value of current variables; In automatic mode, start fault simulation in positive direction by step value. If step value > 0, then the limit value must > current variable setting; else while step value < 0, the limit value must < current variable setting. Keyboard shortcut is "F2"
 F3	The function is opposite to the  button Keyboard shortcut is "F3"
	Lock the current output value, allow adjustment of the analog value to your desired, then release this button for a transient signal. This button is only available in manual mode.
Stop on Trigger	Enable this option for automatically stop outputting once the Result Trigger Logic is received. Otherwise, the test will still output fault values for the pre-set duration of time.
Pickup & Drop	Enable this option for test the pickup & drop off function automatically at one time. Note: This option will disable the **Prefault** and **Fault Interval** state.
Auto Step	Enable this option to switch to automatically increasing or decreasing the step size based on the set time interval (auto-ramping mode).

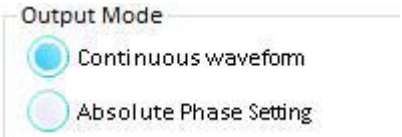
Pre-Fault & Fault Interval

Only after the "Auto Step" is activated, do the Pre-Fault and Fault Interval settings take effect. Please refer to the details for more information： Ramping mode

Variable Setting

Provide variable selection, it can be any channel(s) and any quantity of amplitude, phase angle or frequency.

Wave Output Mode



Continuous waveform	Set the output phase angle as continuous waveform while state changing.
Absolute phase setting	Set the output phase angle as absolute setting while state changing.

U Aux-N Mode

Manual	This option allows users to manually define the UX output.
+U0, -U0, +√3U0, -√3U0 +3U0, -3U0, +√3*3U0, -√3*3U0	These option patterns will be automatically calculated by the software based on the values of UA, UB, and UC in group 1, resulting in a vector sum that is output through the UX channel.

7.1.1 Set Mode

11 output modes are provided
The number of available channels on the interface will automatically adapt based on the varying quantity of voltage/current channels in the test equipment hardware.

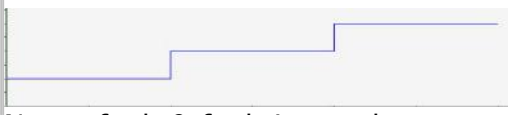
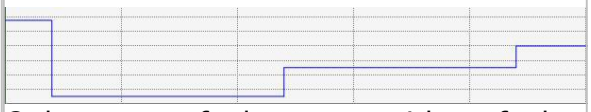
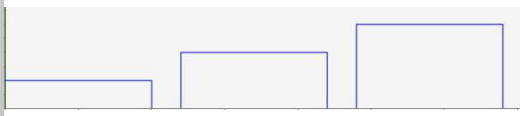
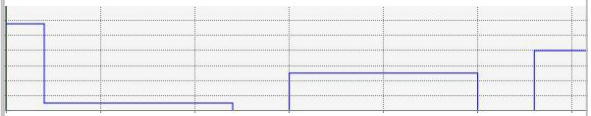
1. Direct	Set Line-Neutral values.
2. Line-Line	Symmetrical, allow set line-line voltage, V0, phase currents and angles, All the frequency value is received from the Fnom of Device tab in Test Object.
3. Symmetrical	Provide the settings for V1, V2, V0, I1, I2, I0 and angles.
4. Power	Provide the settings for real power(W), reactive power(var), phase voltages and angles
5. Fault Values	Provide the settings for fault type, voltage, current and angle
6. Z-I Const	Provide the settings for the fault type, fault impedance and test current. the fault voltage calculated by module. If the fault voltage greater than Vnom*0.9, module will automatically reduce the test current.
7. Z-V Const	Provide the settings for the fault type, fault impedance and test voltage. The fault current is calculated by the module. If the fault current is greater than Imax output, the module will automatically reduce the test voltage.
8. Z-Zs Const	Provide the settings for the fault type, fault impedance and SIR, the fault current and voltage is calculated by the module. ZS = ZL*SIR, ZL is line impedance, by default, the grounding factor of ZS equal to ZL's grounding factor.
9. Z%-I Const	Provide the settings for the fault type, fault impedance in % of selected relative zone impedance, and the test current, the fault voltage is calculated by the module. If the fault voltage is greater than Vnom*0.9, the module will automatically

	reduce the test current.
10. Z%-V Const	Provide the settings for the fault type, fault impedance in % of selected relative zone impedance, and the test voltage, the fault current is calculated by the module. If the fault current is greater than Imax output, the module will automatically reduce the test voltage.
11. Z%-Zs Const	Provide the settings for the fault type, fault impedance in % of selected relative zone impedance and SIR, ZS = ZL*SIR, ZL is line impedance, by default, the grounding factor of ZS equal to ZL's grounding factor.

When selecting the test mode as Z-I, Z-V, Z-Zs, Z%-I, Z%-V, Z%-Zs Const modes, the user can pickup a test impedance from the impedance view with mouse click to get the test point.
The grounding factor and test line length will use the Distance object to define the parameters.

7.1.2 Ramping mode

Ramping modes is different according to whether the mode is active during the "Prefault" and "Interval time" period:

Prefault & Fault Interval	Disabled "Output once only"	Enabled "Output once only"
Normal ramping mode: ☐ Prefault ☐ Fault Interval	 No prefault & fault interval	n/a
Ramping with Prefault: ☑ Prefault ☐ Fault Interval	 Output pre-fault time before each step change, with no fault interval.	 Only one pre-fault output, with no fault interval.
Ramping with Fault Interval: ☐ Prefault ☑ Fault Interval	 No pre-fault time, but output a fault interval after each step change.	n/a
Ramping with Prefault and Fault Interval: ☑ Prefault ☑ Fault Interval	 Each step change outputs both a pre-fault and a fault interval time.	 Only the first time has a pre-fault, with a fault interval after each step change.

7.1.3 Fault Trigger Logic

Users can choose the "AND" or "OR" logic for binary inputs, as well as the number of binary inputs required.

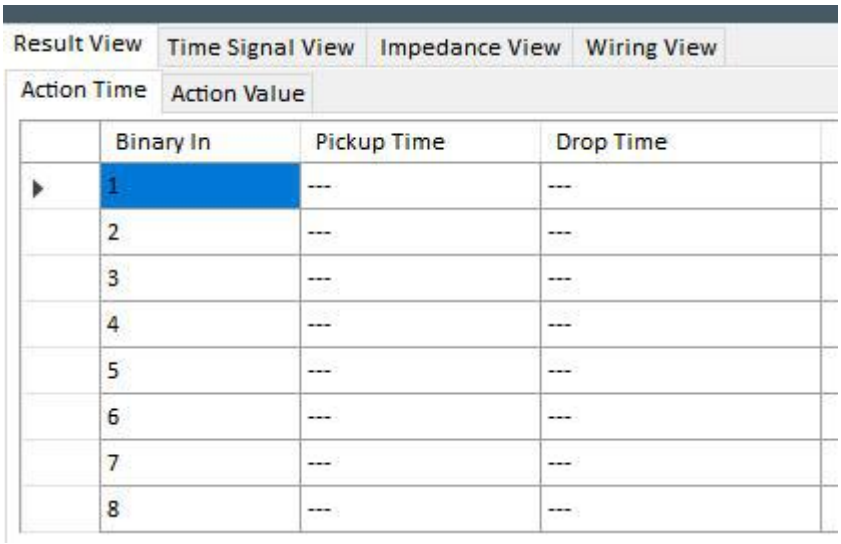
Icon Descriptions:

	Means binary input is activated and the trigger mode is automatically detected;
	Means binary input is activated and the trigger mode only accepts the raise signal(0 -> 1).
	Means binary input is activated and the trigger mode only accepts the drop signal(1 -> 0).
	Means binary input is deactivated.

The status of each input ports is automatically saved while the testing has started. All of the ports detects the turnover trigger signals independently.

The turnover conditions of each binary inputs must fulfill the Deglitch Filter time;

7.1.4 Result View



In the results view, there are two separate tabs that record the action times of binary inputs and the action values of test variables.

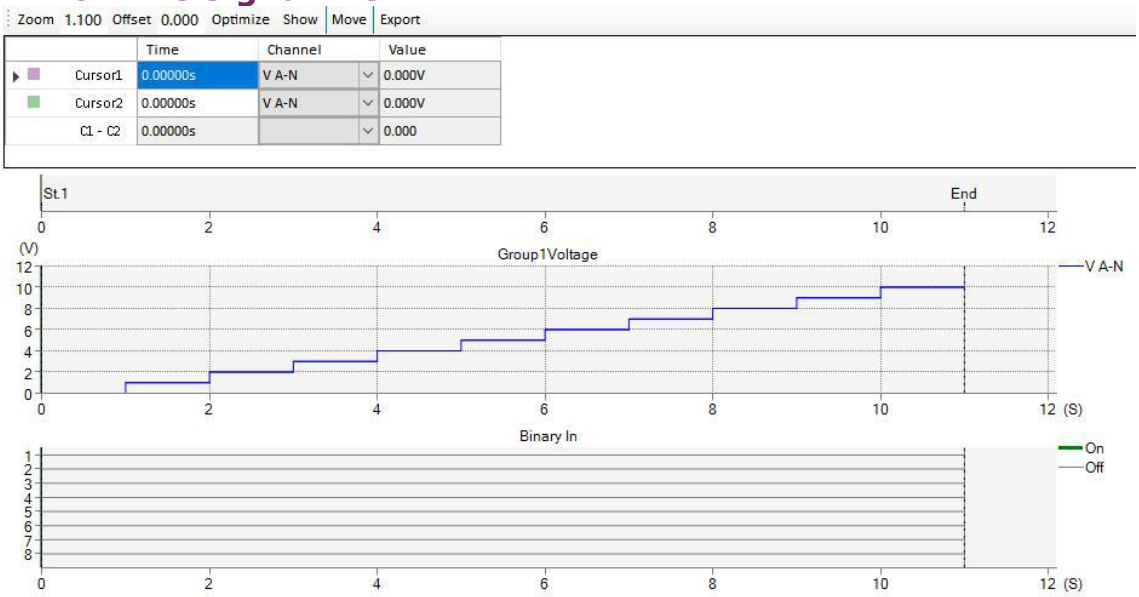
7.1.5 Impedance View

The impedance view automatically refreshes based on the currently corresponding fault type.

The impedance characteristics displayed in the impedance view represent the secondary side impedance settings of the protection device.

When selecting test modes such as Z-I, Z-V, Z-Zs, Z%-I, Z%-V, Z%-Zs constants, users can directly add impedances by selecting points with the mouse on the impedance view.

7.1.6 Time Signal View



The time signal diagram consistently displays the test output signals and binary status, which are calculated prior to the test and then redrawn following the completion of the test. The time signal view for the AC module is only valid under "auto step" enabled.

Buttons:

Zoom	Set the scaling of zoom, default scaling set as 1.1
Offset	Set the definite offset time from the start signal
Optimize	Quickly zoom the TimeChart to the default scaling
Show	The system allows users to select the desired channel time chart to view and also enables them to switch between displaying a Polyline chart or a waveform graph. By default, the Polyline chart is displayed.
Move	A toggle button to activate/deactivate the "Move" function to move the graphic right/left. When the "Move" option is unchecked, you can drag a region on the time signal graph using your mouse. Upon releasing the mouse button, the software will automatically zoom in or out according to the dragged area.
Export	Save the current time signal graph to a COMTRADE format file for playback.

Place the focus on the time signal view, and scrolling the mouse allows for continuous zooming in/out of the signals view.

7.1.7 Wiring View

Displays the corresponding wiring diagram based on the amplifier output configuration in the current hardware setup. (Applies only to analog outputs from the amplifier.)

7.2 Ramping

The Ramping module allows users to edit and manage a ramping state table, which can contain multiple ramping states. Each ramping state can also include multiple variables.

This module's functionality is similar to the automatic testing feature of the AC test module, but it is more powerful than the AC test module. Each ramping state is similar to an automated test within the AC test module.

After setting the tuning parameters and deviation values, the software can automatically determine whether the test results are qualified.

Prerequisites for testing

This module does not require pre-defined test objects, but the step of defining test objects is still very useful for testing.
Define hardware, wiring, and trip signals.
Define ramping states, variables, initial and end values, step size, ramping time, etc.
Define pre-fault states and fault interval states as needed.

Buttons

Add State	Add a state at the end of the list;
Add Variable	Add a variable to the current state;
Remove	Delete a variable. If it is the only variable in the current state, delete the current state.;
Copy	Copy and generate a state identical to the current state.;
Up	Move the state at the current cursor position up in the sorting order;
Down	Move the state at the current cursor position down in the sorting order;
	Move the cursor between states and toggle the selected state.;

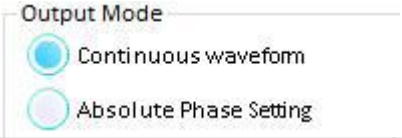
Column of the state list:

Group	Select the group to apply the variables.
Channel	Select the analog output channels to apply the variable. The selectable list will refresh as per to the test mode changed.
Variable	A manifestation of the selected variable. It will refresh as the variable changes.
From	The starting value that the variable will ramp from
To	The stop value that the variable will ramp to
Step	The step value that the variable will be changed to during the ramping process;
△t	Ramping time of each steps
Test Time	This time is automatically calculated as per to the From, To, Step, Time settings
Trigger	The Trigger defines the initial condition (Pre-fault state) for the start of the ramping.

Prefault & Fault Interval

The Pre-fault and fault interval can be activated or deactivated by the user.
Details refer to: Ramping mode

Wave Output Mode



Continuous waveform	Set the output phase angle as continuous waveform while state changing.
Absolute phase setting	Set the output phase angle as absolute setting while state changing.

U Aux-N output

If the U-Aux channel is not selected as a variable, it can be independently output.

Manual	This option allows users to manually define the UX output.
+U0, -U0, +√3U0, -√3U0 +3U0, -3U0, +√3*3U0, -√3*3U0	These option patterns will be automatically calculated by the software based on the values of UA, UB, and UC in group 1, resulting in a vector sum that is output through the UX channel.

7.2.1 Set Mode

11 output modes are provided
The number of available channels on the interface will automatically adapt based on the varying quantity of voltage/current channels in the test equipment hardware.

1. Direct	Set Line-Neutral values.
2. Line-Line	Symmetrical, allow set line-line voltage, V0, phase currents and angles, All the frequency value is received from the Fnom of Device tab in Test Object.
3. Symmetrical	Provide the settings for V1, V2, V0, I1, I2, I0 and angles.
4. Power	Provide the settings for real power(W), reactive power(var), phase voltages and angles
5. Fault Values	Provide the settings for fault type, voltage, current and angle
6. Z-I Const	Provide the settings for the fault type, fault impedance and test current. the fault voltage calculated by module. If the fault voltage greater than Vnom*0.9, module will automatically reduce the test current.
7. Z-V Const	Provide the settings for the fault type, fault impedance and test voltage. The fault current is calculated by the module. If the fault current is greater than Imax output, the module will automatically reduce the test voltage.
8. Z-Zs Const	Provide the settings for the fault type, fault impedance and SIR, the fault current and voltage is calculated by the module. ZS = ZL*SIR, ZL is line impedance, by default, the grounding factor of ZS equal to ZL's grounding factor.
9. Z%-I Const	Provide the settings for the fault type, fault impedance in % of selected relative zone impedance, and the test current, the fault voltage is calculated by the module. If the fault voltage is greater than Vnom*0.9, the module will automatically reduce the test current.
10. Z%-V Const	Provide the settings for the fault type, fault impedance in % of selected relative zone impedance, and the test voltage, the fault current is calculated by the module. If the fault current is greater than Imax output, the module will automatically reduce the test voltage.
11. Z%-Zs Const	Provide the settings for the fault type, fault impedance in % of selected relative zone impedance and SIR, ZS = ZL*SIR, ZL is line impedance, by default, the grounding factor of ZS equal to ZL's grounding factor.

When selecting the test mode as Z-I, Z-V, Z-Zs, Z%-I, Z%-V, Z%-Zs Const modes, the user can pickup a test impedance from the impedance view with mouse click to get the test point.
The grounding factor and test line length will use the Distance object to define the parameters.

7.2.2 Trigger Logic

Users can choose the "AND" or "OR" logic for binary inputs, as well as the number of binary inputs required.

Icon Descriptions:

	Means binary input is activated and the trigger mode is automatically detected;
	Means binary input is activated and the trigger mode only accepts the raise signal(0 -> 1).
	Means binary input is activated and the trigger mode only accepts the drop signal(1 -> 0).
	Means binary input is deactivated.

The status of each input ports is automatically saved while the testing has started. All of the ports detects the turnover trigger signals independently.

The turnover conditions of each binary inputs must fulfill the Deglitch Filter time;

7.2.3 Result View

The result view is divided into two parts: Ramp measurements and calculated condition.

Ramp Measurements

Name	Ramp	Group	Signal	Setting	Dev. -	Dev. +	Actual	Dev.	T. Trip	Assessment
Result1	St.1	Group1	Var.1	0.000V	0.000V	0.000V	---	---	---	No Test
Result2	St.1	Group1	Var.2	0.000V	0.000V	0.000V	---	---	---	No Test
Result1	St.2	Group1	Var.1	0.000V	0.000V	0.000V	---	---	---	No Test
Result2	St.2	Group1	Var.2	0.000V	0.000V	0.000V	---	---	---	No Test

Calculated Condition

Name	Function	X	Y	Setting	Dev. -	Dev. +	Actual	Dev.	Assessment
Calculate1	X/Y	Result1	Result1	0.000	0.000	0.000	---	---	No Test

Ramp measurement

The Ramp measurement is automatically generated based on the added ramping states and variables, but users can add set values, positive/negative deviation values to the list for automatic assessment by the program.

The trip time mentioned here is for reference only and not used for evaluation. For precise measurement of trip time, please use state sequences or other dedicated testing modules.

Columns：	
Name	It can be customized by the user to identify the evaluated item in the output report;
Ramp, Group, Signal	Automatically corresponds to the corresponding variable channel of the current ramping state;
Setting	Enter a reference value for evaluation; usually a set value for a voltage, current,

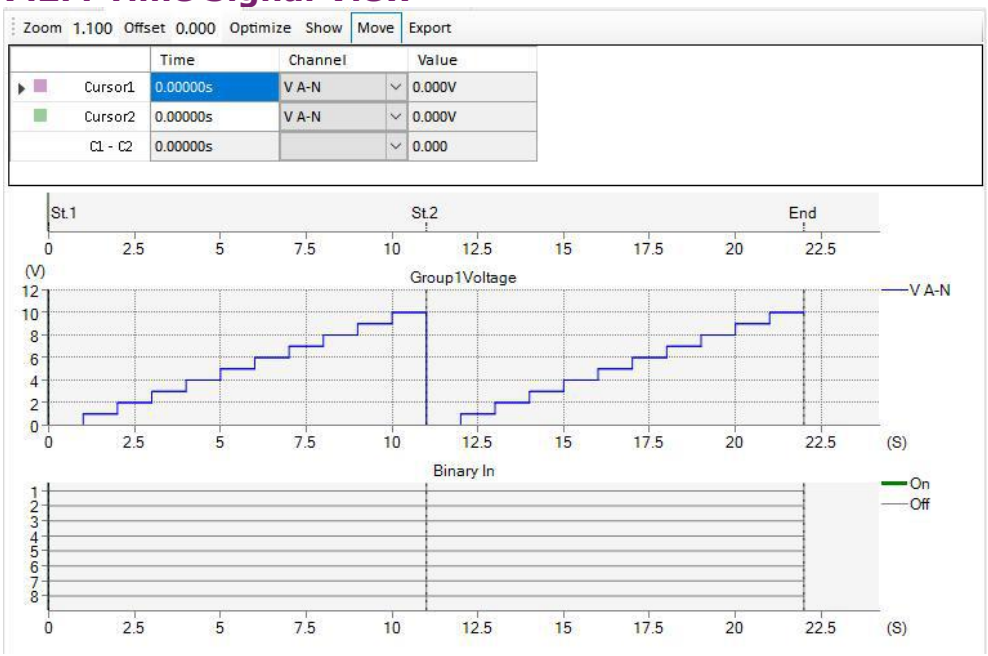
	or impedance; (corresponding to the current variable)
Dev. -	Enter a value for the negative deviation range; (absolute value)
Dev. +	Enter a value for the positive deviation range; (absolute value)
Actual	The actual action value of the currently selected variable; valid after the test finishes;
Dev.	According to the setting value and the Actual value, the calculation is obtained;
T.Trip	Actual action time; (for reference only, not for evaluation)
Assessment	The program automatically gives the evaluation a conclusion according to the setting value, the actual value and the deviation value.

Calculated Condition

When there are more than one ramping state, it can be further calculated by calculating the conditions. For example, in order to calculate the return coefficient, the action value can be measured by the ramping state one, and the return value can be measured by the ramping two, and then the return coefficient can be calculated by defining the formula "result 2 / result 1".

Six function equations are provided for the user to select, and then the setting value and positive and negative deviation can be set like the Ramp measurement to automatically evaluate the new results.

7.2.4 Time Signal View



The time signal diagram consistently displays the test output signals and binary status, which are calculated prior to the test and then redrawn following the completion of the test.

Buttons:

Zoom	Set the scaling of zoom, default scaling set as 1.1
Offset	Set the definite offset time from the start signal
Optimize	Quickly zoom the TimeChart to the default scaling
Show	The system allows users to select the desired channel time chart to view

	and also enables them to switch between displaying a Polyline chart or a waveform graph. By default, the Polyline chart is displayed.
Move	A toggle button to activate/deactivate the "Move" function to move the graphic right/left. When the "Move" option is unchecked, you can drag a region on the time signal graph using your mouse. Upon releasing the mouse button, the software will automatically zoom in or out according to the dragged area.
Export	Save the current time signal graph to a COMTRADE format file for playback.

Place the focus on the time signal view, and scrolling the mouse allows for continuous zooming in/out of the signals view.

7.2.5 Impedance View

The impedance view automatically refreshes based on the currently corresponding fault type.
The impedance characteristics displayed in the impedance view represent the secondary side impedance settings of the protection device.
When selecting test modes such as Z-I, Z-V, Z-Zs, Z%-I, Z%-V, Z%-Zs constants, users can directly add impedances by selecting points with the mouse on the impedance view.

7.2.6 Wiring View

Displays the corresponding wiring diagram based on the amplifier output configuration in the current hardware setup. (Applies only to analog outputs from the amplifier.)

7.3 State Sequencer

This module allows defining a series of states. It can be used to test trip time or other time measurements.

States Tool Buttons and Options

	Append a state to the last.
	Insert a state before the current state
	Copy the current state and append to the last one
	Delete the current state
	Navigate the state to First/Previous/Next/Last
	Display the current position of the state and the total number of states.
	Exchange the state sequence with previous (Move Up) or next (Move Down) state

7.3.1 Set Mode

11 output modes are provided

The number of available channels on the interface will automatically adapt based on the varying quantity of voltage/current channels in the test equipment hardware.

1. Direct	Set Line-Neutral values.
2. Line-Line	Symmetrical, allow set line-line voltage, V0, phase currents and angles, All the frequency value is received from the Fnom of Device tab in Test Object.
3. Symmetrical	Provide the settings for V1, V2, V0, I1, I2, I0 and angles.
4. Power	Provide the settings for real power(W), reactive power(var), phase voltages and angles
5. Fault Values	Provide the settings for fault type, voltage, current and angle
6. Z-I Const	Provide the settings for the fault type, fault impedance and test current. the fault voltage calculated by module. If the fault voltage greater than Vnom*0.9, module will automatically reduce the test current.
7. Z-V Const	Provide the settings for the fault type, fault impedance and test voltage. The fault current is calculated by the module. If the fault current is greater than Imax output, the module will automatically reduce the test voltage.
8. Z-Zs Const	Provide the settings for the fault type, fault impedance and SIR, the fault current and voltage is calculated by the module. ZS = ZL*SIR, ZL is line impedance, by default, the grounding factor of ZS equal to ZL's grounding factor.
9. Z%-I Const	Provide the settings for the fault type, fault impedance in % of selected relative zone impedance, and the test current, the fault voltage is calculated by the module. If the fault voltage is greater than Vnom*0.9, the module will automatically reduce the test current.
10. Z%-V Const	Provide the settings for the fault type, fault impedance in % of selected relative zone impedance, and the test voltage, the fault current is calculated by the module. If the fault current is greater than Imax output, the module will automatically reduce the test voltage.
11. Z%-Zs Const	Provide the settings for the fault type, fault impedance in % of selected relative zone impedance and SIR, ZS = ZL*SIR, ZL is line impedance, by default, the grounding factor of ZS equal to ZL's grounding factor.

When selecting the test mode as Z-I, Z-V, Z-Zs, Z%-I, Z%-V, Z%-Zs Const modes, the user can pickup a test impedance from the impedance view with mouse click to get the test point.

The grounding factor and test line length will use the Distance object to define the parameters.

7.3.2 Advance output mode

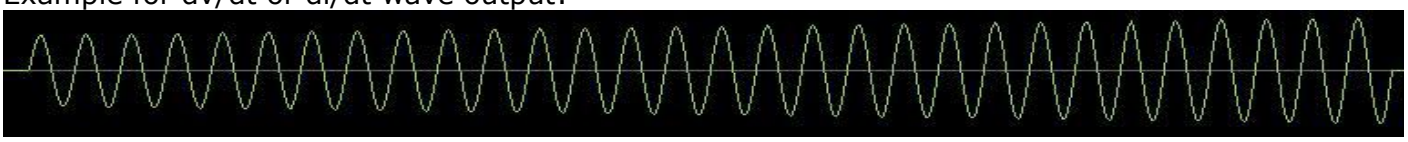
Clicking the "dv/dt,di/dt,df/dt" button in the parameter settings area allows access to advanced options. Here, users can enable linear changes (dv/dt, di/dt, df/dt) for any channel within a state. The initial value for the change is set in the output parameter interface, while the advanced settings page allows for setting the change amount and final value.

Users can also set the closing angle and superimposed non-periodic components for the current state.

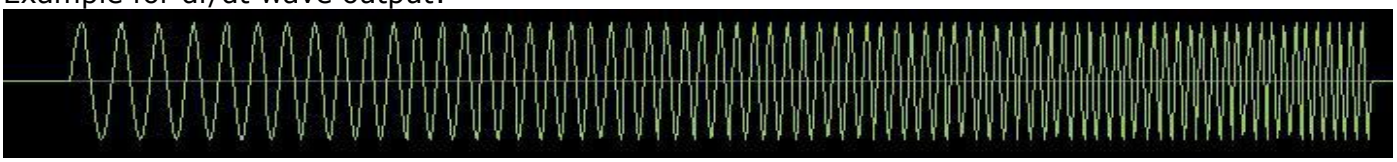
Note:

- The time period of dv/dt and df/dt is limited by the total time duration of the current state. If the state time is longer than that of dv/dt, di/dt or df/dt, then the Voltage or Frequency outputs will remain the end value of dv/dt, di/dt or df/dt until the end of the state.
- When the "dv/dt,di/dt,df/dt" setting is activated, the border of the "dv/dt,di/dt,df/dt" button will turn **red**.

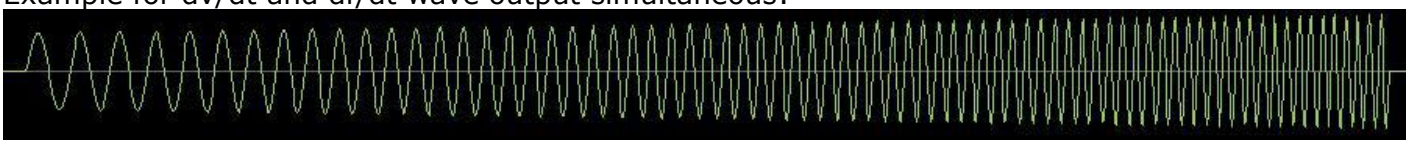
Example for dv/dt or di/dt wave output:



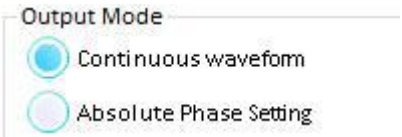
Example for df/dt wave output:



Example for dv/dt and df/dt wave output simultaneous:



Wave Output Mode



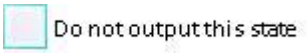
Continuous waveform	Set the output phase angle as continuous waveform while state changing.
Absolute phase setting	Set the output phase angle as absolute setting while state changing.

For the first state, the waveform output mode can only be set to absolute phase angle mode.

U Aux-N Mode

Manual	This option allows users to manually define the UX output.
+U0, -U0, +√3U0, -√3U0 +3U0, -3U0, +√3*3U0, -√3*3U0	These option patterns will be automatically calculated by the software based on the values of UA, UB, and UC in group 1, resulting in a vector sum that is output through the UX channel.

Do not output this state



If this option is activated, during the experiment, this state will be automatically skipped, as if this state does not exist.

7.3.3 Trigger

Define fault triggering or conditions for state changes.

Time	Trigger by time settings
Binary	Trigger by binary input settings logic
Binary + Time	Trigger by both of binary input settings logic and time settings, the smaller of the two will be used
Key-press	Trigger by keyboard command pressed
GPS or IRIG-B	Trigger by a GPS or IRIG-B time setting, usually with a PPS or PPM signal

Icon Descriptions:

	Means binary input is activated and the trigger mode is automatically detected;
	Means binary input is activated and the trigger mode only accepts the raise signal(0 -> 1).
	Means binary input is activated and the trigger mode only accepts the drop signal(1 -> 0).
	Means binary input is deactivated.

The status of each input ports is automatically saved while the testing has started. All of the ports detects the turnover trigger signals independently.

The turnover conditions of each binary inputs must fulfill the Deglitch Filter time;

7.3.4 Binary Out

You can choose the open/closed state of any binary outputs during the output of this state.

7.3.5 Result View

Display the trip time for each binary input signal in the test for all states.
It can also be used to quickly switch between states. When a state is selected with the mouse, the interface automatically switches to display the values of that state.

7.3.6 Event Recorder

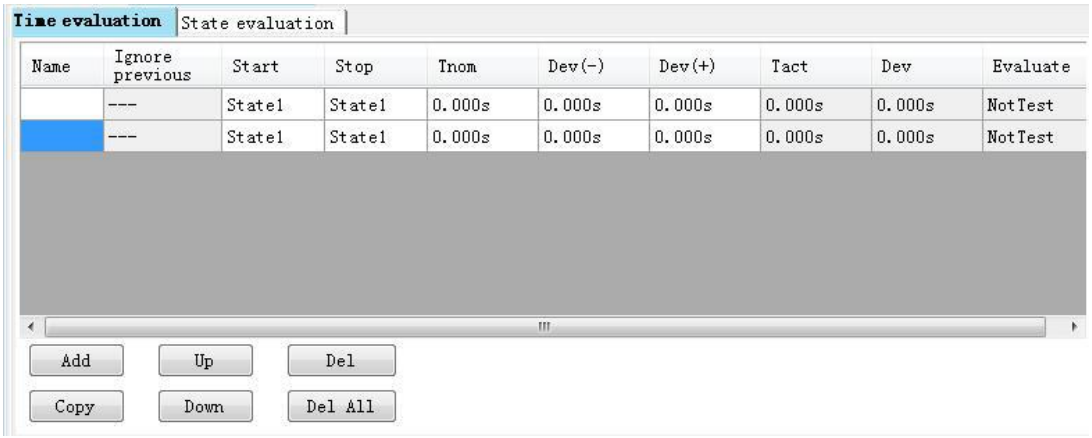
Record the changing states and tripping times of all binary input and output contacts.

7.3.7 Result Evaluation

The result evaluation is divided into time evaluation and state evaluation.
When the state sequence is tested in a repeated loop, the result evaluation is only performed for the first sequence.

7.3.7.1 Time Evaluation

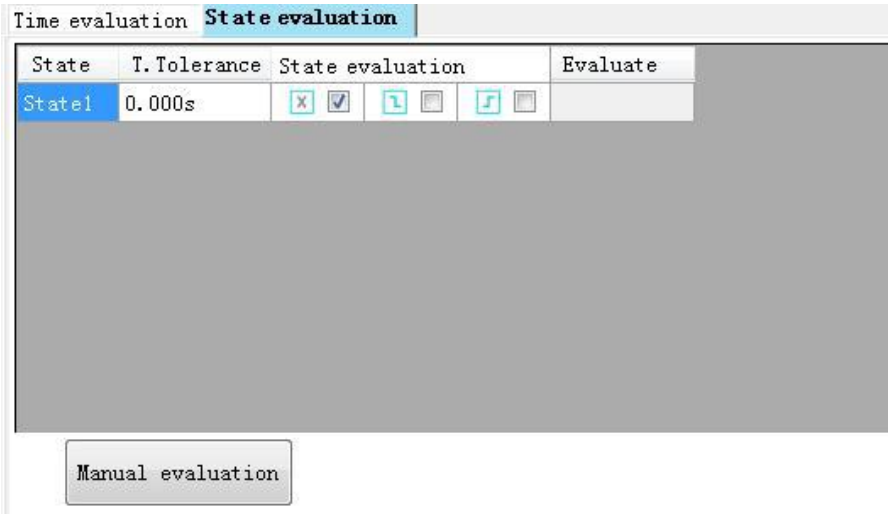
Time evaluation allows users to customarily add any evaluations, and the evaluation results are based on the actual trip time of the state sequence. This evaluation specifically focuses on trip time evaluation. For evaluating the action states of input signals, please use State Evaluation.



Columns:	
Name	It can be customized by the user to identify the evaluated item in the output report;
Ignore previous	When "0-> 1" or "1-> 0" is selected in the "start" item, it is optional to filter interference signals that are not used previously; while the default is blank, it automatically starts from the beginning of state 1.
Start	Select the state while the timer starts, start the timing at the beginning of the state; you can also choose to start the timer according to the action logic "0-> 1" or "1-> 0"; (used in conjunction with ignore previous)
Stop	Select the state while the timer ends, start the timing at the beginning of the state; If the "ignore previous" option is activated, then the evaluation results for the "stop" status can only be obtained after the "ignore previous" state.
T.nom	Enter a reference value for evaluation; usually a set value for trip time;
Dev (-)	Enter a value for the negative deviation range; (absolute value)
Dev (+)	Enter a value for the positive deviation range; (absolute value)
T.act	Actual action time; after the test is completed, it is calculated automatically by the``Start'' and``stop'' state options;
Dev	According to the T.nom value and the T.Act value, the calculation is obtained.
Evaluate	The program automatically gives the evaluation conclusion according to T. Nom, T.act and deviation value.

7.3.7.2 State Evaluation

Time evaluation allows the users to customarily define any evaluation, and the evaluation results are based on the actual binary input status of each sequence. This evaluation is only for the binary inputs status. If you want to evaluate the tripping time, please use the Time Evaluation.



All states are automatically listed here. The users can select the results to be evaluated for each state, and after the test is completed, the program is automatically evaluated according to the action logic of the binary input.

	No evaluation.
	Evaluate whether the binary input logic of the current state is from 1-> 0 (from closed to open)
	Evaluate whether the binary input logic of the current state is from 0-> 1 (from open to closed)

After the test is complete, the user can press "manual evaluation" to modify the status evaluation results, the modified evaluation results only affect the output report.

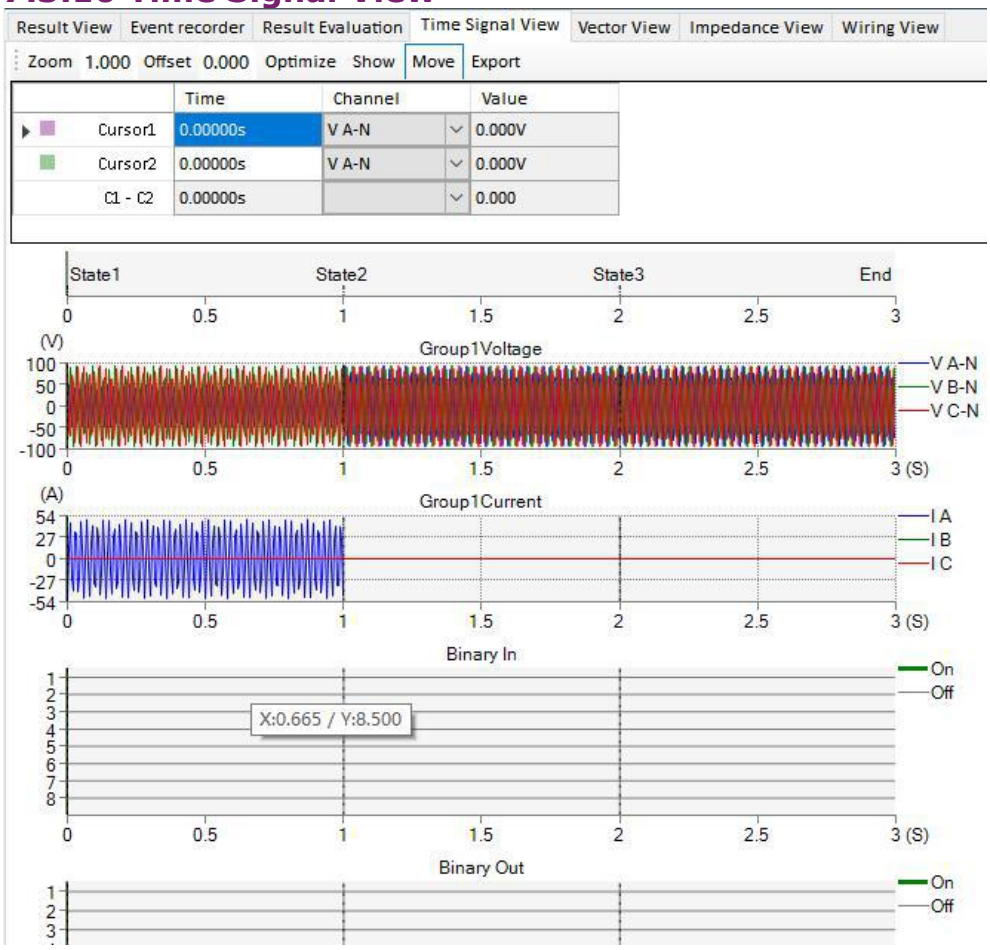
7.3.8 Impedance View

The impedance view automatically refreshes based on the currently corresponding fault type.
The impedance characteristics displayed in the impedance view represent the secondary side impedance settings of the protection device.
When selecting test modes such as Z-I, Z-V, Z-Zs, Z%-I, Z%-V, Z%-Zs constants, users can directly add impedance by selecting points with the mouse on the impedance view.

7.3.9 State Table

Arrange and display all states from left to right, allowing for easy viewing, comparison, or modification of all parameters of each state.

7.3.10 Time Signal View



The time signal diagram consistently displays the test output signals and binary status, which are calculated prior to the test and then redrawn following the completion of the test.

Buttons:

Zoom	Set the scaling of zoom, default scaling set as 1.1
Offset	Set the definite offset time from the start signal
Optimize	Quickly zoom the TimeChart to the default scaling
Show	The system allows users to select the desired channel time chart to view and also enables them to switch between displaying a Polyline chart or a waveform graph. By default, the Waveform chart is displayed.
Move	A toggle button to activate/deactivate the "Move" function to move the graphic right/left. When the "Move" option is unchecked, you can drag a region on the time signal graph using your mouse. Upon releasing the mouse button, the software will automatically zoom in or out according to the dragged area.
Export	Save the current time signal graph to a COMTRADE format file for playback.

Place the focus on the time signal view, and scrolling the mouse allows for continuous zooming in/out of the signals view.

7.3.11 Wiring View

Displays the corresponding wiring diagram based on the amplifier output configuration in the current hardware setup. (Applies only to analog outputs from the amplifier.)

7.4 Frequency Test

The frequency test module provides the functionality to define and perform tests for frequency relays by df/dt, under-frequency, tripping time, dv/dt, under-voltage latch, under-current latch, etc.

The difference of under-frequency / under-voltage protection with other traditional protections.

	Under-frequency / Under-voltage Relay	Traditional relay
Functions	In order to ensure the normal operation of the power network, under-frequency is used to ensure the normal power consumption of important load in order to get rid of the unimportant load when the power load is lacking and the supply is seriously smaller than the demand.	remove the fault equipment in time when the short circuit fault occurs
Protected object	In order to protect the entire power grid	To protect some electrical equipment
Protection principle	When the voltage amplitude on the line (or bus) is felt, the frequency drops slowly below the set value, that is, there is no short circuit fault on the line, but the voltage amplitude is reduced because the load is too large.	When the voltage amplitude on the line (or bus) is felt, the frequency suddenly drops below the set value, that is, a short circuit fault occurring on the line.
The selectivity of the removal device	Removal of normal load in preset order	Removal of fault load

Prerequisites for testing

It is not necessary to set the Test Object prior to testing.

Define the hardware, the routing and wiring and trip commands.

Select test mode, setting the test values and times of states, add to the test table to be performed.

Test Mode

This module contains 2 classify modes for under-frequency relays and under-voltage relays.

Under Frequency:
Frequency
Time
df/dt
Under-U Latch
Under-I Latch
Under Voltage:
Voltage
Time
dV/dt

Common parameters:

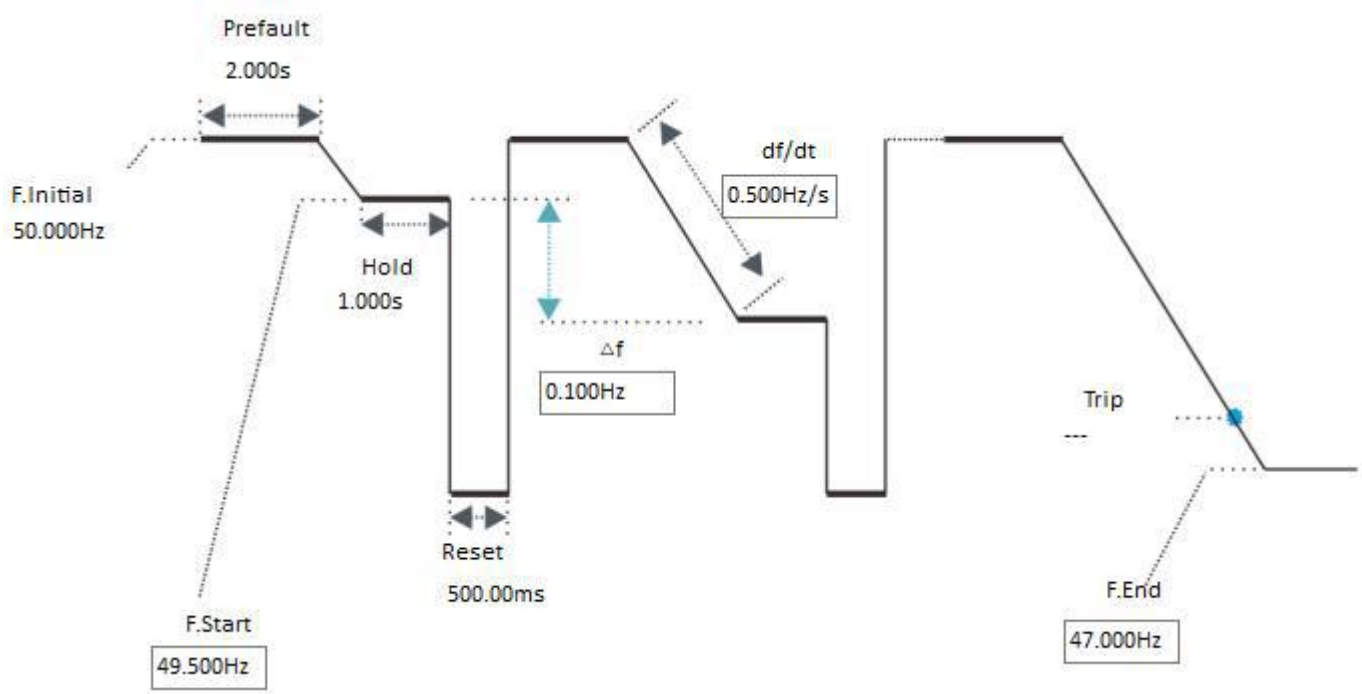
1.	Prefault output	Define the pre-fault voltage, current values, and angle relationships (in a three-phase positive sequence condition).
2.	Prefault time	During the prefault state, using the output config with the starting frequency value.
3.	Interval time	No output in this state.
4.	Fault time	Maximum time of fault state automatically calculated by module.
5.	Hold time	A stable state after the variable slipped if no tripping is met.
6.	Nominal Frequency	Use the Fnom value defined in the Device object.

7.4.1 Under-Frequency

This category is used for testing protection functions related to Frequency slip (df/dt).

7.4.1.1 Frequency

This function aims to check the tripping frequency value of the under-frequency protection.



In the Under-frequency test, the "F. Start" and "F. End" defined the destination frequency value to be ramp, software controlling the frequency signal from "F. Initial" slides to the ramping destination.

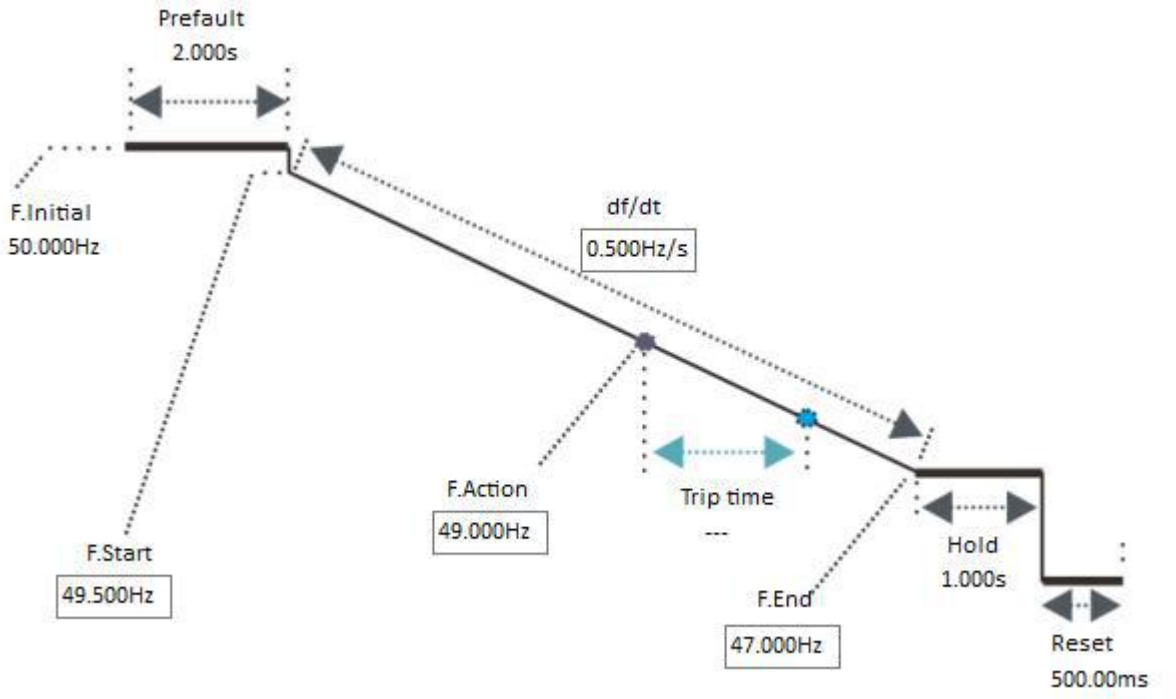
The "F. Start" is required to be greater than the action frequency of the protection setting. If the protection relay has the "F. Start" requirement, it should also be greater than the "F. Start" of the protection. The "F. End" should be set as less than the action frequency of the protection relay to ensure the protection relay can meet the trip conditions.

Parameters:

1.	F.Start	Define the starting value of the end frequency to which the frequency will slide during the test. Typically, this value is set to be greater than the tripping frequency of the protection.
2.	△F	Define the step increment or decrement of the end frequency in each test cycle. Reducing this value can increase the precision of the test results.
3.	F.End	Define the final value of the end frequency to which the frequency will slide during the test. Typically, this value should ensure that the protection can trip properly and is usually set to be lower than the tripping frequency of the protection. **Note:** Usually, this value needs to be greater than 45 Hz. It can cause the protection relay to be blocked and ensure the validity of the test results.
4.	df/dt	Define the slip df/dt from the starting frequency to the end frequency. Typically, this value is set to be lower than the protection df/dt latch value.

7.4.1.2 Time (#Under-Frequency)

This function aims to check the tripping time of under-frequency protection.



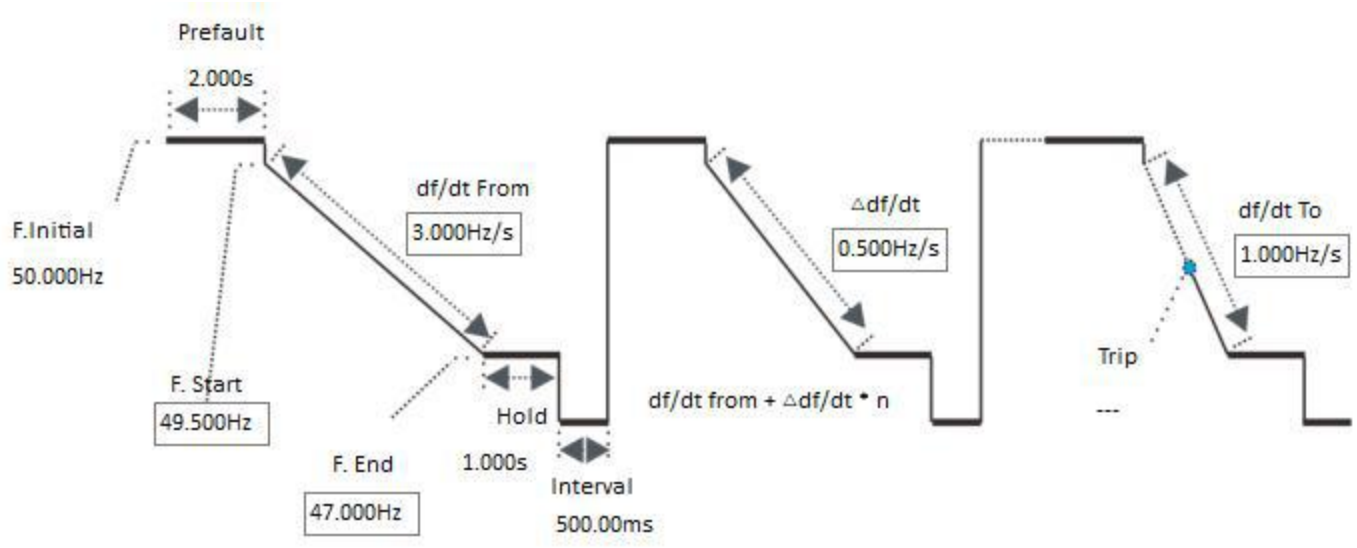
The method of measuring the action time is: the frequency slides from the "F. Start" value to the "F. End" value, and waits for the protection relay to meet the trip condition. During testing, the "F. End" value should be set slightly less than the action frequency setting of the protection relay to ensure the successful action of tripping.

Parameters:

1.	F.Start	Defined the initial frequency on start. Usually is set to Fnom.
2.	F.Action	Defined the start point of timer of a particular frequency. Usually this value is the tripping frequency of the protection.
3.	F.End	Defined the destination frequency value.
4.	df/dt	Defined the slip from the start frequency to the destination frequency. This value must be less than the df/dt latch value of the protection relay.

7.4.1.3 df/dt

This function aims to check the df/dt latch value of under-frequency protection



In the df/dt latch test, The frequency slides from the "F. Start" to the "F. End" according to the defined "df/dt" slip value, this is a test cycle; the "df/dt" is fixed in each cycle, and it ramps from "df/dt From" to "df/dt To" with "△ df/dt" settings in every next cycles.

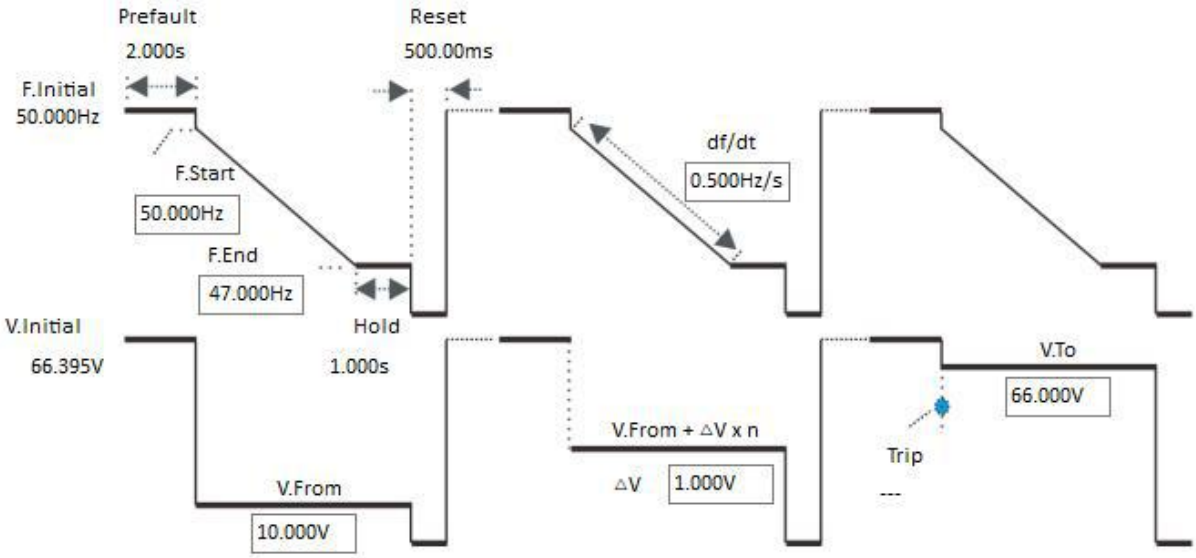
The process of this test is that when the test has started, the start df/dt value set as greater than the slips setting of the protection relay, the protection is in the disallowed action status, and then the df/dt value is adjusted to be less than the slip latch value. While the protection has tripped, at this time, the current df/dt value is recorded, and the df/dt latch value is to be calculated.

Parameters:

1.	F. Start	Defined the initial frequency once each steps have started. Usually is set to Fnom.
2.	F. End	Defined the destination frequency value. Must less than tripping frequency settings.
3.	df/dt From	Defined the start df/dt slip value. This value has to be great than df/dt latch value of the protection relay, to make the protection relay in the lockout status.
4.	df/dt To	Defined the destination df/dt slip value. This value has to be less than df/dt latch value of the protection relay, to make the protection relay into the trip permit status.
5.	△df/dt	Defined the ramping step df/dt value from start df/dt to destination df/dt. Reducing this value can increase the accuracy of the test result.

7.4.1.4 Under-U Latch (#Under-Frequency)

This function aims to check the under-voltage latch value of df/dt protection.



In the under-U latch test, The frequency slides from the "F. Start" to the "F. End" according to the defined "df/dt" value, this is a test cycle;

At the same time, there is a fixed voltage output value in every cycle, and it is ramping from "V. From" to "V. To" with "△V" settings in every next cycles.

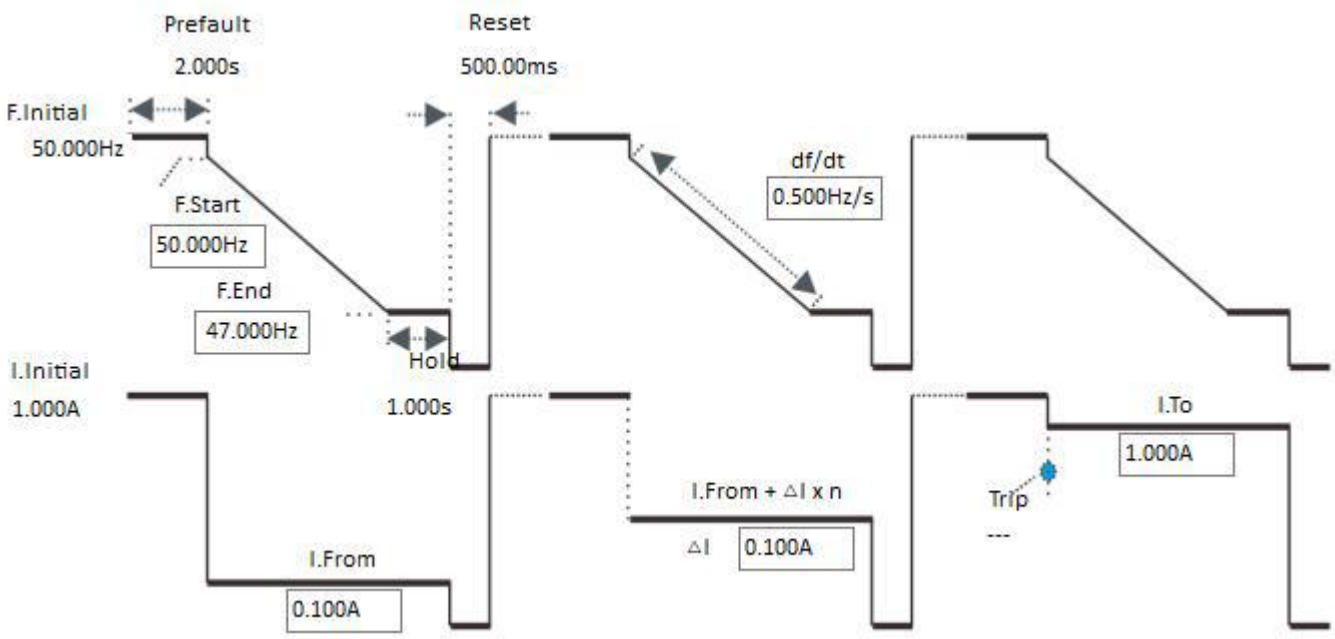
The process of this test is that when the test has started, the "V. From" is set as less than the under-U latch value of the protection, so the protection is in the disallowed action status, and then the voltage value is increased to be greater than the under-U latch value. While the protection has tripped, at this time, the voltage value is recorded, and the under-U latch value to be calculated.

Parameters:

1.	F.Start	Defined the initial frequency on the beginning of each steps . Usually is set to Fnom.
2.	F.End	Defined the destination frequency value. Needs to be be less than the tripping frequency settings.
3.	df/dt	Defined the slip from the start frequency to the stop frequency. Usually this value should be less than the df/dt latch value of protection relay.
4.	V.From	Defined the testing under-voltage start value. This value must make the protection relay into the lockout status.
5.	V.To	Defined the testing under-voltage destination value. This value has to make the protection relay into the trip permit status. Usually it can be set to Vnom.
6.	△V	Defined the ramping step voltage from the start to the destination under-voltage. Reducing this value can increase the accuracy of test result.

7.4.1.5 Under-I Latch (#Under-Frequency)

This function aims to check the under-current latch value of df/dt protection.



In the under-I latch test, The frequency slides from the "F.Start" to the "F.End" according to the defined "df/dt" value, this is a test cycle;

At the same time, there is a fixed current value outputs in every cycle, and it is ramping from the "I. From" to "I. To" with "△I" settings in every next cycles.

The process of this test is that when the test has started, the "I. From" is set as less than the under-I latch value of the protection, so the protection is in the disallowed action status, and then the current value is increased to become great than the under-I latch value. While the protection has tripped, at this time, the current value is recorded, and the under-I latch value to be calculated.

Parameters:

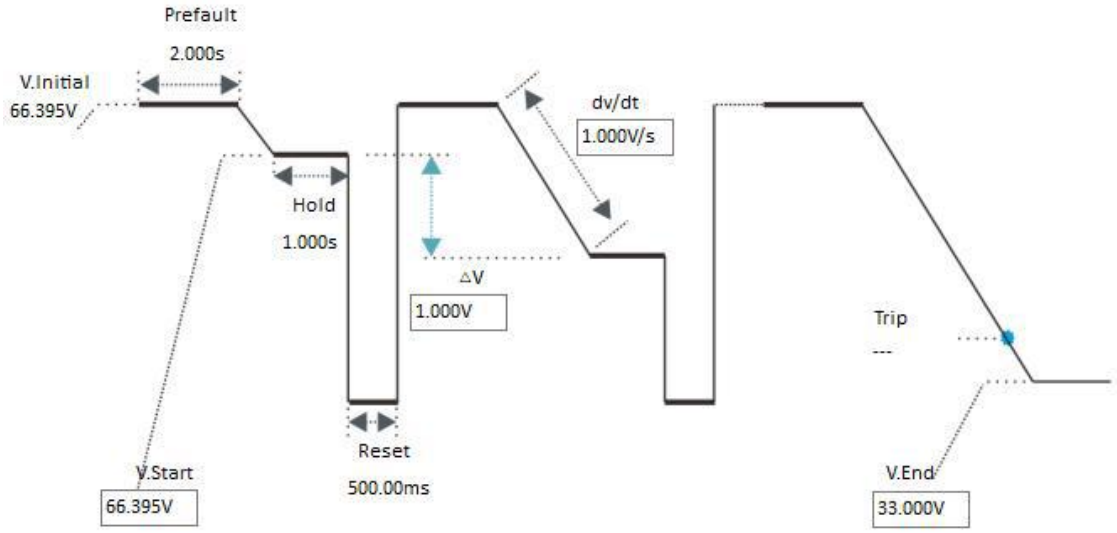
1.	F.Start	Defined the initial frequency on each the beginning of each steps. Usually is set to Fnom.
2.	F.End	Defined the destination frequency value. to be less than the tripping frequency settings.
3.	df/dt	Defined the slip from the start frequency to the stop frequency. Usually this value should be less than the df/dt latch value of protection relay.
4.	I.From	Defined the testing under-current start value. This value must make the protection relay into the lockout status.
5.	I.To	Defined the testing under-current destination value. This value has to make the protection relay into the trip permit status. Usually it can be set to be great than 1.2*Ipickup.
6.	△I	Defined the ramping step current from the beginning to the destination under-current. Reducing this value can increase the accuracy of test result.

7.4.2 Under-Voltage

This category is used for testing protection functions related to voltage slip (dv/dt).

7.4.2.1 Voltage

This function aims to check the tripping voltage value of the under-voltage protection.



In the Under-voltage test, the "V. Start" and "V. End" defined the destination value to be ramp, software controlling the voltage signal from "V. Initial" slides to the ramping destination.

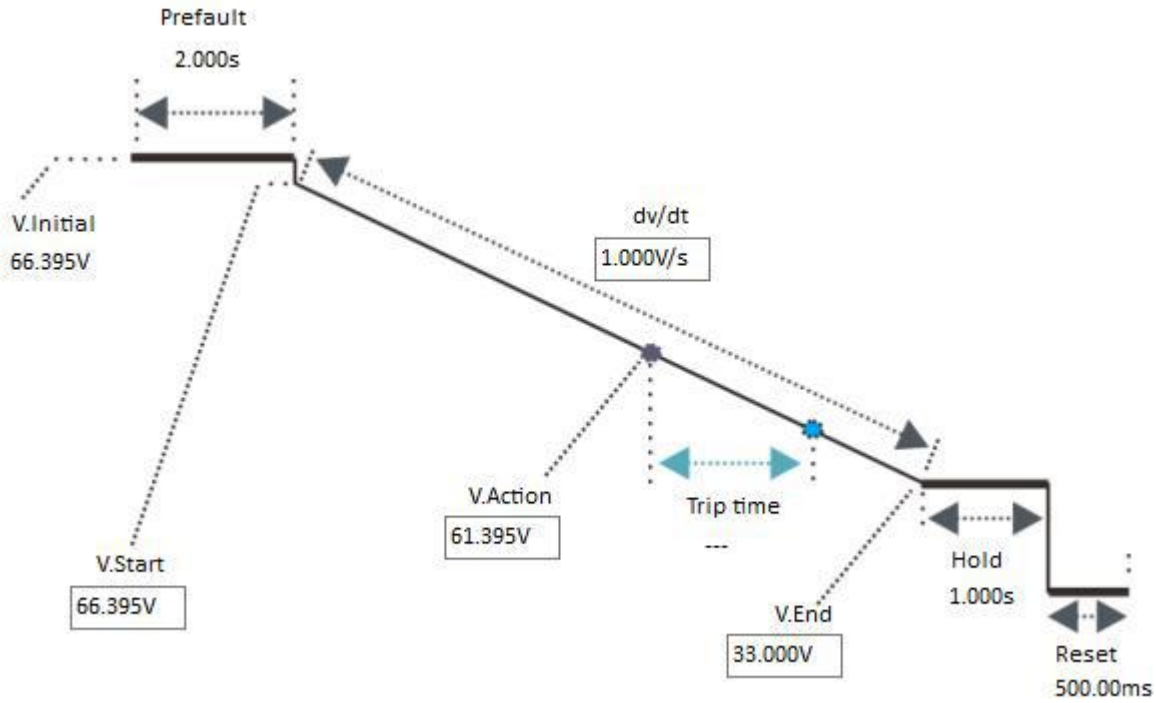
the "V. Start" is required to be greater than the action under-voltage of the protection setting. "V. End" is set as less than the action under-voltage of the protection relay to ensure the protection relay can meet the trip conditions.

Parameters:

1.	V. Start	Define the starting value of the end voltage to which the voltage will slide during the test. Typically, this value is set to be greater than the tripping voltage of the protection.
2.	△V	Defined the ramping step voltage value from the "V. Initial" to the destination voltage. Reducing this value can increase the accuracy of test result.
3.	V. End	Define the final value of the end voltage to which the voltage will slide during the test. Typically, this value should ensure that the protection can trip properly and is usually set to be lower than the tripping voltage of the protection.
4.	dv/dt	Defined the slip from the "V. Start" to the "V. End". Usually this value should be less than the dv/dt latch value of protection relay.

7.4.2.2 Time (#Under-Voltage)

This function aims to check the tripping time of under-voltage protection.



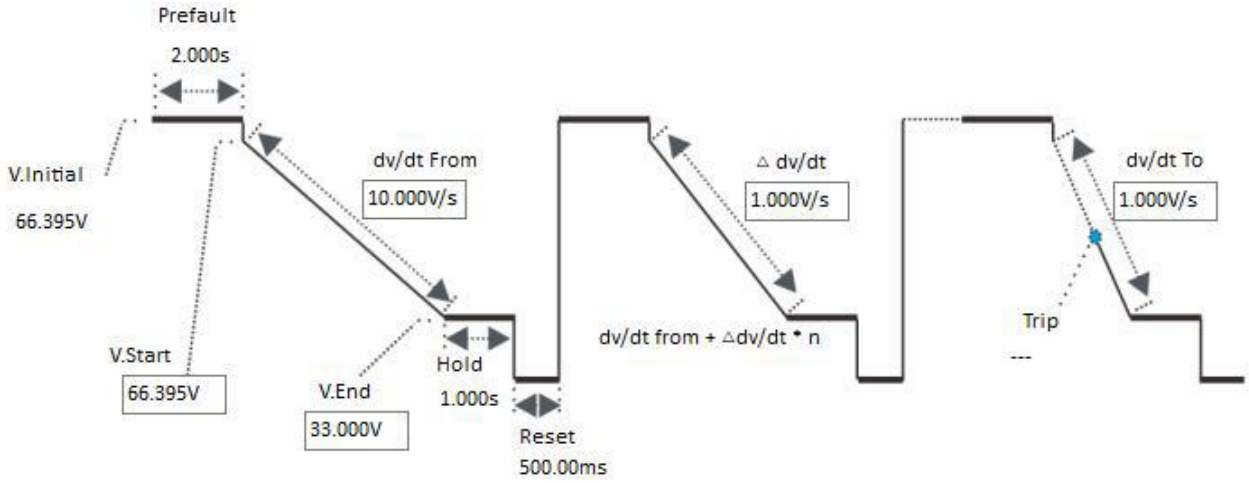
The method of measuring the action time is: the voltage slides from the "V.Start" to the "V.End", and waits for the protection relay to meet the trip condition. During testing, the "V.End" should be set slightly less than the under-voltage action setting of the protection relay to ensure successful tripping.

Parameters:

1.	V.Start	Defined the initial voltage on start. Usually is set to Vnom.
2.	V.Action	Defined the starting point of the timer of a particular voltage. Usually this value is the tripping voltage of the protection.
3.	V.End	Defined the destination voltage value.
4.	dv/dt	Defined the slip from the starting voltage to the destination voltage. This value should be less than the dv/dt latch value of protection relay.

7.4.2.3 dv/dt

This function aims to check the dv/dt latch value of under-voltage protection



In the dv/dt latch test, The voltage slides from the "V.Start" to the "V.End" according to the defined "dv/dt" slip value, this is a test cycle; the "dv/dt" is fixed in each cycle, and it ramping from "dv/dt From" to "dv/dt To" with "△ dv/dt" settings in every next cycles.

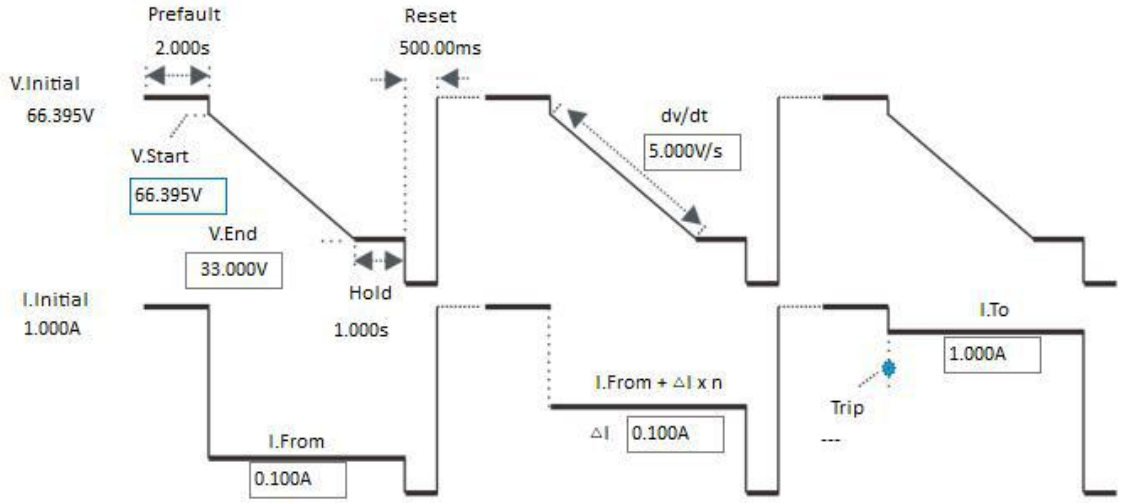
The process of this test is that when the test has started, the "dv/dt From" value set as greater than the slips setting of the protection relay, the protection is in the disallowed action status, and then the dv/dt value is adjusted to be less than the slip latch value. While the protection has tripped, at this time, the dv/dt value is recorded, and the dv/dt latch value is to be calculated.

Parameters:

1.	V.Start	Defined the initial voltage on the starting of each steps. Usually is set to Vnom.
2.	V.End	Defined the destination voltage value. Must be less than the under-voltage tripping value.
3.	dv/dt From	Defined the start dv/dt slip value. This value has to be greater than dv/dt latch value of the protection relay, to make the protection relay into the lockout status.
4.	dv/dt To	Defined the destination dv/dt slip value. This value has to be less than dv/dt latch value of the protection relay, to make the protection relay into the trip permit status.
5.	△dv/dt	Defined the ramping step dv/dt value from the starting dv/dt to the destination dv/dt. Reducing this value can increase the accuracy of test result.

7.4.2.4 Under-I Latch (#Under-Voltage)

This function aims to check the under-current latch value of dv/dt protection.



In the under-I latch test, The voltage slides from the “V.Start” value to the “V.End” value according to the defined slip dv/dt value, this is a test cycle;

At the same time, there is a fixed current value outputs in every cycle, and it is ramping from "I.From" to "I.To" with "△I" settings in every next cycles.

The process of this test is that when the test is started, the "I.From" set as less than the under-I latch value of the protection, so the protection is in the disallowed action status, and then the current value is move toward to great than the under-I latch value, while the protection tripped, at this time, the current value is recorded, and the under-I latch value to be calculated.

Parameters:

1.	V.Start	Defined the initial Voltage on each steps start. Usually is set to Vnom.
2.	V.End	Defined the destination Voltage value. to be less than under-voltage settings.

3.	dv/dt	Defined the slip from the start Voltage to the stop Voltage. Usually this value should less than the dv/dt latch value of protection relay.
4.	I.From	Defined the testing under-current start value. This value must make the protection relay into lockout status.
5.	I.To	Defined the testing under-current destination value. This value have to make the protection relay into the trip permit status. Usually it can be set to great than 1.2*Ipickup.
6.	△I	Defined the ramping step current from start to destination under-current. Reduce this value can increase the accuracy of test result.

7.5 Harmonic Test

Harmonic test module allow the user to manually or automatically output 2 groups of voltages, currents and frequencies statically or as ramp outputs with specific superposition harmonics.

Prerequisites for testing

It is not necessary to set the Test Object prior to testing.

Define the hardware, the routing and wiring and trip commands.

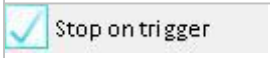
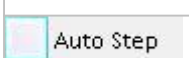
Use "+" mark in the columns head of main view to add new harmonic orders to be superposition.

Define the Variables, Test mode, Prefault, etc in the main view.

Columns define

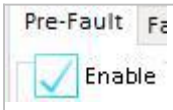
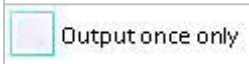
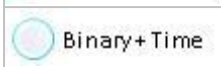
THD	Total harmonic distortion
RMS	Root mean square value (fundamental + harmonics)
1	RMS of fundamental wave (include magnitude and phase angle)
+	Press to add and define customized harmonics (include magnitude and phase angle, the harmonic angle is based on the fundamental wave); The harmonics are selectable from 2~63 times. Once the harmonic is defined, the "+" symbol will be shown as the harmonic times, press it again can delete it.

Buttons and Options

	In manual mode, Increase the value of the current variables; In automatic mode, start fault simulation in positive direction by step value. If step value > 0, then the limit value must > currently variable value setting; else while step value < 0, the limit value must < currently variable value setting. Keyboard shortcut is "F2"
	The function reversed to button. Keyboard shortcut is "F3"
	Lock the current output value, allow to set the analog value to your liking, then release this button for a transient signal. This button is only available in manual mode.
	Enable this option to automatic stop outputs while the received trigger command has met the Result Trigger Logic.
	Enable this option will shift to the auto-step mode.
	Enable this option to display the THD and Harmonics magnitude in percentage value from the fundamental voltages or currents.

Prefault & Fault Interval

Prefault & Fault Interval are available only when "Auto Step" is activated

	Enable this option to activate the prefault state in pulse-ramping mode. The prefault output value allows for custom setting, usually V=Vnom, I=0.0A;
	Enable this option will limit the prefault output state effective only in the first run time.
	Define the output time for prefault state.
	Prefault state will switch to the fault state by a Binary inputs command or once the time was met.
	Prefault state will switch to the fault state by a keyboard command.
	Enable this option to add a state after the fault state. The time and value of the fault interval allows for custom settings, usually V=0.0V, I=0.0A; Enable this option will shift to the pulse ramping mode.

Variable setting

Provide variable selection, it can be any channel(s), order and any quantity of amplitude, phase angle or frequency.

7.5.1 Harmonic Signal View

Harmonic signal view shows the 10 cycles length of the fundamental output signal;
Buttons & Input fields:

Buttons & Input fields:

Zoom	Set the scaling of zoom, default scaling set as 1.1;
Offset	Set the definite offset time from the start signal.
Optimize	Quickly zoom the TimeChart to the default scaling.
Show	Allow the user to select the signals channel that you want to show on the characteristic.
Move	A toggle button to activate/deactivate the "Move" function to move the graphic to the right/left.

Place the focus on the characteristic view and scrolling the mouse can continuous zoom in/out the signals. Hold down and drag the mouse to draw a rectangular to zoom in the selected area.

7.5.2 Trigger Logic

Users can choose the "AND" or "OR" logic for binary inputs, as well as the number of binary inputs required.

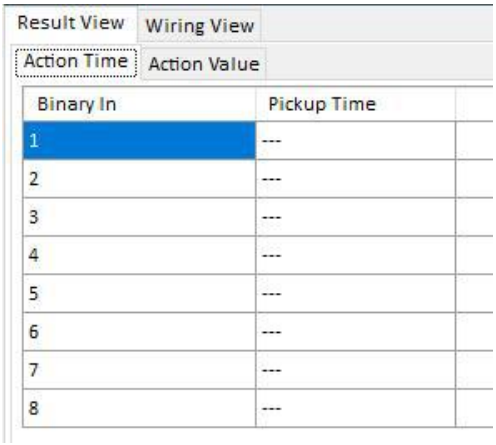
Icon Descriptions:

	Means binary input is activated and the trigger mode is automatically detected;
	Means binary input is activated and the trigger mode only accepts the raise signal(0 -> 1).
	Means binary input is activated and the trigger mode only accepts the drop signal(1 -> 0).
	Means binary input is deactivated.

The status of each input ports is automatically saved while the testing has started. All of the ports detects the turnover trigger signals independently.

The turnover conditions of each binary inputs must fulfill the Deglitch Filter time;

7.5.3 Result View



In the results view, there are two separate tabs that record the action times of binary inputs and the action values of test variables.

7.6 Transplay

The transplay module has the following functions:

- Allow the user to import the **Comtrade** format transient data file and performs playback;
- With manual trigger, binary trigger, GPS trigger, etc;
- All data of any voltage or current channel are editable and superimposed;
- The output value of each current and voltage channel is adjusted proportionally and converted from the primary value to the secondary value;
- The data of the original record is interpolated and calculated;
- By setting the repetition start time, repeat the interval and repeat times, repeat a certain section of the waveform;
- Prolonging the output time of the normal state or repeating the output of a certain fault waveform;

Prerequisites for testing

It is not necessary to set the Test Object prior to testing.

Define the hardware, the routing and wiring and trip commands.

Load the transient data file using the 

of toolbar, adjust the ratios scaled of the amplitudes of the analog output channels.

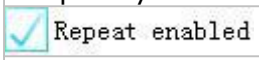
Prefault Output Config

Define the prefault state output area and trigger conditions of fault state.

Time Trigger	Trigger by time settings.

Binary	Trigger by binary input settings logic.
Key-press	Trigger by keyboard command pressed.
GPS or IRIG-B	Trigger by a GPS or IRIG-B time setting, usually is a PPS or PPM signal.
	Define a fixed value of the prefault state output. If this mode is enabled, the angle of waveform may not be continuous while the state has switched to the fault state.
Start	Defined the prefault area of the transient data to be performed in the prefault state.
End	
Repeat	Number of repeats in the prefault state.

Fault Output Setting

Max.Fault time	Defined the maximum time limit of the fault state to be playback.
Start	Defined the start time of the transient data to be playback. If the prefault state has defined an area, then this start time will automatically continue from the end of the prefault waveform.
Frequency	Display the nominal frequency of the transient data to be playback.
	Enable this option to repeatedly playback an area of the transient data.
Counts	Number of repeats of the playback in the defined fault area.
Start	Defined the start time of the fault area to be playback repeatedly.
End	Defined the end time of the fault area to be playback repeatedly.

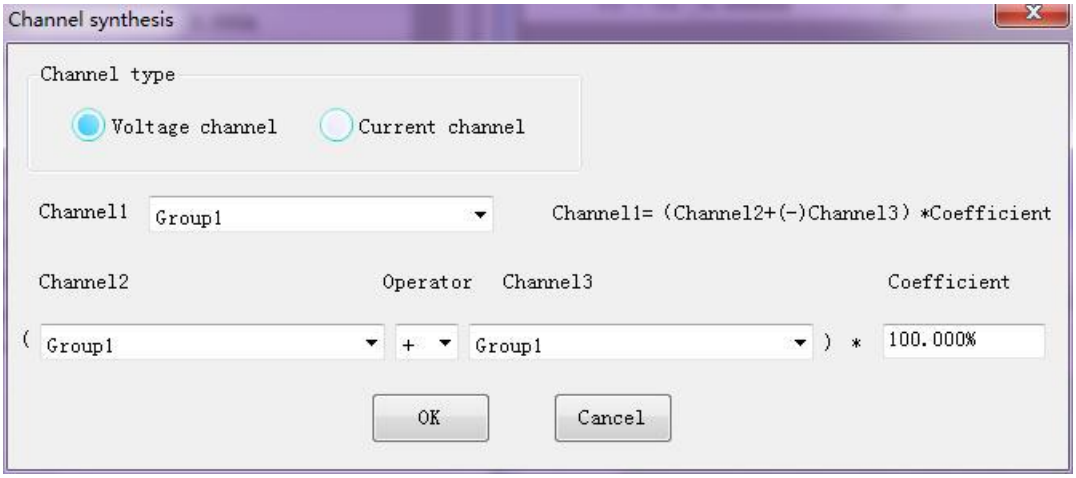
Value type for display

	Switch the display of the Maximum/Minimum values. P-P: peak to peak RMS: root-mean-square P-P = RMS * √2 Comtrade file uses P-P value for record, but Relay test kit always uses RMS value to perform output.

7.6.1 Channels Combine

The channel combine function on the toolbar allows the users to adjust and calculate the imported waveforms before output;

The adjusted waveform data can be applied to the specified channel for playback;



One channel can be adjusted at a time;
if multiple channels need to be adjusted, the process can be repeated as many times as necessary.

7.6.2 Binary output

The user can set the binary output time while performing the transient playback, it has 2 modes:
Custom binary output: Binary output action follows the customary "binary config" settings
Use comtrade binary input settings: Binary output action adjusts according to the comtrade file defined.

7.6.3 Advance

The user can select different interpolation algorithm to perform the transient data.

Binary input trigger

Defined the binary inputs Logic to be effective during playback of the transient data to measure the trip time.
The user can select "Or" / "And" logic of the selected Binary inputs.
The status of each input ports are automatically saved while the testing starts. All of the ports are independent as they detect the turnover trigger signals.
The turnover conditions of each binary inputs must fulfill the Deglitch Filter time.

7.6.4 Information

Display the general information of the loaded comtrade file.

7.7 Distance Test

The distance module provides the functionality to define and perform tests for distanced relays by zone ranges and the trip times defined in the impedance characteristics.

The Test View area provides 4 tabs for setting the parameters: Shot Test, Search Test, Test Parameter and Binary Setting

Prerequisites for testing

The setting and characteristics of the relay under test has to be defined in the Distance tab of Test Object prior to testing.

Define the hardware, the routing and wiring and trip commands.

Define the Fault Model, Test time, Trigger config, etc in the "Test Parameter" tab of the main view.

7.7.1 Shot Test

The aim of the shot test is to check the reaches of the individual zones and trip times with any test points.

Add Test Points

Tests are defined in the impedance plane. Adding test points can be achieved by right clicking on the impedance plane or entering the test point parameters into the input fields "|Z|, Phi, R, X" by keyboard entry.

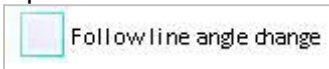
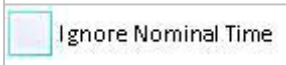
All test points are added to a test table. This table will automatically be sorted by the defined fault type and linked to the impedance view.

Base on the selected fault type and test points and fault model (I constant / V constant / Z constant), the voltages or currents at the relay location are calculated automatically and displayed on the Vector View.

Buttons:

Add	Add the defined point to the test table below.
Remove	Delete the currently selected test point from the Test points list.
Remove All	Clear the test list
Check	Individually test the test point at the current cursor position within the list.

Options:

	If active, the impedance of test points will be recalculated by the percentage of the defined zone characteristics after the line angle automatically adjusts.
	If active, the impedance of test points will be calculated by the percentage of the defined zone characteristics.
	If active, the time of fault state will use the "maximum fault time". Existing points will not refresh once this option is selected. It is only effective for the new test points.

7.7.2 Search Test

The aim of search test is to determine the exact reach and check their trip times of the individual zones by applying several shots along a search line. The number of shots is calculated according to the zones define and the automatic search resolution.

Add search Line

Search line is defined by a terminal point (same as shot test) and the line length and line angle, or manually drawn by the mouse from the impedance plane.

Base on the selected fault type and test points and fault model (I constant / V constant / Z constant), the voltages or currents at the relay location are calculated automatically.

Typically, one end of the search line should be within the impedance zone, while the other end should be outside the impedance zone. If both ends are within the same impedance zone or outside of it, no impedance boundary can be identified.

Buttons:

Add	Add the defined search line to the test table below.
Add Multi...	Quickly add multiple fault types of a defined search line.
Sequence	Quickly add multiple search lines and multiple fault type based on an origin terminal shot point to the test list.

Remove	Delete the currently selected search line.
Remove All	Clear the test list

Options:

Ignore Nominal Characteris	If active, the assessment of search procedure will not be referred to the defined zone characteristics.

7.7.3 Test Parameter

Fault Model

Fault Model include 3 types as below:

I=Constant	Fixed test current. The fault voltage is calculated by the module. If the fault voltage is greater than Vnom*0.9, the module will automatically reduce the test current.
U=Constant	Fixed test voltage. The fault current is calculated by the module. If the fault current is greater than the Imax output, the module will automatically reduce the test voltage.
Z=Constant	ZS is fixed. The fault current and voltage are calculated by the module according to the impedance of ZS and testing point. The grounding factor of ZS is defined in the Distance Object.

This Model is a global setting used for both shot test and search test.

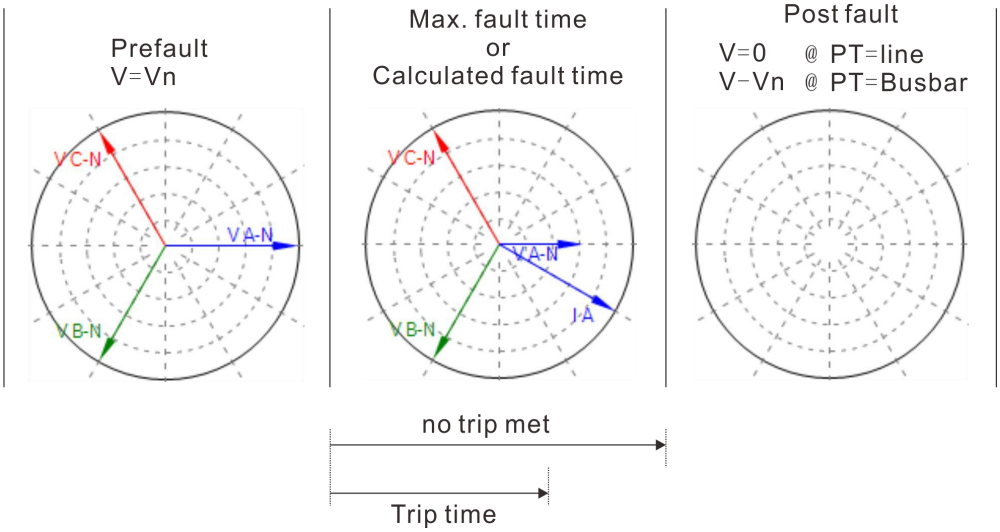
Test Time and Trigger mode

Each shot consists of 3 states: Prefault, Max-fault and Postfault .

The exact prefault time becomes effective only if the Fault Trigger config is set at "Time" mode.

If "Ignore Nominal Time" or "Ignore Nominal Characteristic" are activated, the "Max Fault time" value is always effective for use in the test. Otherwise, the "Max Fault time" will be automatically calculated by the module according the data of the defined test object.

The presence of voltage in the interval state depends on the location of the PT.(defined in the Distance Object)



Trigger Config

Define the fault trigger conditions.

Time	Triggered by the Prefault time

Key-press	Triggered by pressing the keyboard command
GPS or IRIG-B	Triggered by a GPS or IRIG-B time setting. This is usually a PPS or PPM signal.

CB simulator

Simulate the circuit breaker trip delay and close delay time if the resulting trigger signal is connected from the circuit breaker.

Load Setting

Current	Load current is effective only in the prefault state
Phase	Offset angle between the load current and voltage.

Fault Inception

This setting allows using the phase angle of the specified voltage, and hence the angle of the fault current at the inception of the fault. Before the fault turns into a steady state, it is possible to simulate the DC offset transient behavior.

Random	This mode allows the use of a randomly generated fault angle at inception.
Setting	The fault angle at inception can be freely adjusted by entering a value in the close angle field.
DC offset	Enable this option to activate the DC offset transient behavior.
Atten Const	Define the T.constant of DC offset, during the T.constant, voltage output is calculated by: 1/(10 ^ (Δt / T.constant))

U Aux-N config

Set the U Aux-N channel output during the shot testing.

Manual	This mode allows the user to manually define the U Aux-N output.
+3U0,-3U0, +√3*3U0,-√3*3U0	These modes will automatically calculate the U Aux-N output from the vector sum of 3-phase network.
Refer-VA, VB, VC, VAB, VBC, VCA	Directly quote the values of the selected channel.

7.7.4 Binary Setting

Binary Input Define

Allow the user to customize the binary input as per the relay trip command.

Binary Output definition

This table allows the user to define the binary output independently.
Column explain:

Binary output	Activate the specified binary outputs and set the initial status.  Disabled  Initialize as NO status.  Initialize as NC status.

Reference mode	1. Reference fault: Binary output turnover function starting from the start of fault time.
	2. Reference prefault: Binary output turnover function starting from the start of prefault time.
	3. Reference input: Binary output turnover function starting from the defined binary input trigger.
Reference binary in	Define the reference binary input channel.
Delay time	Binary outputs after this time will be turnover
Hold time	Keeping this time after the binary output has turnover

7.7.5 Impedance View

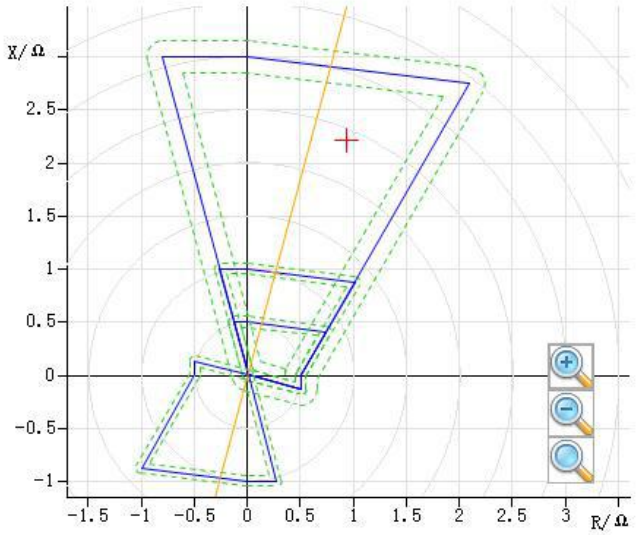
Impedance view is grouped by the fault type and automatically links to the currently selected fault type.

The Impedance view always shows the characteristic in secondary value of the relay settings.

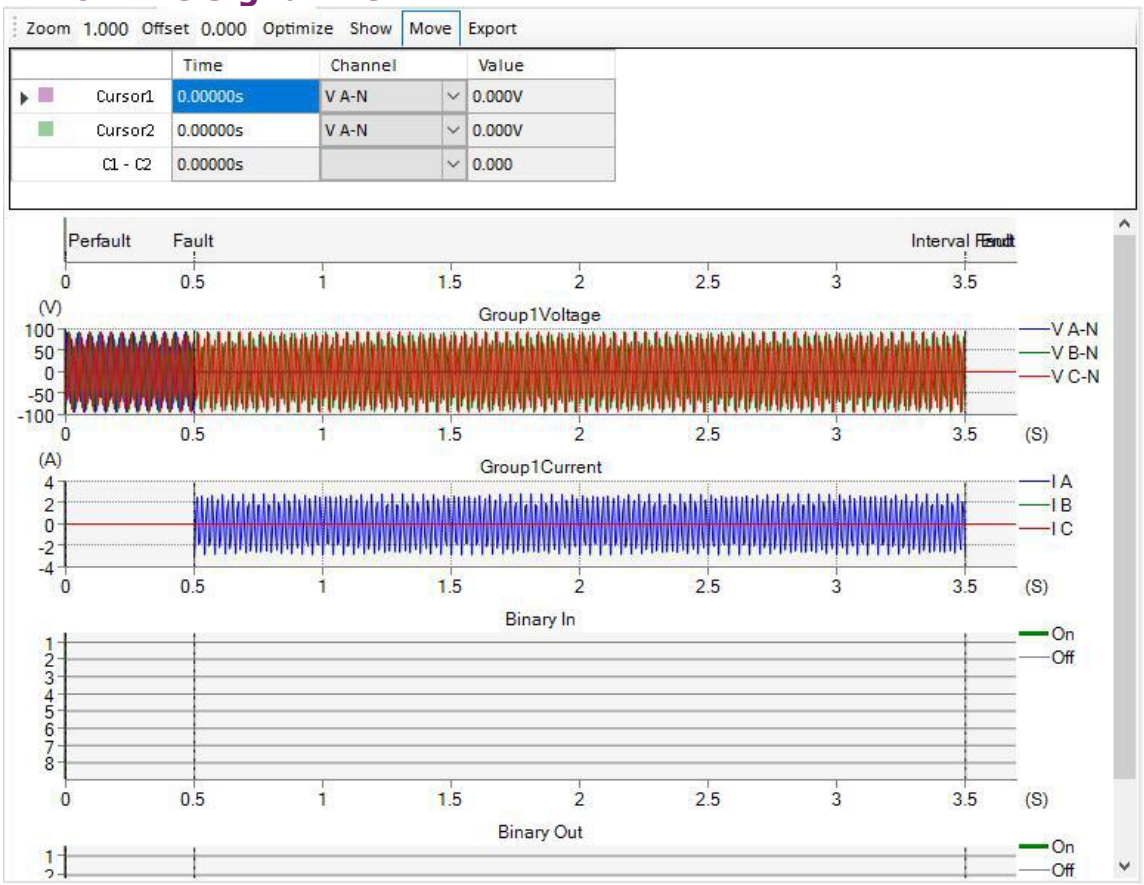
The user can pickup a test impedance from the impedance view with a mouse click.

After completion of the test, "Passed" points will be displayed in ''green'' color, "Failed" points are displayed in "red" color.

On the right side of the impedance view, 3 magnifying glasses are provided to quickly zoom in, zoom out, or return to the default view.



7.7.6 Time Signal View



The time signal diagram consistently displays the test output signals and binary status, which are calculated prior to the test and then redrawn following the completion of the test.

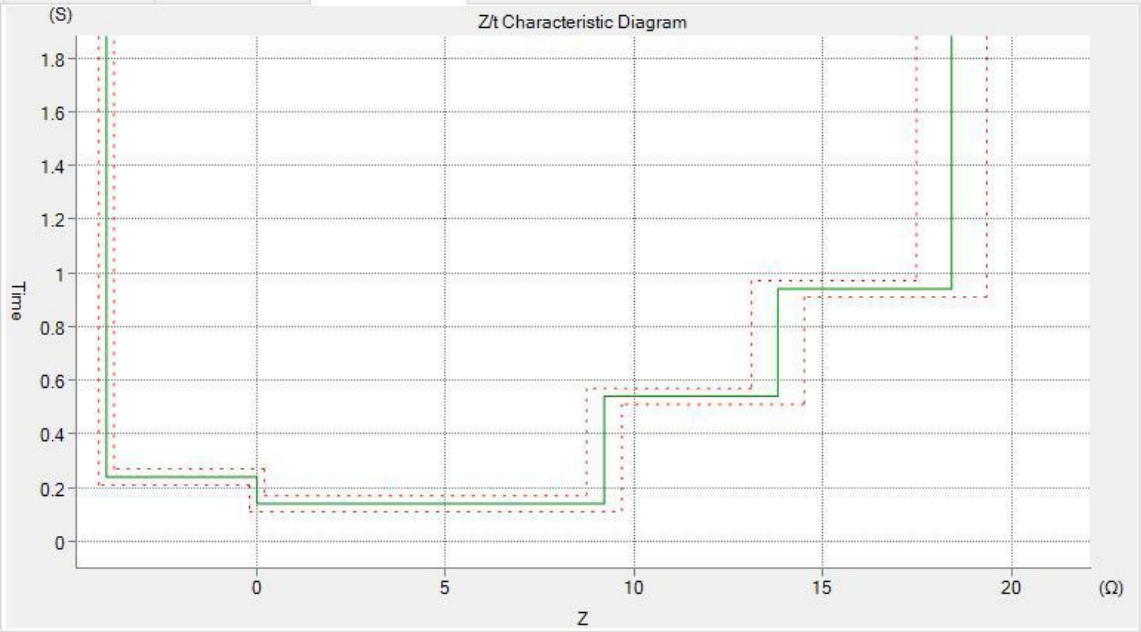
Buttons:

Zoom	Set the scaling of zoom, default scaling set as 1.1
Offset	Set the definite offset time from the start signal
Optimize	Quickly zoom the TimeChart to the default scaling
Show	The system allows users to select the desired channel time chart to view and also enables them to switch between displaying a Polyline chart or a waveform graph. By default, the Waveform chart is displayed.
Move	A toggle button to activate/deactivate the "Move" function to move the graphic right/left. When the "Move" option is unchecked, you can drag a region on the time signal graph using your mouse. Upon releasing the mouse button, the software will automatically zoom in or out according to the dragged area.
Export	Save the current time signal graph to a COMTRADE format file for playback.

Place the focus on the time signal view, and scrolling the mouse allows for continuous zooming in/out of the signals view.

7.7.7 Z/t Characteristic

At the Z/t plane, show the current Z/t characteristics of the test object and all of the added test points in the same angle from testing list.



7.8 Overcurrent Test

The Overcurrent module allows for testing of the over-current relays with DMT, IDMT, thermal I^2T and customized curve characteristics.

Prerequisites for testing

The setting of the characteristics and tripping element of the relay under test has to be defined in the Overcurrent object tab of Test Object prior to testing.

To test the directional relays, the three voltages are required in addition. This has to be defined in the Setting Parameter tab.

Define the hardware, the routing and wiring and trip commands.

Define the Max Fault time, Fault voltage, Load current, Prefault and interval time in the Setting Parameter tab.

7.8.1 Test Point

In this tab, a single test or multiple tests can be added to the table for testing the tripping characteristic of the relay.

Add test points

Adding test points can be achieved by right clicking on the overcurrent Characteristic or manually entering the test point parameters into the input fields "Test Current", "Angle(I)".

All test points are added to a test table. This table will be automatically sorted by the defined fault type to be linked to the Overcurrent Characteristic view.

Based on the selected fault type and test points, the voltages or currents at the relay location are automatically calculated and displayed on the Vector View.

Buttons:

Add	Add the defined point to the test table below.
Add Multi...	Quickly add multiple fault type of a defined test point.
Remove	Delete the currently selected test point from the Test points list.
Remove Type	Delete all the test points of the currently selected fault type.

Remove All	Clear the test list
Check	Perform testing of the currently selected test point.

All test points added into a test list, it will automatically sort while add.
The sort priority is:
1. Fault type
2. Fault angle. (ascending)
3. Fault current magnitude. (ascending)

Check Result

All test points assess the Trip time and Pickup current should be within the tolerance bands set at the Current and Time Tolerances at Overcurrent tab of the Test Object.

7.8.2 Setting Parameter

Test Time Setting

Each shot test consists of 3 states: Prefault, Max-fault and Postfault .

Prefault and Fault Interval are both optional. It is recommended to keep a minimum Prefault of 500ms.

Max Fault time	Define the maximum time for the fault output if the trigger condition is not met.
Relative Max Time	Maximum fault time relative to Td. in consideration with the positive tolerance. This value has to be compare with the max fault time. The system always uses the smaller one of these time values. (Td: Time index scales the time axis of the curve.)

Fault Voltage

Enable Fault Voltage	Select this option if you want to apply the fault voltage during the fault state. For directional relays, this option is always activated. For non-directional relays, voltage output may be necessary to aviod tripping of other relay functions.
V Fault LN V Fault LL	These fields define the voltage applied to the faulty phases during the fault state. The LN voltage is applied for all fault types except for the two-phase faults. The LL voltage is applied for the two-phase faults only.
Nominal Voltage LN Nominal Voltage LL	These fields are for information and values set in the **Device** tab of **Test Object**.

Load Current

Relative Nom	Set the load current as the multiple of Inominal.
Relative Fault current	Set the load current as the multiple the Ifault.
Load angle	The phase angle of the load current.

Note: if the added test points on the Overcurrent Characteristic are shown in RED circle, and the assessment shows "Load current too high", that means the test point cannot be tested. This is due to the test module's constraints. Please reduce the current load setting values.

7.8.3 Binary Setting

Binary Input Define

Allow the user to customize the binary input as per the relay trip command.

Binary Output definition

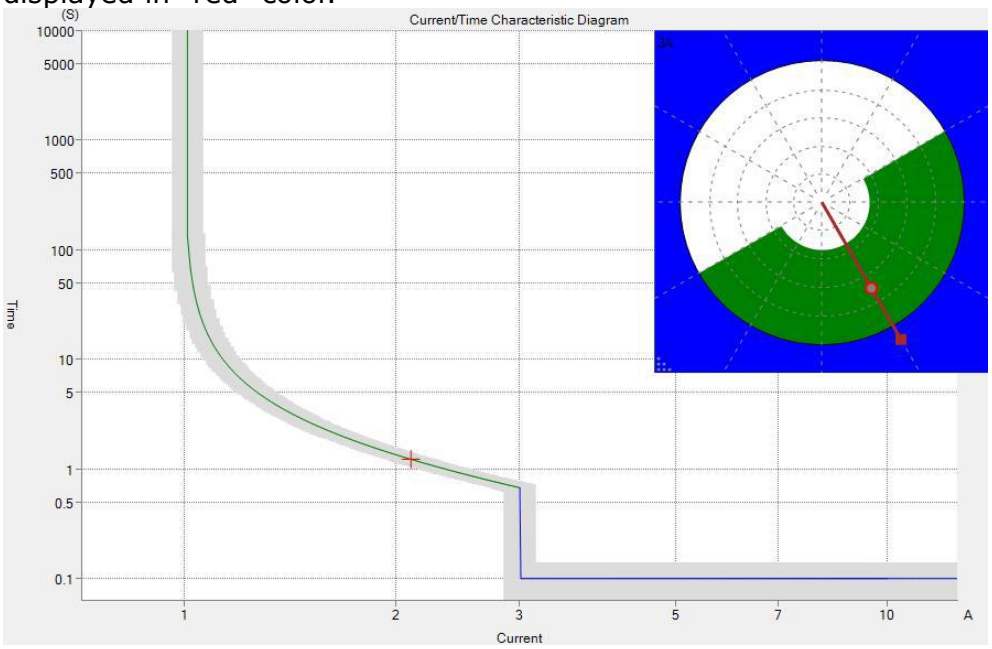
This table allows the user to define the binary output independently.
Column explain:

Binary output	Activate the specified binary outputs and set the initial status.  Disabled  Initialize as NO status.  Initialize as NC status.
Reference mode	1. Reference fault: Binary output turnover function starting from the start of fault time.
	2. Reference prefault: Binary output turnover function starting from the start of prefault time.
	3. Reference input: Binary output turnover function starting from the defined binary input trigger.
Reference binary in	Define the reference binary input channel.
Delay time	Binary outputs after this time will be turnover
Hold time	Keeping this time after the binary output has turnover

7.8.4 Overcurrent Characteristic

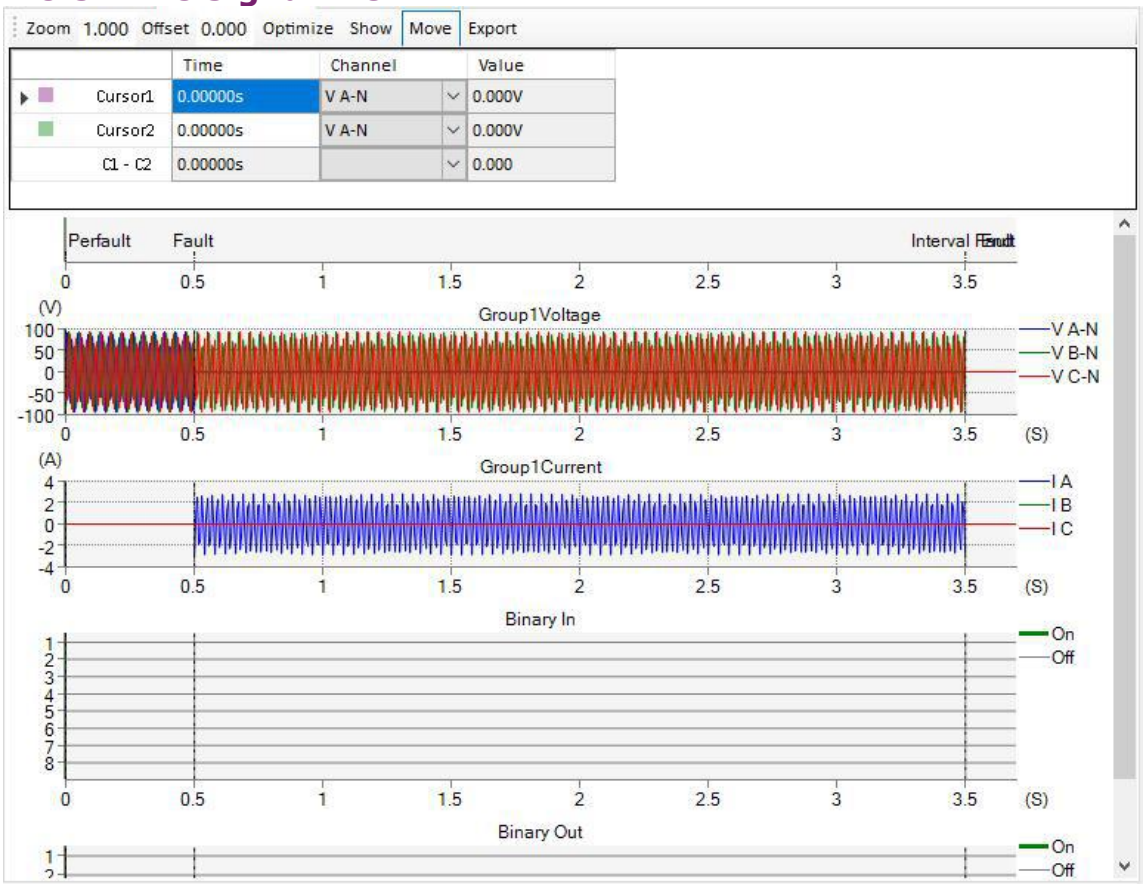
Overcurrent Characteristic view is separated by the fault type and automatically links to the currently selected fault type.

After completion of the test, "Passed" points will be displayed in green color, "Failure" points will be displayed in "red" color.



All test points are marked with a cross cursor, the vertical size is adjusted according to the tolerances of trip time, the horizontal size is adjusted according to the I tolerances of the test point.

7.8.5 Time Signal View



The time signal diagram consistently displays the test output signals and binary status, which are calculated prior to the test and then redrawn following the completion of the test.

Buttons：

Zoom	Set the scaling of zoom, default scaling set as 1.1
Offset	Set the definite offset time from the start signal
Optimize	Quickly zoom the TimeChart to the default scaling
Show	The system allows users to select the desired channel time chart to view and also enables them to switch between displaying a Polyline chart or a waveform graph. By default, the Waveform chart is displayed.
Move	A toggle button to activate/deactivate the "Move" function to move the graphic right/left. When the "Move" option is unchecked, you can drag a region on the time signal graph using your mouse. Upon releasing the mouse button, the software will automatically zoom in or out according to the dragged area.
Export	Save the current time signal graph to a COMTRADE format file for playback.

Place the focus on the time signal view, and scrolling the mouse allows for continuous zooming in/out of the signals view.

7.9 Differential Test

The Bias Curve Differential module is tested by simulating faults inside and outside of the protected zone. It contains 2 modes, the "Shot Test" and "Search Test".

Each test modes creates a test list. The module will perform the list though determining the shot or search.

For a search point consisting of several shots, the Ibias was given and Idiff was calculated and searched.

Prerequisites for testing

The setting and characteristics of the relay under test have to be defined in the Differential object tab of Test Object prior to testing.

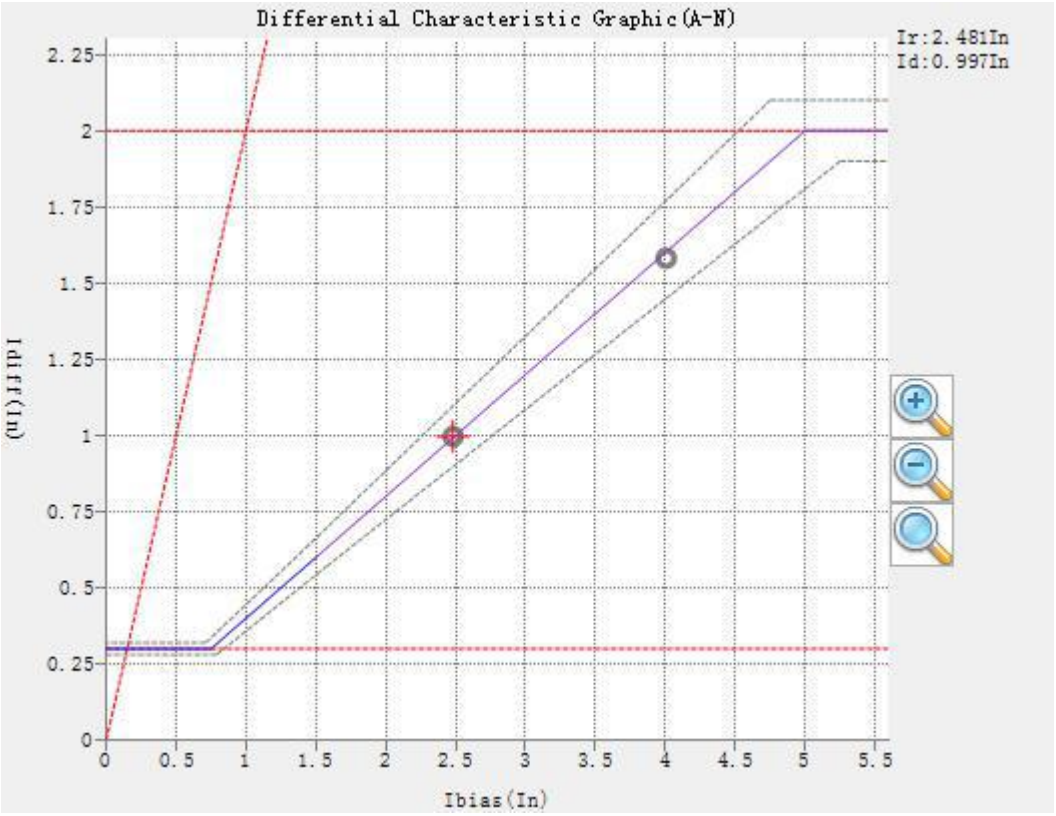
Define the hardware, the routing and wiring and trip commands.

Define the Test time, Voltage output, Trigger config, etc in the "General" and " Binary Setting" tab of the main view.

Differential Characteristic View

Differential Characteristic view is separated by the fault type and automatically linked to the currently selected fault type.

Place the focus on the Differential Characteristic view. Hold down and drag the mouse to draw a rectangle to zoom in the selected area.



On the right side of the Characteristic, 3 magnifying glasses buttons are provided for quickly zoom in, zoom out, or return to the default view.

All added test points are also displayed on the feature graph. After the testing is completed, points that are determined as "Passed" are shown in green, while points that are determined as "Failed" are shown in red.

7.9.1 Shot Test

Add Test Points

Tests are defined in the Differential Characteristic diagram. Adding test points can be achieved by clicking the "Add" button or manually entering the test point parameters into the input fields "Idiff", "Ibias".

All test points are added to a test table. This table will be automatically sorted by the defined fault type and linked to the Differential Characteristic diagram.

Based on the selected fault type and test points, the voltages or currents at the relay location are calculated automatically and displayed on the Vector View.

Buttons:

Add	Add the defined point to the test table below.
Remove	Delete the currently selected test point from the Test points list.
Remove All	Clear the test list
Check	Perform testing for the currently selected test point.

Result

In a shot test, all test points assessing whether or not a trip occurs during the test time set at the Diff time settings at the Differential tab of Test Object.

7.9.2 Search Test

Add Test Lines

Test lines are defined in the Differential Characteristic diagram. Adding test lines can be achieved by clicking the "Add" button, or entering the test point parameters manually into the input fields "Ibias".

All test lines are added to a test list and linked to the Differential Characteristic diagram.

Each test line consists of several shots. While searching for the line, the Ibias is fixed, the Idiff is calculated and controlled by the module, and the final boundary of the Idiff value is determined by whether it is inside or outside protected zone.

Based on the selected fault type and test points, the voltages or currents at the relay location are calculated automatically and displayed on the Vector View.

Enabling the "Ignore Nominal Characters" option will cover the entire range Idiff scanning from 0 to Idiff>>, this option may need more shot points for each lines.

Reducing the Resolution value can improve the accuracy of the result, but needs more shot points.

Buttons:

Add	Add the defined search line to the test table below.
Add Sweep	Add multiple lines from a starting value to an ending value by a step, the exact lines are automatically calculated.
Remove	Delete the currently selected search line.
Remove All	Clear the test list.
Check	Perform testing on the currently selected test line.

Result

In a Search test, all test lines assessing the Idiff should be within the tolerance bands set at the Current Tolerances at the Differential tab of Test Object.

7.9.3 General Setting

Test Time

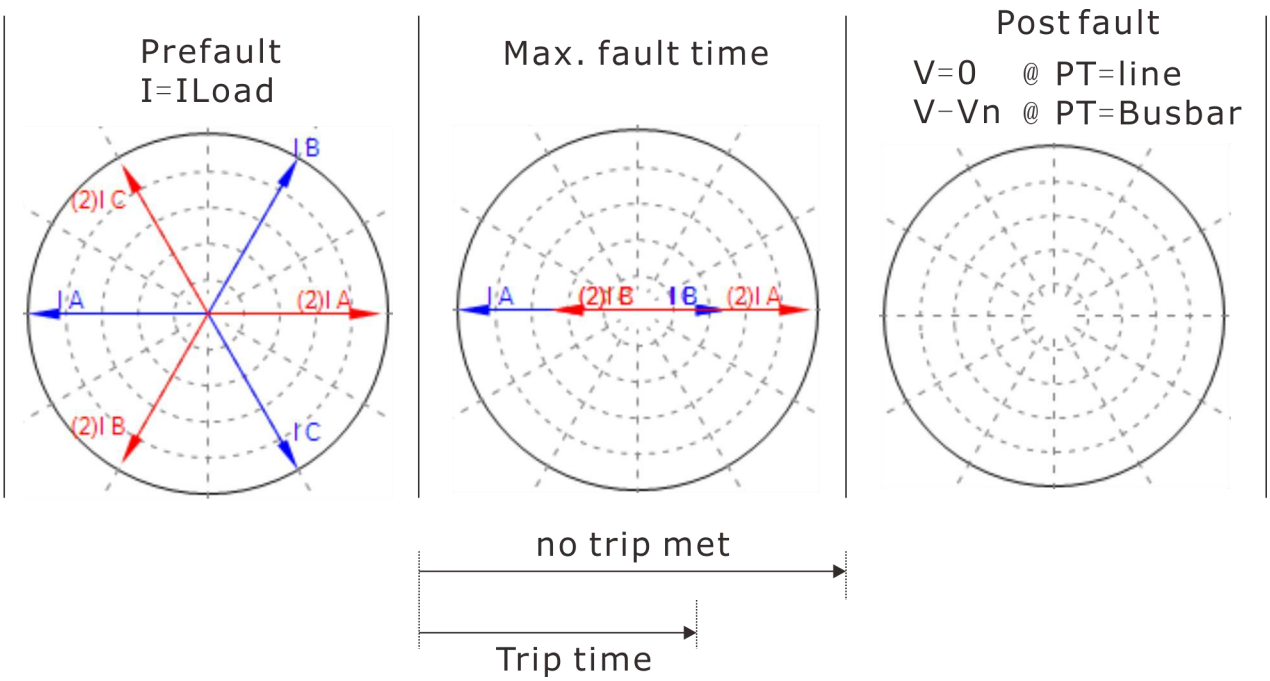
Each shot consists of 3 states: Prefault, Max-fault and PostFault.

The Max Fault Time becomes effective only if the shot point has non-tripping time or the tripping time is longer than this Max Fault time and the trigger condition is not met within this time.

By default, Max Fault time and Interval time equal the Max test time and Reset time at the Differential tab of Test Object.

The exact prefault time becomes effective only before the Prefault option is enabled and is set as "Time" mode. It is recommended to keep a minimum Prefault of 500ms.

The prefault current only applies in the prefault state.
If the prefault mode is set as GPS trigger, the fault start trigger depends on the GPS time setting, which is usually a PPS or PPM signal.



Voltage output

Enabling the voltage output option will apply the voltage output to the selected winding.
The presence of voltage in the interval state depends on the location of the PT.

PT=on Line	Vinterval = 0V
PT=on busbar	Vinterval = Vnom

Current Output

When the "Object Type" in the Differential object is set to "Transformer" and the "Count" is set to 3, different test windings can be selected at this location. Otherwise, it is not selectable.

Additionally, it is possible to map the output test signals of each winding to the specific set of physical output channels. Users can switch between different wiring groups according to their needs.

7.9.4 Binary Setting

Binary Input Define

Allow the user to customize the binary input as per the relay trip command.

Binary Output definition

This table allows the user to define the binary output independently.
Column explain:

Binary output	Activate the specified binary outputs and set the initial status.  Disabled  Initialize as NO status.  Initialize as NC status.
Reference mode	1. Reference fault: Binary output turnover function starting from the start of fault time.
	2. Reference prefault: Binary output turnover function starting from the start of prefault time.
	3. Reference input: Binary output turnover function starting from the defined binary input trigger.
Reference binary in	Define the reference binary input channel.
Delay time	Binary outputs after this time will be turnover
Hold time	Keeping this time after the binary output has turnover

7.10 Differential Configuration

The Diff Configuration module tests wiring and configuration of the test object by simulating faults that are located outside the protected zone. If in such a test case the relay trips anyhow, this indicates a configuration or wiring fault within the protection rack.

Prerequisites for testing

The setting and characteristics of the relay under test have to be defined in the Differential object tab of Test Object prior to testing.

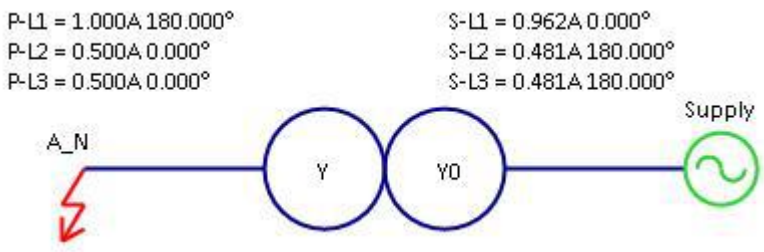
Define the hardware, the routing and wiring and trip commands.

Define the Test time, Voltage output, Trigger config, etc in the "General" and " Binary Setting" tab of the main view.

Test Model View

The testing model view automatically generates the corresponding model diagram based on the defined test objects and selected test windings.

The model diagram displays the output values of the current test points.



7.10.1 Test Point

1. First, select the test winding and decide whether to apply a load current.
2. Choose the winding side for the measured value and the type of measurement.
3. Determine the fault type.
4. Determine the fault current value (Itest) to be tested.
5. Click "Add" to add the test point to the test list.

Buttons:

Add	Add the defined point to the test table below.
Remove	Delete the currently selected test point from the Test points list.
Remove All	Clear the test list
Check	Perform testing of the currently selected test point.

Test Result

In Differential Configuration testing, all protection should remain reliably untripped when all test points are output. The testing evaluation requires manual completion by the testing personnel. (Manually select "Passed" or "Failed").

7.10.2 Binary Setting

Binary Input Define

Allow the user to customize the binary input as per the relay trip command.

Binary Output definition

This table allows the user to define the binary output independently.
Column explain:

Binary output	Activate the specified binary outputs and set the initial status.  Disabled  Initialize as NO status.  Initialize as NC status.
Reference mode	1. Reference fault: Binary output turnover function starting from the start of fault time.
	2. Reference prefault: Binary output turnover function starting from the start of prefault time.
	3. Reference input: Binary output turnover function starting from the defined binary input trigger.
Reference binary in	Define the reference binary input channel.
Delay time	Binary outputs after this time will be turnover
Hold time	Keeping this time after the binary output has turnover

7.11 Harmonic Restraint

The Harmonic Restraint module checks the correct relay behavior of the harmonic restraint of the differential function. It contains 2 modes, the "Shot Test" and "Search Test".

Each test mode creates a test table. The module will perform the table list determine the shot or search.

For a search line consisting of several shots, the Idiff was given and the Percentage of harmonics is calculated and searched for each search line.

Three currents are required for the Harmonic Restraint test. It is carried out on the reference winding side.

Prerequisites for testing

The setting and characteristics of the relay under test have to be defined in the Differential tab of Test Object prior to testing.

Define the hardware, the routing and wiring and trip commands.

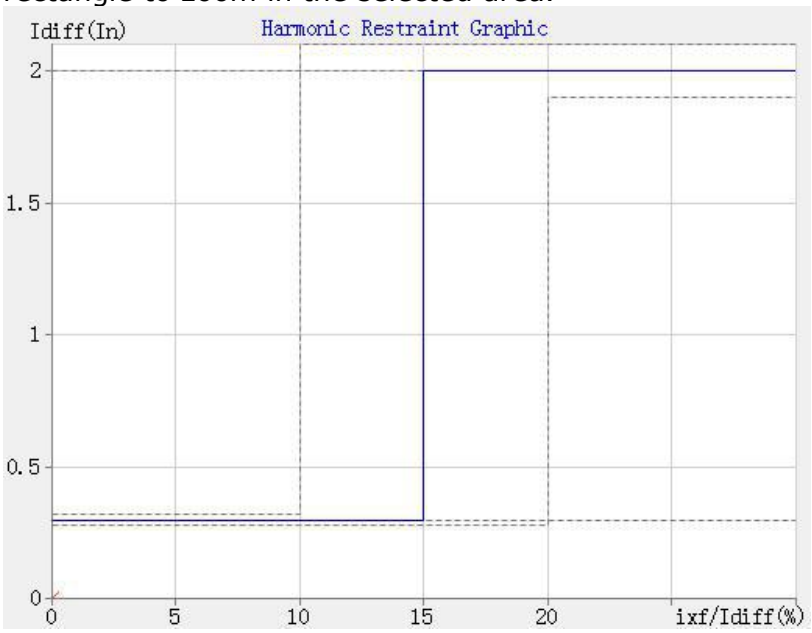
In the "General" tab of main view, define the Test time, Trigger config, etc.

Harmonic Restraint Characteristic View

The harmonic suppression characteristic view is distinguished by the harmonic order and automatically linked to the currently selected fault type.

All added test points are displayed on the characteristic graph. After the testing is completed, points that are determined as "Passed" are shown in green, while points that are determined as "Failed" are shown in red.

Place the focus on the Harmonic Restraint vector view. Hold down and drag the mouse to draw a rectangle to zoom in the selected area.



7.11.1 Shot Test

Add Test Points

Tests are defined in the Differential Harmonic Characteristic diagram. Select the harmonic count of your choice. Adding test points can be achieved by clicking the "Add" button, or manually entering the test point parameters into the input fields "Idiff", "Ixf/Idiff", "Angle".

Only one harmonic can be tested at a time. You can add more harmonic restraint instances to the current test center for more harmonic counts.

Harmonic with the suffix "N/A" is not available.

All test points are added to a test table. This table will be automatically sorted by the defined fault type and linked to the Differential Harmonic Characteristic diagram.

Based on the selected fault type and test points, the voltages or currents at the relay location are calculated automatically and displayed on the Vector View.

Buttons:

Add	Add the defined point to the test table below.
Delete	Delete the currently selected test point from the Test points list.
Delete All	Clear the test list
Check	Perform testing on the currently selected test point.

Result

In a shot test, all test points assess whether or not a trip occurs during the test time set at the Diff time settings at Differential tab of the Test Object.

7.11.2 Search Test

Add Test Lines

Test lines are defined in the Differential Harmonic Characteristic diagram. Select the harmonic count of your choice. Adding test lines can be achieved by clicking the "Add" button, or manually entering the test point parameters into the input fields "Idiff".

Only one harmonic can be tested at a time. You can add more harmonic restraint instances to the current test center for more harmonic counts.

Harmonic with the suffix "N/A" are not available.

All test lines are added to a test table and linked to the Differential Characteristic diagram.

Each test line consists of several shots. While searching the line, the Idiff is fixed, the Ixf/Idiff is calculated and controlled by the module, the final boundary of the Ixf/Idiff value is determined from the inside or outside protected zone.

Based on the selected fault type and test points, the currents at the relay location are calculated automatically and displayed on the Vector View.

Enabling the "Ignore Nominal Characters" option will cover the entire range of Ixf/Idiff scanning from 0 to 100%>>, this option may need more shot points for each lines.

Reducing the Resolution value can improve the accuracy of the result but need more shot points. The minimum resolution of the Ixf/Idiff is 0.1%.

Buttons:

Add	Add the defined search line to the test table below.
Add To	Add multiple lines from a starting value to an ending value by a step. The exact lines are automatically calculated.
Delete	Delete the search line for the currently selected test point along of the search line.
Delete All	Clear the test list
Check	Perform testing on the currently selected test line.

Result

In a Search test, all test lines assessing the Ixf/Idiff should be within the tolerance bands set at the Harmonic Tolerances at Differential tab of the Test Object.

7.11.3 General

Test Parameter

Each test point includes three states: pre-fault, fault, and post-fault.
The maximum fault time is only limited by this time if the test point does not trip or if the trip time of the test point is greater than the maximum fault time.

In the differential test object, we default the maximum fault time and fault interval time to be equal to the maximum test time and reset time. It is recommended to keep a minimum Prefault of 500ms.

Voltage output

Enabling the voltage output option will apply the voltage output to the selected winding.
The presence of voltage in the interval state depends on the location of the PT.

PT=on Line	Vinterval = 0V
PT=on busbar	Vinterval = Vnom

7.11.4 Binary Setting

Binary Input Define

Allow the user to customize the binary input as per the relay trip command.

Binary Output definition

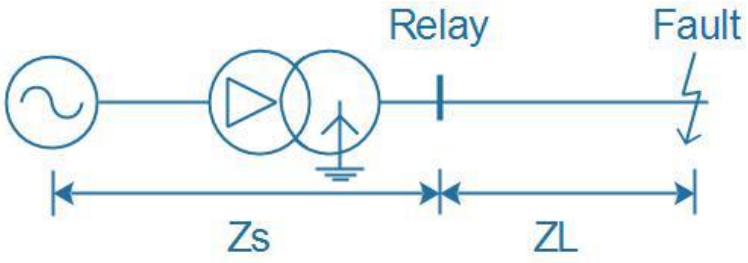
This table allows the user to define the binary output independently.
Column explain:

Binary output	Activate the specified binary outputs and set the initial status.  Disabled  Initialize as NO status.  Initialize as NC status.
Reference mode	1. Reference fault: Binary output turnover function starting from the start of fault time.
	2. Reference prefault: Binary output turnover function starting from the start of prefault time.
	3. Reference input: Binary output turnover function starting from the defined binary input trigger.
Reference binary in	Define the reference binary input channel.
Delay time	Binary outputs after this time will be turnover
Hold time	Keeping this time after the binary output has turnover

7.12 Reclose Test

This module is used for testing the auto-reclosing processed together with a line protection, which can simulate the before/after state of the reclose state with post-acceleration.

This module uses the Ux channel to simulate the line extracting voltage, allow for setting the amplitude, phase angle and changing the reference channel.



Prerequisites for testing

The setting and characteristics of the relay under test has to be defined in the Distance tab of Test Object prior to testing.

Define the hardware, the routing and wiring and trip/reclose commands.

In the "Parameter" tab of main view, define the Fault Model, Test time, Trigger config, etc.

7.12.1 Test

Add Shot Pint

Tests are defined in the impedance plane. Adding test points can be achieved by right clicking on the impedance plane or manually entering the test point parameters into the input fields "|Z|", "Phi", "R", "X".

All test points are added to a test table. This table will be automatically sorted by the defined fault type and linked to the impedance view.

Based on the selected fault type and test points and fault model (I constant / V constant / Z constant), the voltages or currents at the relay location are calculated automatically and displayed on the Vector View.

Buttons:

Shot	Add the defined point to the test table below for shot test.
Zone Verify	Quickly add multiple fault types of a defined sequence point for fixed value verification.
Delete	Delete the currently selected test point from the Test points list.
Delete All	Clear the test list
Check	Perform testing on the currently selected test point.

Options:

Follow line angle change	If active, the impedance of test points will recalculate after the line angle has changed.
Relative 0.000%	If active, the impedance of test points will be calculated by the percentage of the defined zone characteristics.
Fault Permanent	Enabling this option for permanent fault simulation. The fault still exists after the reclose state. By default, the module is set as the transient mode.

Result

All test points given a trip time, reclose time and second trip(post-acceleration) time.

7.12.2 Fault Transfer

This tab allows the user to enable a transfer fault impedance and the start reference.

Transfer fault impedance can be manually defined at the input fields "|Z|", "Phi", "R", "X".

Transfer time can define the start reference. It may happen in the first fault state or the reclosed state.

Transfer time defines the lag time of the fault after the transfer time refer condition.

7.12.3 Parameter

Test Time

Each shot consists of 5 states: Prefault, fault state, post-fault, reclosed and post-acceleration.

The exact prefault time becomes effective only if the Fault Trigger mode is set as "Time" mode.

The maximum fault time is limited to the beginning and end of the fault.

The presence of voltage in the post-fault and post-acceleration state depends on the location of the PT.(defined in the Distance Object)

Fault Trigger Mode

Define the fault trigger conditions.

Time	Trigger by Prefault time
Key-press	Trigger by keyboard command pressed
{8} Turnover	Trigger by Binary input 8 turnovers
GPS or IRIG-B	Trigger by a GPS or IRIG-B time setting, this is usually a PPS or PPM signal.

Fault Model

Fault Model include 3 types as below:

I=Constant test current	Fixed test current. The fault voltage is calculated by the module. If the fault voltage is greater than Vnom*0.9, the module will automatically

	reduce the test current.
U=Constant test voltage	Fixed Test voltage. The fault current is calculated by the module. If the fault current is greater than the Imax output, the module will automatically reduce the test voltage.
Z=Constant source impedance	Fixed ZS, the fault current and voltage are calculated by the module. The grounding factor of ZS is defined in the Distance Object.

CB Simulator (Delay Config)

The lag time setting can simulate the circuit breaker trip delay and close delay time if the resulting trigger signal is connected from the circuit breaker.

Load Setting

Current	Load current is effective only to the prefault state
Phase	Offset angle between the load current and voltage.

U Aux Setting

Set the Ux channel output during the shot testing.

Custom	This mode allows the user to manually set the Ux output to apply to all states.
+3U0,-3U0, +√3*3U0,-√3*3U0	These modes will be applied to all states with the Ux output that are automatically calculated from the 3-phase network.
Sync.VA, ...Sync.VCA	This mode also requires an additional setting for the Ux output value, where the extra set UX output value is used in the post-fault state. In other states, the reference channel value will be automatically used as the UX output value.

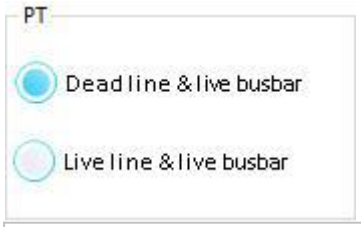
Fault Inception

This setting allows the use to specify the phase angle of the voltage, and hence the angle of the fault current at the time of fault inception. Before the situation of the fault becomes steady, it is possible to simulate the DC offset transient behavior.

Random	This mode allows the use of a random number generator for the fault inception angle.
Setting	The fault inception angle can be freely adjusted by entering a value in the close angle field.
DC offset	Enabling this option to activate the DC offset transient behavior.
Atten Const	Define the T.constant of DC offset. During the T.constant, voltage output is calculated by: 1/(10 ^ (Δt / T.constant))

Extended zone activation: If an extended zone is defined in the test object, it needs to be activated in order to test its characteristics; otherwise, the extended zone will not take effect.

PT position



Dead line & live busbar	After the fault trip, the value of V.fault channel = 0V.
Live line & live busbar	After the fault trip, the value of V.fault channel = V.nom

7.12.4 Binary Setting

Binary Input Define

In the program, binary input 1/2/3 are defined to correspond to TripA/B/C or TripABC, while binary input 4 is defined as the "Reclose" command input.

Binary Output definition

This table allows the user to define the binary output independently.
Column explain:

Binary output	Activate the specified binary outputs and set the initial status. Disabled Initialize as NO status. Initialize as NC status.
Reference mode	1. Reference fault: Binary output turnover function starting from the start of fault time.
	2. Reference prefault: Binary output turnover function starting from the start of prefault time.
	3. Reference input: Binary output turnover function starting from the defined binary input trigger.
Reference binary in	Define the reference binary input channel.
Delay time	Binary outputs after this time will be turnover
Hold time	Keeping this time after the binary output has turnover

7.12.5 Impedance View

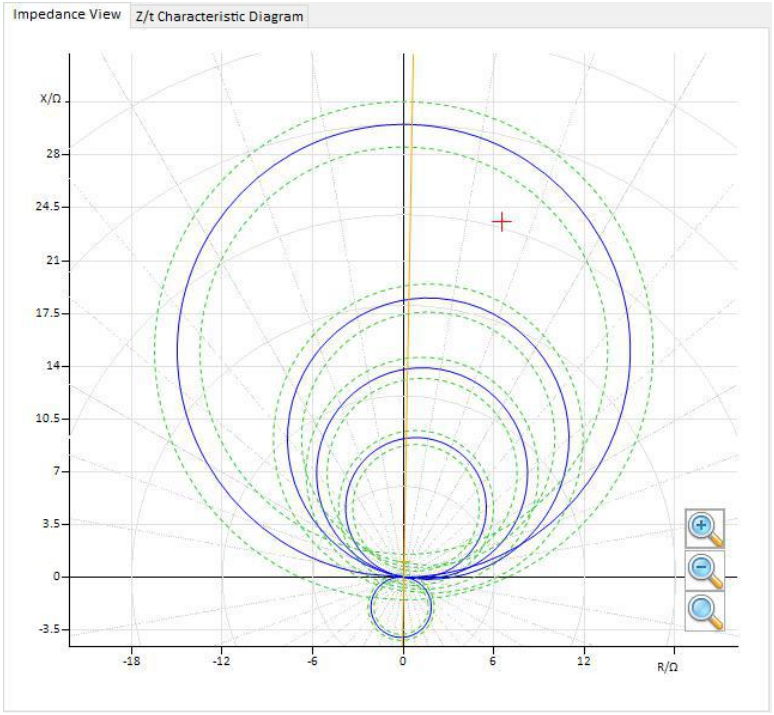
Impedance view is grouped by the fault type and automatically links to the currently selected fault type.

The Impedance view always shows the characteristic in secondary value of the relay settings.

The user can pickup a test impedance from the impedance view with a mouse click.

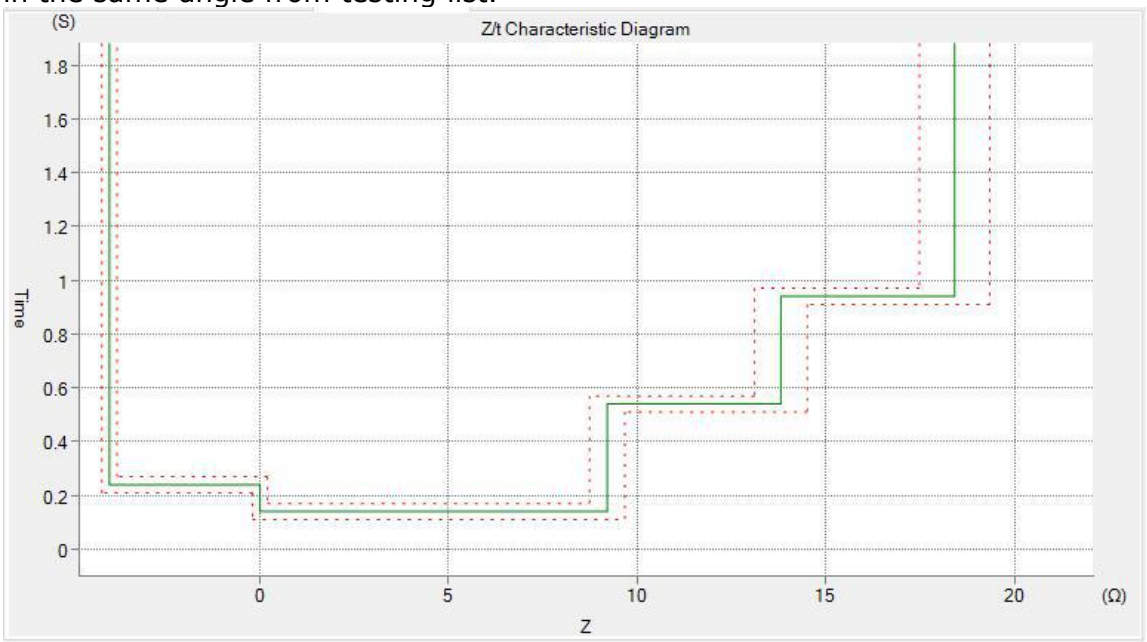
After completion of the test, "Passed" points will be displayed in ''green'' color, "Failed" points are displayed in "red" color.

On the right side of the impedance view, 3 magnifying glasses are provided to quickly zoom in, zoom out, or return to the default view.



7.12.6 Z/t Characteristic

At the Z/t plane, show the current Z/t characteristics of the test object and all of the added test points in the same angle from testing list.



7.13 Synchronizer

This module aims to perform a synchronism check by simulating an environment to connect a generator to the network or power grid.

Prerequisites for testing

The setting and characteristics of the synchronizing relay under test have to be defined in the Synchronizer tab of Test Object prior to testing.

Define the hardware, the routing and wiring and trip commands.

Select a test item and parameters settings then add to the test table to perform testing.

Initial parameters setting

Grid Side (Vs)	This is the reference system. Hence its phase angle is set to 0 degrees. The amplitude and frequency value from the "Device" tab of the test object. The wiring type combo is used to simulate the voltage channels of the power grid by defining the voltage output channels.
Generator Side (Vg)	This is the generator side. The values are initialized according to the test item. The wiring type combo is used to simulate the voltage channels of the generator by defining the voltage output channels.

Test Parameter

Each function test time is limited by the "Max-Sync" time setting.

A Pre-sync time is a period when voltages are outputting before issuing a "Start" binary output signal to the synchronizing relay. At the end of the pre-sync time, the start signal is issued. To obtain this purpose, any one of the binary outputs should be activated and set as "Reference fault" mode.

Delay time is used for "Slips acceleration latch" function and is applicable only when synchronization is obtained between the Vg and Vs sides. During this time period, the KRT will continue to output voltages.

7.13.1 Action Voltage

This function performs a ramping voltage on the Vg side for the voltage that has not met the synchronization conditions. Each ramping step time is automatically calculated by the difference of frequency between Vg and Vs sides. The synchronized voltage will be returned as the result.

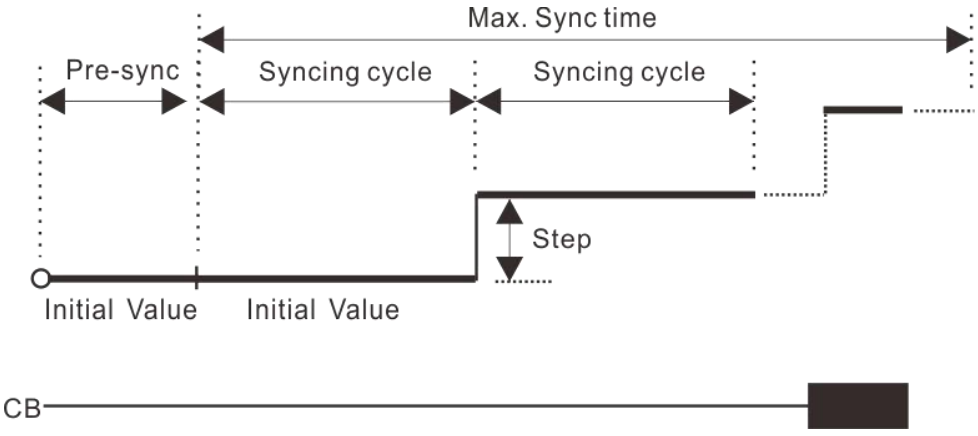
In this function test, the frequency of Vg side must be set as "met the synchronization condition".

Parameters:

A "V step" value defines the ramping voltage range of each steps.

The syncing cycle time is automatically calculated by the module.

Process on Vg side:



Test Result:

Record the "V. Action (voltage pickup value)" of the synchronization protection.

7.13.2 Action Frequency

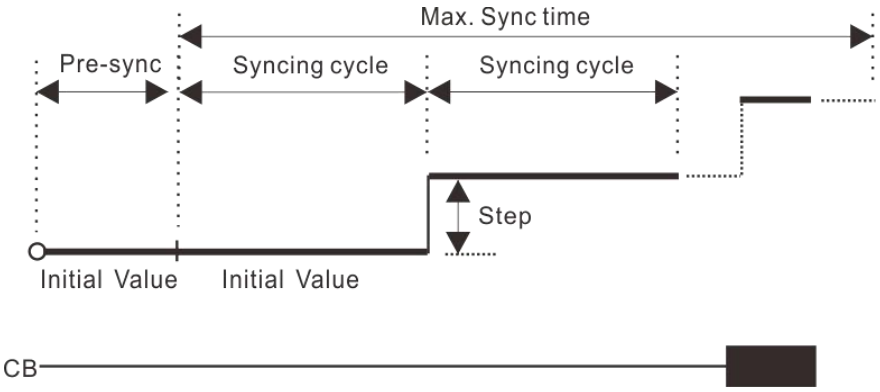
This function performs a ramping frequency on the Vg side for the frequency that has not met the synchronization conditions. Each ramping step time is automatically calculated by the difference of frequency between Vg and Vs sides. The synchronized frequency will be returned as the result.

In this function test, the voltage of Vg side must be set as "met the synchronization condition" or equal to Vs side.

A "F step" value defines the ramping frequency range of each steps.

The syncing cycle time is automatically calculated by the module.

Process on Vg side:



Test Result:

Record the "F. Action (frequency pickup value)" of the synchronization protection.

7.13.3 Angle/Time

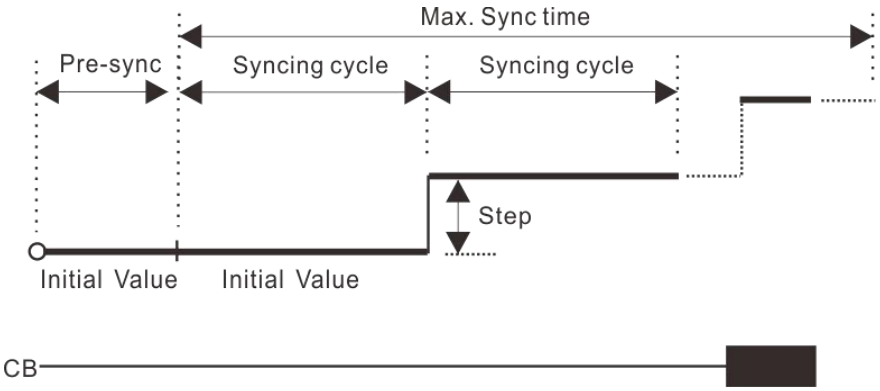
This function performs a ramping frequency on the Vg side for the frequency that has not met the synchronization conditions. Each ramping step time is automatically calculated by the difference of frequency between Vg and Vs sides. The synchronized Lead-Angle and Lead-Time will be returned as the result.

In this function test, the voltage of Vg side must be set as "met the synchronization condition" or equal to Vs side.

A "F step" value defines the ramping frequency range of each steps.

The syncing cycle time is automatically calculated by the module.

Process on Vg side:



Test Result:

Record the “Lead Angle”, “Lead Time”, “Action Time” and "F. Action" of the synchronization protection.

7.13.4 Electric Zero

This function performs a fixed outputs test for the Electric Zero type synchronize relay.

In this function test, the voltage and frequency of Vg side must be set as met the synchronization conditions and the frequency should not equal to the Vs side.

Test Result:

Record the “Return Angle”, “Action Time” and "Action Angle" of the synchronization protection.

7.13.5 Pulse Width Control-F

This function performs a fixed outputs test for the pulse width of the frequency adjustment signal.

In this function test, the frequency of Vg side should be set as have not met the synchronization conditions.

7.13.6 Pulse Width Control-V

This function performs a fixed outputs test for the pulse width of the voltage adjustment signal.

In this function test, the voltage of Vg side should be set as have not met the synchronization conditions.

7.13.7 Slips acceleration latch

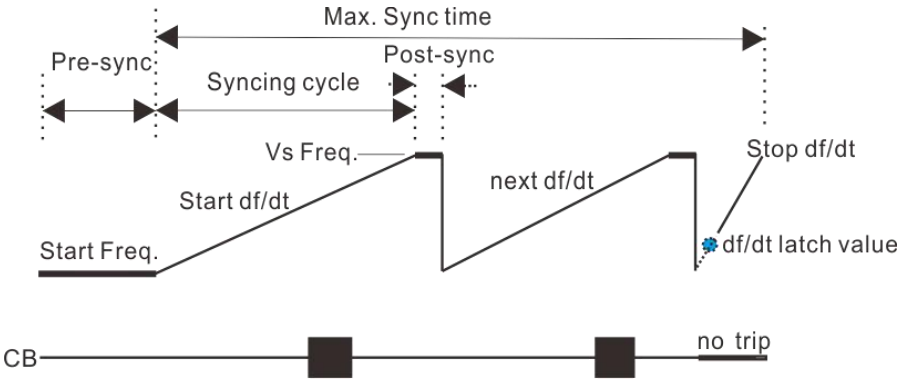
This function performs a ramping df/dt on the Vg side, simulating a slips acceleration to test the synchronization relay from an action permitted to latched status. The first latched df/dt value will be returned as the result.

In this function test, the voltage and frequency of Vg side must be set as have met the synchronization conditions.

The ramping df/dt value is defined by the "From", "To" and "Step" settings.

The syncing cycle time is automatically calculated by the module.

Process on Vg side:



Test Result:

Record the "F. Slip" of the synchronization protection.

7.13.8 Auto Synchronizer

This function performs an automatic voltage and frequency adjustment for the synchronization relay, the synchronized Lead-Angle and Lead-Time will be returned as the results.

In this function test, the voltage and frequency of Vg side settings, at least one of them should not have met the synchronization conditions.

The adjustment △v/△t and △f/△t values have to be defined.

Test Result:

Record the "Lead Angle", "Lead Time", "V. Action" and "F. Action" of the synchronization protection.

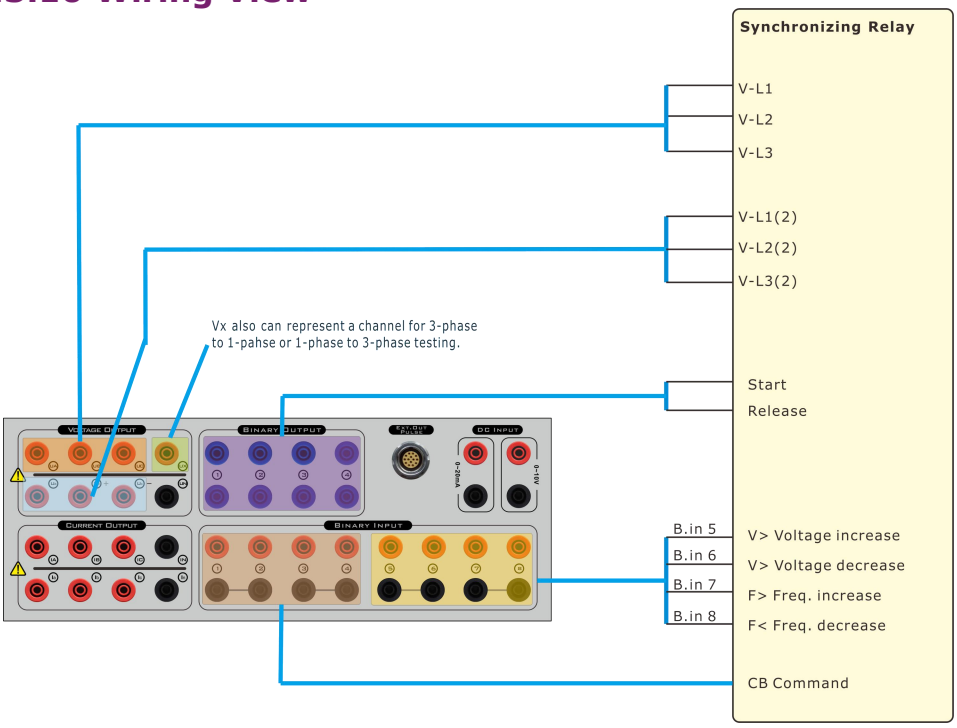
7.13.9 Binary Settings

Define of Binary inputs	
Binary inputs: 1~4	CB tripping command from the synchronization relay
Binary input: 5	The voltage increase adjustment signal
Binary input: 6	The voltage decrease adjustment signal
Binary input: 7	The frequency increase adjustment signal
Binary input: 8	The frequency decrease adjustment signal

Binary outputs (Allow user generate a start/release signal to the synchronization relay)	
Binary output	Activate the specified binary outputs and set the initial status. Disabled Initial as NO status. Initial as NC status.
Reference mode	1. Reference fault: Binary output turnover function starting from the beginning of the fault time.
	2. Reference prefault: Binary output turnover function starting from the beginning of the prefault time.
	3. Reference input: Binary output turnover function starting from the defined binary input trigger.
Reference binary in	Define the reference binary input channel.
Delay time	Binary outputs after this time will be turnover

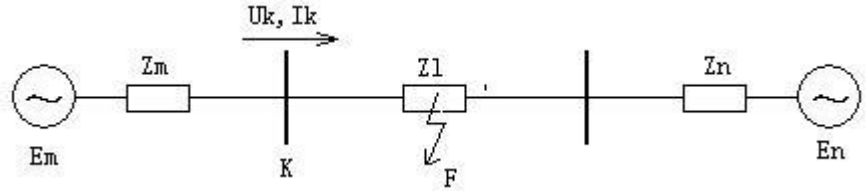
Binary outputs (Allow user generate a start/release signal to the synchronization relay)	
Hold time	Keeping the time after the binary output has turnover

7.13.10 Wiring View



7.14 Power Swing

The power oscillation module simulates the oscillation process of the system and the voltage and current output at the protection installation (K point) when the fault occurs in the system, as shown in the figure below, using a two-terminal transmission system as a model.



Em: Generator side
En: System side

It is mainly used to analyze the action characteristics of generator out-of-step protection, oscillation de-listing device, and the influence of the system oscillation on the action behavior of line protection such as distance, zero sequence, etc.

Prerequisites for testing

It is not necessary to set the Test Object prior to testing.

Define the hardware, the routing and wiring and trip commands.

According to the system model, enter the corresponding parameters into the software "system Model" tab.

Set Test parameters to Software "Test parameters" setting tab

According to the test requirements, choose whether to add the "Fault on oscillate" section.

7.14.1 Test Parameter

Parameter setting:	
Frequency	The output frequency of voltage and current during power angle δ oscillation; generally set as the rated frequency
Osc. type	The generator side voltage Em angle δ oscillation mode, the program provides three ways, including: **Swing:** The generator angle δ swings, the power angle δ starts from the "start angle" and swings between the "start angle" and "end angle". **Rotary (CW)**: the power angle δ starts from the "start angle" and rotates in the clockwise direction in the 360° range. **Rotary (CCW)**: the power angle δ starts from the "start angle" and rotates in the counter-clockwise direction in the 360° range.
Start Angle	Initial angle of oscillation
End Angle	Available only for the swing oscillate type as it represents the stop angle of oscillation
Cycle	The time required to complete 1 cycle of oscillation of the power angle δ; **Rotary:** 0～360° is a cycle; **Swing:** Start angle → End angle → Start angle;
Times of Osc.	Sets the number of the power oscillation (that is, the number of sliders)
Pre-fault t.	Output time of the state before oscillation Before entering the oscillation, the tester will first output the pre-oscillation state for a period of time to ensure the protection is reliable. The pre-oscillation state is calculated automatically by the software according to the starting angle of the oscillation and combined with the system model.

Fault on oscillate (Check this box to set up a fault in the oscillation)	
Fault start time	Fault trigger time, which takes the entry oscillation as the reference point of the time scale.
Fault time	Fault trigger time, which takes the entry oscillation as the reference point of the time scale
Fault type	Seven types of faults are provided: AN, BN, CN, AB, BC, CA, and ABC; Software automatically calculates the voltage and current values of A, B, C three-phase according to the setting of the system model and the corresponding fault impedance parameters.
Fault current	Fault short circuit current
Impedance	Short circuit point F to protection installation (K point) short circuit impedance Zf. Polar coordinates form: amplitude, angle

7.14.2 System Model

System Impedance	
Zm	Impedance of the generator side
Zn	Impedance of the system side
Zl	Impedance of the connection line

Em/En potential	
En	The voltage amplitude of En side; The voltage does not change and the angle is fixed to 0° in the oscillation process.
Em/En	A factor used to calculate generator side voltage Em, Em=En*factor; In the oscillation process, the amplitude of the voltage does not change, and the angle δ oscillates.

Oscillate parameters	
Center point Z Center point angle	According to the impedance parameters of the system, the out-of-step central impedance is calculated automatically. (representing the impedance of the equivalent power supply within the generator)
Max U, Max I, Min U, Min I	Peak value of the instantaneous Voltage and current in Oscillation process

CT/PT	
CT polarity:	Dir. Busbar: CT polarity toward busbar is positive, current flow from busbar to line is positive; Dir. Line: CT polarity toward line is positive, current flow from line to busbar is positive;
PT position:	Busbar: Voltage of Post-fault = Vnom Line: Voltage of Post-fault = 0V

Binary Inputs

Used to receive the relay tripping signals.

Binary output	

Control the binary outputs turn-over at the beginning of the oscillation.

Turn time	Flip moment, how long does it take to flip after the test starts.
Hold time	How much time to reset the binary outputs after the turnover have maintained; set to 0 to maintain until the end of the test

7.14.3 Swing Test Diagram

According the system parameter settings (Zm, Zn, Zl, En and Em/En factor), software will calculate the swing path line and show on this diagram view.(the red color trace on above). The start angle point marked as green color.

	Show / Hide the zone impedance which defined in the distance object settings.
	Zoom in
	Zoom out.
	Default zoom view.

8. Optional Modules

8.1 Energy Meter

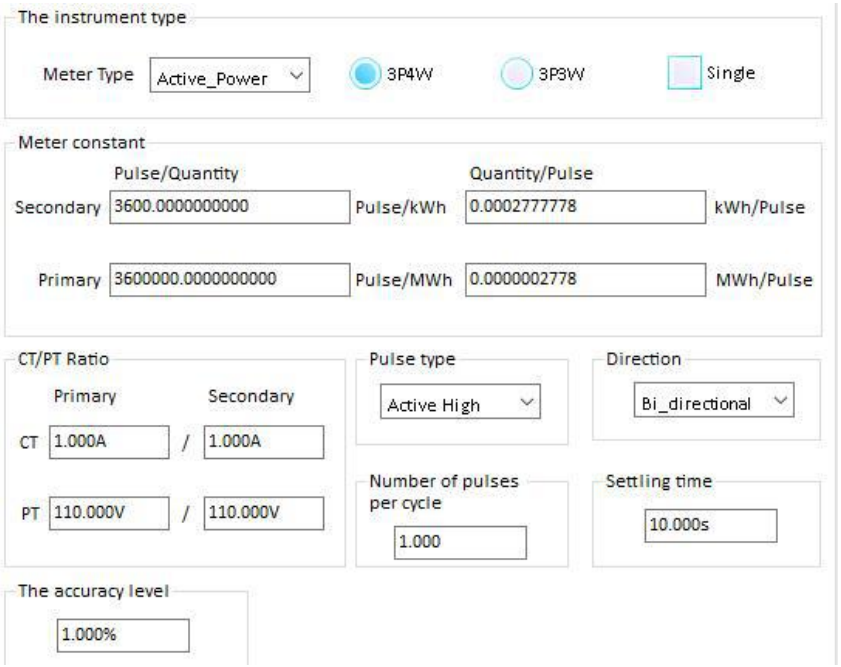
This module is used to calibrate the function and accuracy of energy meters.

Prerequisites for testing:

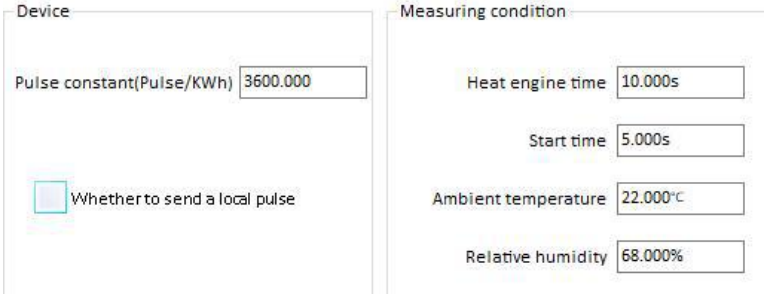
It is not necessary set the Test Object prior to testing;

First, set the energy meter type, pulse constant, CT/PT ratio, pulse type, etc on the "Meter" tab page;

Configure hardware type, wiring mode; (The pulse I/O ports refer the hardware introduction of relay test kit)



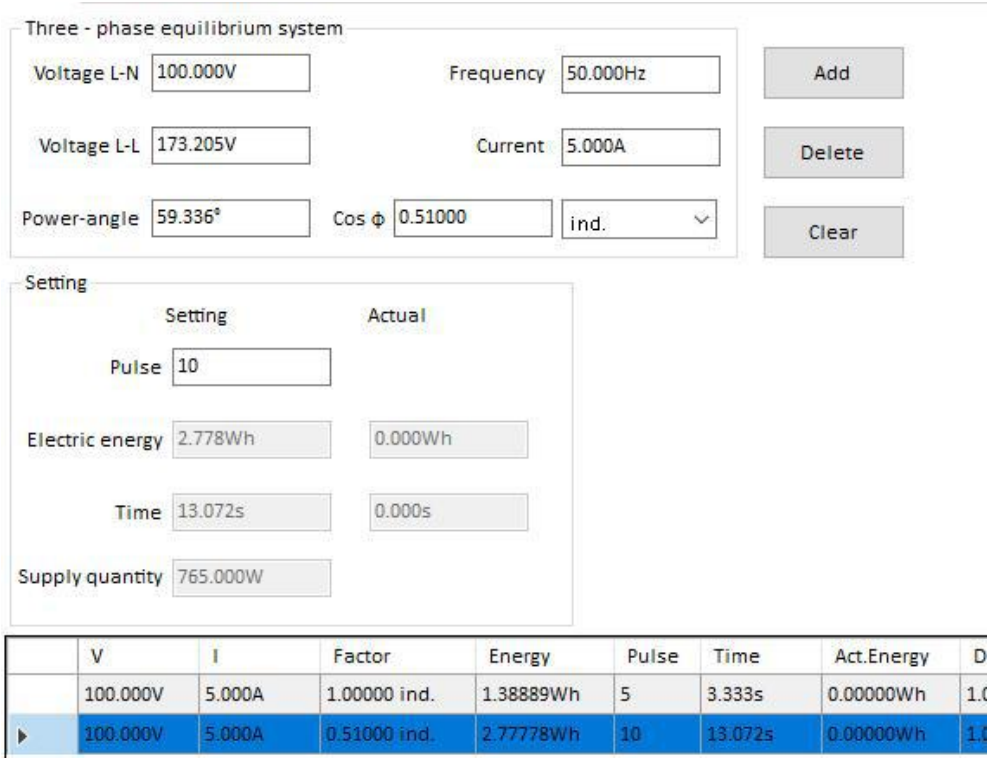
If necessary, you can configure the pulse output constant and whether pulse output is required on the "Settings" page, as well as the heat engine time, startup time during the test process, etc;



With reference to the energy meter to be tested, the output parameters are set in the "three-phase equilibrium system" area of the "Test" tab;

Set the number of pulses and deviations for the test and add them to the test list to be tested.

Press "Start(F5)" to start testing, and the software automatically evaluates the test results.



Note: Before start testing, please ensure the "Photoelectric conversion sampler" must connected and working well.

8.2 Transducer

This module is used to calibrate the function and accuracy of transducers.

Prerequisites for testing:

The tested transducer device needs to be predefined in the test object, including "transducer functions," "output" parameters, "Tolerance," "Numbers of phases," "characteristic definition," and so on. Refer to the "Transducer Object" description.

On the "Setting parameter" page, select the input for "measured quantity," "test phase," "wiring method," and so on.

3. After adding appropriate test points to the test list on the "test point" page, the testing can be started. The test result software will automatically evaluate based on the settings in the test object.

Buttons:

Add	Add the defined point to the test table below.
Add Multiple	Quickly add multiple fault type of a defined test point.
Remove	Delete the currently selected test point from the Test points list.
Remove All	Clear the test list
Check	Perform testing of the currently selected test point.

8.2.1 Setting Parameter

Measured Quantity: (Input quantity)

The dropdown options list automatically corresponds to the set of functions selected in the "Transducer Object". During testing, it is necessary to choose one option for testing.

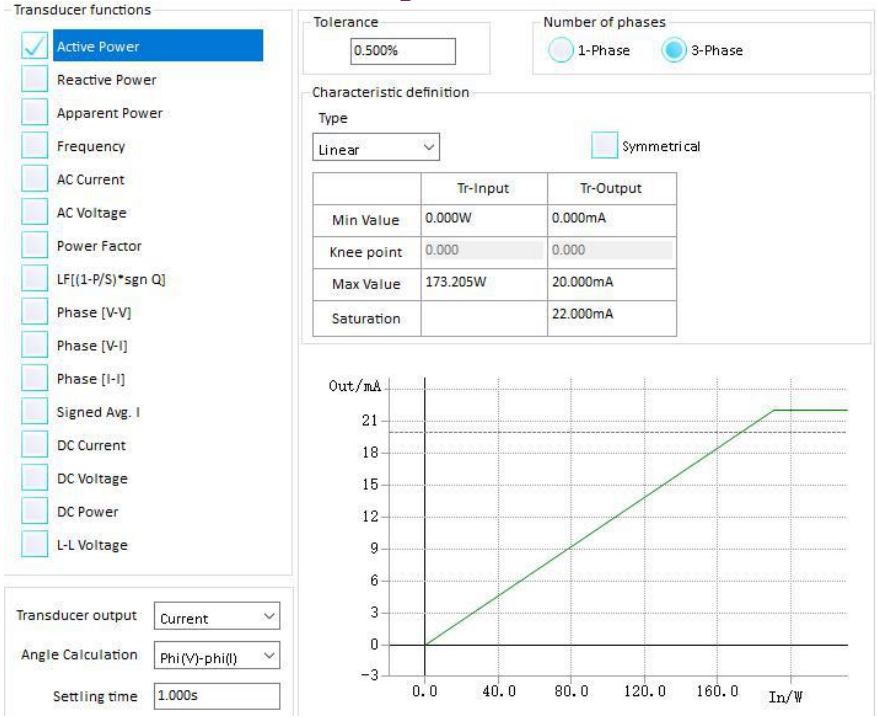
Test Phase

When testing single-phase functionality, you can choose which phase channel of the test instrument to output. You can also select the option to output three phases simultaneously with a phase difference of 120 degrees.

Measurement conditions

The "Ambient temperature" and "Relative humidity" inputs will be merged and included in the output report as part of the recorded data.

8.2.2 Transducer Object



Transducer functions	Check the corresponding checkbox options based on the functionalities possessed by the transducer under test.
Transducer output	Current/Voltage/Open Loop Choose based on the output characteristics of the transducer under test.
Angle Calculation	Phi(V)-Phi(I) / Phi(I)-Phi(V)
Setting time	Each test point requires waiting for the transducer to achieve stable output.
Tolerance	Enter the allowable deviation values based on the design specifications of the transducer under test.
Number of phases	Based on the design functionality of the transducer under test and the testing requirements, select either "single-phase" or "three-phase."
Characteristic definition	Based on the functionality and design parameters of the transducer under test, select the "characteristic type" as well as the input and output values.
Note: "Tolerance", "Number of phases" and "characteristic definition" are bound to the currently activated "transducer functions" in a one-to-one correspondence. Different transducer functionalities may have different "Tolerance", "Number of phases" and "characteristic definition." When switching the "transducer functions" the "Tolerance", "Number of phases" and "characteristic definition" will automatically switch accordingly.	

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