OMICRON

ARCO Control

User Manual

Manual Version: ENU 1139 06 05

The product information, specifications, and technical data embodied in this manual represent the technical status at the time of writing and are subject to change without prior notice.

We have done our best to ensure that the information given in this manual is useful, accurate and entirely reliable. However, OMICRON does not assume responsibility for any inaccuracies which may be present.

The user is responsible for every application that makes use of an OMICRON product.

OMICRON translates this manual from the source language English into a number of other languages. Any translation of this manual is done for local requirements, and in the event of a dispute between the English and a non-English version, the English version of this manual shall govern.

Contents

About this manual

The purpose of this user manual is to familiarize you with the *ARCO Control* software and to show you how to properly use it in various application areas. The manual contains important information on how to use *ARCO Control* safely, properly, and efficiently. Following the instructions in this user manual will help you to prevent danger, repair costs, and possible down time due to incorrect operation.

This manual is to be supplemented by existing national safety standards for accident prevention and environmental protection.

This user manual shall be read and observed by all personnel operating *ARCO Control*. Reading the user manual of *ARCO Control* alone does not release you from the duty of complying with all safety regulations relevant and applicable for working on systems in any power distribution network.

In addition to this user manual and the applicable safety regulations in the country and at the site of operation, the usual technical procedures for safe and competent work shall be heeded.

This user manual describes the *ARCO Control* software for controlling and configuring ARCO test sets. In order to get familiar with ARCO test sets, refer to the corresponding reference manuals.

1 Introduction

1.1 Designated use

ARCO Control is designed to optimally meet the requirements for testing recloser and sectionalizer controls (henceforth referred to as 'recloser controls') together with ARCO test sets.

ARCO Control enables the control of ARCO test sets via a Windows PC or an Android tablet. Its instant availability and easy operation concept make *ARCO Control* the ideal solution for the quick verification of recloser controls.

The intuitive user interface makes setting up tests particularly easy and convenient. The slider control allows you to adjust output quantities quickly and accurately. The test tools and integrated fault models for testing recloser controls support the tester in getting reliable results.

1.2 Safety

1.2.1 Safety symbols used

In this manual, the following symbols indicate safety instructions for avoiding hazards.

WARNING

Death or severe injury can occur if the appropriate safety instructions are not observed.

1.2.2 Safety instructions

You can find basic safety instructions for working with ARCO test sets on page 108. For more detailed safety instructions, refer to the ARCO 400 Reference Manual that can be downloaded via the OMICRON Customer Portal (www.omicronenergy.com/customer).

1.3 General warnings regarding ARCO test sets

WARNING

Death or severe injury caused by high voltages or currents at the outputs of the ARCO test set possible.

- ► Before operating an ARCO test set, carefully read the corresponding reference manual and the safety instructions provided therein.
- ► Be careful when the **I/0** key of *ARCO Control* is displayed in red or when the screen area is highlighted by a red frame. This means that the outputs of the connected ARCO test set are active, and the ARCO test set can output dangerous voltages and currents.
- ► ARCO test sets may only be operated by trained personnel.

2 Requirements / Installation

2.1 System requirements

ARCO Control can be installed on Windows PCs and Android tablets that meet the criteria below.

Windows PC:
- Windows 7 (32-bit and 64-bit)
- Windows 8, incl. 8.1 (32-bit and 64-bit)
- Windows 10 (32-bit and 64-bit)

Android tablet:
- Google Android version 4.4.x or later
- Screen resolution 1024 x 600 pixels (WSVGA) or more

2.2 Requirements for using ARCO Control

To control an ARCO test set with *ARCO Control*, you need the following:

- Either a Windows PC or an Android tablet with *ARCO Control* installed.
- For wired connection (Windows PC only): Ethernet cable or USB cable to connect to the ARCO test set.
- For wireless connection (Windows PC and Android tablet): Wi-Fi stick that is included in the delivery.

The ARCO test set is not required for using *ARCO Control* in **demo mode** on a suitable Windows PC or Android tablet.

2.3 Installation

Windows PC: Insert the installation disk into your drive and follow the on-screen instructions. Should the installation not start automatically, open Windows Explorer and navigate to your disk drive. Then, double-click the file **autorun.exe**

Android tablet: Download the *ARCO Control* app from the Google Play Store™ or refer to the OMICRON website for corresponding information or a corresponding link. You can also use the QR code on the right to download the app. Then, install the app on your Android tablet. The app does not require any specific permissions.

2.4 Updating the ARCO firmware

To update the ARCO firmware, you need to connect the ARCO test set to your Windows PC with *ARCO Control* installed. An update via Wi-Fi connection or Android tablet is not possible.

As soon as you connect *ARCO Control* to an ARCO test set with old firmware, you are automatically prompted to update the ARCO firmware. Follow the on-screen instructions to perform the update.

3 Connecting to the ARCO test set

3.1 Wireless connection

The Wi-Fi feature is not available in all countries. To check the availability in your country, contact OMICRON's Technical Support or the OMICRON Sales Department.

3.1.1 Wi-Fi connection to Windows PC

Proceed as follows to establish a wireless connection to the ARCO test set:

1. Plug the Wi-Fi stick (that is included in the delivery) into your ARCO test set.
2. Connect the ARCO test set to power supply, and switch it on.
3. Switch on your PC, and start *ARCO Control*.
4. On the **Test Set Selection** screen, select your ARCO test set. If the ARCO test set isn't available in the list, click the **Scan Wi-Fi** button.
5. Click the **Connect** button.
6. Select one of the two possible Wi-Fi network configurations:
   - Configure the device as access point
   - Connect to an external access point

Configure the device as access point

If you choose this configuration, the ARCO test set becomes the Wi-Fi router. For the Wi-Fi network, you can either use the default DHCP configuration of the ARCO test set or enter individual parameters for the DHCP configuration. Then, enter a password for you Wi-Fi connection.

Follow the on-screen instructions to associate your ARCO test set to *ARCO Control*. Then, the configuration is completed and you can start working.

Connect to an external access point

Choose this option if you want to use an already existing external Wi-Fi network. From the drop-down list, select the desired external access point, and enter the corresponding password.

Follow the on-screen instructions to associate your ARCO test set to *ARCO Control*. Then, the configuration is completed and you can start working.

3.1.2 Wi-Fi connection to Android tablet

Proceed as follows to establish a wireless connection to the ARCO test set:

1. Make sure that the latest version of *ARCO Control* is installed on your Android tablet.
2. Plug the Wi-Fi stick into the USB port of *ARCO 400*.

3. Connect *ARCO 400* to power supply, and switch it on.
4. Switch on your Android tablet.
5. Open the Wi-Fi menu on your Android tablet.
6. Select your *ARCO 400* test set. You can identify *ARCO 400* by its serial number. The serial number is visible on the name plate at the rear of *ARCO 400*.

7. Enter the Wi-Fi password.
8. Start *ARCO Control*.
9. On the **Test Set Selection** screen, select your *ARCO 400* test set.
10. Touch the **Connect** button and follow the on-screen instructions.

3.1.3 Reset Wi-Fi configuration

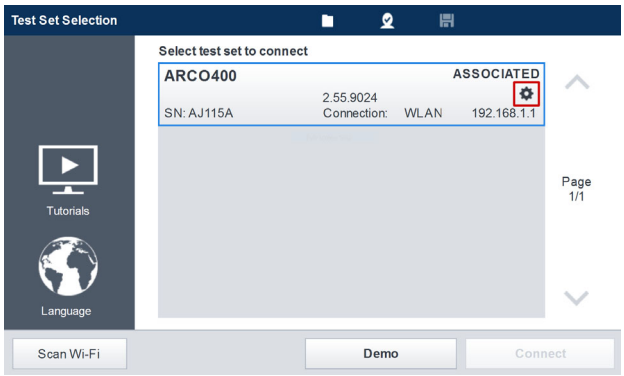
There are three different possibilities to reset your Wi-Fi configuration:

- **Option 1:**

  If you have chosen to establish the Wi-Fi connection via ’Connect to an external access point’ (→ page 9), unplug and replug the Wi-Fi stick at the ARCO test set to reset this configuration.

- **Option 2:**

  Reset the Wi-Fi configuration and unassociate the ARCO test set by clicking the ⚙ button on the **Test Set Selection** screen. You need to enter the device password to reset the configuration.



- **Option 3:**

  If options 1 and 2 are not applicable, select the **Associate** button at the front of the *ARCO 400* test set to reset the Wi-Fi configuration. Press the **Associate** button while powering up *ARCO 400*.

  Note, however, that this does not only reset the Wi-Fi configuration to factory default, but also the adapter/controller configuration and the IP configuration of the network interfaces (which is DHCP/AutoIP for both network interfaces).

3.1.4 Wi-Fi troubleshooting

If you are experiencing problems when trying to establish a Wi-Fi connection, try to eliminate them by applying the remedies proposed below:

- Keep a distance of min. 1 m/3 ft and max. 30 m/98 ft between your Windows PC/Android tablet and *ARCO 400* test set.
- Try to establish visual contact between your Windows PC/Android tablet and the Wi-Fi stick at your *ARCO 400* test set.
- Only use supported Wi-Fi sticks for your *ARCO 400* test set.
- Update the Wi-Fi driver on your Windows PC/Android tablet to the latest version.
- Try to connect to an external access point instead of using the device as access point (→ page 9).

If you are still not able to establish a Wi-Fi connection, try to use a wired connection (via Ethernet or USB cable) instead. See section 'Wired connection (Windows PC only)' below.

3.1.5 Disclaimer

The quality, performance, and stability of the Wi-Fi connection is subject to different factors, such as location or surrounding infrastructure (for example, metal or glass walls, etc.), the operating system used on your Windows PC/Android tablet, and/or Wi-Fi chipsets involved in the communication. Even though we carefully designed, implemented, and tested our Wi-Fi support, OMICRON does not guarantee an accurate communication via Wi-Fi. You may experience communication dropouts, instability of the connection, and, under certain circumstances, the inability to establish a connection to the device via Wi-Fi.

3.2 Wired connection (Windows PC only)

Proceed as follows to establish a wired connection to the ARCO test set:

1. Either connect the RJ45 Ethernet interface of the PC to the RJ45 ETH interface of the ARCO test set, or connect the USB interface of the PC to the USB port (USB type B) of the ARCO test set.
2. Connect the ARCO test set to power supply, and switch it on.
3. Switch on your PC, and start *ARCO Control*.
4. On the **Test Set Selection** screen, choose the appropriate ARCO test set, and click the **Connect** button.
5. If *ARCO Control* could not find or connect to the ARCO test set, only the **Demo** button is enabled. Click the **Demo** button to use *ARCO Control* in offline (demo) mode without an ARCO test set. For more information on how to proceed when the connection could not be established, see section FAQ on page 111.

4 User interface and operating elements

4.1 Operating elements of ARCO Control

The figure below shows the operating elements of *ARCO Control* on Windows PCs. The operating elements of *ARCO Control* on Android tablets are similar.

View Last Report button

Display the test report saved last.

Help button

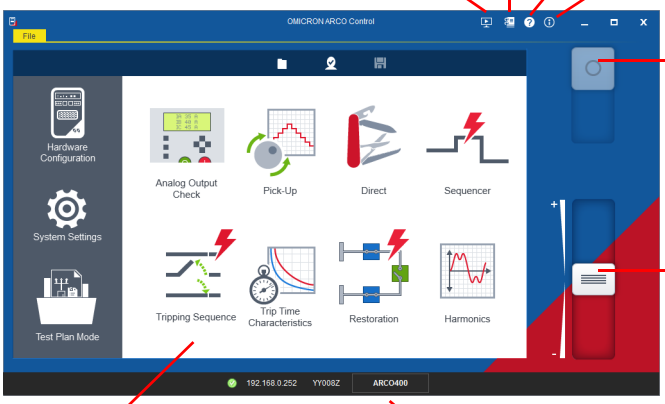
Display the user manual.

Video button

Open the video tutorials.
Available on Windows PCs only.

Info button

Display copyright and open source license information.



I/0 key

The **I/0** key changes its skin and function depending on the state of the application. See the table below for more information.

Slider control

Move the slider control up and down to use it as an alternative to the numerical keyboard (numpad) to set or change test quantities. When you let go of the slider control, it moves back to its initial position.

Screen area

Screen area for operating *ARCO Control*.
See page 14 for more information.

Test set information

Shows the connected test set and the application mode. Touch/click the **Test set selection** button to choose a different test set or switch to demo mode.

Behavior of the I/0 key

The **I/0** key is disabled. It is not possible to activate the ARCO outputs. This state applies in the following situations:

- During the test configuration after selecting a test tool.
- If no test tool is selected (for example, while the Hardware Configuration screen or the main menu is displayed).
- When you are using *ARCO Control* in demo mode.

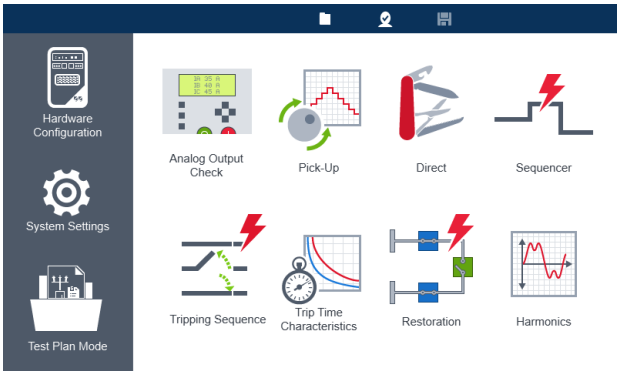
The displayed test tool is ready for testing. Slide down the **I/0** key to activate the ARCO outputs and to apply the values that have been specified in the test tool to the recloser control under test.

The ARCO outputs are active. Touch/click the activated **I/0** key to deactivate the ARCO outputs.

The ARCO outputs are deactivated automatically if you leave the test tool and go back to the main menu or if you close the software.

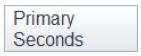
Screen area

The screen area is the central operating element of *ARCO Control*. Touching/clicking an icon or button will select and execute the corresponding function of the software.



ARCO Control is organized in several components. The central element of the software is the main menu shown in the figure above. From the main menu, you can directly access the various test tools, the hardware configuration, and the system settings.

4.2 Meaning of icons used in the user interface

	Show/hide the numerical keypad (numpad) or the fixed values pad for entering values.
	Change the predefined fixed value offered in the fixed values pad to the value currently set in the input field, or reset the predefined value to the factory default.
	Return to the main menu.
	Test report configuration icons (**Save on user request**, **Always ask** and **Auto save**). For more detailed information, refer to page 101.
	Open a file explorer view to select the folder for saving test reports on your device.
	Save test report. This button is displayed when the **Save on user request** mode is selected (→ page 105). It becomes active as soon as test results are available in a test tool.
	Toggle the display between vector view and table view. When you switch from table view to vector view, the diagram is automatically scaled according to the displayed values (to ensure that all values are visible).
	Reset the values to the default settings or clear the keyboard input field when defining a comment or specifying a file name (→ page 101).
	Launch the binary output configuration, the binary input configuration or select one or more binary inputs for the **Off on trigger** option or the **Monitored signals** option (→ page 29).
	Select this button to open the adapter management from the **Controller Selection** screen or to open the VT or CT ratio settings from the **Nominal Values** screen of the hardware configuration. Select the diagram scaling in the **Trip Time Characteristics** tool (logarithmic or linear), reset the zoom factor, clear the diagram, or display the tolerances (i.e., the maximum and minimum allowed trip time characteristics).
	Zoom buttons in the **Trip Time Characteristics** tool. Enlarge or reduce the scaling of the x axis in the diagram.
	Set the value of I_{test} (vertical blue line) to the center of the x axis in the currently displayed diagram (**Trip Time Characteristics** tool only).
	Unit manager. Select between primary or secondary values and between time in seconds or cycles.
	CT star point connection on **load** side or CT star point connection on **source** side (→ page 24). Touch/click the icon to select the CT star point connection (CT grounding). *ARCO Control* automatically adapts the phase settings according to this selection.

4.3 Keyboard shortcuts (Windows PC only)

Shortcut	Function
F1	Open user manual.
F2	Return to **Home** screen.
F10	Save test results in test report.
ESC	Discard all changes that you have made in the currently selected field.
CTRL + F5	Activate or deactivate outputs.
F8	Toggle between fault and prefault states the **Direct** test tool.

5 Video tutorials

To give you an overview of *ARCO Control* and make you familiar with its main features, OMICRON offers corresponding video tutorials.

Windows PC: You have two possibilities to access the video tutorials in *ARCO Control*:

- Via the **File** menu. Go to **File > Tutorials** and select the desired video tutorial.
- Via the **Video** button  (either in the side bar of the **Test Set Selection** screen or on the *ARCO Control* header bar).

Android tablet: The video tutorials are not installed with *ARCO Control*. However, you can download them from the OMICRON customer area (www.omicronenergy.com/customer). Go to **Software Downloads > ARCO Control**, select the desired video tutorial and download it.

6 Launching ARCO Control

After connecting the Android tablet or Windows PC to the ARCO test set (→ page 9), proceed as follows:

1. Launch *ARCO Control* on your Android tablet or Windows PC.
2. The **Test Set Selection** screen is displayed. The list shows all available ARCO test sets in the network. Select the appropriate ARCO test set, and select the **Connect** button. If your ARCO test set is not associated with your Android tablet or Windows PC yet, you will be requested to push the **Associate** button on the ARCO test set.

   Alternatively, if you would like to use *ARCO Control* in offline (demo) mode without an ARCO test set, select the **Demo** button.
3. Then, the test mode selection screen is displayed. Choose the test mode as described in section 6.1.
4. If using the **Test Plan Mode**: Select and execute your test plan as described in section 7.

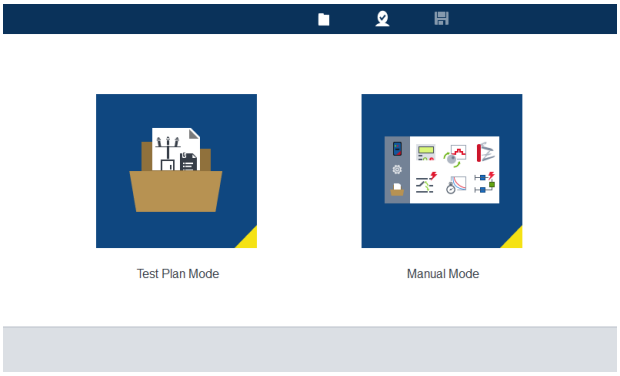
   If using the **Manual Mode**: Choose a controller adapter as described in section 6.2.

6.1 Choosing the test mode: Test Plan mode or Manual mode

ARCO Control does not only support the manual setup and execution of tests, it also supports the step-by-step execution of predefined test plans prepared with the OMICRON *ReCoPlan* software. You can find the installation files for *ReCoPlan* on the DVD that was included in the delivery or in the download section of the OMICRON customer area (www.omicronenergy.com/customer).

ReCoPlan test plans contain all settings required for the test tasks defined, such as the controller selection, the hardware configuration settings, the test tool settings, and the order of their execution.

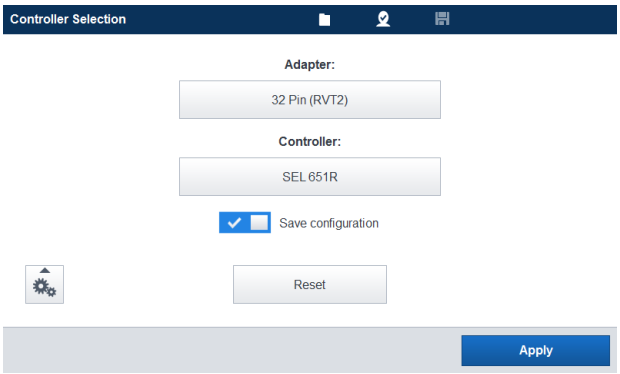
The screen for selecting the test mode is displayed after the Test Set Selection screen.



Select **Manual Mode** to manually setup and execute tests with *ARCO Control*. *ARCO Control* then displays the **Controller Selection** screen described in section 6.2.

Select **Test Plan Mode** to execute a predefined test plan prepared with the *ReCoPlan* software. Select and execute your test plan as described in section 7.

6.2 Controller selection



The **Controller Selection** screen is automatically displayed after selecting the manual test mode of *ARCO Control* (→ page 17). To access the controller selection during normal operation, open the **Hardware Configuration** (→ page 22), and select the **Controller selection** button.

OMICRON provides ready-made controller adapters for common reclosers and sectionalizers to facilitate the connection between the recloser/sectionalizer control under test and the ARCO test set. You can find a list of these controller adapters on the OMICRON website (www.omicronenergy.com). The connected controller adapter is automatically detected and pre-selected in the **Controller Selection** screen. Then, you only need to choose the corresponding type of the recloser/sectionalizer control under test. Settings that are specific for the selected adapter/controller combination are then automatically applied to the hardware configuration.

If your recloser/sectionalizer type is not listed for selection, select **Other**. Then, you can freely perform all relevant settings in the hardware configuration.

The **Save configuration** toggle switch allows you to save the selected adapter/controller combination (including the serial number of the connected adapter). Next time you connect the same adapter, the saved configuration is automatically applied and the **Controller Selection** screen is skipped.

Select the button to open the **Adapter Management** screen. Use this screen to import new adapter definitions (→ page 32).

Touch/click the **Apply** button to confirm your selection and enter the hardware configuration.

7 Executing test plans in Test Plan mode

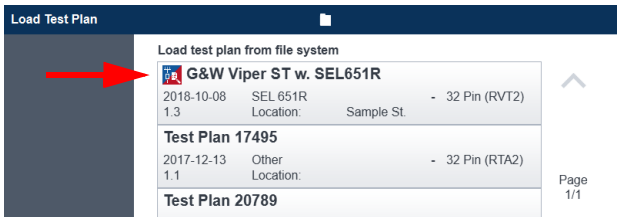
Test plans for *ARCO Control* can be predefined with the OMICRON *ReCoPlan* software. For more information, refer to the *ReCoPlan* Help.

Proceed as follows to execute a predefined test plan:

1. Open a test plan.

   You have two options to open a test plan:

   - **Option 1** (for Windows PCs only)**:** Open the test plan directly from *ReCoPlan* by clicking the **Execute test plan** button on the *ReCoPlan* ribbon. *ARCO Control* is started automatically, and the *ReCoPlan* icon is displayed next to the test plan name.

   - **Option 2:** Save the test plan to the folder defined in *ARCO Control* (→ page 33). Launch *ARCO Control*, and after the test set selection, choose **Test Plan Mode**. Select the test plan to be opened, and touch/click the **Apply** button to confirm your selection.

     If your test plan is not listed, touch/click the file explorer icon in the title bar and select the folder containing your test plan.

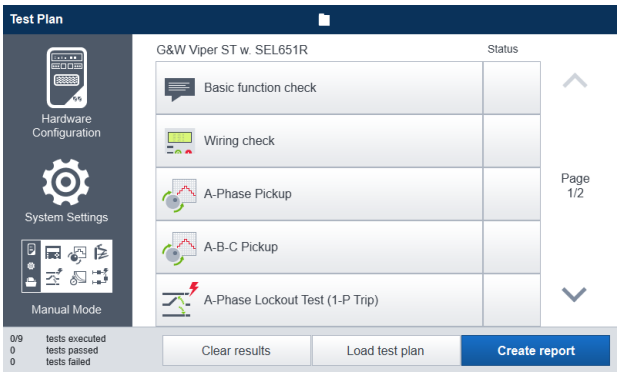
     Only test plans that were defined for the currently connected adapter can be opened. Other test plans can only be opened in demo mode.

2. Adjust the settings.

   ARCO Control automatically adjusts the controller selection, the hardware configuration, and the settings required for the test tools as defined in the test plan.

   The hardware configuration settings adjusted by the *ReCoPlan* test plan are read-only, except for the **report information** and the **f nom**, **V nom (L-L)**, and **I load (prefault)** values. However, it is possible to change the predefined test tool settings.

   The **Test Plan** screen shows a list of all test tasks defined in the test plan.

3. Execute the test plan.

   You have two possibilities to execute the test plan:

   - **Manually**

     Select the test task to be performed, and execute the test tasks one after another from top to bottom.

     ARCO Control automatically opens the corresponding test tool with the settings defined in the test plan, and you can perform the test as described for the specific test tool (→ page 34).

     If required, you can change the predefined test settings according to your needs. If the test tool supports a multi-stage process for defining the test settings, select the respective "back" button at the bottom of the screen (e.g., **Fault**, **Sequence**, **Test Points**, etc.) to go back and change the test settings. For example, in the **Trip Time Characteristics** tool you can change the fault type or select another trip time characteristic if such a characteristic has been made available in the *ReCoPlan* test plan.
     The results of such modified tests are stored in the test report. However, it is not possible to save test plans modified this way. Modifying and saving test plans is only possible in the *ReCoPlan* software.

     Select the **Finished** button in the test tool‘s screen to close the test tool.

   - **Automatically**

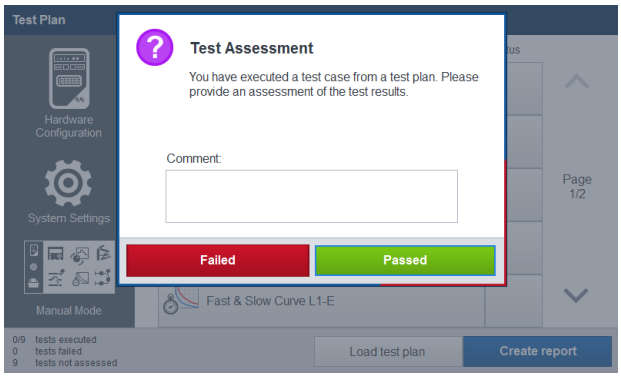
     Slide down the **I/0 key** to automatically execute all test tools. During the automatic test execution, *ARCO Control* only shows the test screens of the corresponding test tools. You get back to the **Test Plan** screen when the test sequence is completed.

     The test sequence stops if any error occurs during test execution. You can also stop the test sequence manually by sliding up the **I/O key**.

     There are a few test tools that require manual input: **Analog Output Check**, **Direct**, and **Pick-Up**. For these test tools, *ARCO Control* opens the test screen but does not automatically execute the test. You need to start and stop the test manually. Once you have completed the test and entered the test assessment, the automatic test execution continues.

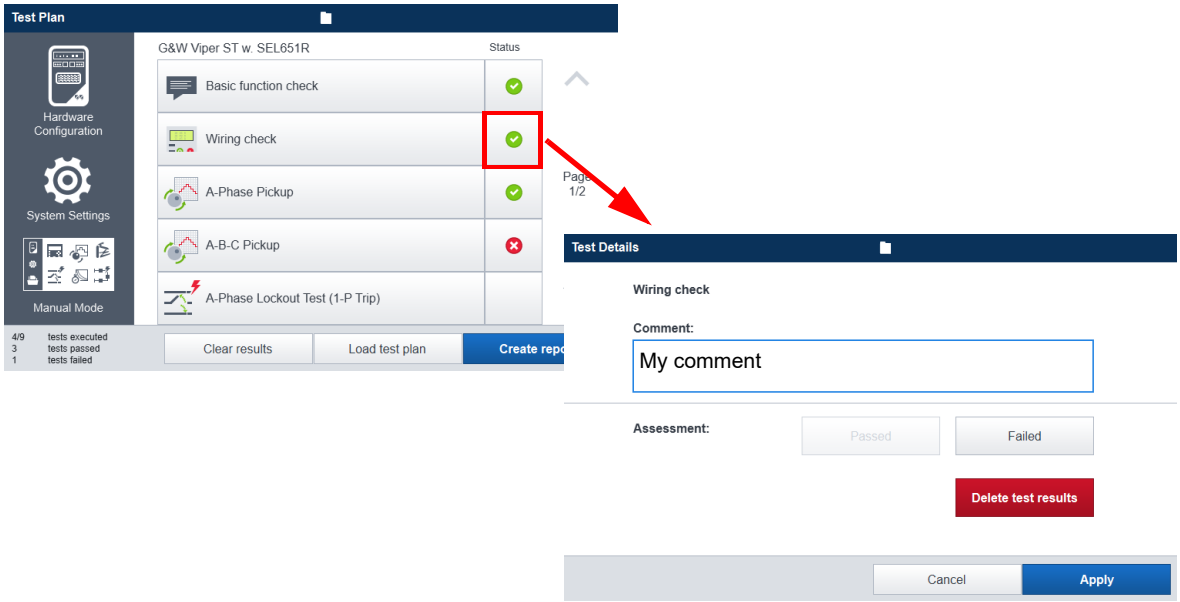
4. Assess the test results.

   Depending on the test tool, the test is either automatically assessed as passed or failed, or you need to do this manually. In addition, you can enter a comment concerning the test result.



Your test assessment is displayed in the **Status** field of the respective test (passed or failed).

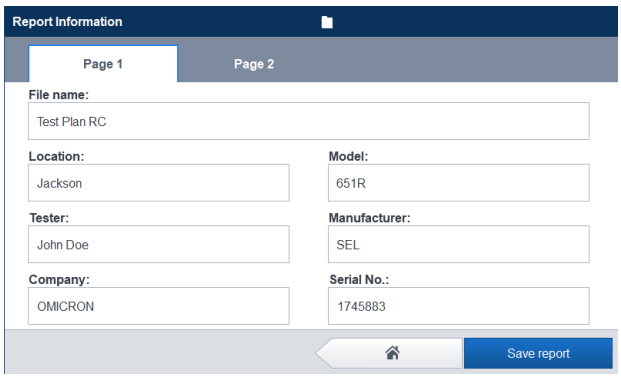
Touching/clicking the **Status** field opens a dialog where you can change the test assessment, enter a comment, or delete the test results for the respective test tool.



To delete the test results and custom settings for all test tools, click the **Clear results** button at the bottom of the **Test plan** screen.

5. Create a test report.

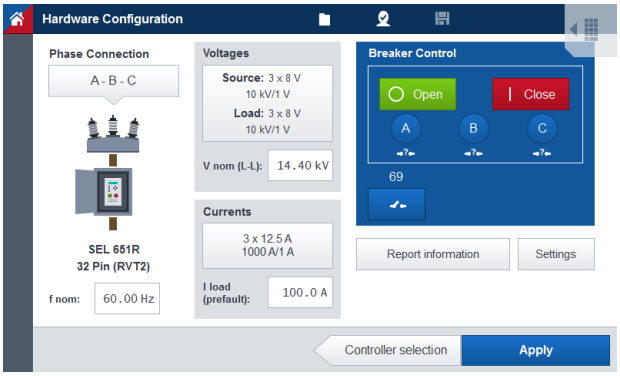
   Once you have performed all test tasks defined in the test plan, select the **Create report** button in the **Test Plan** screen to save a test report for the test plan. The **Report Information** dialog is displayed where you can specify the file name and enter report information to be printed in the test report. Except the file name, all report information is taken from the test plan. Touch/click an input field to modify its content.



6. Load another test plan.

   If desired, select the **Load test plan** button in the **Test Plan** screen to load another test plan.

8 Hardware configuration



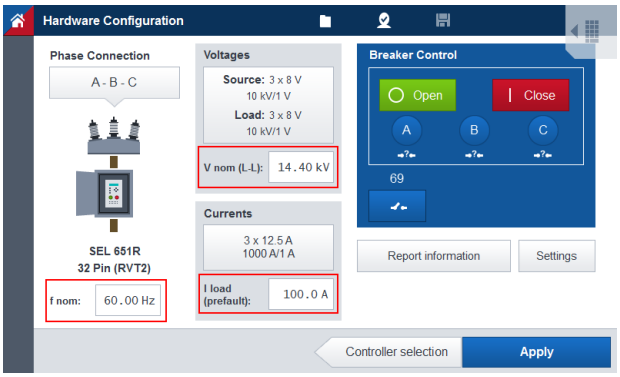
The hardware configuration contains the nominal settings and properties of the recloser control under test as well as the configuration of the ARCO test set used for the test.

The hardware configuration is automatically displayed after the test mode selection (→ page 17). To access the **Hardware Configuration** screen during normal operation, select the **Hardware Configuration** icon in the main menu.

The hardware configuration settings are automatically predefined according to your controller and adapter selection (→ page 18). The different components of the hardware configuration are introduced in this chapter.

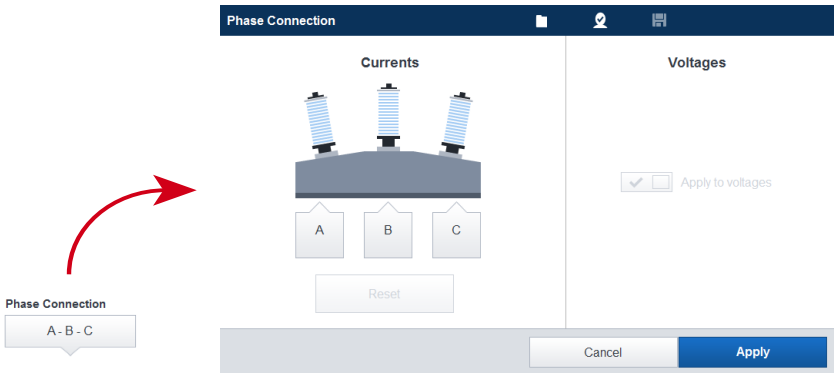
Once you have completed your hardware configuration settings, select the **Apply** button to confirm your settings and enter the main menu.

8.1 Nominal values



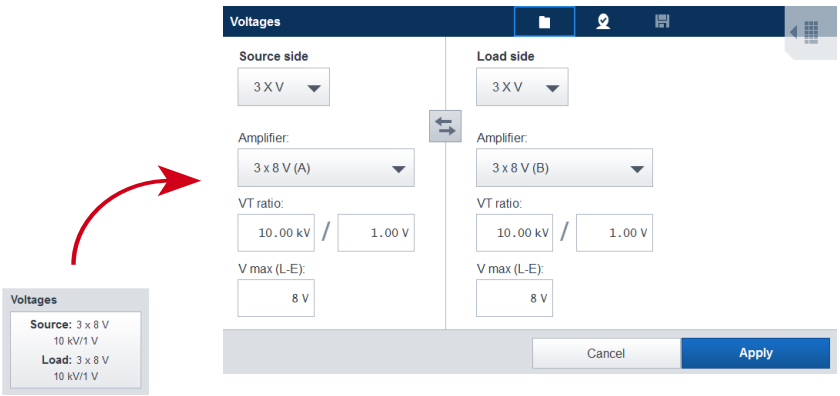
The fields for the nominal values of the recloser control (i.e., nominal frequency, primary L-L voltage, and typical load current) are pre-filled with standard default values. Therefore, you need to adjust these values manually in correspondence with the recloser control under test.

8.2 Phase connection



At **Phase Connection** you can change the assignment of the phases to the ARCO current and voltage outputs. Touch/click the phase labels of the current outputs to assign the phases. Select the **Apply to voltages** toggle switch to apply the phase sequence selected for the currents to the voltage outputs.

8.3 Voltages



In the **Voltages** screen**,** you can enable or disable the output of voltages by the ARCO test set, and, if enabled, select the configuration of the ARCO voltage outputs. Disabling the voltage output will deactivate the controls in this screen and disable the voltage outputs in the respective screens of the test tools.

Use the **Source side** and **Load side** drop-down lists to define whether the voltage transformer is installed on the source side or on the load side (the connection of the voltage transformer influences the voltage output during the postfault state, for example), to enable or disable the output of voltages, and to select the appropriate ARCO voltage outputs.

The voltage output configuration is predefined according to the adapter and controller selected in the **Controller selection** screen (→ page 18).

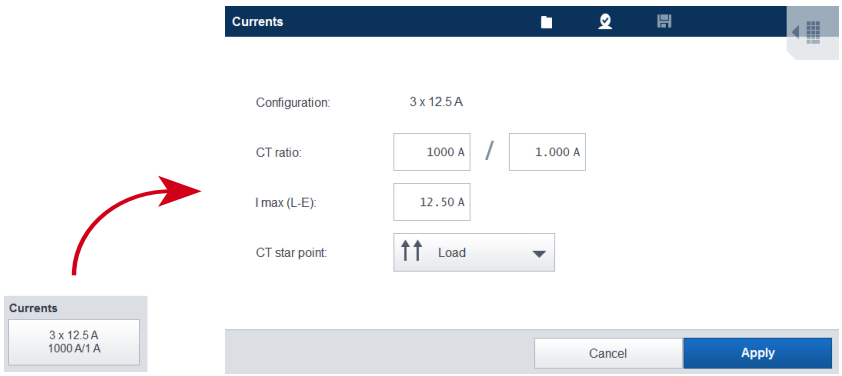
Amplifier drop-down list: Choose the amplifier that is used both for the source side and for the load side. Basically, there is amplifier A and amplifier B. For example, if you select amplifier A for the source side, amplifier B is automatically selected for the load side (and vice versa). Both amplifiers can output either 8 V or 150 V (you need a separate license for the 150 V option).

Be careful to select the correct voltage amplifier configuration for the recloser control you are testing. Otherwise, the voltage input at the recloser control might be damaged.

VT ratio fields: When using the 150 V outputs of the ARCO test set, enter the nominal primary and secondary values for the VTs of the system under test. When using the 8 V outputs, enter the nominal ratio of the capacitive or resistive voltage sensor (e.g., 10 kV/1 V).

V max (L-E) field: Define the maximum allowed voltage for the recloser control under test.
To improve the output duration, set the maximum allowed voltage to the minimum required voltage for the recloser control under test. The compliance voltage of the voltage output of the ARCO test set will be optimized to lower the power dissipation in the linear amplifiers.

8.4 Currents



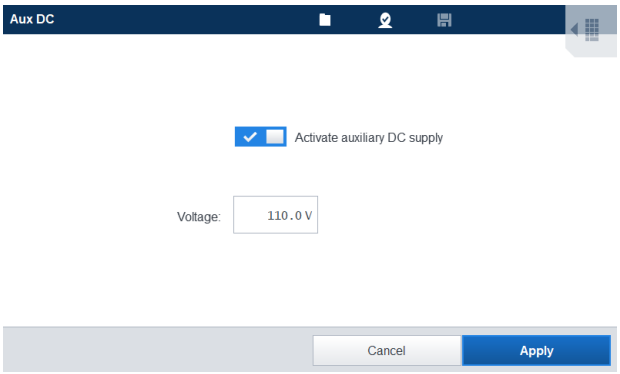
At **Currents**, the configuration of the ARCO current outputs is automatically preset according to your adapter and controller selection (→ page 18) and cannot be changed.

CT ratio fields: For the 3 x 12.5 A configuration, you can enter the CT ratio in ampere. If using a Rogowski sensor configuration, enter the ratio as stated on the type plate of the Rogowski current sensor (e.g.: 1000 A / 2 V).

I max (L-E) field: Enter the maximum allowed current for the recloser control under test.

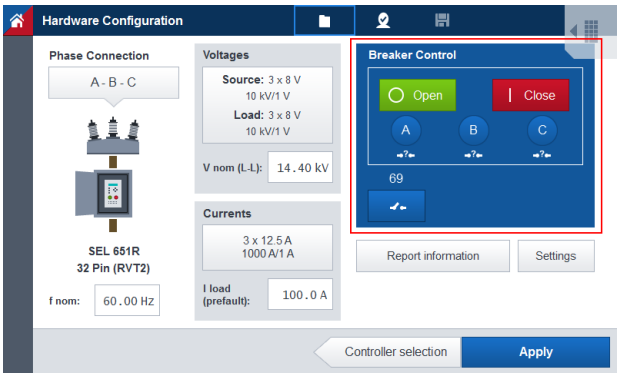
CT star point drop-down list: Select the CT star point connection (load side or source side).

8.5 Aux DC



At **Aux DC**, activate or deactivate the auxiliary DC supply of the ARCO test set and set the voltage value. Note, however, that the **Aux DC** function is only available when a *BOB2* box is connected. Otherwise, the **Aux DC** button is not even visible.

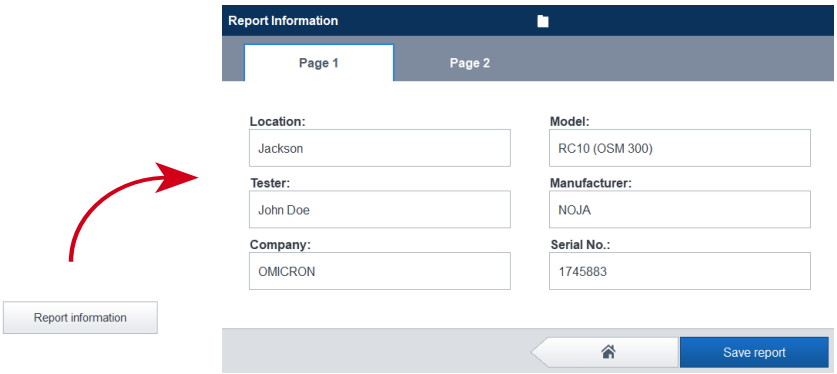
8.6 Breaker control



The **Open** and **Close** buttons in the *ARCO Control* software have the same functionality as the OPEN and CLOSE push buttons at the front panel of the ARCO test set. With these buttons, you can change the position of the simulated circuit breaker (CB) to be either open or closed. If enabled by the controller adapter, you can also toggle a 69 switch that represents the recloser's yellow handle contact. Furthermore, if you are testing single- or tripple-phase reclosers, you can individually set the CB position for each of the three phases to open or closed.

Usually, when you connect your ARCO test set via a controller adapter cable to the recloser control, the CB position is automatically selected. If you are using a *BOB2* box, however, the position of the simulated CB is shown as undefined until you complete the hardware configuration by clicking the **Apply** button. Only then is the configuration downloaded to the *BOB2* box. This allows you to double-check your settings before downloading them to the *BOB2* box.

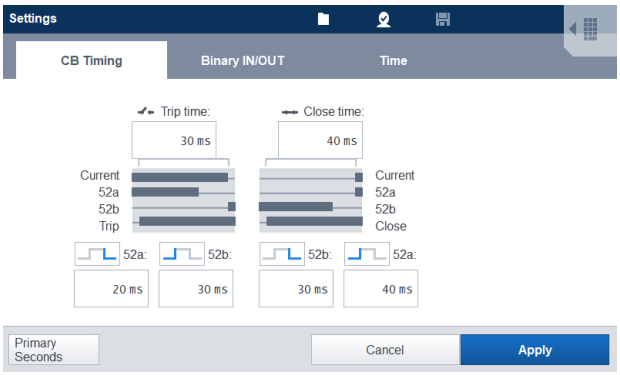
8.7 Report information



In the **Report Information** screen**,** enter general information about the recloser control under test and the tester. The information given here is printed in the test report. If you selected one of the predefined controller types in the controller selection, the **Model**, **Manufacturer** and **Application** fields are filled out accordingly.

8.8 Settings

8.8.1 CB timing



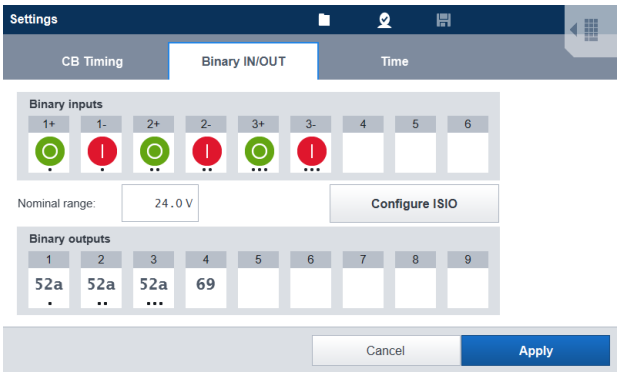
At **CB Timing**, you can set the time that the simulated circuit breaker needs for the trip and close actions. The values that are displayed in this screen are preset according to your adapter and controller selection (→ page 18).

The **Trip time** is the total time until the current flow is definitely interrupted after the occurrence of the trip signal. The **52a** time is the time until the 52a auxiliary contact opens after the occurrence of the trip signal. The **52b** time is the time until the 52b auxiliary contact closes after the occurrence of the trip signal. The time set for 52b must be longer than or equal to the 52a time.

The **Close time** is the time until the current flow is restored after the occurrence of the close command. The **52b** time is the time until the 52b auxiliary contact opens after the occurrence of the close command. The **52a** time is the time until the 52a auxiliary contact closes after the occurrence of the close command. The time set for 52a must be longer than or equal to the 52b time.

Touching/clicking the **Apply** button in this screen just prepares the breaker model settings in *ARCO Control*. The transmission of the breaker model settings to the ARCO test set is only performed when you select the **Apply** button in the **Hardware Configuration** screen.

8.8.2 Binary IN/OUT



In this section, the binary inputs and outputs of the ARCO test set are already predefined according to your adapter and controller selection (→ page 18) and cannot be changed.

The colors used for the trip signals and the close commands, however, can be switched in the system settings (→ page 31).

or	General trip signal.	or	General close command.
or	Trip signal for phase A, B or C.	or	Close command for phase A, B or C.

The **nominal range** defines the nominal rated voltage for the trip and close inputs. With this field, you set the nominal range for all inputs. The actual threshold in the ARCO test set is then set to 0.7 x threshold value.

The binary input/output configuration can be opened from the hardware configuration screen or by touching/clicking the wrench symbol in the test tools.

Configure ISIO

ISIO 200 is supported by the **Pick-Up** (**Current pick-up** test mode) and **Sequencer** test tools only.

ISIO 200 is a binary input/output terminal with an IEC 61850 interface. To use *ISIO 200* together with an ARCO test set and *ARCO Control*, connect *ISIO 200* to one of the ARCO test set's ETH ports.

For more information on *ISIO 200*, refer to the *ISIO 200* User Manual that you can download from the OMICRON Customer Portal (www.omicronenergy.com/customer).

In *ARCO Control*, you can define up to eight binary inputs for I*SIO 200*:

1. Touch/Click the **Configure ISIO** button.
2. Enter the serial number of the connected *ISIO 200*.
3. Assign a signal to the binary inputs: Select an input, and choose a signal from the drop-down list. You can choose between two different signal types: **Pick-up** and **Generic**. The generic signal is any signal other than the pick-up or trip/close signals.

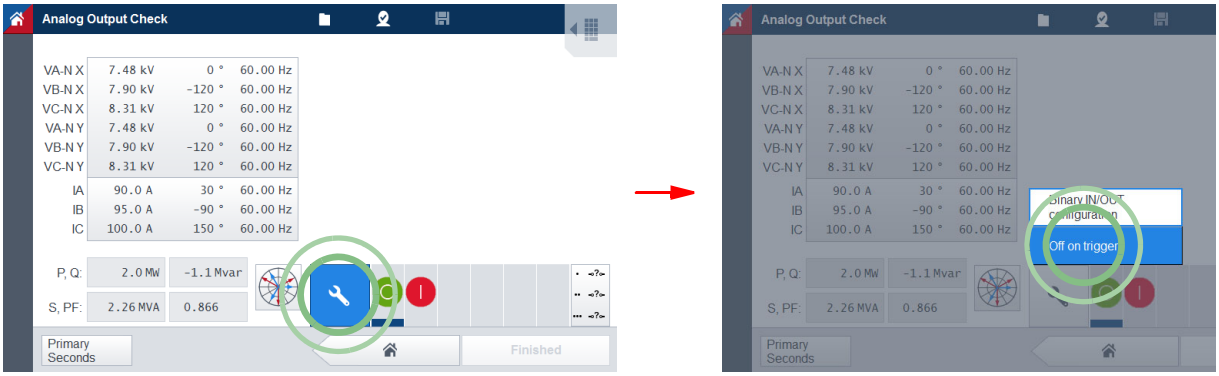
   You can use pick-up signals as trigger signals in the **Pick-Up** and **Sequencer** test tools. However, you can use generic signals as trigger signals in the **Sequencer** test tool only.
4. In the **Name tag** field, enter a name for each signal.
5. Touch/Click the **Apply** button to save your settings.

Off on Trigger option

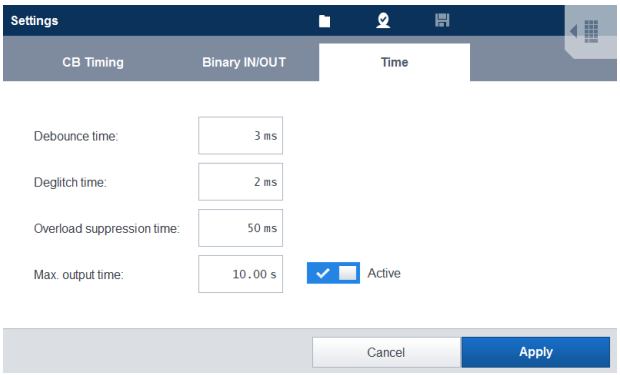
The test tools **Analog Output Check**, **Pick-Up** and **Direct** provide the possibility to trigger on one or more binary inputs. Then, all ARCO outputs are switched off immediately upon reception of the trigger event on the specified binary input.

Touch/click the wrench symbol in the test tool's screen to select the **Off on Trigger** option. In the subsequent screen, select the binary inputs to be configured with this function.

Inputs selected for the **Off on Trigger** option are marked by a dark blue bar below the input symbol.



8.8.3 Time



At **Time** you can specify a debounce time and/or a deglitch time and the overload suppression time of the ARCO test set.

The test tools **Analog Output Check**, **Pick-up** and **Direct** further allow for a maximum time limit to be set for the test outputs. This can be used to protect the recloser control from damaging test signals being applied for inappropriate lengths of time.

The **debounce time** is used to suppress bouncing of the input signal. A **deglitch time** can be configured to suppress short spurious pulses. The deglitch time results in an additional dead time and causes a signal delay (refer to figure 8-1 on page 30). For some recloser adapters, it is required to set a deglitch time per default.

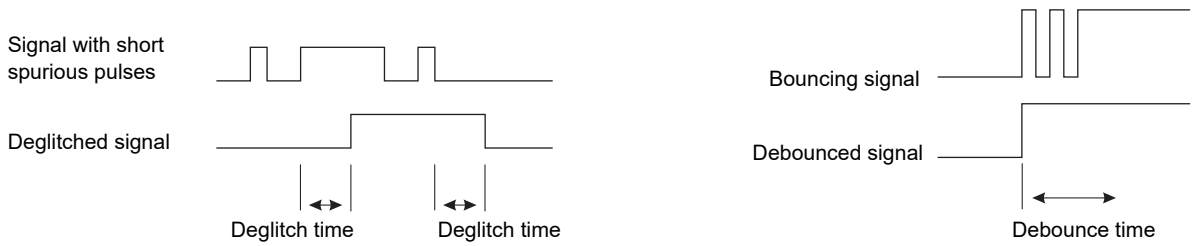


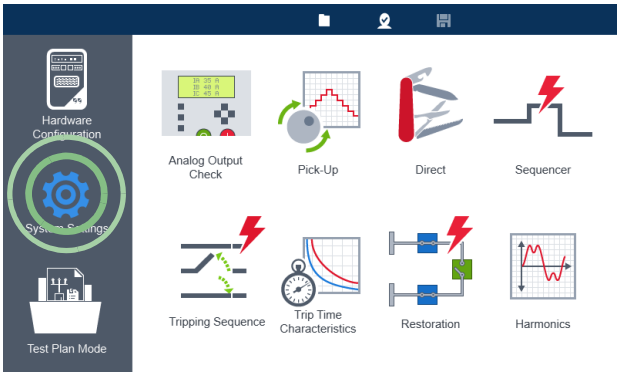
Figure 8-1:Deglitch time and debounce time

The **overload suppression time** defines the overload detection "sensitivity" of the ARCO test set, i.e., the time the overload has to be present to be detected.

This option can be used to suppress overload messages in the test report where they are not relevant for the test (for example, if the overload occurs during the prefault).

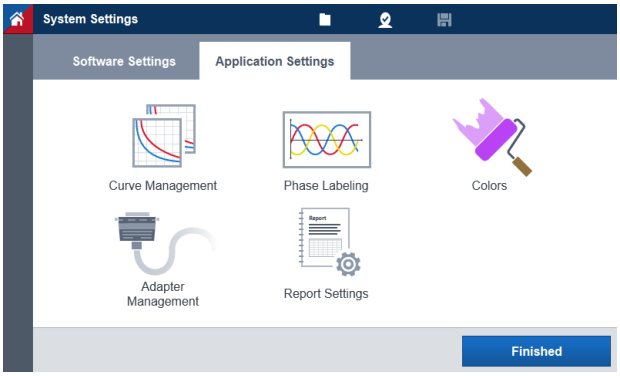
The shorter the overload suppression time, the higher the overload detection sensitivity.

9 System settings



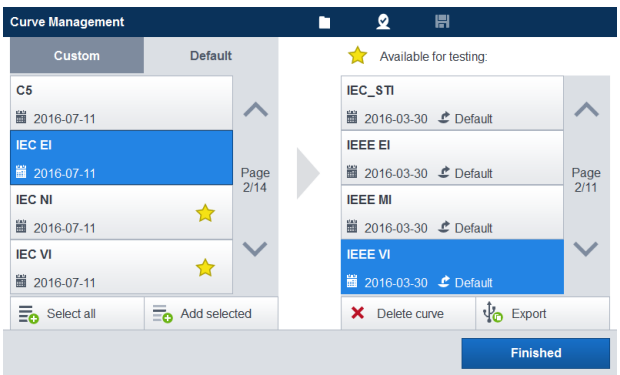
Select the **System Settings** icon in the main menu to access the internal software settings. The system settings are organized in two tabs: **Software Settings** and **Application Settings**.

9.1 Application settings



The following settings are available in the **Application Settings** tab:

- **Curve Management**: Use this screen to choose the set of characteristics available for testing in the **Trip Time Characteristics** test tool (→ page 60).



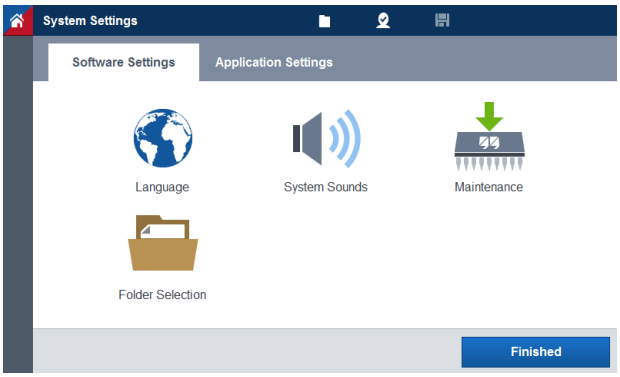
Select the **Custom** tab on the left to display your custom characteristics (alphabetical order) stored in the custom curves folder specified using either the file explorer icon in the title bar or the **Folder Selection** button in the **Software Settings** tab (→ page 31).

Select the **Default** tab to display all characteristics stored in the *ARCO Control* folder. Then, select one or more characteristics in the list and touch/click the **Add selected** button to copy them to the **Available for testing** list on the right (20 characteristics max.). This list holds the favorite characteristics available for selection in the **Curves** screen of the **Trip Time Characteristics** test tool. To delete a characteristic from the **Available for testing** list, select it and touch/click the **Delete curve** button. Touch/click the **Export** button to export a selected characteristic to the custom curves folder.

For details about defining user-defined characteristics that can be transferred to *ARCO Control*, refer to page 69.

- **Phase Labeling**: Select your preferred phase names, for example A-B-C-N or L1-L2-L3-E, etc.
- **Colors**: Define the colors used to display the fast and the slow curve in the **Trip Time Characteristics** test tool (→ page 60), and switch the colors used for the trip and close signal icons (→ page 28). The color setting for the trip and close signals is automatically defined by the connected ARCO test set. If you change this setting in *ARCO Control*, this change is applied to the ARCO test set and the corresponding colors are shown by its OPEN and CLOSE LEDs. The new color setting is stored in the ARCO test set and persisted whenever you connect it to *ARCO Control* again.
- **Adapter Management**: Use this screen to update or reset your user-defined or standard OMICRON controller adapter configurations.
- **Report settings**: Use the toggle switches to include/exclude certain information in your test report.

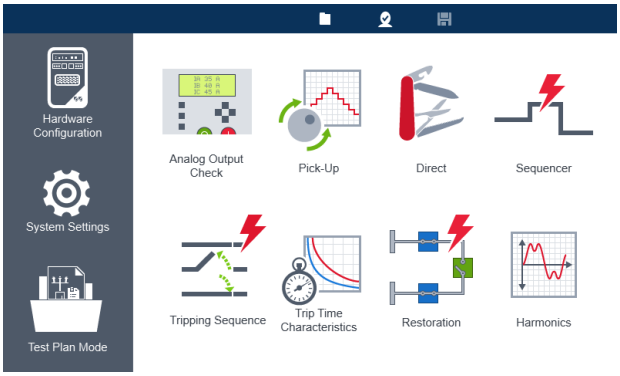
9.2 Software settings



The following settings are available in the **Software Settings** tab:

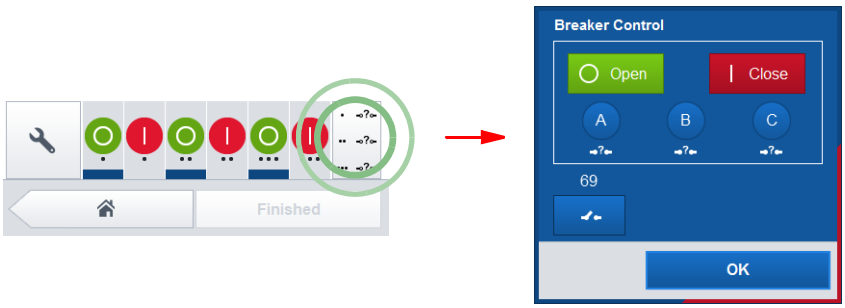
- **Language**: Select the user interface language.
- **System Sounds**: Switch the sound on or off.
- **Maintenance:** Reset *ARCO Control* to the factory settings, read the IP address currently assigned to your Android tablet or Windows PC, and check the current version of your *ARCO Control* installation. In addition, you can reset the controller adapter configurations stored in the ARCO test set, access the ARCO web interface, select a log level, and start OMICRON Assist (if you have been asked to do so by OMICRON Technical Support).
- **Folder Selection:**
  - On a Windows PC: Select the preferred folders to store your test reports, test plans, and custom curves.
  - On an Android tablet: Select your preferred folders to store your test reports and test plans and define the application data folder.

10 Test tools



ARCO Control contains various test tools, each providing a special functionality for specific manual test tasks. Select the corresponding icon to access a tool.

All test tools indicate the states of the circuit breaker simulation (CB simulation) in the ARCO test set. When you select the CB state field, a dialog opens where you can manually change the state of the circuit breaker. Always make sure that the states of the circuit breaker simulation comply with the actual states on the recloser control.



10.1 Analog output check

The **Analog Output Check** test tool verifies the wiring between the ARCO test set and the recloser control under test. It allows direct control of the outputs using preset values.

The displayed values are fixed values derived from the nominal values set in the hardware configuration. Select the voltages or currents table to do one of the following:

- Configure the voltages/currents to be asymmetric, symmetric, or off. When you select asymmetric voltages, they are calculated as follows:

VA-N X:	95 % of V_{nom}	VA-N Y:	95 % of V_{nom}
VB-N X:	100 % of V_{nom}	VB-N Y:	100 % of V_{nom}
VC-N X:	105 % of V_{nom}	VC-N Y:	105 % of V_{nom}

- Use only one phase and switch off the other two phases (by selecting VA-N, VB-N, or VC-N).
- Use only the voltage triple of the source side or the load side and switch off the voltages of the other side (3 or 6 voltages).
- Set the phase shift of the currents in order to change the ratio of real power to active power (120° between the phases remains unchanged).

The **P**, **Q** field displays the corresponding real and reactive power calculated from the output values.

The **S, PF** field shows the apparent power (S) and the power factor (PF) that are also automatically calculated from the output values.

Slide down the **I/0** key to inject these values to the recloser control. To check the wiring of the ARCO outputs, read the values measured by the recloser control and compare them with the values displayed in the screen. Select the **I/0** key to switch off the ARCO outputs again.

You cannot output currents in the **Analg Output Check** test tool if the position of the simulated circuit breaker is open (→ page 25). Therefore, if you define values for the current output, *ARCO Control* automatically closes the simulated circuit breaker when the test is started.

The **Analog Output Check** tool supports the **Off on Trigger** option for the binary inputs (→ page 28).

10.2 Pick-up

The **Pick-Up** tool measures the pick-up value of a specific protection function of the recloser control under test by ramping the current, voltage, or frequency up and down manually or automatically.

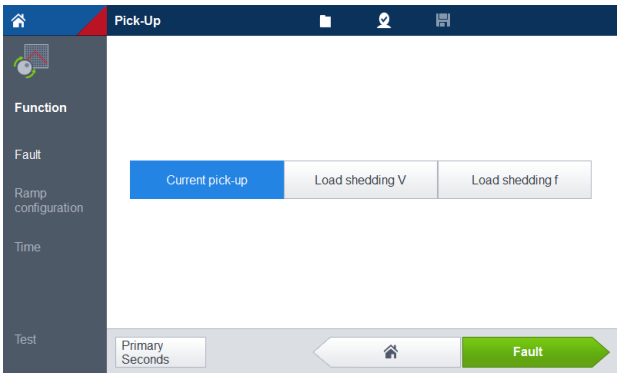
Three application modes are available in the **Pick-Up** tool:

- **Current pick-up** (→ page 37)
  Measures the pick-up value of the overcurrent protection function.
- **Load shedding V** (→ page 40)
  Measures the pick-up value of the undervoltage protection function.
- **Load shedding f** (→ page 43)
  Measures the pick-up value of the underfrequency protection function.

To display the final **Pick-Up** test screen, proceed through a several-stage process of defining the application mode, the fault values applied during the test, etc.

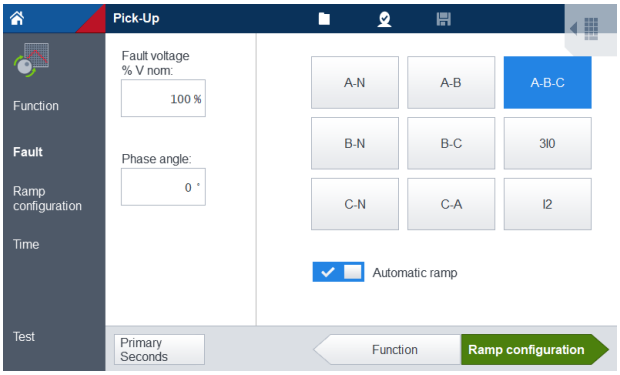
The **Pick-Up** tool supports the **Off on Trigger** option for the binary inputs (→ page 28).

10.2.1 Current pick-up mode



Select the **Current pick-up** mode in the **Function** screen to measure the pick-up value of the overcurrent protection function of the recloser control under test. To carry out this measurement, *ARCO Control* automatically sets the state of the simulated circuit breaker to 'closed'.

Select the **Fault** button to proceed to the **Fault** screen.



In the **Fault** screen, enter the percentage of the nominal voltage and the phase angle to be applied during the measurement (**Fault voltage % V nom** and **Phase angle**).

Select one of the predefined fault types: phase-ground, phase-phase, 3-phase, zero sequence (3I0), or negative sequence (I2). The fault type defines the phase(s) ramped during the measurement (i.e., selecting a two-phase fault will ramp the output value for the two phases selected). No current is output for the remaining phase(s) that are not affected by the selected fault type.

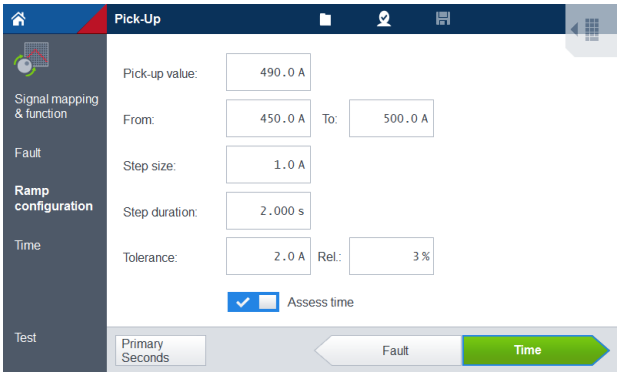
For zero sequence (3I0) and negative sequence (I2) faults, the ARCO test set outputs the following values:

Zero sequence (3I0)	**Negative sequence (I2)**
VA (VL1) = Fault voltage ∠ 0°	VA (VL1) = Fault voltage ∠ 0°
VB (VL2) = Nominal voltage ∠ - 120°	VB (VL2) = Fault voltage ∠ - 120°
VC (VL3) = Nominal voltage ∠ 120°	VC (VL3) = Fault voltage ∠ 120°
IA (IL1) = Itest / 3 ∠ φ	IA (IL1) = Itest ∠ φ
IB (IL2) = Itest / 3 ∠ φ	IB (IL2) = Itest ∠ (φ + 120°)
IC (IL3) = Itest / 3 ∠ φ	IC (IL3) = Itest ∠ (φ - 120°)

The fault angle φ is the phase angle that you entered in the Fault screen.
Itest is the fault current magnitude.

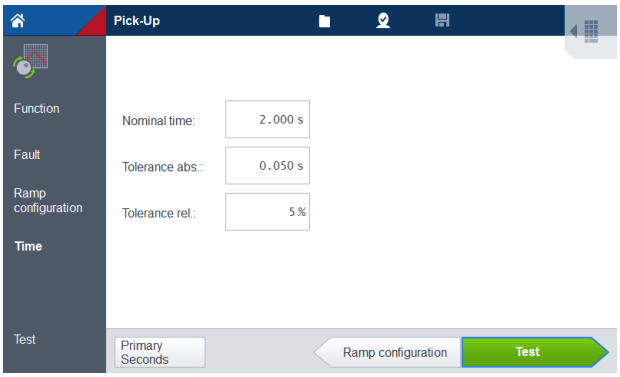
Select the **Test** button to proceed to the test screen.

Optional: If you do not want to ramp the outputs manually, turn on the **Automatic ramp** toggle switch, and select the **Ramp configuration** button to proceed. This will enhance the configuration process for this test mode by another 1 - 2 stages: the **Ramp configuration** screen and, optionally, the **Time** screen.



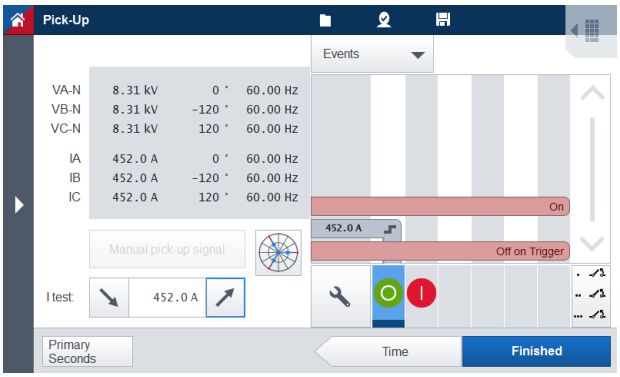
Configure the automatic ramp by defining the **Pick-up value** and entering the ramp's start and end points in the **From** and **To** fields. Then, define the **Step size** and **Step duration** of the ramp as well as the absolute and relative tolerances. Select the **Test** button to proceed to the test screen.

Optional: If you want to assess the time from pick-up to trip or manual stop, turn on the **Assess time** toggle switch. Select the **Time** button to proceed.



In the **Time** screen, enter the nominal time (i.e. the time from pick-up to trip) and define the absolute and relative tolerances.

Select the **Test** button to proceed to the test screen.



In the test screen, the table on the left displays the output values to be applied at the ARCO outputs. Slide down the **I/0** key to activate the ARCO outputs.

If you have not selected the automatic ramp function, enter the start value for your ramp in the **I test** field. Use the ramp up button or the slider control to increase the current. *ARCO Control* will stop the current ramp as soon as a pick-up or trip signal occurs.

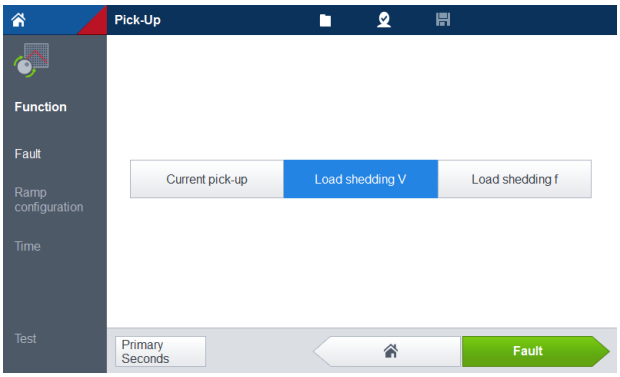
The ramp up/down buttons provide toggling functionality, i.e., you can stop and continue the ramp at any time by touching/clicking the ramp up/down button again (please note that stopping the ramp does not deactivate the ARCO outputs).

In addition to stopping the ramp at a pick-up or trip signal, you can stop the ramp and indicate the pick-up event manually by touching/clicking the **Manual pick-up signal** button.

Select the **I/0** key to deactivate the ARCO outputs.

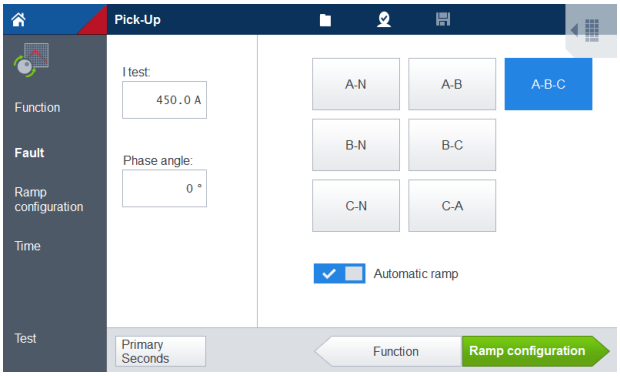
The **Events** window on the right displays the measured pick-up values.

10.2.2 Load shedding V mode



Select the **Load shedding V** mode in the **Function** screen to measure the pick-up value of the undervoltage protection function of the recloser control under test.

Select the **Fault** button to proceed to the **Fault** screen.



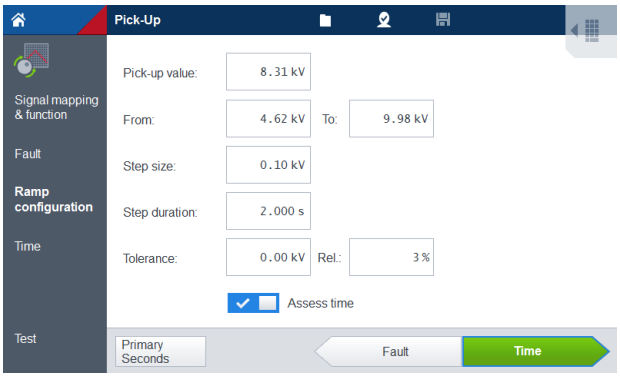
In the **Fault** screen, enter the current and the phase angle to be applied during the measurement (**I test** and **Phase angle**).

Select one of the predefined fault types: phase-ground, phase-phase, or 3-phase. The fault type defines the phase(s) ramped during the measurement (i.e., selecting a two-phase fault will ramp the output voltage of the two phases selected). The nominal voltage is output for the remaining phase(s) that are not affected by the selected fault type.

Select the **Test** button to proceed to the test screen.

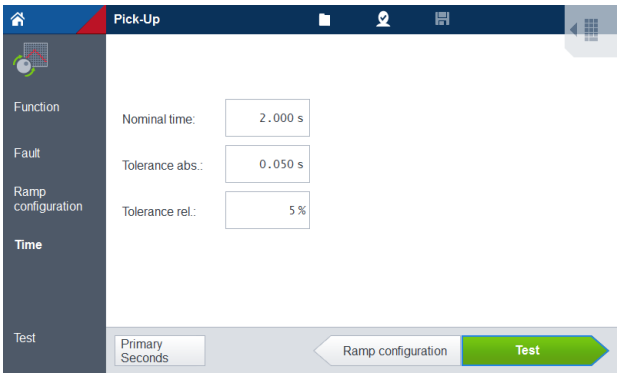
Optional: If you do not want to ramp the outputs manually, turn on the **Automatic ramp** toggle switch, and select the **Ramp configuration** button to proceed. This will enhance the configuration process for this test mode by another 1 - 2 stages: the **Ramp configuration** screen and, optionally, the **Time** screen.

The following two screens, **Ramp configuration** and **Time**, are optional.



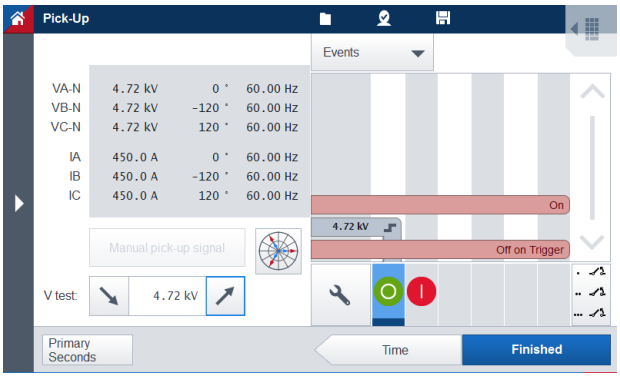
Configure the automatic ramp by defining the **Pick-up value** and entering the ramp's start and end points in the **From** and **To** fields. Then, define the **Step size** and **Step duration** of the ramp as well as the absolute and relative tolerances. Select the **Test** button to proceed to the test screen.

Optional: If you want to assess the time from pick-up to trip or manual stop, turn on the **Assess time** toggle switch. Select the **Time** button to proceed.



In the **Time** screen, enter the nominal time (i.e. the time from pick-up to trip) and define the absolute and relative tolerances.

Select the **Test** button to proceed to the test screen.



In the test screen, the table on the left displays the output values to be applied at the ARCO outputs. Slide down the **I/0** key to activate the ARCO outputs.

If you have not selected the automatic ramp function, enter the start value for your ramp in the **V test** field. Use the ramp up button or the slider control to increase the voltage. *ARCO Control* will stop the voltage ramp as soon as a trip signal occurs.

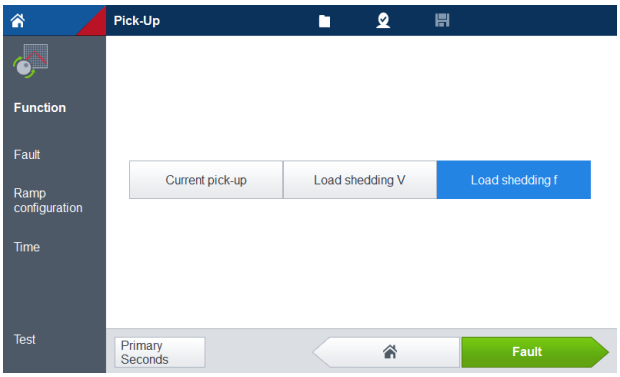
The ramp up/down buttons provide toggling functionality, i.e., you can stop and continue the ramp at any time by touching/clicking the ramp up/down button again Please note that stopping the ramp does not deactivate the ARCO outputs).

In addition to stopping the ramp at a trip signal, you can stop the ramp and indicate the pick-up event manually by touching/clicking the **Manual pick-up signal** button.

Select the **I/0** key to deactivate the ARCO outputs.

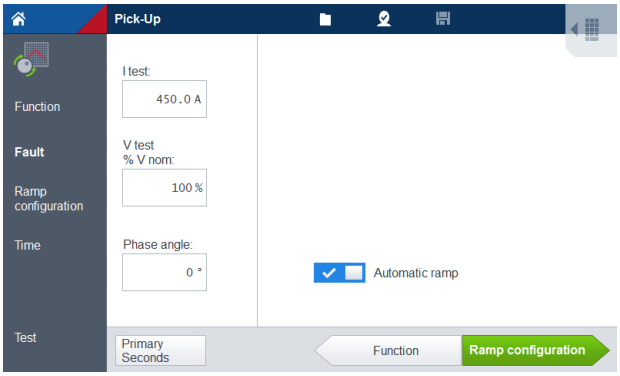
The **Events** window on the right displays the measured pick-up values.

10.2.3 Load Shedding f mode



Select the **Load Shedding f** mode in the **Function** screen to measure the pick-up value of the underfrequency protection function of the recloser control under test.

Select the **Fault** button to proceed to the **Fault** screen.

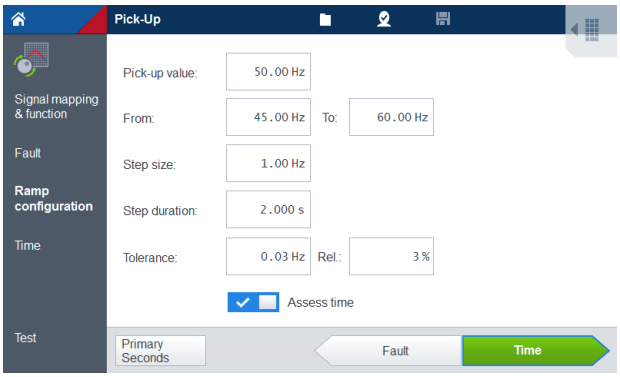


In the **Fault** screen, enter the current, the percentage of the nominal voltage, and the phase angle to be applied during the measurement in the corresponding fields (**I test**, **V test % V nom**, and **Phase angle**).

Select the **Test** button to proceed to the test screen.

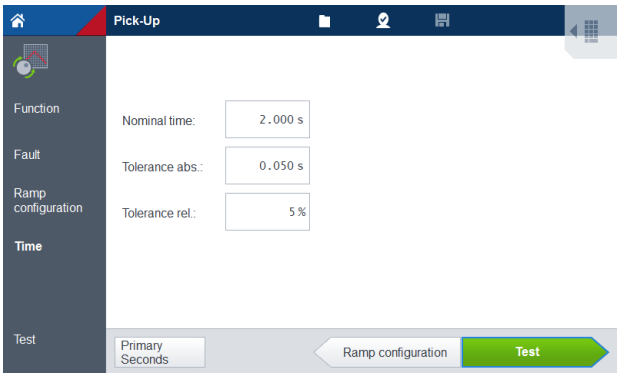
Optional: If you do not want to ramp the outputs manually, turn on the **Automatic ramp** toggle switch, and select the **Ramp configuration** button to proceed. This will enhance the configuration process for this test mode by another 1 - 2 stages: the **Ramp configuration** screen and, optionally, the **Time** screen.

The following two screens, **Ramp configuration** and **Time**, are optional.



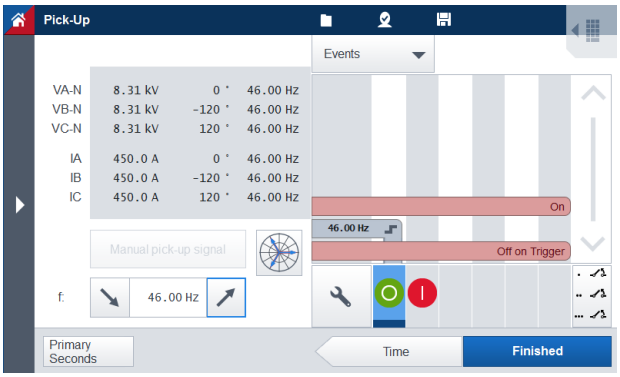
Configure the automatic ramp by defining the **Pick-up value** and entering the ramp's start and end points in the **From** and **To** fields. Then, define the **Step size** and **Step duration** of the ramp as well as the absolute and relative tolerances. Select the **Test** button to proceed to the test screen.

Optional: If you want to assess the time from pick-up to trip or manual stop, turn on the **Assess time** toggle switch. Select the **Time** button to proceed.



In the **Time** screen, enter the nominal time (i.e. the time from pick-up to trip) and define the absolute and relative tolerances.

Select the **Test** button to proceed to the test screen.



In the test screen, the table on the left displays the output values to be applied at the ARCO outputs. Slide down the **I/0** key to activate the ARCO outputs.

If necessary, enter the start frequency for your ramp in the **f** field. By default, the field is set to the nominal frequency.

If you have not selected the automatic ramp function, use the ramp up button or the slider control to increase the frequency. *ARCO Control* will stop the frequency ramp as soon as a trip signal occurs.

The ramp up/down buttons provide toggling functionality, i.e., you can stop and continue the ramp at any time by touching/clicking the ramp up/down button again. Please note that stopping the ramp does not deactivate the ARCO outputs.

In addition to stopping the ramp at a trip signal, you can stop the ramp and indicate the pick-up event manually by touching/clicking the **Manual pick-up signal** button.

Select the **I/0** key to deactivate the ARCO outputs.

The **Events** window on the right displays the measured pick-up values.

10.3 Direct

The **Direct** tool allows you to directly control all outputs of the ARCO test set. It is used for all functions that cannot be tested with one of the other test tools. By changing the values while the ARCO outputs are active (i.e., during the test), it is also possible to perform pick-up measurements.

Set the output values for the prefault state and the fault state. Select a field in the values table to select the value to be changed and use the slider control or the numpad to set the value.

After sliding down the **I/0** key, the ARCO test set injects the selected values to the recloser control. You can toggle between the prefault and the fault state as well as change the output values (e.g., ramp the currents up or down) while the outputs are active. Select the **I/0** key to switch off the ARCO outputs again.

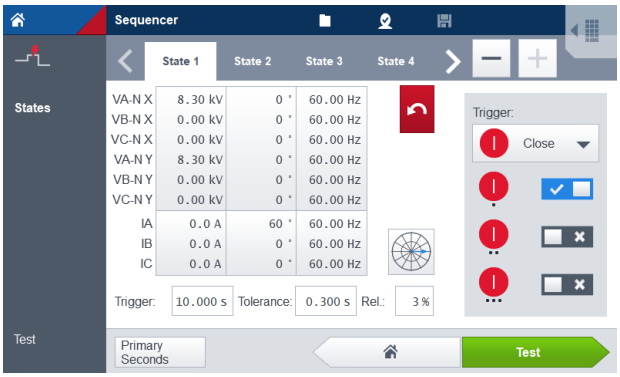
The **Events** window on the right displays the input events with the measured times.

You cannot output currents in the **Direct** test tool if the position of the simulated circuit breaker is open (→ page 25). Therefore, if you define values for the current output, *ARCO Control* automatically closes the simulated circuit breaker when the test is started.

The **Direct** tool supports the **Off on Trigger** option for the binary inputs (→ page 28).

10.4 Sequencer

The **Sequencer** tool allows you to define a sequence of states to be output by the ARCO test set. This can be used to determine trip times or other time measurements with automatic assessment.



You can add up to 20 states to your test sequence by selecting the + button. To remove states, select the − button.

The values in the voltage and current tables are automatically preset according to your adapter and controller selection (→ page 18). To change them, select a field and enter a new value.

You can reset your changes by clicking the button.

Enter the output duration (in seconds) in the **Duration** field. When you select a trigger, the entered duration becomes the expected trip time.

Select a trigger condition from the drop-down list to control the progression of the test sequence. You can select **Trip** or **Close,** and if you are using an *ISIO 200* device, you can select it's pick-up signal or one of it's generic signals as a trigger. You can define the signals of *ISIO 200* in the **Hardware configuration**, section **Settings** (→ page 29).
For any trigger signal you can define an absolute and a relative test tolerance. If you are testing a triple- or single-phase recloser, you can also define single phases for the trip and close trigger.

Proceed to the test screen, and slide down the **I/O** key to start the test sequence. The sequence waits for the expected trip time plus tolerance for a trigger to occur. The test stops if no trigger occurs.

The **States** window on the right displays the test results, i.e. the different states with the measured times. The test is successful when a trigger occurs within the defined time.

10.5 Tripping sequence

The **Tripping Sequence** tool tests the correct tripping and reclosing programming of recloser and sectionalizer controls. The tool determines whether the device under test is able to trip, reclose and/or lock out correctly and in the configured cycle. For this purpose, the tool is also able to simulate a downstream or upstream recloser in the grid, if necessary.

Two application modes are available for the **Tripping Sequence** tool:

- **Sectionalizer** (→ page 49)

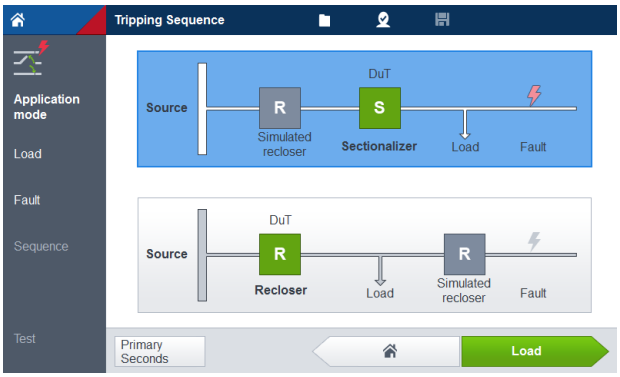
  Tests if a sectionalizer control trips correctly and in the correct cycle by simulating an upstream recloser in the grid.

- **Recloser** (→ page 52)

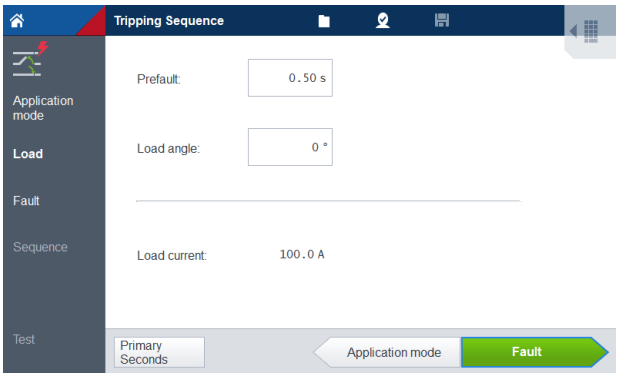
  Tests if a recloser control performs the configured number of reclosing attempts and locks out in the correct cycle (if required, by simulating a downstream recloser in the grid).

To display the final **Tripping Sequence** test screen, proceed through a four- or five-stage process (depending on the selected application or configuration) of defining the application mode, the load and fault values, the tripping sequence configuration, etc.

10.5.1 Sectionalizer mode



The **Application mode** screen is displayed after selecting the **Tripping Sequence** tool in the main menu. It shows schematic diagrams of the possible applications. Touch/click the upper diagram to select the **Sectionalizer** mode. Select the **Load** button to proceed.

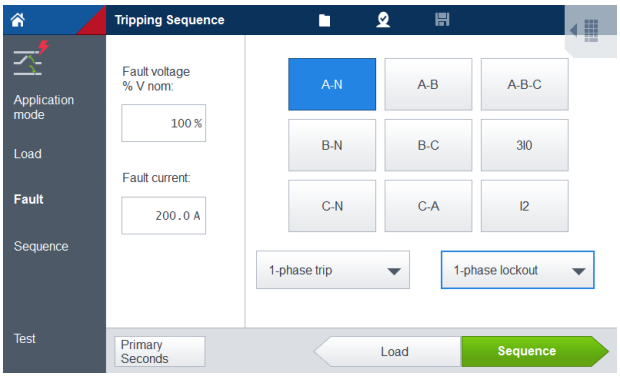


Use the **Load** screen to define the prefault state applied prior to the first cycle of the test sequence. During this state, *ARCO Control* applies the displayed load current with the specified load angle to the device under test. Enter the duration (in seconds) of the prefault state in the **Prefault** field.

The **Load angle** field is inactive if the voltages have been disabled in the hardware configuration (→ page 23).

The **Load current** field is read-only. The displayed value is taken from the nominal values in the hardware configuration (→ page 22).

Select the **Fault** button to proceed to the next screen.

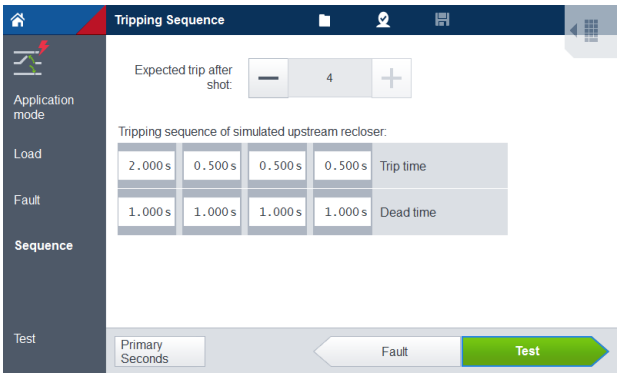


Use the **Fault** screen to define the values applied during the fault state. Enter the percentage of the nominal voltage to be applied in the **Fault voltage % V nom** field. Enter the value of the desired fault current in the **Fault current** field. Select one of the predefined fault types: phase-ground, phase-phase, 3-phase, zero sequence (3I0), or negative sequence (I2). For 3I0 and I2 output values → page 37.

Only applicable for 3-phase sectionalizers with single-phase tripping functionality:

- For **phase-ground** faults, select whether tripping of the device under test is expected on only one phase or on all three phases (**1-phase trip** or **3-phase trip**). If you select **1-phase trip**, you also have to select whether lockout is expected on only one phase or on all three phases (**1-phase lockout** or **3-phase lockout**).
- For **phase-phase** faults, select whether tripping of the device under test is expected on both phases or on all three phases (**2-phase trip** or **3-phase trip**). If you select **2-phase trip**, you also have to select whether lockout is expected on both phases or on all three phases (**2-phase lockout** or **3-phase lockout**).

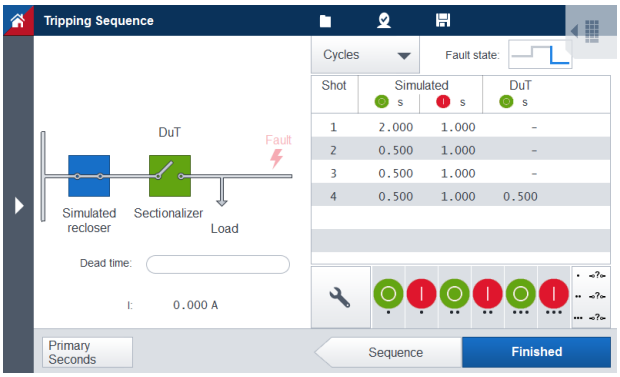
Select the **Sequence** button to proceed to the next screen.



In the **Sequence** screen, use the **Expected trip after shot** field to define the cycle during which the sectionalizer is expected to trip (max. 4). For example, if set to 2, tripping of the sectionalizer is expected during the dead time of the second cylce.

Use the **Trip time** and **Dead time** fields in the table to define the tripping sequence cycles of the simulated upstream recloser.

Select the **Test** button to proceed to the test screen of the **Tripping Sequence** tool.



Slide down the **I/0** key to start the test sequence and activate the ARCO outputs. *ARCO Control* applies the prefault state and the test sequence previously defined in the **Sequence** screen. The test stops automatically when the test sequence is over.

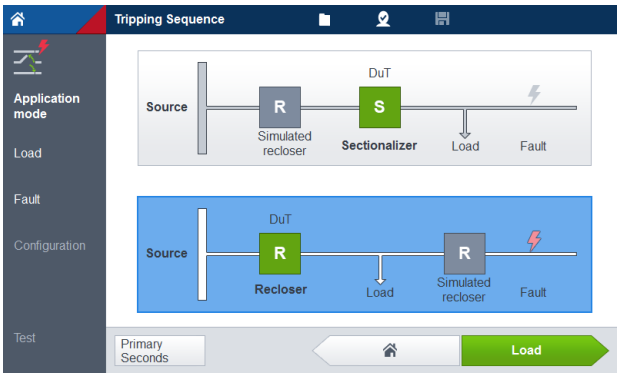
The ARCO test set automatically simulates a closed circuit breaker position before the test is started. However, if the sectionalizer control is programmed to reset only after a predefined amount of time, the sectionalizer control will trip and lock out as soon as the test is started. To avoid this, you need to enter the sectionalizer control's reset time as the prefault time for the test.

The schematic diagram on the left shows the application with the particular switching states of the devices during the test. The screen also shows the progress of the prefault time for each cycle and the current applied during the test.

The **Cycles** table on the right displays (for each cycle) the times of the simulated trip and close signals of the recloser and the measured tripping time of the device under test (**DuT**). The test is successful if tripping of the sectionalizer occurs during the dead time of the last cycle.

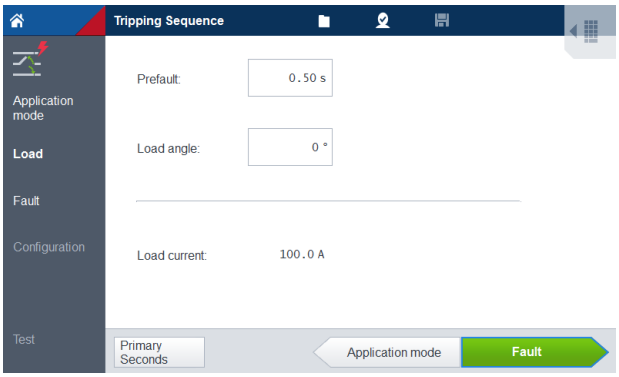
You can switch this window to **Events** in order to display the switching events with the measured times.

10.5.2 Recloser mode



The **Application mode** screen is displayed after selecting the **Tripping Sequence** tool in the main menu. It shows schematic diagrams of the possible applications. Touch/click the lower diagram to select the **Recloser** mode.

Select the **Load** button to proceed.

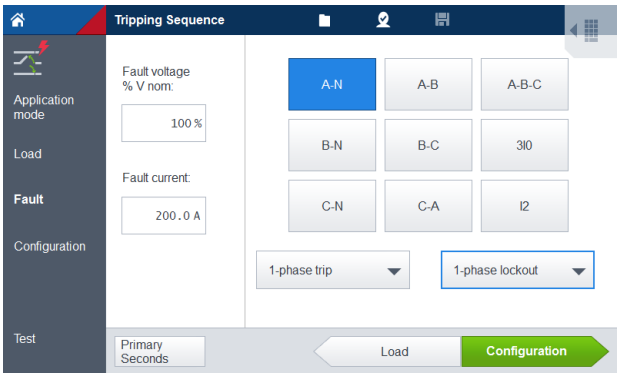


Use the **Load** screen to define the load state (prefault state) applied prior to the first cycle of the test sequence. During this state, *ARCO Control* applies the displayed load current with the specified load angle to the device under test. Enter the duration (in seconds) of the prefault state in the **Prefault** field.

The **Load angle** field is inactive if the voltages have been disabled in the hardware configuration (→ page 23).

The **Load current** field is read-only. The value displayed is taken from the nominal values in the hardware configuration (→ page 22).

Select the **Fault** button to proceed.

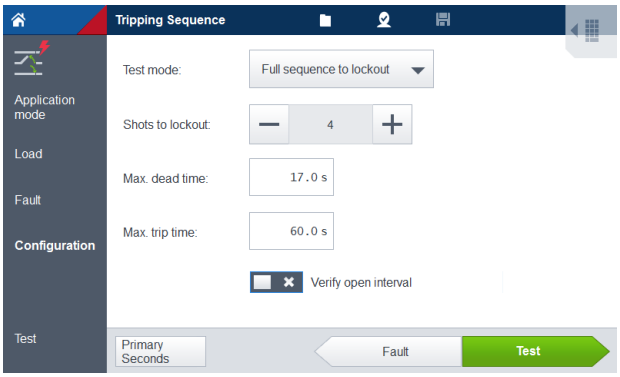


Use the **Fault** screen to define the values applied during the fault state. Enter the percentage of the nominal voltage to be applied in the **Fault voltage % V nom** field. Enter the fault current in the **Fault current** field. Select one of the predefined fault types: phase-ground, phase-phase, 3-phase, zero sequence (3I0), or negative sequence (I2). For 3I0 and I2 output values → page 37.

Only applicable for 3-phase reclosers with single-phase tripping functionality:

- For **phase-ground** faults, select whether tripping of the device under test is expected on only one phase or on all three phases (**1-phase trip** or **3-phase trip**). If you select **1-phase trip**, you also have to select whether lockout is expected on only one phase or on all three phases (**1-phase lockout** or **3-phase lockout**).
- For **phase-phase** faults, select whether tripping of the device under test is expected on both phases or on all three phases (**2-phase trip** or **3-phase trip**). If you select **2-phase trip**, you also have to select whether lockout is expected on both phases or on all three phases (**2-phase lockout** or **3-phase lockout**).

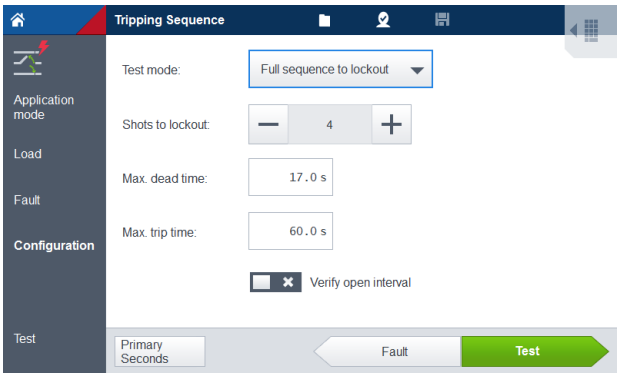
Select the **Configuration** button to proceed.



In the **Configuration** screen, use the **Test mode** field to select your test application:

- Full sequence to lockout (→ page 54)
- Successful reclose (→ page 56)
- Coordination with downstream recloser (→ page 58)

Test mode: Full sequence to lockout

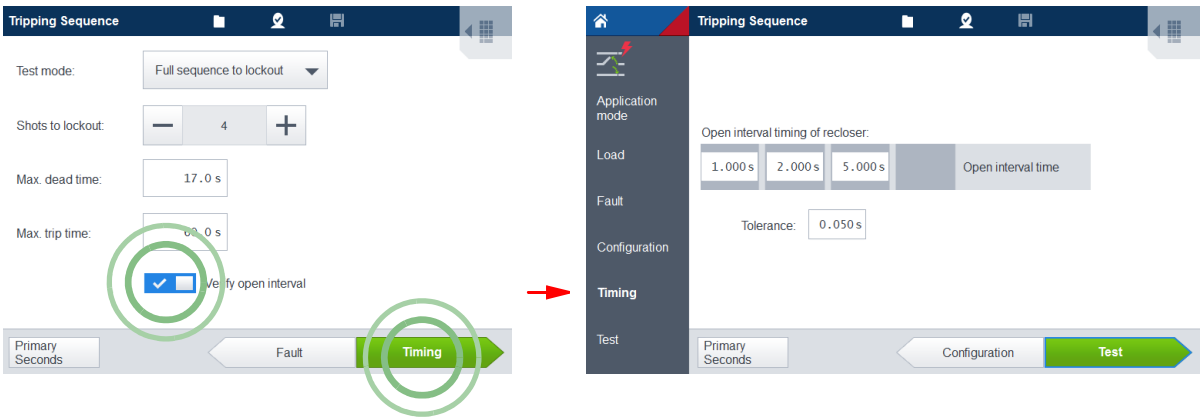


Use the **Full sequence to lockout** test mode to test whether the recloser control under test enters the lockout state after the configured number of shots. Select the **Full sequence to lockout** test mode in the **Configuration** screen.

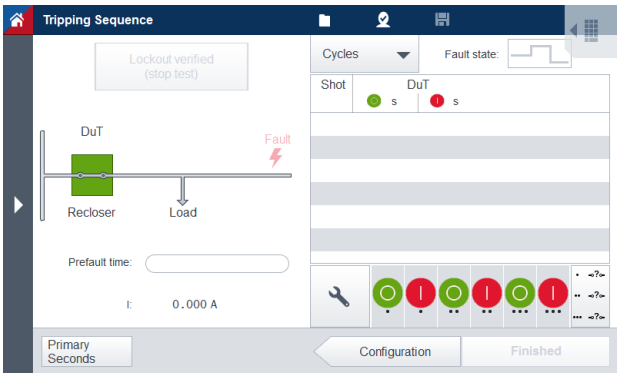
Use the **Shots to lockout** field to set the cycle during which the recloser control is expected to enter the lockout state (max. 5). In other words, no close signal must occur after the number of shots defined in this field.

Set the **Max. dead time** and the **Max. trip time** to a value longer than the longest dead time and trip time setting for the recloser control. These values are used to abort the test if the recloser control under test does not behave as expected.

Select the **Verify open interval** option to include the verification of the recloser's open intervals in the test. This will enhance the configuration process for this test mode by another stage, the **Timing** screen (see below). Use this screen to set the expected open intervals of the recloser and the tolerance.



Select the **Test** button to proceed to the test screen of the **Tripping Sequence** tool.



Slide down the **I/0** key to start the test sequence and activate the ARCO outputs. *ARCO Control* applies the prefault state and then the number of shots previously defined in the **Configuration** screen. The test stops automatically when the test sequence is over.
When you have selected the **Verify open interval** option: If the open interval of the recloser control under test exceeds the defined time (plus tolerance), the test is aborted.

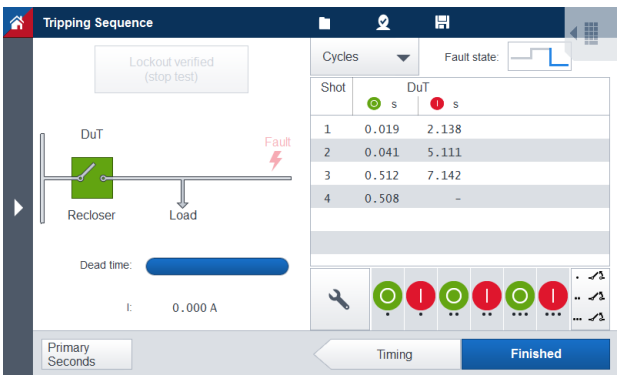
The ARCO test set automatically simulates a closed circuit breaker position before the test is started. However, if the recloser control is programmed to reset only after a predefined amount of time, the recloser control will trip and lock out as soon as the test is started. To avoid this, you need to enter the recloser control's reset time as the prefault time for the test.

The schematic diagram on the left shows the application with the switching states of the recloser control during the test. The **Device under Test** will show the actual open and close status of the device during the tripping sequence test.The screen also shows the progress of the dead time for each cycle and the current applied during the test.

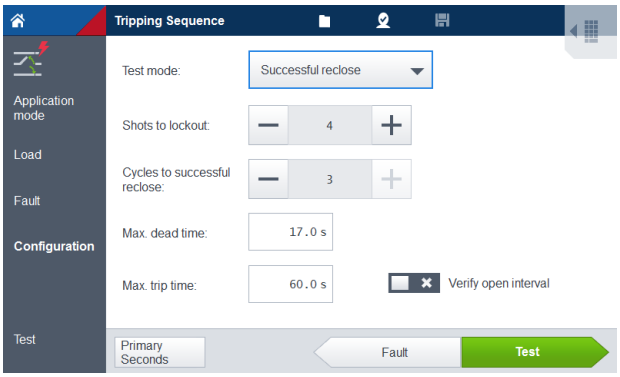
The **Cycles** table on the right displays (for each cycle) the times measured for the recloser control under test (**DuT**). You can switch this window to **Events** in order to display the switching events with the measured times.

The test is successful when the tripping and reclosing times match the operation of the recloser control curves. Example: The figure below shows that the trip times in the first column for the fast and slow curves are correct, and the reset times in the second column match the open interval of the recloser control settings.The fourth shot does not have an open interval time because the recloser is opened and locked out.

By touching/clicking the **Lockout verified** button you can manually confirm the lockout of the recloser control, for example, to cut short the testing time in case of a long dead time setting. This button is only active while the test sequence is running.



Test mode: Successful reclose



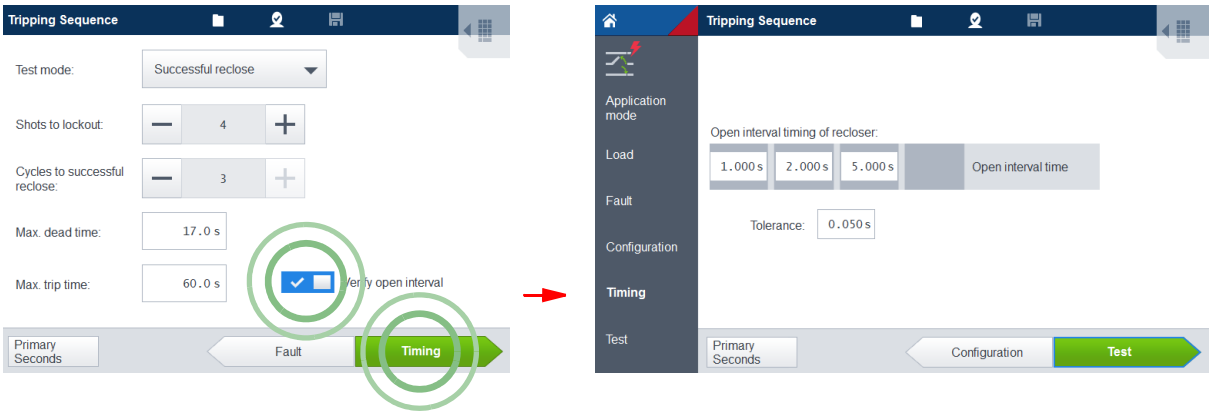
Use the **Successful reclose** test mode to test whether the recloser control under test is able to perform successful reclosing in case of a fault and to return to normal operation if the fault condition disappears.

Use the **Shots to lockout** field to set the cycle during which the recloser control is expected to enter the lockout state (max. 5).

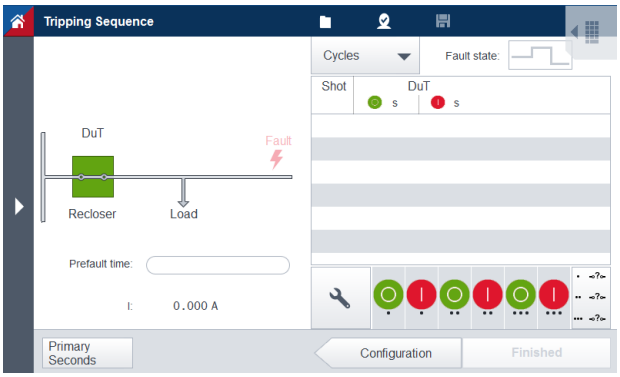
Use the **Cycles to successful reclose** field to set the number of reclosing cycles to be performed during the test. No open signal must occur after the number of cycles defined in this field.

Set the **Max. dead time** and the **Max. trip time** to a value longer than the longest dead time and trip time parameterized for the recloser control. These values are used to abort the test if the recloser control under test does not behave as expected.

Select the **Verify open interval** option to include the verification of the recloser's open intervals in the test. This will add another test screen to allow configuration of the open interval times as programmed in the recloser control.



Select the **Test** button to proceed to the test screen of the **Tripping Sequence** tool.



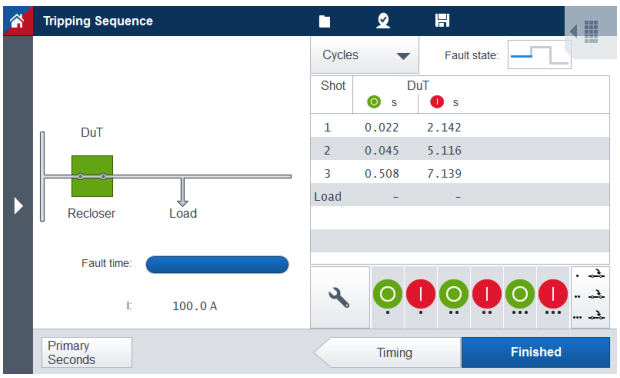
Slide down the **I/0** key to start the test sequence and activate the ARCO outputs. *ARCO Control* applies the prefault state and then the number of fault shots previously defined in the **Cycles to successful reclose** field. Then, the normal load current is applied to verify that the recloser control does not trip again during normal operation. The test stops automatically when the test sequence is over.
When you have selected the **Verify open interval** option: If the open interval of the recloser control under test exceeds the defined time (plus tolerance), the test is aborted.

The ARCO test set automatically simulates a closed circuit breaker position before the test is started. However, if the recloser control is programmed to reset only after a predefined amount of time, the recloser control will trip and lock out as soon as the test is started. To avoid this, you need to enter the recloser control's reset time as the prefault time for the test.

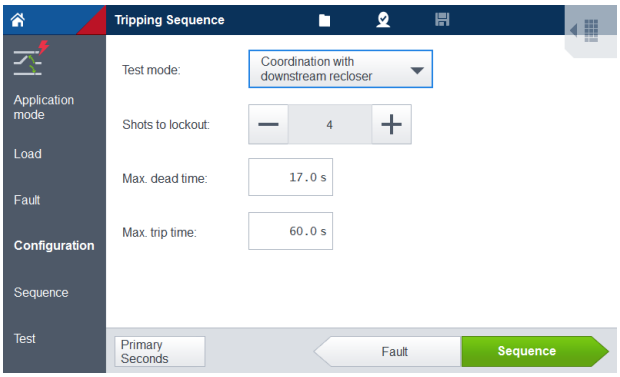
The schematic diagram on the left shows the application with the switching states of the recloser control during the test. The screen also shows the progress of the prefault time and the fault time for each cycle, and the current applied during the test.

The **Cycles** table on the right displays (for each cycle) the times measured for the recloser control under test (**DuT**). You can switch this window to **Events** in order to display the switching events with the measured times.

The test is successful when the tripping and reclosing times match the operation of the recloser control curves. The figure below shows that the trip times in the first column for the fast and slow curves are correct, and the reset times in the second column match the open interval of the recloser control settings.



Test mode: Coordination with downstream recloser



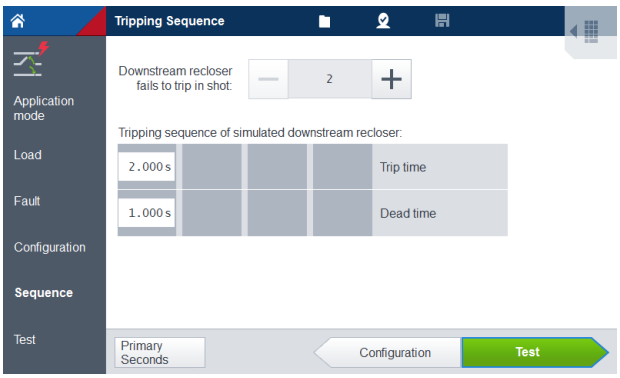
Use this test application to test the behavior of a recloser taking into account its coordination with a downstream recloser in the grid (sequence coordination).

Select the **Coordination with downstream recloser** test mode in the **Configuration** screen.

Use the **Shots to lockout** field to set the cycle during which the recloser control under test is expected to trip. In other words, no close signal must occur after the number of shots defined in this field.

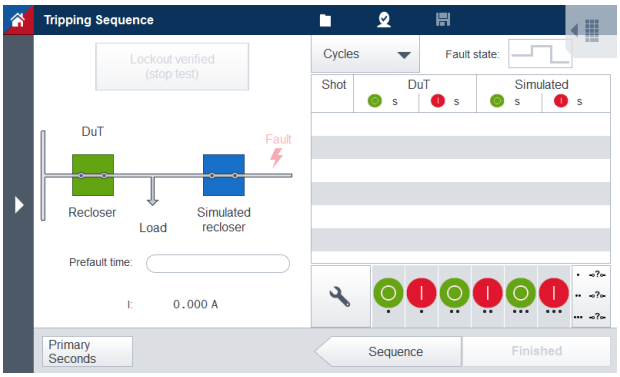
Set the **Max. dead time** and the **Max. trip time** to a value longer than the longest dead time and trip time setting for the recloser control. These values are used to abort the test if the recloser control under test does not behave as expected.

Select the **Sequence** button to proceed to the next screen.



In the **Sequence** screen, define the behavior of the simulated recloser. Use the **Downstream recloser fails to trip in shot** field to select the shot when the simulated downstream recloser does not trip anymore and thus remains closed. This is the shot when the first tripping of the recloser control under test is expected. For example, if set to 2, the simulated recloser performs one reclosing cycle and then remains in the on state. Use the **Trip time** and **Dead time** fields in the table to define the tripping sequence cycles of the simulated downstream recloser.

Select the **Test** button to proceed to the test screen of the **Tripping Sequence** tool.



Slide down the **I/0** key to start the test sequence and activate the ARCO outputs. *ARCO Control* applies the prefault state and then the number of fault shots previously defined in the **Shots to lockout** field of the **Configuration** screen. The test stops automatically when the test sequence is over.

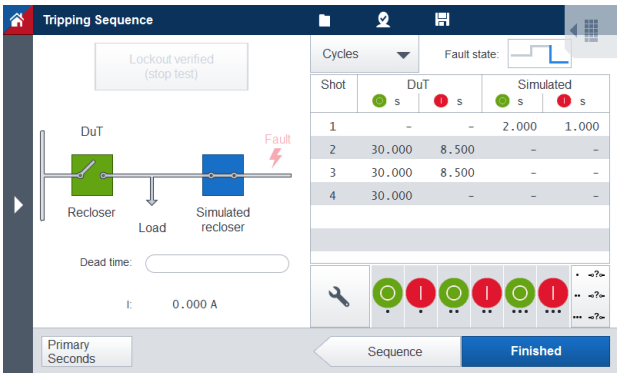
The ARCO test set automatically simulates a closed circuit breaker position before the test is started. However, if the recloser control is programmed to reset only after a predefined amount of time, the recloser control will trip and lock out as soon as the test is started. To avoid this, you need to enter the recloser control's reset time as the prefault time for the test.

The schematic diagram on the left shows the application with the switching states of the reclosers during the test. The screen also shows the progress of the prefault time and the dead time for each cycle, and the current applied during the test.

The **Cycles** table on the right displays (for each cycle) the times measured for the recloser control under test (**DuT**) and the simulated times of the downstream recloser. You can switch this window to **Events** in order to display the switching events with the measured times.

The test is successful if the recloser control under test trips the first time in the cycle following the last reclosing of the simulated recloser and locks out in the last cycle configured for the test.

By touching/clicking the **Lockout verified** button you can confirm the lockout of the recloser control manually. This button is only active while the test sequence is running.



10.6 Trip time characteristics

The **Trip Time Characteristics** tool tests the tripping characteristic of a recloser control. It displays the trip times measured for a set of fault currents applied during the cycles of the test sequence. The results are displayed together with the nominal tripping characteristic, which enables the quick and easy assessment of the results.

Two modes are available for the **Trip Time Characteristics** tool:

- **Trip time test only** (→ page 61)

  The tool only considers the trip command of the recloser. The next cycle of the test sequence is started directly after a pause time. The circuit breaker is closed by *ARCO Control* prior to the test to reset the reclosing timer of the controller.

- **Full sequence to lockout** (→ page 64)

  ARCO Control considers the trip and the close command of the recloser. The next cycle of the test sequence is not started until *ARCO Control* receives the close command. The test sequence is aborted automatically if no close command occurs.

For each mode the test can be executed as an automatic sequence of configured test currents or by manually adjusting the test current while the outputs are active, i.e., while the test sequence is running.

To display the final **Trip Time Characteristics** test screen, proceed through a five-stage process of defining the mode, the characteristic(s), the prefault values, the fault type, and the test sequence including the test points and the total number of cycles.

Refer to page 68 for detailed information on the calculation of the tolerance bands for the tripping characteristic.

Refer to page 69 for information on how to define custom characteristics.

Monitored Signals option

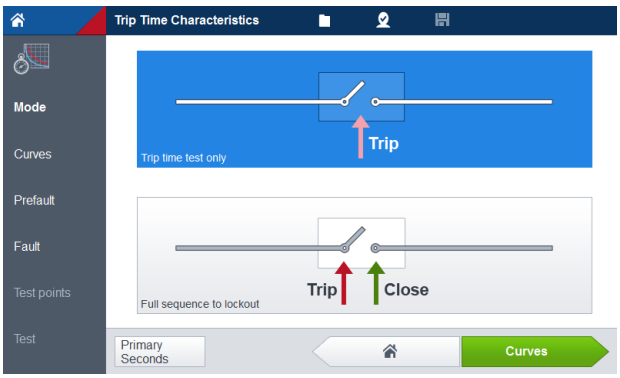
The **Trip Time Characteristics** test tool provides the possibility to monitor one or more binary inputs and to display the occurring events in the characteristics diagram of the test tool (→ page 60).

Select the wrench symbol in the test tool's screen to select the **Monitored Signals** option. In the subsequent screen, select the binary inputs to be configured with this function.

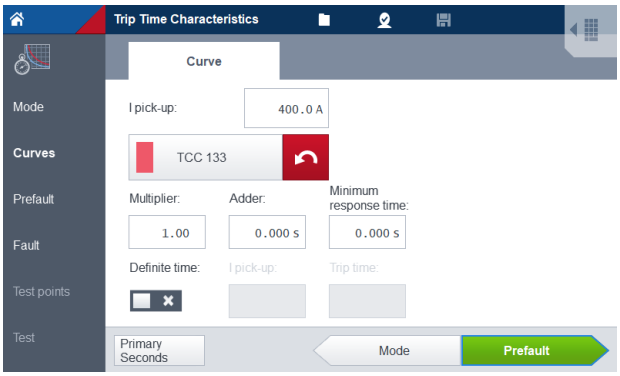
Inputs selected for the **Monitored signals** option are marked by a dark blue bar below the input symbol.

10.6.1 Trip time test only mode

The **Mode** screen is displayed after selecting the **Trip Time Characteristics** tool in the main menu.



Select the **Trip time test only** mode, and select the **Curves** button to proceed to the curves selection screen.



In the **Curves** screen, select the tripping characteristic from the **Curve** list box. Refer to page 31 for information on how to choose the set of characteristics available for selection or page 69 for information on how to create custom characteristics.

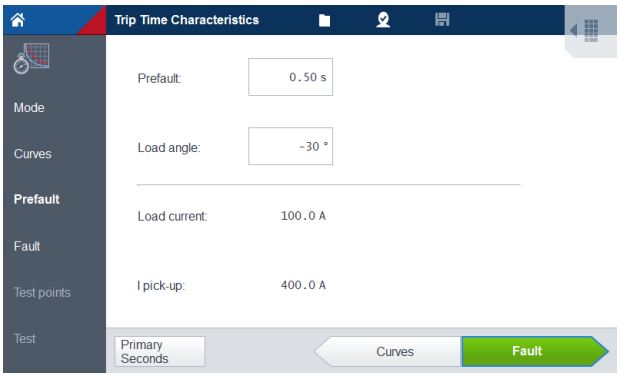
Use the **I pick-up** field to define the nominal pick-up current for the characteristic.

Enter a factor other than 1.00 in the **Multiplier** field to displace the characteristic horizontally. Use the **Adder** field to enter a time offset in seconds for the characteristic. This will displace the specified characteristic vertically.

In the **Minimum response time** field, define the minimum trip time of the selected curve.

To configure an additional, definite time characteristic, turn on the **Definite time** toggle switch. Define the current and time values for the characteristic in the respective fields (**I pick-up** and **Trip time**).

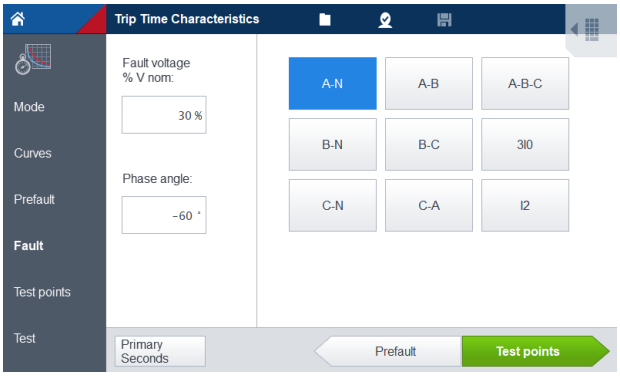
Select the **Prefault** button to proceed.



Use the **Prefault** screen to define the prefault state applied prior to the first cycle of the test sequence. During this state, *ARCO Control* applies the displayed load current with the specified load angle to the recloser control under test.

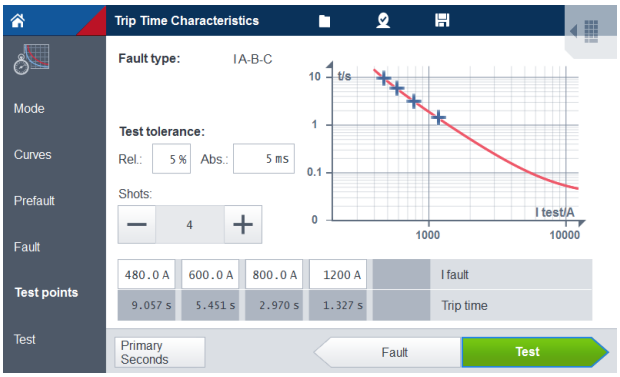
Enter the duration (in seconds) of the prefault state in the **Prefault** field. The **Load angle** field is inactive if the voltages have been disabled in the hardware configuration (→ page 23). The **Load current** and **I pick-up** fields are read-only. The load current value displayed is taken from the nominal values in the hardware configuration (→ page 22).

Select the **Fault** button to proceed to the **Fault** screen in order to define the values applied during the fault state.



Enter the percentage of the nominal voltage to be applied during the fault state in the **Fault voltage % V nom** field and specify the phase angle. Select one of the predefined fault types: phase-ground, phase-phase, or 3-phase, zero sequence (3I0), or negative sequence (I2). For 3I0 and I2 output values → page 37.

Select the **Test points** button to proceed.



Use the **Test Points** screen to define the test sequence.

At **Test tolerance**, specify the permitted relative and absolute tolerances for the characteristic (tolerance band calculation, see page 68). Depending on the test case, the higher of the two values will be used for the test.

Set the number of shots for your test sequence in the **Shots** field (max. 5). According to the number of shots selected, the table displays a fault current field and a trip time field for each shot. Define your test points by entering the test current in the **I fault** field. The corresponding trip time is automatically calculated according to the selected characteristic.

Select the **Test** button to proceed to the test screen of the **Trip Time Characteristics** tool.

Slide down the **I/0** key to start the test sequence and activate the ARCO outputs.

ARCO Control automatically closes the circuit breaker and applies the prefault state as well as the test sequence previously defined in the **Test points** screen. As soon as *ARCO Control* receives a trip signal, the measurement point is marked by a cross. Then, after the predefined dead time, the next shot of the test sequence is applied.

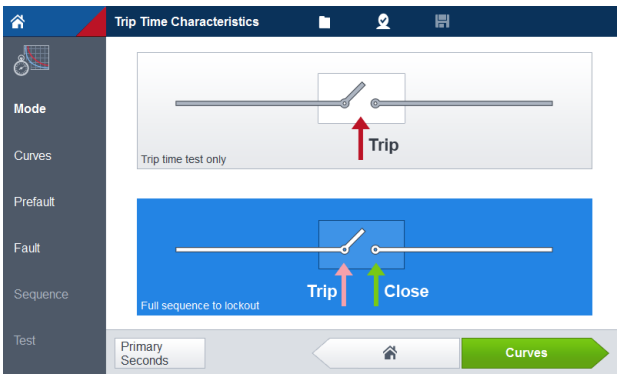
The test stops automatically when the test sequence is over, i.e., after all shots of the defined test sequence were output.

Move the slider control to analyze your test shots. The measured values for the test shots are displayed by "flags".

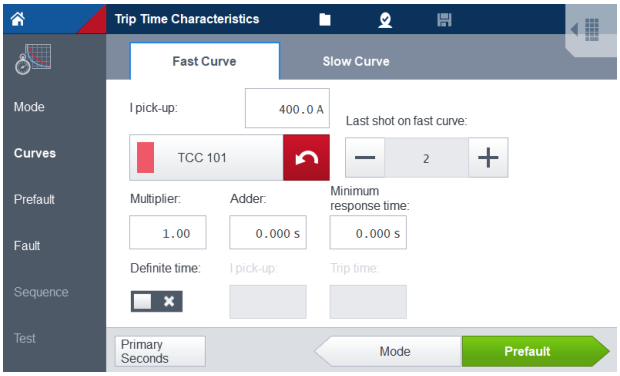
Use the settings button to switch between linear and logarithmic scaling, clear the diagram, reset the zoom factor, or display the tolerances (i.e., the maximum and minimum allowed trip time characteristics).

10.6.2 Full sequence to lockout mode

The **Mode** screen is displayed after selecting the **Trip Time Characteristics** tool in the main menu.



Select the **Full sequence to lockout** mode, and select the **Curves** button to proceed to the curves selection screen.



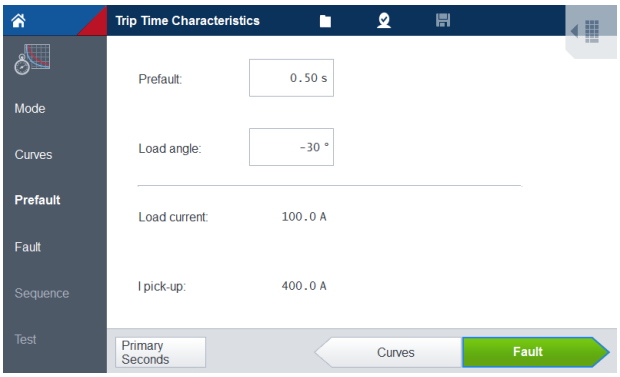
Select the tripping characteristics for the **Fast curve** and the **Slow curve** in the corresponding tabs. Refer to page 31 for information how to choose the set of characteristics available for selection or page 69 for information how to create custom characteristics.

In the **Fast curve** tab, use the **I pick-up** field to define the nominal pick-up current of the characteristics. Use the **Last shot on fast curve** field to select the number of shots to be performed using the fast tripping characteristic. For example, if set to 2, the recloser performs two trippings using the fast tripping characteristic and then switches to the slow curve for the remaining cycles.

For the fast curve and the slow curve: Enter a factor other than 1.00 in the **Multiplier** field to displace the curve horizontally. Use the **Adder** field to enter a time offset in seconds for the curve. This will displace the characteristic vertically. In the **Minimum response time** fields, define the minimum trip time of the selected curve.

To configure an additional, definite time characteristic, turn on the **Definite time** toggle switch. Define the current and time values for the characteristic in the respective fields (**I pick-up** and **Trip time**).

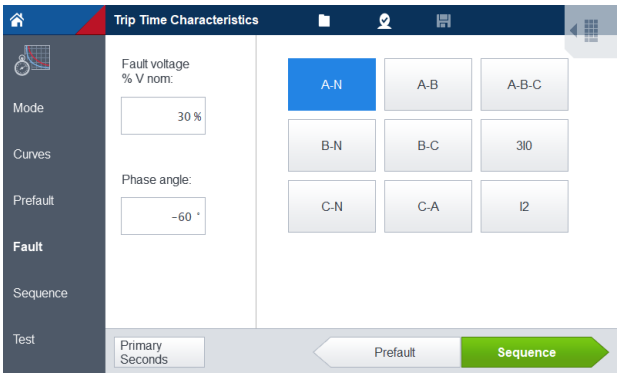
Select the **Prefault** button to proceed.



Use the **Prefault** screen to define the prefault state applied prior to the first cycle of the test sequence. During this state, *ARCO Control* applies the displayed load current with the specified load angle to the recloser control under test.

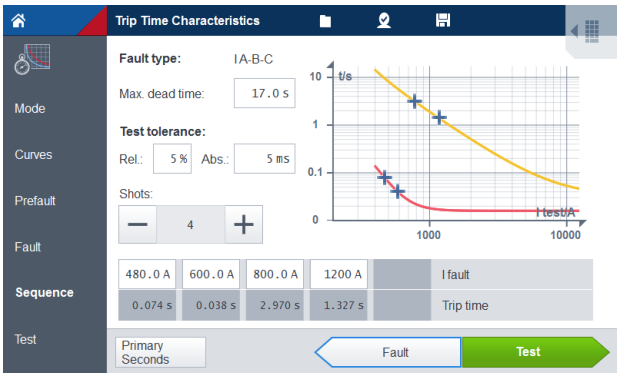
Enter the duration (in seconds) of the prefault state in the **Prefault** field. The **Load angle** field is inactive if the voltages have been disabled in the hardware configuration (→ page 23). The **Load current** and **I pick-up** fields are read-only. The load current value displayed is taken from the nominal values in the hardware configuration (→ page 22).

Select the **Fault** button to proceed to the **Fault** screen in order to define the values applied during the fault state.



Enter the percentage of the nominal voltage to be applied during the fault state in the **Fault voltage % V nom** field and specify the phase angle. Select one of the predefined fault types: phase-ground, phase-phase, or 3-phase, zero sequence (3I0), or negative sequence (I2). For 3I0 and I2 output values → page 37.

Select the **Sequence** button to proceed.



Define the test sequence in the **Sequence** screen.

Set the **Max. dead time** to a value longer than the dead time defined in the controller settings. This is the maximum time *ARCO Control* will wait for a close signal to occur during the cycle. The test is aborted unsuccessfully if no close signal occurs during this time span.

At **Test tolerance**, specify the permitted relative and absolute tolerances for the characteristic (tolerance band calculation, see page 68). Depending on the test case, the higher of the two values will be used for the test.

Set the number of shots for your test sequence in the **Shots** field (max. 5). According to the number of shots selected, the table displays a fault current field and a trip time field for each shot. Define your test points by entering the test currents in the **I fault** fields. The corresponding trip times are automatically displayed according to the selected characteristic (fast and slow curve).

Select the **Test** button to proceed to the test screen of the **Trip Time Characteristics** tool.

Slide down the **I/0** key to start the test sequence and activate the ARCO outputs.

ARCO Control applies the prefault state and the test sequence previously defined in the **Sequence** screen. As soon as *ARCO Control* receives a tripping signal, the measurement point is marked by a cross. The next cycle of the test sequence is started as soon as *ARCO Control* receives the close signal of the recloser. If no close signal occurs during the maximum dead time, the test is aborted unsuccessfully.

The test is stopped automatically when the test sequence is over, i.e., after all shots of the defined test sequence were output.

Move the slider control to analyze your test shots. The measured values for the test shots are displayed by "flags". The **Fast Trip** field and the **Slow Trip** field display the nominal trip times according to the fast and the slow characteristic for the test current set in the **I test** field.

Use the settings button  to switch between linear and logarithmic scaling, clear the diagram, reset the zoom factor, or display the tolerances (i.e., the maximum and minimum allowed trip time characteristics).

10.6.3 Information on tolerance band calculation

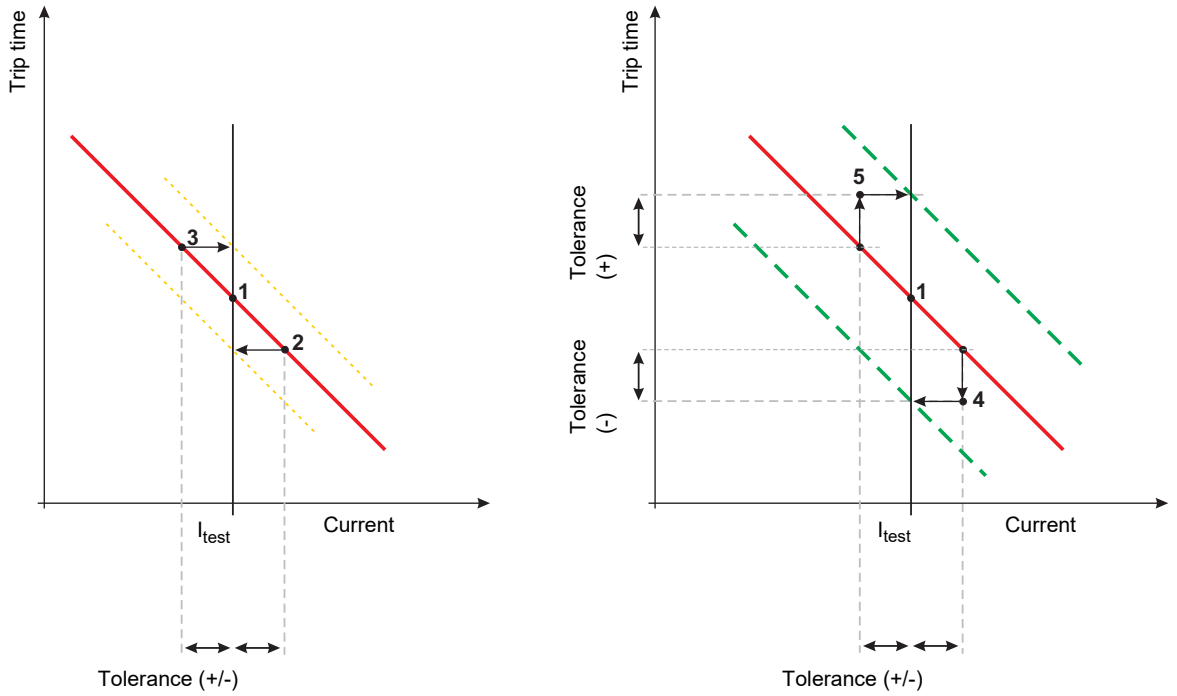
The calculation of the permitted tolerances considers the current measurement tolerances and the operating time tolerances of the recloser control. Therefore, the effective resulting tolerance range is larger than the tolerance set for the test in the **Tolerance** field of the **Test Points / Sequence** screen (→ page 63 and page 66).

This is explained below:

Point 1 is the ideal tripping time for tolerance-free operation on the nominal tripping characteristic (red).

Points 2 & 3 deliver the resulting tolerance range when taking into account the permitted current tolerances **only** (i.e., still assuming tolerance-free operation regarding to time). This theoretical tolerance range is displayed in yellow.

Points 4 & 5 deliver the effective overall tolerance range (green) including the operating time tolerances.



10.6.4 Creating custom characteristics

ARCO Control provides a set of predefined characteristics for the **Trip Time Characteristics** test tool on delivery. However, it is also possible to create additional and custom characteristics and make them available in *ARCO Control*. For this, the characteristics have to be available in XML file format.

Characteristics can be defined in two different formats:

- Tabular characteristics
- Formula characteristics

Both characteristic types are described below.

Use any XML or text editor to create the file defining the characteristic and save it to the Android file system using the file extension .xml. Use the **Curve Management** function in the system settings to make the characteristic available for testing (→ page 31).

Tabular characteristics

Defining a characteristic in tabular form means to define a series of x/y value pairs, each representing one point of the characteristic. The range between two points will be interpolated linearly.

The **x_axis** value of a point defines the current as a multiple of the pick-up current entered in the **Curves** screen of the **Trip Time Characteristics** test tool. The **y_axis** value defines the corresponding tripping time in seconds.

The XML file of a tabular characteristic must look as follows:

```
<?xml version="1.0" encoding="utf-8"?>
<Curve comment="Kyle 140" notation_form="point_notation">
  <point x_axis="1.000000" y_axis="27.524000" />
  <point x_axis="1.014000" y_axis="26.574000" />
  <point x_axis="1.027000" y_axis="25.657000" />
  <point x_axis="1.041000" y_axis="24.771000" />
  ...
  <point x_axis="200.000000" y_axis="0.984000" />
</Curve>
```

Characteristic name

x/y value pairs defining the characteristic

Formula characteristics

Formula characteristics are calculated according to the following formula:

$$t(I_{rms}) = \left(\frac{A}{\left(\frac{I_{rms}}{I_{pick\text{-}up}} \right)^{P} - C} + B \right) \cdot TD + TS + K$$

$t\ (I_{rms})$ is the tripping time for the corresponding fault current.

I_{rms} is the fault current.

$I_{pick\text{-}up}$ is the pick-up current entered in the **Curves** screen of the test tool.

The parameters A, B, C, P, TD, TS and K have to be specified in the XML file defining the characteristic.

The XML file of a formula characteristic must look as follows:

```
<?xml version="1.0" encoding="utf-8"?>
<Curve comment="BslrD" notation_form="parameter_notation">
  <A>0.480000</A>
  <B>0.214000</B>
  <C>1.000000</C>
  <TD>1.000000</TD>
  <TS>0.000000</TS>
  <K>0.028000</K>
  <P>1.563000</P>
</Curve>
```

Characteristic name

Parameters defining the characteristic

10.6.5 Naming reference for trip time characteristics of recloser controls

The following trip time characteristics are available for testing recloser controls with the **Trip Time Characteristics** tool of *ARCO Control*.

The tables list the new curve name together with its alternative (old) curve name, and provides the corresponding name of the point-based and/or formula-based curve available from OMICRON for import into *ARCO Control*.

A corresponding trip time characteristics library for testing TCC elements is provided for download in the OMICRON customer area (www.omicronenergy.com/customer).

IEC curves

Curve name	Alternative curve name	Available point-based curve	Available formula-based curve
IEC normal inverse	C1	-	IEC NI
IEC very inverse	C2	-	IEC VI
IEC extremely inverse	C3	-	IEC EI
IEC long time inverse	C4	-	IEC LTI
IEC short time inverse	C5	-	IEC STI

IEEE curves

Curve name	Alternative curve name	Available point-based curve	Available formula-based curve
IEEE extremely inverse	-	-	IEEE EI
IEEE moderately inverse	-	-	IEEE MI

SEL curves

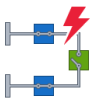
Curve name	Alternative curve name	Available point-based curve	Available formula-based curve
SEL U1	-	-	SEL U1
SEL U2	-	-	SEL U2
SEL U3	-	-	SEL U3
SEL U4	-	-	SEL U4
SEL U5	-	-	SEL U5

Traditional recloser characteristics

Curve name	Alternative curve name	Available point-based curve	Available formula-based curve
101	A	Kyle101	TCC101
102	1	Kyle102	TCC102
103	17	Kyle103	TCC103
104	N	Kyle104	TCC104
105	R	Kyle105	TCC105
106	4	Kyle106	TCC106
107	L	Kyle107	TCC107
111	8PLUS	Kyle111	TCC111
112	15	Kyle112	TCC112
113	8	Kyle113	TCC113
114	5	Kyle114	-
115	P	Kyle115	TCC115
116	D	Kyle116	TCC116
117	B	Kyle117	TCC117
118	M	Kyle118	TCC118
119	14	Kyle119	TCC119
120	Y	Kyle120	TCC120
121	G	Kyle121	-
122	H	Kyle122	-
131	9	Kyle131	TCC131
132	E	Kyle132	TCC132
133	C	Kyle133	TCC133
134	Z	Kyle134	TCC134
135	2	Kyle135	TCC135
136	6	Kyle136	-
137	V	Kyle137	TCC137
138	W	Kyle138	TCC138
139	16	Kyle139	-
140	3	Kyle140	TCC140
141	11	Kyle141	TCC141
142	13	Kyle142	TCC142
151	18	Kyle151	TCC151
152	7	Kyle152	TCC152
161	T	Kyle161	TCC161
162	KP	Kyle162	TCC162

Curve name	Alternative curve name	Available point-based curve	Available formula-based curve
163	F	Kyle163	TCC163
164	J	Kyle164	-
165	KG	Kyle165	TCC165
200	-	Kyle200	TCC200
201	-	Kyle201	TCC201
202	-	Kyle202	TCC202

10.7 Restoration



The **Restoration** tool tests the correct behavior of recloser controls with voltage sensing functionality, offering features for the automatic restoration of the power supply after a permanent fault on a line segment. The tool determines whether the device under test is able to close, trip and lock out correctly and within the configured times. For this purpose, the tool is able to simulate another upstream or downstream recloser in the grid.

Two application modes are available in the **Restoration** tool:

- **Recloser (N/C)** (→ page 81)

  Tests line reclosers that are closed during normal operation. Four kinds of tests are available in this mode to test the following recloser functions:

  - Automatic opening in case of loss of voltage on both sides (→ page 82).
  - Automatic closing in case of recurring voltage on one side with closing on a healthy line or on a fault (→ page 84 and page 86).
  - Automatic opening in case of voltage drop on both sides (→ page 88).
  - Automatic opening in case of an upstream fault (→ page 90).

- **Tie Recloser (N/O)** (→ page 92)

  Tests tie point reclosers that are open during normal operation. Two kinds of tests are available in this mode to test the following recloser functions:

  - Automatic closing in case of loss of voltage on one side (→ page 93).
  - Automatic tripping with subsequent lockout if the recloser closes on an existing fault on the load side (→ page 95).

To display the final **Restoration** test screen, proceed through a three- or four-stage process (depending on the selected application mode and test mode) to define the following:

- Application mode
- Test mode and recloser configuration
- Load or fault conditions for the load side

The application example on page 75 explains the use cases for the available application modes and tests.

The **Restoration** tool requires the configuration of 6 voltages (3 for the source side and 3 for the load side) in the hardware configuration (→ page 23).

10.7.1 Application examples explaining the use cases

These examples explain the use cases for the different application modes and tests that are available in the **Restoration** tool.

Example 1:

Applies to test modes **Open for loss of voltage on both sides, Loss of voltage side 1/2,** and **Close for voltage on load side only.**

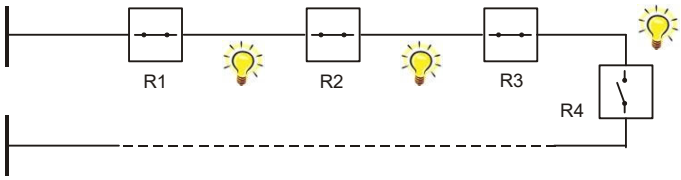
This example shows an open ring feeder with several reclosers:

- R1, R2 and R3 are line reclosers (normally closed during operation).
- R4 is the tie point recloser (normally open during operation).
- The protection scheme does not provide communication between the recloser controls.
- A permanent fault occurs between R1 and R2.

The assumed sequence is as follows:

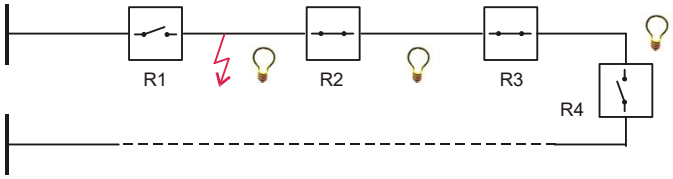
1. **Normal operation**

   R1, R2 and R3 are closed during normal operation. Tie recloser R4 is open. All customers are supplied with power.



2. **Fault between R1 and R2**

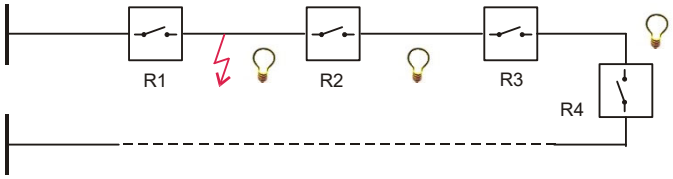
   A permanent fault occurs between R1 and R2. R1 trips and finally enters the lockout state. Customers between R1 and R4 are no longer supplied with power.



3. **R2 and R3 trip**

   R2 and R3 trip one after the other due to the loss of voltage on both sides to isolate the line segments.

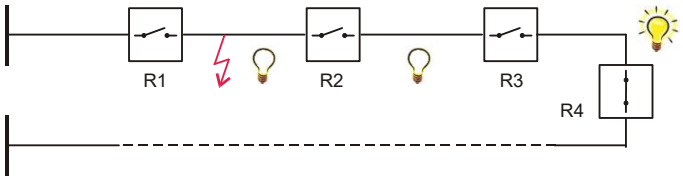
   Select the **Recloser (N/C)** application mode with the **Open for loss of voltage on both sides** test to test this behavior (→ page 82).



4. **R4 closes**

   The tie recloser R4 detects a loss of voltage on one side. R4 closes after its configured close time to restore the power supply for the customers between R3 and R4.

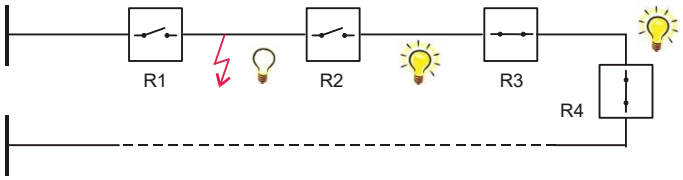
   Select the **Tie Recloser (N/O)** application mode with the **Loss of voltage side 1/2** test to test this behavior (→ page 93).



5. **R3 closes again**

   With the closing of tie recloser R4, R3 detects voltage recovery on its load side. R3 closes after its configured close time to restore power supply for the customers between R2 and R3.

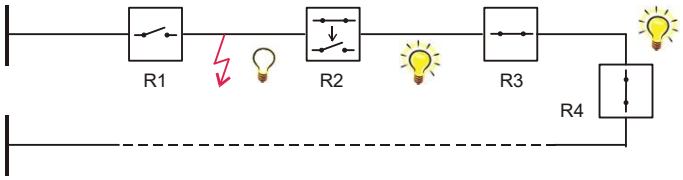
   Select the **Recloser (N/C)** application mode with the **Close for voltage on load side only** test and **successful closing** to test this behavior (→ page 84).



6. **R2 tries to close and locks out**

   With the closing of R3, R2 detects voltage recovery on its load side. R2 tries to close after its configured close time. Since the fault is still present, R2 trips and enters the lockout state.

   Select the **Recloser (N/C)** application mode with the **Close for voltage on load side only** test and **unsuccessful closing** to test this behavior (→ page 86).

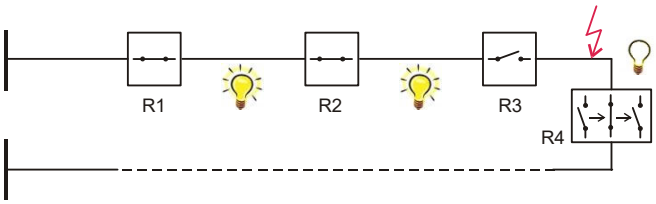


   Result: Only the customers between R1 and R2 are not supplied with power as long as the fault exists. Power supply for all other customers could be restored by the reclosers R3 and R4 during steps 4 and 5.

If the fault is located directly on the load side of the tie recloser

If the fault is located after R3 (i.e., directly on the load side of the tie recloser), R4 will also detect a loss of voltage on one side and therefore also try to close after its configured close time. Since in this case the tie recloser directly closes on the fault, the tie recloser trips within its max. trip time and then enters the lockout state.

Select the **Tie Recloser (N/O)** application mode with the **Fault on side 1/2** test to test this behavior (→ page 95).



Example 2:

Applies to test modes **Open for voltage drop on both sides** and **Open for loss of voltage on both sides.**

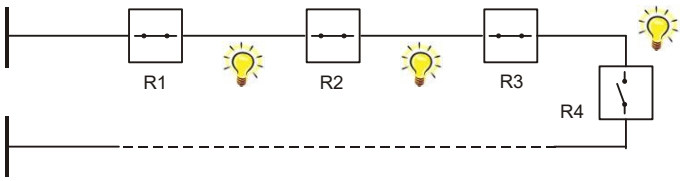
This example shows an open ring feeder with several reclosers:

- R1, R2 and R3 are line reclosers (normally closed during operation).
- R4 is the tie point recloser (normally open during operation).
- The protection scheme does not provide communication between the recloser controls.
- A permanent fault occurs between the substation and R1.

The assumed sequence is as follows:

1. **Normal operation**

   R1, R2 and R3 are closed during normal operation. Tie recloser R4 is open. All customers are supplied with power.

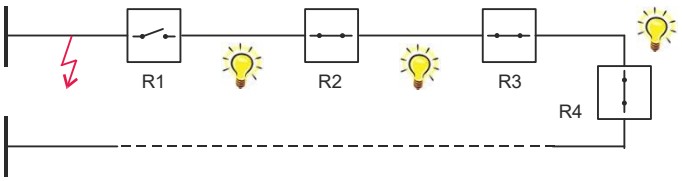


2. **Fault upstream of R1**

   A permanent fault occurs upstream of R1. Due to the voltage drop, R1 trips after a defined time and enters the lockout state. After a timer programmed into tie recloser R4 expires due to the voltage loss on one side, R4 closes and restores power to customers between R1 and R4 from the second feeder line.

   Select the **Recloser (N/C)** application mode with the **Open for voltage drop on both sides** (→ page 88) or the **Open for loss of voltage on both sides** test mode (→ page 82) to test the behavior of R1.

   Select the **Tie Recloser (N/O)** application mode with the **Loss of voltage side 1/2** test to test the behavior of R4 (→ page 93).



Example 3:

Applies to test mode **Open for upstream fault.**

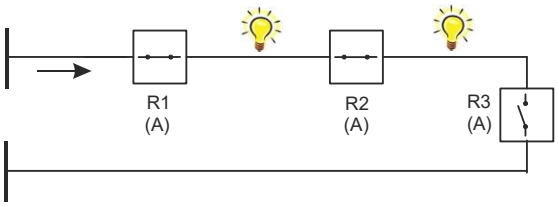
This example shows an open ring feeder with several reclosers:

- R1 is a feeder recloser (normally closed during operation).
- R2 is a mid-point recloser (normally closed during operation).
- R3 is the tie point recloser (normally open during operation).
- The protection scheme does not provide communication between the recloser controls.
- A permanent fault occurs between R1 and R2.

The assumed sequence is as follows:

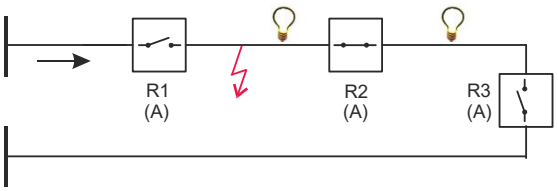
1. **Normal operation**

   R1 and R2 are closed during normal operation. The tie recloser R3 is open. All customers are supplied with power.



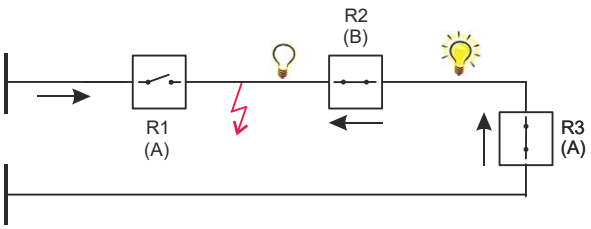
2. **Fault between R1 and R2**

   A permanent fault occurs between R1 and R2. R1 trips and finally enters the lockout state. Customers between R1 and R3 are no longer supplied with power.



3. **R2 changes protection group**

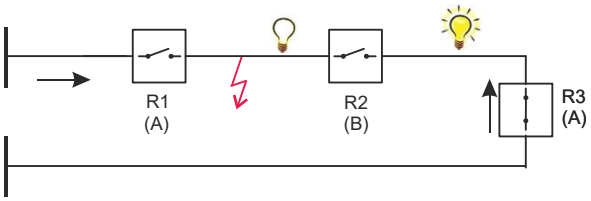
   After a previously defined amount of time, R2 changes from protection group "A" to protection group "B" in preparation for a change in power flow direction. Then, R2 closes to reconfigure supply to the feeder.



4. **R2 trips to lockout**

   Since the fault is still present, R2 trips and enters the lockout state.

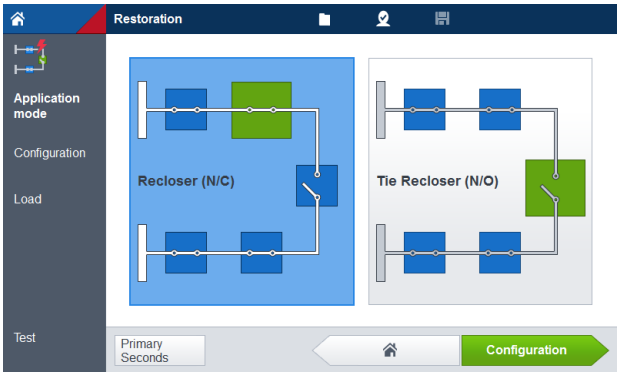
   Select the **Recloser (N/C)** application mode with the **Open for upstream fault** test to test this behavior of the mid-point recloser R2 (→ page 90).



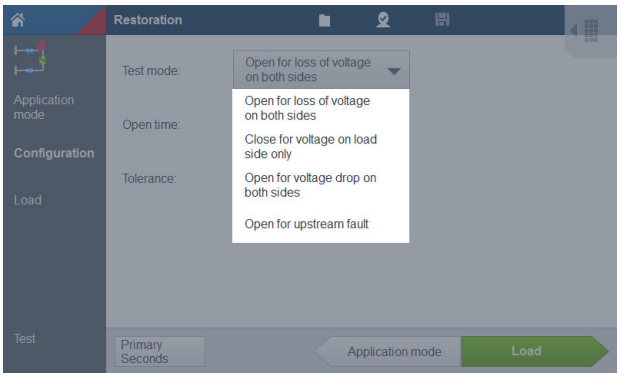
   Result: Only the customers between R1 and R2 are not supplied with power as long as the fault exists. Power supply for all other customers could be restored by the tie recloser R3.

10.7.2 Recloser (N/C) application mode

The **Application** mode screen is displayed after selecting the **Restoration** tool in the main menu. It shows schematic diagrams of the possible application modes.



Touch/click the left diagram to select the **Recloser (N/C)** application mode. Select the **Configuration** button to proceed.

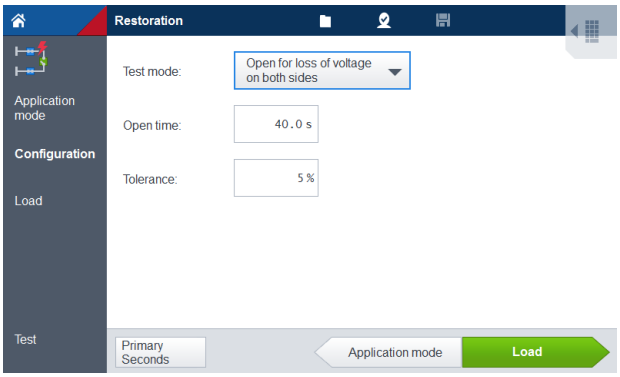


In the **Configuration** screen, select your test application from the **Test mode** field:

- **Open for loss of voltage on both sides** (→ page 82)
- **Close for voltage on load side only**:

  For this application you furthermore have to select whether closing is performed
  - on a healthy line (**successful closing**; → page 84)
  - or on an existing fault (**unsuccessful closing**; → page 86)
- **Open for voltage drop on both sides** (→ page 88)
- **Open for upstream fault** (→ page 90)

Test mode: Open for loss of voltage on both sides

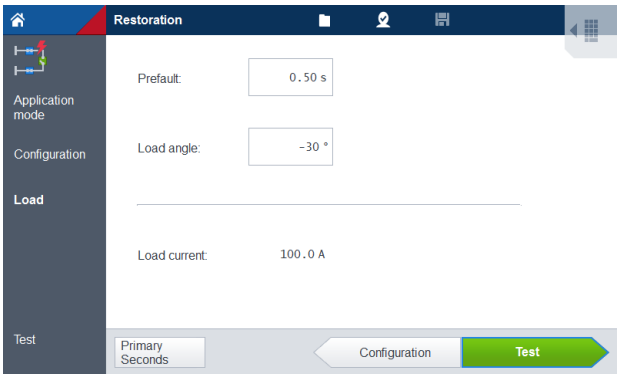


Select this test mode to test whether the recloser control opens within the configured time if it detects a loss of voltage on both sides, for example because an upstream recloser tripped (refer to step 3 of the application example on page 75).

For this test, make sure that the switching states of the circuit breaker simulation in the ARCO test set and the recloser control under test are closed prior to the test.

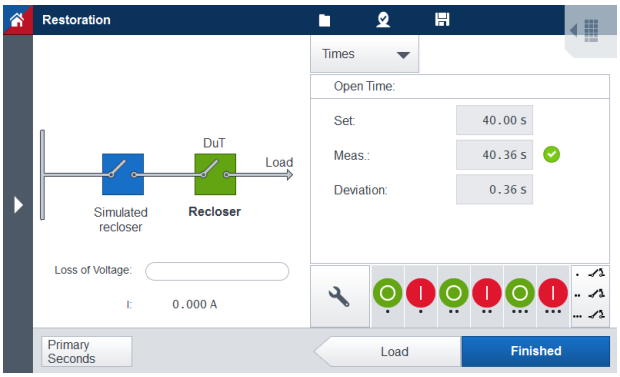
Enter the configured **Open time** and the permitted **Tolerance** of the recloser control under test.

Select the **Load** button to proceed.



In the **Load** screen, enter the duration of the prefault state in the **Prefault** field. This is a time of "normal operation" before the recloser control under test detects the loss of voltage. During the prefault state, *ARCO Control* applies the displayed load current with the phase angle set in the **Load angle** field. The load current value is taken from the nominal values defined in the hardware configuration (→ page 22).

Select the **Test** button to proceed to the test screen of the **Restoration** tool.



The schematic diagram on the left shows the application with the switching states of the reclosers during the test.

Slide down the **I/0** key to start the test and activate the ARCO outputs.

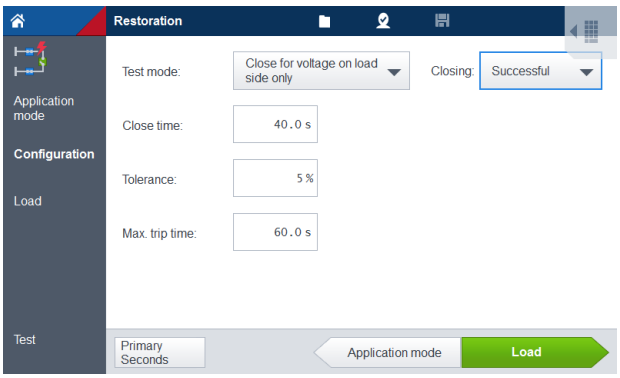
ARCO Control applies the prefault state for the specified time. After the prefault state, *ARCO Control* applies the "loss of voltage" state (all voltages and currents = 0) and measures the time required by the recloser control to open.

The test stops automatically when the test sequence is finished.

The **Times** area on the right displays the configured open time of the recloser control in the **Set** field and the measured open time with the calculated deviation from the set value in the **Meas.** and **Deviation** fields. You can switch this window to **Events** in order to display the switching events with the measured times.

If the measured open time of the recloser control is within the permitted range, the test is assessed as OK and a green check mark is displayed. Otherwise, a red X is displayed to indicate that the test failed.

Test mode: Close for voltage on load side only (with successful closing)

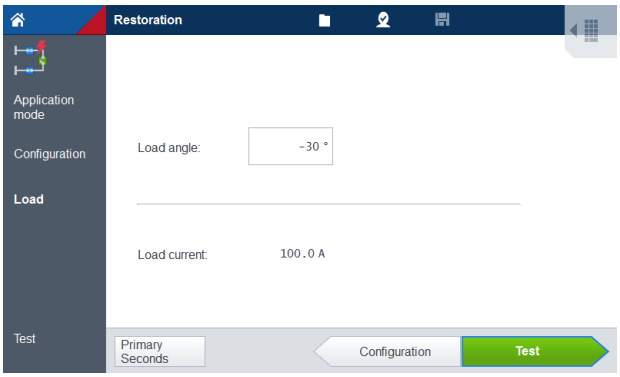


Select this test mode to test whether the recloser control closes within the configured time after detection of a voltage recovery on its load side, for example because a downstream tie recloser closed to restore the power supply after a fault (refer to step 5 of the application example on page 76).

For this test, make sure that the switching states of the circuit breaker simulation in the ARCO test set and the recloser control under test are open prior to the test.

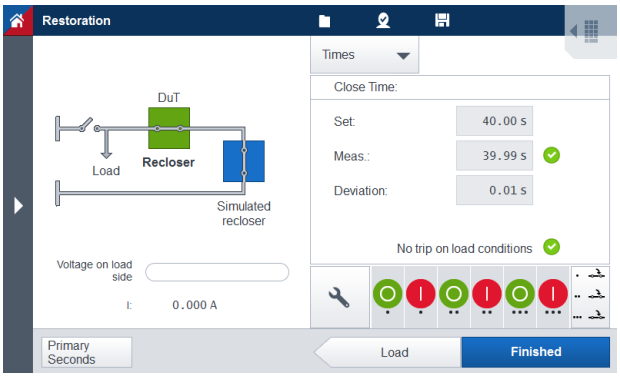
Enter the configured **Close time**, the **Tolerance** permitted for the close time, and the **Max. trip time** of the recloser control under test.

Select the **Load** button to proceed.



In the **Load** screen, enter the phase angle for the load current in the **Load angle** field. The load current value is taken from the nominal values defined in the hardware configuration (→ page 22). This current is applied after the closing action to test possible tripping of the recloser control during normal load conditions.

Select the **Test** button to proceed to the test screen of the **Restoration** tool.



The schematic diagram on the left shows the application with the switching states of the reclosers during the test.

Slide down the **I/0** key to start the test and activate the ARCO outputs.

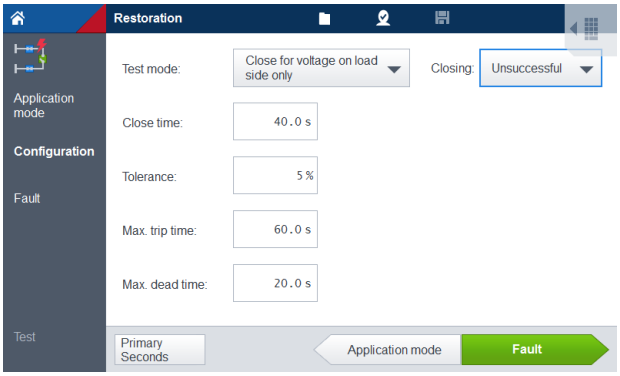
ARCO Control applies the nominal voltage to the load side of the recloser control and measures its time required to close. After closing, *ARCO Control* applies the nominal voltages to both sides and the load current for the maximum trip time of the recloser control.

The test stops automatically when the test sequence is finished.

The **Times** area on the right displays the configured close time of the recloser control in the **Set** field and the measured close time with the calculated deviation from the set value in the **Meas.** and **Deviation** fields. You can switch this window to **Events** in order to display the switching events with the measured times.

If the measured close time of the recloser control is within the permitted range and the recloser control did not trip during the output of the load current, the test steps are assessed as OK and green check marks are displayed. Otherwise, a red X is displayed next to the failed test result.

Test mode: Close for voltage on load side only (with unsuccessful closing)

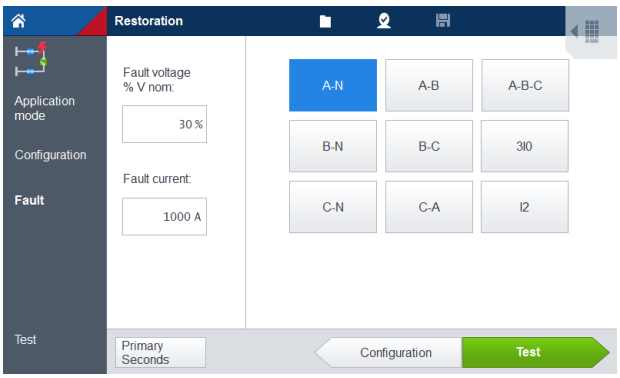


Select this test mode to test whether the recloser control closes within the configured time after detection of a voltage recovery on its load side, and then properly trips and locks out if this closing is done on an existing fault (refer to step 6 of the application example on page 76).

For this test, make sure that the switching states of the circuit breaker simulation in the ARCO test set and the recloser control under test are open prior to the test.

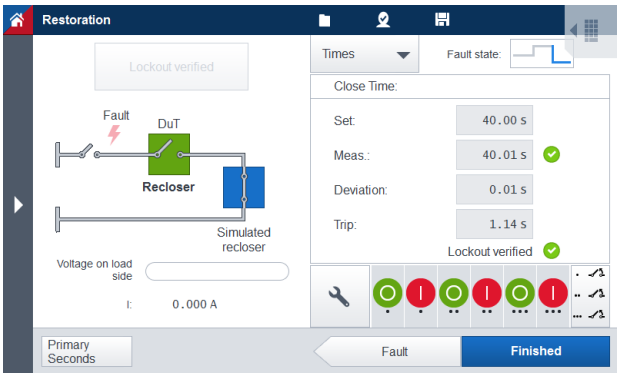
Enter the configured **Close time** and the **Tolerance** permitted for the close time as well as the **Max. trip time** and the **Max. dead time** of the recloser control under test.

Select the **Fault** button to proceed.



Use the **Fault** screen to define the values applied during the fault state. Enter the percentage of the nominal voltage to be applied in the **Fault voltage % V nom** field. Enter the fault current in the **Fault current** field. Select one of the predefined fault types: phase-ground, phase-phase, 3-phase, zero sequence (3I0), or negative sequence (I2). For 3I0 and I2 output values → page 37.

Select the **Test** button to proceed to the test screen of the **Restoration** tool.



The schematic diagram on the left shows the application with the switching states of the reclosers during the test.

Slide down the **I/0** key to start the test and activate the ARCO outputs.

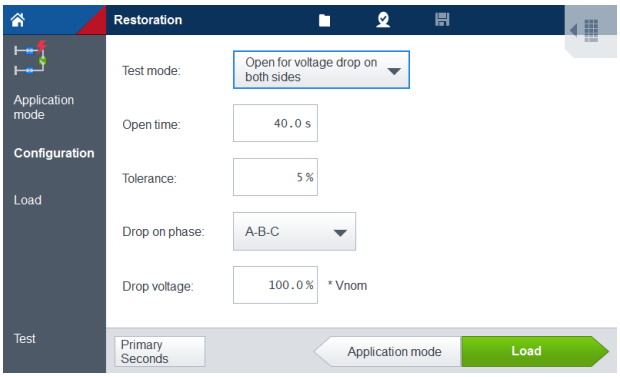
ARCO Control applies the nominal voltage to the load side of the recloser control and measures its time required to close. After closing, *ARCO Control* applies the fault state for the maximum trip time of the recloser control. After that, the nominal voltage is again applied to the load side for the maximum dead time to verify that the recloser control is in the lockout state.

The test stops automatically when the test sequence is finished. By touching/clicking the **Lockout verified** button you can confirm the lockout and stop the test sequence manually, for example, to cut short the testing time in case of a long dead time setting. This button is only active while the test sequence is running.

The **Times** area on the right displays the configured close time of the recloser control in the **Set** field and the measured close time with the calculated deviation from the set value in the **Meas.** and **Deviation** fields. The **Trip** field displays the maximum trip time set in the **Configuration** screen. You can switch this window to **Events** in order to display the switching events with the measured times.

If the measured close time of the recloser control is within the permitted range, and the recloser control entered the lockout state as expected, the test steps are assessed as OK and green check marks are displayed. Otherwise, a red X is displayed next to the failed test result.

Test mode: Open for voltage drop on both sides

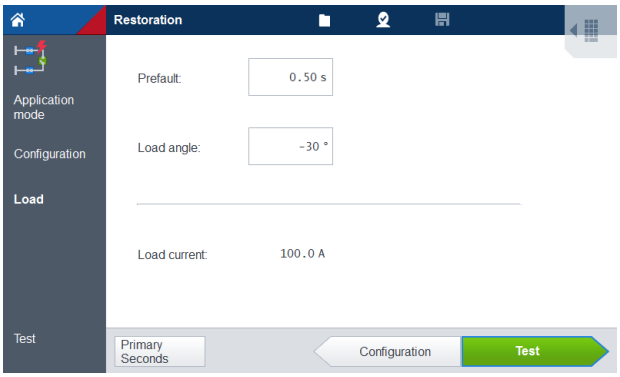


Select this test mode to test whether the recloser control opens within the configured time if it detects a voltage drop on both sides.

For this test, make sure that the switching states of the circuit breaker simulation in the ARCO test set and the recloser control under test are closed prior to the test.

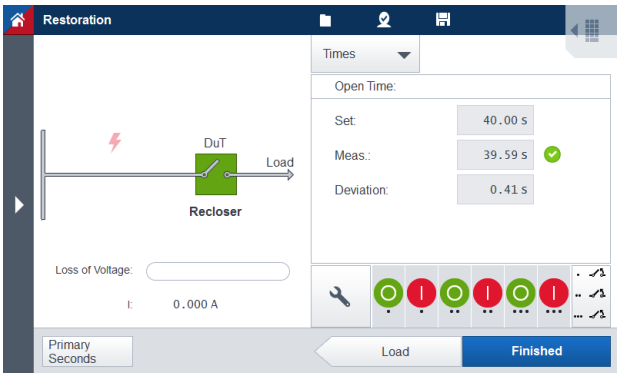
Enter the configured **Open time** and the permitted **Tolerance** of the recloser control under test, select the **phase** on which the voltage drop occurs, and enter the **Drop voltage** (in percent of nominal value).

Select the **Load** button to proceed.



In the **Load** screen, enter the duration of the prefault state in the **Prefault** field. This is a time of "normal operation" before the recloser control under test detects the voltage drop. During the prefault state, *ARCO Control* applies the displayed load current with the phase angle set in the **Load angle** field. The load current value is taken from the nominal values defined in the hardware configuration (→ page 22).

Select the **Test** button to proceed to the test screen of the **Restoration** tool.



The schematic diagram on the left shows the application with the switching state of the recloser during the test and the voltage drop.

Press the **I/0** key to start the test and activate the ARCO outputs.

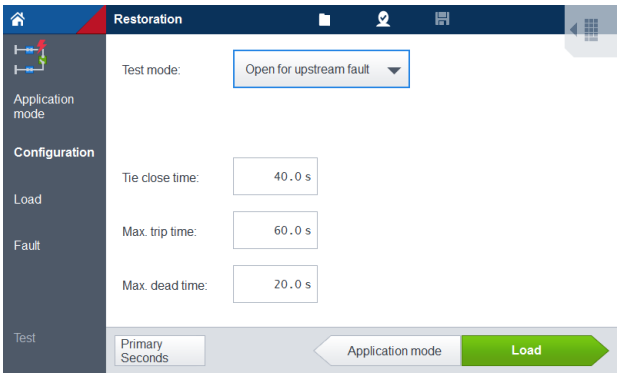
ARCO Control applies the prefault state for the specified time. After the prefault state, *ARCO Control* applies the "voltage drop" state and measures the time required by the recloser control to open.

The test stops automatically when the test sequence is finished.

The **Times** area on the right displays the configured open time of the recloser control in the **Set** field and the measured open time with the calculated deviation from the set value in the **Meas.** and **Deviation** fields. You can switch this window to **Events** in order to display the switching events with the measured times.

If the measured open time of the recloser control is within the permitted range, the test is assessed as OK and a green check mark is displayed. Otherwise, a red X is displayed to indicate that the test failed.

Test mode: Open for upstream fault

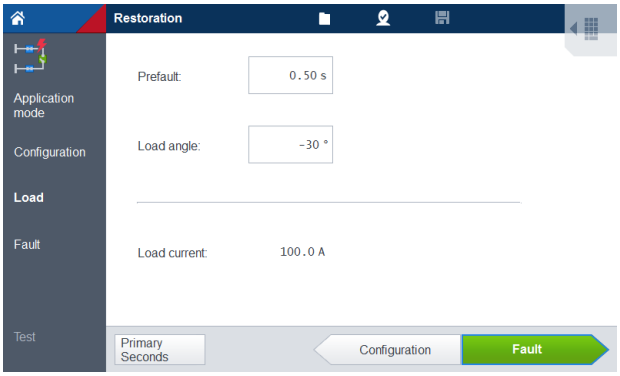


Select this test mode to test whether the recloser control opens within the configured time if it detects an upstream fault.

For this test, make sure that the switching states of the circuit breaker simulation in the ARCO test set and the recloser control under test are closed prior to the test.

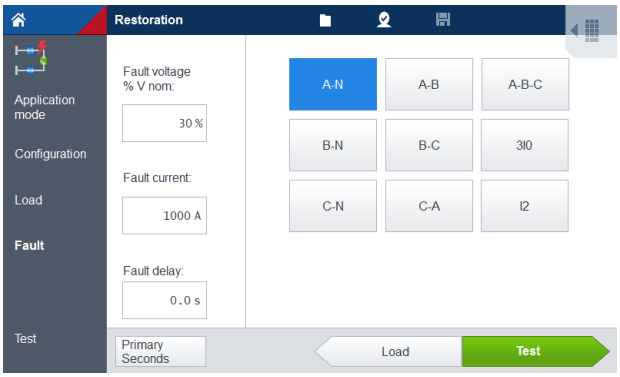
Enter the configured **Tie close time** and the permitted **Max. trip time** and **Max. dead time** of the recloser control under test.

Select the **Load** button to proceed.



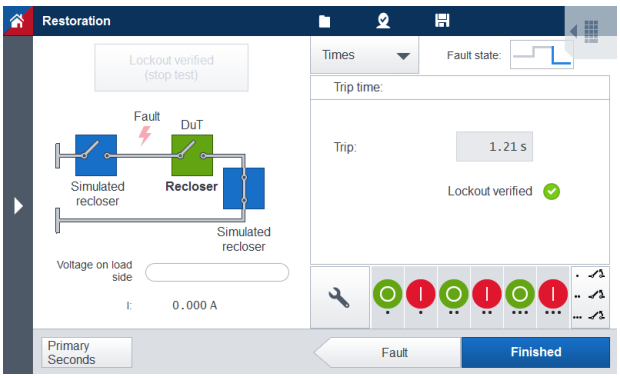
In the **Load** screen, enter the duration of the prefault state in the **Prefault** field. This is a time of "normal operation" before the recloser control under test detects the fault. During the prefault state, *ARCO Control* applies the displayed load current with the phase angle set in the **Load angle** field. The load current value is taken from the nominal values defined in the hardware configuration (→ page 22).

Select the **Fault** button to proceed to the fault screen of the **Restoration** tool.



Use the **Fault** screen to define the values applied during the fault state. Enter the percentage of the nominal voltage to be applied in the **Fault voltage % V nom** field. Enter the **Fault current** and the **Fault delay** in the respective fields. Select one of the predefined fault types: phase-ground, phase-phase, 3-phase, zero sequence (3I0), or negative sequence (I2). For 3I0 and I2 output values → page 37.

Select the **Test** button to proceed to the test screen of the **Restoration** tool.



The schematic diagram on the left shows the application with the switching states of the reclosers during the test.

Press the **I/0** key to start the test and activate the ARCO outputs.

ARCO Control applies the prefault state for the specified time. After the prefault state, *ARCO Control* applies the "zero" state, i.e. 0 V are output for the defined tie close time. Then, the fault values are output in reverse direction (i.e. defined load angle + 180°) for the max. trip time of the recloser control. After that, the nominal voltage is again applied for the maximum dead time to verify that the recloser control is in the lockout state.

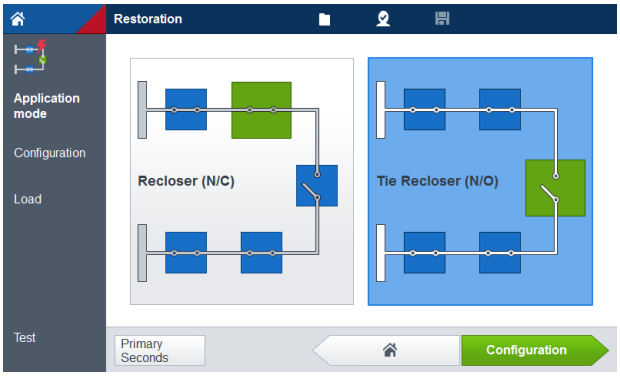
The test stops automatically when the test sequence is finished. By touching/clicking the **Lockout verified** button you can confirm the lockout and stop the test sequence manually, for example, to cut short the testing time in case of a long dead time setting. This button is only active while the test sequence is running.

The **Times** area on the right displays the measured trip time.

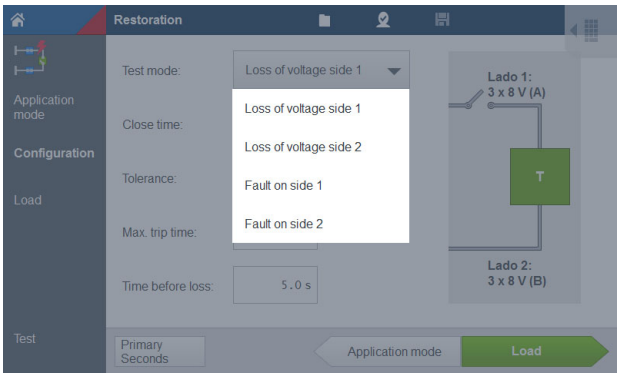
If the measured trip time of the recloser control is within the permitted range, and the recloser control entered the lockout state as expected, the test steps are assessed as OK and a green check mark is displayed next to **Lockout verified**. Otherwise, a red X is displayed.

10.7.3 Tie Recloser (N/O) application mode

The **Application** mode screen is displayed after selecting the **Restoration** tool in the main menu. It shows schematic diagrams of the possible application modes.



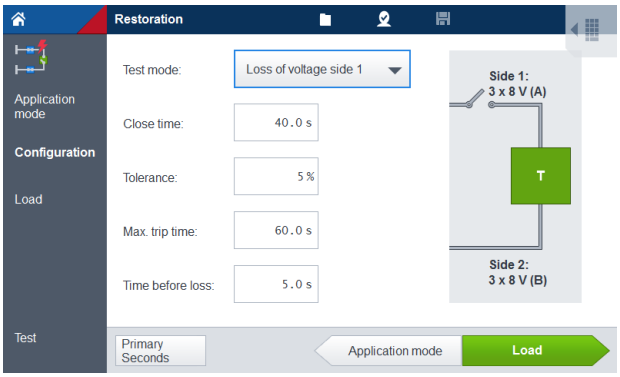
Touch/click the right diagram to select the **Tie Recloser (N/O)** application mode. Select the **Configuration** button to proceed.



In the **Configuration** screen, select your test application from the **Test Mode** field:

- **Loss of voltage on side 1 / 2** (→ page 93)
- **Fault on side 1 / 2** (→ page 95)

Test mode: Loss of voltage on side 1 / 2

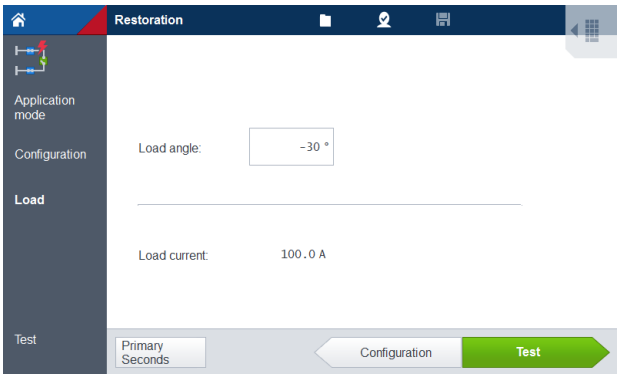


Select this test mode to test whether the tie point recloser control closes within the configured time if it detects a loss of voltage on its load side; for example, because one of the upstream reclosers normally supplying this side tripped due to a fault on the line (refer to step 4 of the application example on page 76). Select the corresponding option to define the "load side" to be on side 1 or side 2 of the tie point recloser control.

For this test, make sure that the switching states of the circuit breaker simulation in the ARCO test set and the recloser control under test are open prior to the test.

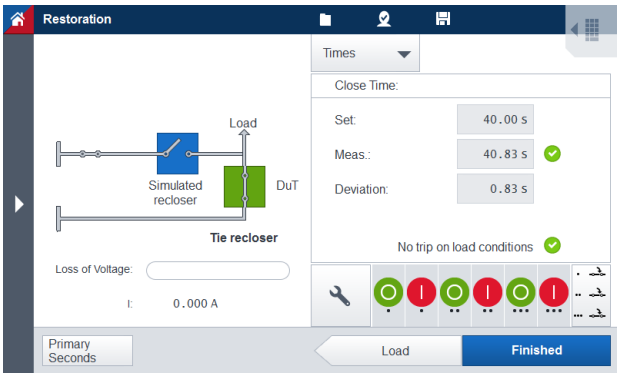
Enter the configured **Close time**, the **Tolerance** permitted for the close time, and the **Max. trip time** of the recloser control under test. Use the **Time before loss** field to define a time of "normal operation" before the tie recloser control detects the loss of voltage. During this time, *ARCO Control* applies the nominal voltage to both sides of the recloser control.

Select the **Load** button to proceed.



In the **Load** screen, use the **Load angle** field to enter the phase angle of the load current applied after the closing action. The load current value is taken from the nominal values defined in the hardware configuration (→ page 22).

Select the **Test** button to proceed to the test screen of the **Restoration** tool.



The schematic diagram on the left shows the application with the switching states of the reclosers during the test.

Slide down the **I/0** key to start the test and activate the ARCO outputs.

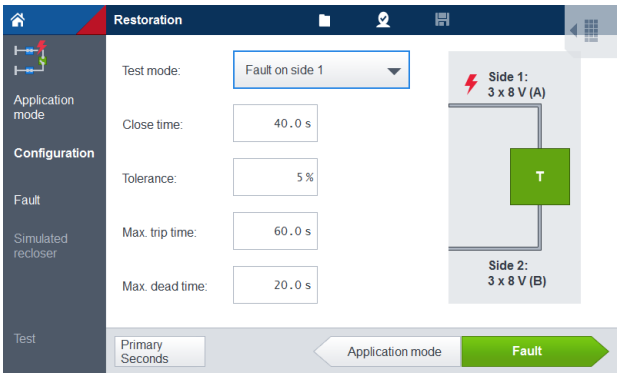
ARCO Control applies the nominal voltages to both sides of the recloser control for the specified time of normal operation ("time before loss"). Then *ARCO Control* switches off the voltage on the selected load side and measures the time required by the recloser control to close. After closing, *ARCO Control* applies the nominal voltage and the load current for the maximum trip time of the recloser control.

The test stops automatically when the test sequence is finished.

The **Times** area on the right displays the configured close time of the recloser control in the **Set** field and the measured close time with its calculated deviation from the set value in the **Meas.** and **Deviation** fields. You can switch this window to **Events** in order to display the switching events with the measured times.

If the measured close time of the recloser control is within the permitted range, and the recloser control did not trip during the output of the load current, the test is assessed as OK and green check marks are displayed. Otherwise, a red X is displayed next to the failed test result.

Test mode: Fault on side 1 / 2

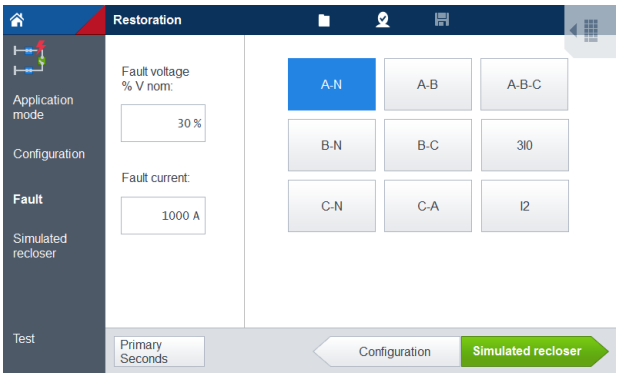


Select this test mode to test whether the tie point recloser control closes within the configured time if it detects a loss of voltage on its load side, and then properly trips and locks out if this closing is done on an existing fault (refer to the last step of the application example on page 77). Select the corresponding option to define the "load side" to be on side 1 or side 2 of the tie point recloser.

For this test, make sure that the switching states of the circuit breaker simulation in the ARCO test set and the recloser control under test are open prior to the test.

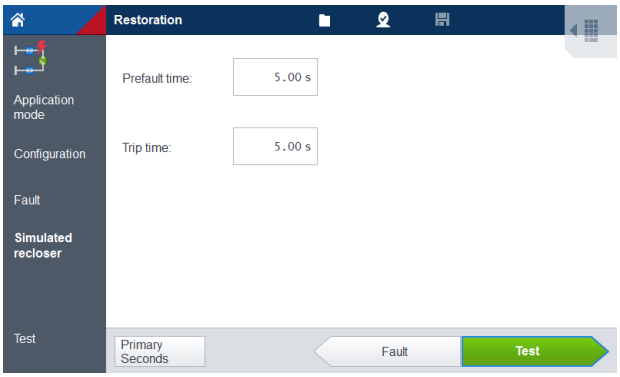
Enter the configured **Close time** and the **Tolerance** permitted for the close time as well as the **Max. trip time** and the **Max. dead time** of the recloser control under test.

Select the **Fault** button to proceed.



Use the **Fault** screen to define the values applied during the fault state. Enter the percentage of the nominal voltage to be applied in the **Fault voltage % V nom** field. Enter the fault current in the **Fault current** field. Select one of the predefined fault types: phase-ground, phase-phase, 3-phase, zero sequence (3I0), or negative sequence (I2). For 3I0 and I2 output values → page 37.

Select the **Simulated recloser** button to proceed.

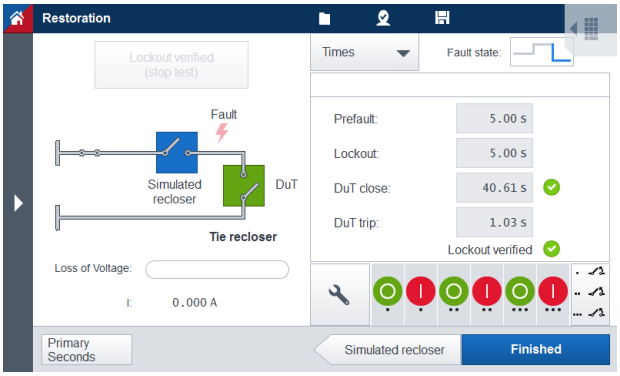


In the **Simulated recloser** screen, use the **Prefault time** field to define a time of "normal operation" before the simulated recloser detects a fault. During this time, *ARCO Control* applies the nominal voltage to both sides of the tie recloser control.

Use the **Trip time** field to enter the trip time of the simulated recloser, i.e., the time the simulated recloser requires to lockout in case of a fault. During this time, *ARCO Control* applies the fault voltage to the load side and the nominal voltage to the other side of the tie recloser under test.

In the application example given on page 75, recloser R3 is the simulated recloser for this test mode.

Select the **Test** button to proceed to the test screen of the **Restoration** tool.



The schematic diagram on the left shows the application with the switching states of the reclosers during the test.

Slide down the **I/0** key to start the test and activate the ARCO outputs.

The test sequence is as follows:

1. *ARCO Control* applies the nominal voltage to both sides of the tie recloser control for the prefault time.
2. Then, *ARCO Control* applies the fault voltage to the load side and the nominal voltage to the other side of the tie recloser control for the set trip time of the simulated recloser.
3. After the simulated recloser went into lockout, *ARCO Control* applies the "loss of voltage" state (no voltage on the load side, nominal voltage on the other side of the tie recloser control under test).
4. *ARCO Control* measures the time required by the tie recloser control to close.

5. After closing, *ARCO Control* applies the fault state (fault voltage on both sides of the tie recloser control and fault current) for the maximum trip time of the tie recloser control and measures the time required by the tie recloser to trip and enter the lockout state.
6. Finally, *ARCO Control* again applies no voltage on the load side and nominal voltage on the other side of the tie recloser control under test for the maximum dead time to verify the lockout.

The test stops automatically when the test sequence is finished. By touching/clicking the **Lockout verified** button you can confirm the lockout and stop the test sequence manually, for example, to cut short the testing time in case of a long dead time setting. This button is only active while the test sequence is running.

The **Times** area on the right displays the prefault time and the trip time set for the simulated recloser in the **Prefault** and **Lockout** fields, and the measured close time and trip time of the tie recloser control under test in the **DuT close** and **DuT trip** fields. You can switch this window to **Events** in order to display the switching events with the measured times.

If the measured close time of the recloser control is within the permitted range and the recloser control entered the lockout state as expected, the test steps are assessed as OK and green check marks are displayed. Otherwise, a red X is displayed next to the failed test result.

10.8 Harmonics

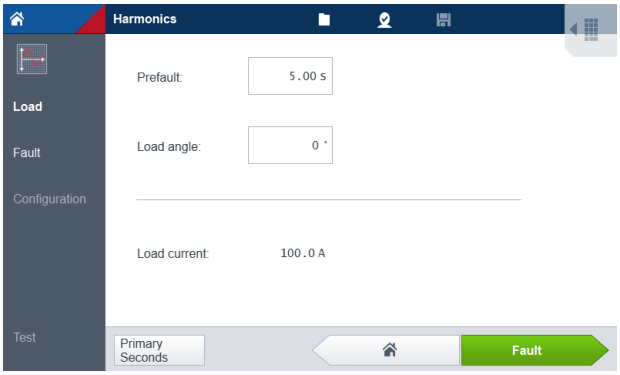
The **Harmonics** tool allows you to test the inrush restraint and harmonic blocking functions of recloser controls.

An inrush of current can occur when, for example, a downstream transformer de-energizes and is then re-energized again. Such an inrush might cause the overcurrent protection elements of the recloser control to operate. That's were the inrush restraint and harmonic blocking functions come into effect. These functions are supported by many recloser controls and ensure that the recloser control can distinguish between inrush currents and real faults.

You can test the inrush restraint and harmonic blocking functions by considering the asymmetric nature of inrush that causes harmonics. The harmonic content of the inrush current provides information that helps to differentiate between inrush conditions and faults.

For testing inrush restraint and harmonic blocking functions, it is sufficient to consider the 2nd harmonic only.

To display the final test screen, proceed through a three-stage process of defining the load conditions, fault values, and harmonics configuration.

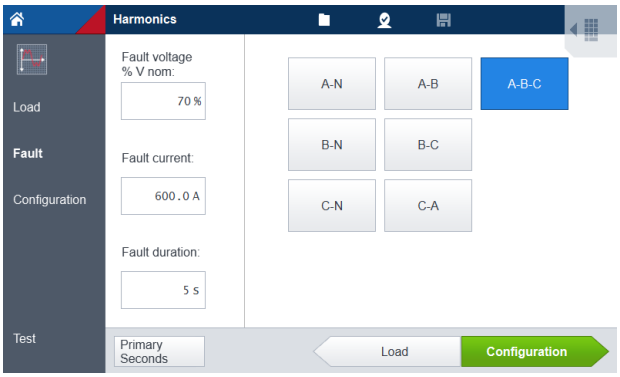


In the **Load** screen, enter the duration of the prefault state in the **Prefault** field. During this state, *ARCO Control* applies the load current with the specified load angle to the device under test.

The **Load angle** field is inactive if voltages have been disabled in the hardware configuration (→ page 23).

The **Load current** field is read-only. The displayed value is taken from the nominal values that are defined in the hardware configuration (→ page 22).

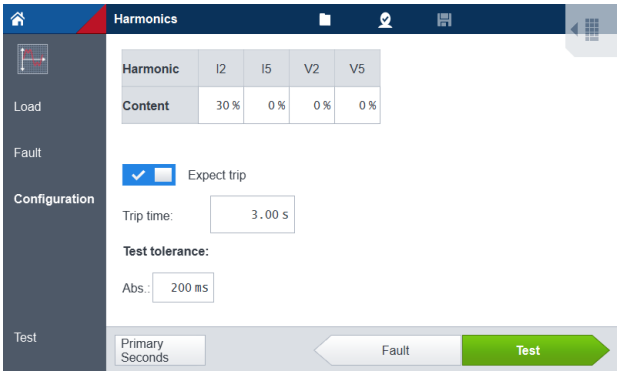
Select the **Fault** button to proceed to the next screen.



In the **Fault** screen, define the values to be applied during the fault state. Enter the percentage of the nominal voltage to be applied in the **Fault voltage % V nom** field and the value of the fault current in the **Fault current** field. Define the **Fault duration**, i.e., the time during which the ARCO test set injects the harmonics to the selected phases. Select one of the predefined fault types: phase-ground, phase-phase, or 3-phase.

The harmonics are superimposed on and in phase with the fundamental of the faulted phases.

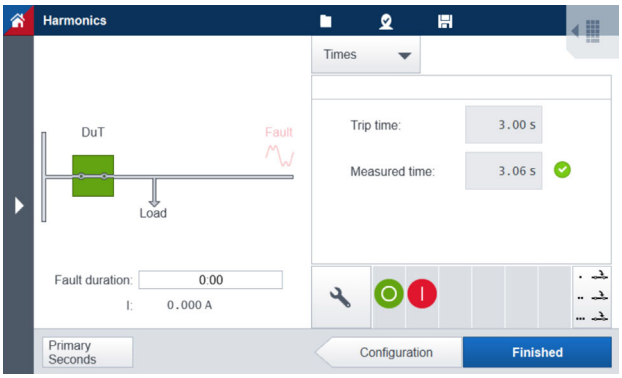
Select the **Configuration** button to proceed to the next screen.



In the **Configuration** screen, enter the content of the 2nd harmonic for currents. The content of the harmonic is defined as a certain percentage of its fundamental.

Then, you can choose between two different test scenarios:

- **No trip expected**
  - To test whether the recloser control is "blocking" and no trip occurs.
  - Configuration: Turn off the **Expect trip** toggle switch, and select the **Test** button to proceed directly to the test screen.
- **Trip expected**
  - In this test scenario, a trip is expected to occur before the defined fault duration ends.
  - Configuration: Turn on the **Expect trip** toggle switch, and define a trip time. The recloser control restraints the trip for the duration of this time. Therefore, the trip time needs to be smaller than the fault duration time. Furthermore, you can also define a time for the absolute test tolerance in the **Abs.** field. Then, select the **Test** button to proceed to the test screen.



Slide down the **I/0** key to start the test sequence and activate the ARCO outputs. *ARCO Control* applies the prefault state and the test scenario previously defined in the **Configuration** screen. The test stops automatically when the test sequence is over.

The test assessment depends on the test scenario:

- **No trip expected:** The test is assessed as "passed" if no trip occurs.
- **Trip expected:** If the measured trip time of the recloser control is within the defined range, the test is assessed as "passed" and a green check mark is displayed. Otherwise, a red X is displayed to indicate that the test failed.

11 Saving test reports

You can save the test results obtained with *ARCO Control* as test reports to the file system of your device. To create and/or select a corresponding folder, you can either touch/click the file explorer icon in the title bar or the **Folder selection** button in the system settings (**Software Settings** tab, see page 31).

Android tablet:

Per default, *ARCO Control* automatically creates an **/OMICRON** folder containing a **/report** subfolder in the parent folder selected in the file explorer. Therefore, you need to select this parent folder in the file explorer and not the **/OMICRON/report** folder.

For example, select **/storage/sdcard0/** to store your report under **/storage/sdcard0/OMICRON/report**).

Windows PC:

Per default, *ARCO Control* automatically creates an **/OMICRON ARCO Control** folder containing a **/Report** subfolder in your **My Documents** repository. All further steps are similar to those for Android tablets (see above).

Tip: You can include or exclude certain test report information via the system settings (**Application settings** tab, see page 32).

Saving options

You can choose between three different options to save your test plans: **Save on user request**, **Always ask**, and **Auto save**. To select an option, click the corresponding icon in the title bar on the upper border of the screen area. The icons are described below.

Save on user request

Select this option to save the test reports manually.

When this mode is selected, the **Save test report** button is displayed in the title bar. This button becomes active as soon as test results are available in a test tool. Select this button to save the test report.

In the appearing dialog:

- Enter a comment or test description, if desired.
- Save the test results to an existing test report or create a new test report.

See page 105 for more detailed information.

Always Ask

Each time new test results are available, *ARCO Control* asks you whether you want to save the test results.

In the appearing dialog:

- Enter a comment or test description, if desired.
- Save the test results to an existing test report or create a new test report.

See page 103 for more detailed information.

Auto Save

ARCO Control automatically saves all test reports obtained during a session to one report file. A new file has to be created for each session.

View test report

Select the **View Last Report** button to view the test report on your device.

The test reports are stored in XML and HTML file format. Use the HTML format to display a test report using a Web browser on a PC, for example. The XML format is intended for further processing with suitable software.

Tip: If you would like to use your own company logo for the test report, copy the graphic file of your logo in PNG or JPG format into the **Logo** subfolder of your *ARCO Control* documents repository. If you copy several graphic files into this folder, *ARCO Control* always uses the first one in the list.

The location of the **Logo** subfolder depends on whether you are using *ARCO Control* on a Windows PC or Android tablet:

- Windows PC

  Per default, *ARCO Control* automatically creates an **\OMICRON ARCO Control** folder containing a **\Logo** subfolder in your **Documents** repository.

  Example:
  C:\Users*UserName*\Documents\OMICRON ARCO Control\Logo*YourLogo.png*

  On a Windows PC, there is a separate logo folder for every OMICRON application. This means, you can use different logos for the different test reports.

- Android tablet

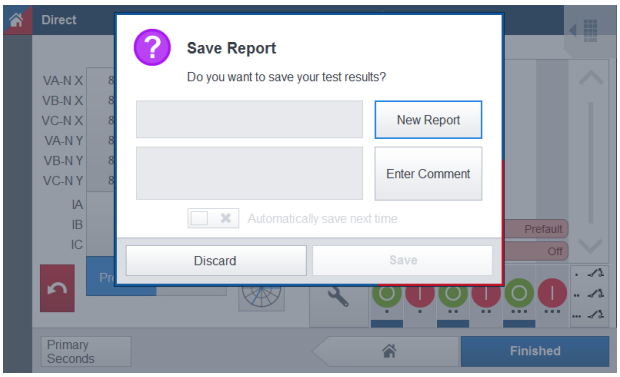
  Per default, *ARCO Control* automatically creates an **\OMICRON** folder containing a **\logo** subfolder in your internal storage.

  Example: *YourDevice*\Internal Storage\OMICRON\logo*YourLogo.png*

  On an Android tablet, there is one common logo folder for all OMICRON applications. This means, you can only use one common logo for all test reports.

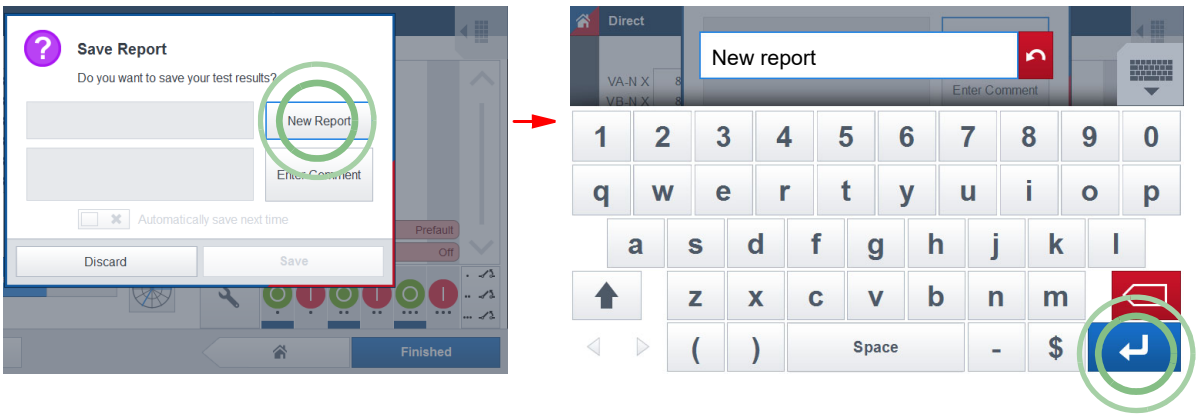
11.1 Always ask

The **Save Report** dialog is displayed when new test results are available in the **Always ask** mode.



Select the **New report** button to enter a new (unique) file name for your test report file or to change a previously defined existing file name.

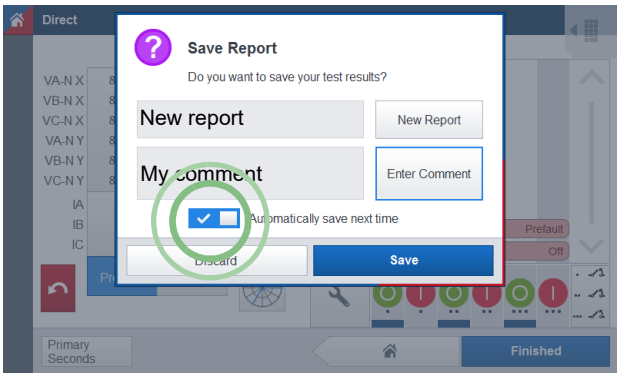
On Android tablets or Windows PCs with touch screen:
Enter a file name using the touch screen keyboard. On the keyboard, select the button to delete the input field. Touch the **Enter** button to confirm your input, close the keyboard, and apply your file name.



Select the **Enter Comment** button to enter a comment for your test; for example, a descriptive name of the test step. You can enter up to 120 characters. This comment is displayed in the test report.

On Android tablets or Windows PCs with touch screen, use the touch screen keyboard to enter a comment (see above).

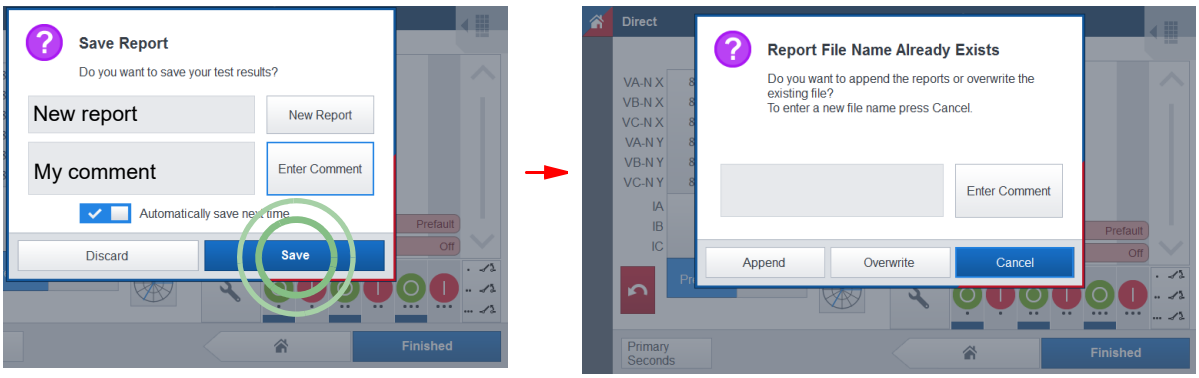
Select the **Automatically save next time** option if you want to use the **Auto save** mode the next time test results are available.



Select the **Discard** button to return to the test tool screen without saving the test report. This will discard the available test results.

Select the **Save** button to save the test results and your comment to the location specified in the **Software settings** (⟶ page 31).

If the specified file name already exists, a second dialog appears where you need to choose whether you want to **Overwrite** the existing file or **Append** the new test results to the test report data contained in this file. Select the **Cancel** button in this dialog to go back to the **Save Report** dialog in order to specify a new file name for your test report.



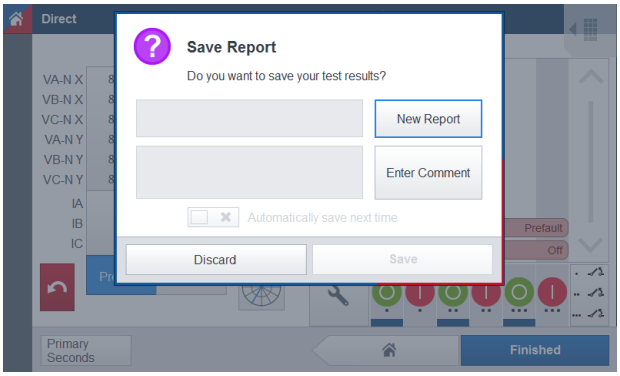
11.2 Save on user request

The saving behavior in the **Save on user request** mode differs depending on whether the test report file name does already exist or not.

If the specified test report file name does not exist yet

If no test report file name has been specified or if the specified test report file name does not exist yet, the **Save Report** dialog is displayed after touching/clicking the save test report button .

Please refer to the descriptions made for the **Always ask** mode on page 103 for more detailed information.

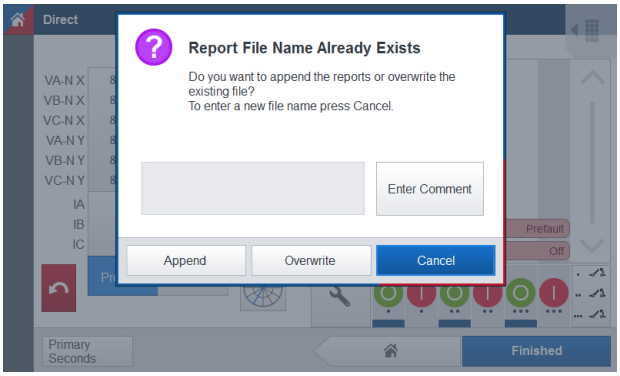


If the specified test report file already exists

If the specified test report file already exists, the **Report File Name Already Exists** dialog is displayed. If desired, select the **Enter comment** button to enter a comment for your test (see page 103 for details).

Choose whether you want to **Overwrite** the existing file or **Append** the new test results to the test report data contained in this file.

To save your test results to a new file, select the **Cancel** button to return to the test tool. Select the icon in the title bar of the test tool and then select the **File Name** field in the appearing dialog to specify a new file name (see page 103 for details).



12 Open source license information

Parts of the *ARCO Control* software are under OMICRON license, other parts are under third party software licenses, including open source. To access the *ARCO Control* software license texts from the software, use the **Info** button (→ page 13).

Both the open source license texts and the necessary source code are provided in the OMICRON Open Source Download Area at www.omicronenergy.com/opensource. Open this web address in your Internet browser, click the **Download Software** button, and navigate to the **ARCO 400/** directory. Look for the file containing your corresponding software version in the file name (for example, **Open Source ARCO Control Android 1.00.zip** for version 1.00 on Android tablets or **Open Source ARCO Control Windows 1.00.zip** for Windows PCs). In addition to some open source code packages, the archive contains an overview on all license information for the *ARCO Control* software.

Parts of the ARCO test set software are under OMICRON license, other parts are under open source software licenses. Both the open source license texts and the necessary source code are provided in the OMICRON Open Source Download Area at www.omicronenergy.com/opensource. Open this web address in your Internet browser, click the **Download Software** button, and navigate to the **ARCO 400/** directory. Look for the file containing your corresponding version in the file name (for example, **Open Source ARCO 400 2.55.zip** for version 2.55). In addition to some open source code packages, the archive contains an overview on all license information of the ARCO test set.

Open source software

The following tables list the open source software packages and their license types for both *ARCO Control* and the ARCO test set image.

ARCO Control software for Windows PCs (version 1.20):

Package	License type
Qt	LGPL
boost	MIT
log4cxx	Apache
openssl	BSD/SSLeay
apr	Apache

Package	License type
apr-util	Apache
expat	MIT
protobuf	BSD
zeromq	MIT

ARCO Control software for Android tablets (version 1.20):

Package	License type
Android Open Source Project	Apache
Qt	LGPL
boost	MIT

Package	License type
openssl	BSD/SSLeay
log4qt	Apache
GNU libstdc++	GPLv3

ARCO test set software (version 2.55):

Package	License type
bme280_driver	BSD
boost	MIT
boot-format	GPL2
buildbot-slave	GPL2
buildbot-worker	GPL2
busybox	GPL2
cmc_avahi	LGPL2
cmc_lics	MISC
cmc_ntp	BSD
cmcweb	MISC
curl	MIT
cython	Apache2
ethtool	GPL2
expat	MIT
fcgi	MIT
functools32	PSF2
glibc	LGPL
hostapd	BSD
http_parser	MIT
iproute2	GPL2
iw	MIT
json2pb	MIT
jsonschema	MIT
libconfigpp	LGPL2
libdaemon	LGPL2
libfaketime	GPL2
libjansson	MIT
liblog4cpp	LGPL
liblua	MIT
libnl	LGPL2
libpcap	BSD
libpcre	BSD
libusbstring	LGPL2
libxml2	MIT
libzmq	LGPL3
libzmqpp	MPL2

Package	License type
mtd-utils	GPL2
ncurses	MIT
net-snmp	BSD
nginx	BSD
nginx_devel_kit	BSD
nginx_mod_lua	BSD
nginx_mod_zip	BSD
omicppc_pwr_fail	GPL2
openresolv	BSD
openssh	BSD
openssl	BSD
procps	GPL2
protobuf	BSD
pyro	MIT
python-future	MIT
python	PSF
pyzmq	LPGL3
rtl8723bu	GPL2
six	MIT
spider2_kernel	GPL2
spider2_pcie	GPL2
spider2_pps_irq	GPL2
spider2_uboot	GPL2
stm32flash	GPL2
twisted	MIT
utf8-cpp	MIT
util-linux (libblkid)	LGPL2.1
util-linux (libuuid)	BSD
vsftpd	GPL2
wlan_fw_brcm	BroadcomFirmware
wlan_fw_rt2870	RalinkFirmware
zlib	BSD
zope.interface	ZPL2.1

13 Important information on ARCO test sets

For detailed descriptions of the individual features and technical details of ARCO test sets, refer to the corresponding reference manuals.

13.1 Safety instructions for ARCO test sets

Before operating ARCO test sets, carefully read the safety instructions below. For more detailed safety instructions, refer to the reference manual of the ARCO test set. Only operate (or even turn on) the ARCO test set after you have read the safety instructions below as well as the reference manual of the ARCO test set and fully understood the instructions therein.

ARCO test sets may only be operated by trained personnel. Any misoperation can result in damage to property or persons.

Be especially careful whenever you find this warning sign on the device and refer to the more detailed safety instructions in the reference manual of the ARCO test set. The reference manual of the ARCO test set can be found on the installation medium.

13.1.1 Rules for use

- An ARCO test set shall only be used when in a technically sound condition. Its use must be in accordance with the safety regulations for the specific job site and application. Always be aware of the dangers of high voltages and mechanical hazards (e.g. a test cable could come loose and fall down from the recloser control). Pay attention to the information provided in the reference manual of the ARCO test set.
- The instructions provided in the reference manual of the ARCO test set are considered part of the rules governing proper usage.

13.1.2 Orderly practices and procedures

- Keep the reference manual of the ARCO test set available on site where the ARCO test set is used.
- Personnel assigned to using the ARCO test set must have read the corresponding reference manual and fully understood the instructions herein.
- Do not carry out any modifications, extensions, or adaptations at the ARCO test set or its equipment.

13.1.3 Operator qualifications

- Testing with an ARCO test set shall only be carried out by authorized and qualified personnel. Before starting to work, clearly establish the responsibilities of all personnel involved.
- Personnel operating an ARCO test set must be familiar with all necessary personal safety equipment.
- Testing with an ARCO test set must comply with all on-site procedures and methods for personal safety and the safety instructions relevant for each test.

13.1.4 Safe operation procedures

- Only operate the ARCO test set when the device is connected to protective earth.
- Before wiring the terminals, verify that the conducting parts are de-energized.
- Do not block the access to safety-relevant test set components like the main power switch or the power cord. In case of an emergency, these components must be freely and quickly accessible.
- Before connecting and disconnecting test objects, verify that all outputs have been turned off. Never connect or disconnect a test object while the outputs are active.
- When disconnecting power supply cables or test leads, verify that the installation is dead, and always start from the device feeding the power or signal.
- Do not operate ARCO test sets outside the specified conditions or when explosive gas or vapors are present.
- When setting up the ARCO test set, make sure that the ventilation holes on the side panel of the device remain unobstructed.
- Do not open the ARCO test set and its equipment or remove any of its housing components.
- The power supply cable must be rated for the nominal voltage and current as specified in section ‘Technical data’. We recommend using the cable that is supplied by OMICRON with the *ARCO 400* test set.

If the ARCO test set seems to be functioning improperly, please contact the OMICRON Technical Support (→ page 113).

13.2 Designated use

ARCO is a test set controlled by the *ARCO Control* software and used for testing recloser and sectionalizer controls in both laboratory and field environments. The device is intended for commercial use by trained personnel and is not suited for private use. Any other use of the ARCO test set is considered improper and may result in damage to property or persons.

WARNING

Death or severe injury caused by high voltage or current possible.

► Always use the ARCO test set as specified in section ’Designated use’ in the corresponding reference manual.

13.3 Basic technical data

In this section, you find general technical data for *ARCO 400* test sets. For detailed technical data, please refer to the corresponding ARCO reference manual.

Basic technical data	
Mains	100 ... 240 V, 50/60 Hz, 10 A, C14 connector according to UL/IEC60320-1 Overvoltage category II (according to IEC 61010-1)
Environment	Operating temperature: - 10 °C ... + 50 °C / + 14 °F ... + 122 °F Storage temperature: - 25 °C ... + 70 °C / - 13 °F ... + 158 °F 5 % ... 95 % relative humidity, no condensation 4,000 m / 13,000 ft (operating altitude), 15,000 m / 49,000 ft (non-operating altitude) Ingress protection rating IP31 (IP32 with front cover) according to EN 60529
Relevant standards	Safety: UL/EN/IEC 61010-1, CAN/CSA-C22.2 No 61010-1-04 EMC: EN/IEC 61326-1, EN/IEC 61000-6-4, FCC Subpart B of Part 15 Class A

14 Frequently asked questions

Why doesn't *ARCO Control* show my ARCO test set in the Test Set Selection screen? (Windows PC)

ARCO Control starts up and displays the **Test Set Selection** screen. If no ARCO test set is shown, possible remedy actions are:

- Switch off your ARCO test set and your PC, and switch them both on again.
- Check the connection cable between your PC and the ARCO test set. If necessary, try a different connection cable.
- If you are using a wireless connection:
  - Check the Ethernet connection between the Wi-Fi router and the ARCO test set. If necessary, try a different Ethernet cable.
  - Check the wireless connection between your PC and the Wi-Fi router.
  - Try a wired connection instead.

Why won't *ARCO Control* connect to the ARCO test set? (Android tablet)

ARCO Control starts up and displays the **Test Set Selection** screen. There is no connection to an ARCO test set, the **Connect** button is disabled, and you can use *ARCO Control* in demo mode only.

Possible cause: The Wi-Fi router is set to DHCP while a fixed IP address is set for the ARCO test set.

Possible remedy actions:

- Reconfigure the Wi-Fi router so that its settings are in accordance with the ARCO test set.
- Connect the Wi-Fi router directly to the ARCO test set, e.g. with the OMICRON Device Link, and change its settings to DHCP.

Why does *ARCO Control* display "No valid activation key for current ARCO"?

Please order a valid *ARCO Control* activation key for the connected ARCO test set.

Why can't I open ReCoPlan test plans in ARCO Control?

If you have only bought the *ARCO Control* Basic Package, you cannot open or execute *ReCoPlan* test plans with *ARCO Control*. You need to buy a corresponding license.

Do I need a new activation key if I want to change from a Windows PC to an Android tablet (or vice versa)?

Every ARCO Control activation key can be used for Windows PCs and Android tablets alike. Therefore, you can change between a Windows PC and an Android tablet at any time without needing a new activation key.

How do I upgrade *ARCO Control* to the latest version? (Android tablet)

The Google Play Store™ will automatically notify you if there are any updates for your *ARCO Control* installation available. Please install all updates to keep *ARCO Control* up to date. If necessary, download the latest version from the Google Play Store™.

Support

When you are working with our products we want to provide you with the greatest possible benefits. If you need any support, we are here to assist you!

24/7 Technical support – get support

www.omicronenergy.com/support

At our technical support hotline, you can reach well-educated technicians for all of your questions. Around the clock – competent and free of charge.

Make use of our 24/7 technical support hotlines:

Americas: +1 713 830-4660 or +1 800-OMICRON

Asia-Pacific: +852 3767 5500

Europe / Middle East / Africa: +43 59495 4444

Additionally, you can find our Service Center or Sales Partner closest to you at www.omicronenergy.com.

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