MI 3281 WR Analyser
Instruction manual
Ver.1.4.4, code no. 20753098

Distributor:

Manufacturer:

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DATA BACKUP AND LOSS:

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CE	Mark on your equipment certifies that it meets requirements of all subjected EU regulations.

[QR code]	Hereby, Metrel d.o.o. declares that the MI 3281 is in compliance with Directive 2014/53/EU (RED) and all other subjected EU directive. The full text of the EU declaration of conformity is available at the following internet address https://www.metrel.si/DoC.

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i.   About the Instruction manual

- This Instruction manual contains detailed information on the WR Analyser, its key features, functionalities and use.
- It is intended for technically qualified personnel responsible for the product and its use.
- Please note that LCD screenshots in this document may differ from the actual instrument screens in details due to firmware variations and modifications.
- *Metrel* reserve the right to make technical modifications without notice as part of the further development of the product.

TABLE OF CONTENTS

1 General Description

1.1 **Features**

WR Analyser (MI 3281) is a test instrument with IP protection: IP65 (case closed), IP40 (case open), intended for diagnosing of winding resistance of single and three phase transformers.

Available functions and features offered by the Winding Resistance Analyser:
- Winding resistance measurement of single and three phase transformer
- Winding resistance measurement of single and three phase transformer with manual or automatic tap changer test
- Demagnetization of single and three phase transformer
- Auto Sequence®
- Visual Test
- Memory Organizer

A 4.3'' (10.9 cm) colour LCD display with touch screen offers easy-to-read results and all associated parameters. The operation is straightforward and clear to enable the user to operate the instrument without the need for special training (except reading and understanding this Instruction Manual).

Test results can be stored on the instrument. PC software that is supplied as a part of standard set, enables transfer of measured results to PC where can be analysed or printed.

2 Safety and operational considerations

2.1 Warnings and notes

In order to maintain the highest level of operator safety while carrying out various tests and measurements *Metrel* recommends keeping your MI 3281 WR Analyser instruments in good condition and undamaged. When using the instrument, consider the following general warnings:

- The ⚠ symbol on the instrument means »Read the Instruction manual with special care for safe operation«. The symbol requires an action!
- If the test equipment is used in a manner not specified in this Instruction manual, the protection provided by the equipment could be impaired!
- Read this Instruction manual carefully, otherwise the use of the instrument may be dangerous for the operator, the instrument or for the equipment under test!
- Do not use the instrument or any of the accessories if any damage is noticed!
- Consider all generally known precautions in order to avoid risk of electric shock while dealing with hazardous voltages!
- Do not connect the instrument to a mains voltage different from the one defined on the label adjacent to the mains connector, otherwise the instrument may be damaged and safety impaired.
- Do not connect the instrument to an energized transformer!
- Make sure that the air intake and air outlet ventilation openings are open and clean before operation. Do not cover it! This can lead to overheating.
- Service intervention or adjustment is only allowed to be carried out by competent authorized personnel!
- Use only standard or optional test accessories supplied by your distributor!
- Do not use the equipment in a wet environment, around explosive gas, vapour.

Markings on the instrument:

- ⚠   Read the Instruction manual with special care to safety operation«. The symbol requires an action!

- 🔥   Surface near this sign can overheat. Do not touch during operation!

- ⓥ   Emergency stop switch. Press in case of any emergency!

- CE   Mark on your equipment certifies that this equipment meets requirements of all subjected EU regulations.

- UKCA   Mark on your equipment certifies that this equipment meets requirements of all subjected UK regulations.

- ⌧   This equipment shall be recycled as electronic waste.

⚠ Warnings related to measurement functions:

Working with the instrument
- Make sure that the tested object is disconnected (from mains and from the load) before you connect any MI 3281 clips to the test object! One side of earth connection can remain connected.
- Always connect accessories to the instrument and to the test object before starting measurement. Do not touch test leads or crocodile clips during measurement.
- Do not touch any conductive parts of equipment under test during the test. There is a risk of electric shock!
- Do not connect test terminals to an external voltage higher than 50 V DC or AC (CAT IV environment) to prevent any damage to the test instrument!

Handling with inductive loads
- Note that large inductances (transformers) can store large amount of energy, which can lead to hazardous electric shock and equipment damage if disconnected during measurement.
- Never touch the measured object during testing until it is totally discharged.
- After all the measurements are done, demagnetization of transformer should be performed, to avoid high inrush currents.

2.2 **Standards applied**

The WR Analyser instrument is manufactured and tested in accordance with the following regulations:

Electromagnetic compatibility (EMC)

EN 61326 - 1	Electrical equipment for measurement, control and laboratory use - EMC requirements – Part 1: General requirements

Safety (LVD)

EN 61010 - 1	Safety requirements for electrical equipment for measurement, control and laboratory use – Part 1: General requirements
EN 61010 - 2 - 030	Safety requirements for electrical equipment for measurement, control and laboratory use – Part 2-030: Particular requirements for testing and measuring circuits
EN 61010 - 031	Safety requirements for hand-held probe assemblies for electrical measurement and test.

Some further recommendations

IEC 60076-1	Power transformers – Part 1: General
IEEE C57.12.90	Standard Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEC 61869-2	Instrument transformers – Part 2: Additional requirements for current transformers

Note about EN and IEC standards
- Text of this manual contains references to European standards. All standards of EN 6XXXX (e.g. EN 61010) series are equivalent to IEC standards with the same number (e.g. IEC 61010) and differ only in amended parts required by European harmonization procedure.

2.3 **Emergency stop procedure**

Emergency stop switch shall be used in case of any emergency situations.

Press EMERGENCY STOP switch to instantly Stop the measurement. The measurement will stop and immediately begin to discharge the transformer. Turn the switch clockwise to release it.

In case of any instrument failure, press EMERGENCY STOP switch and leave the instrument for at least half an hour before unplugging it from mains and from the transformer. It is recommended to unplug the test connectors on instrument first and then remove the clips from the transformer. Instrument shall be sent to authorized service.

3 Terms and definitions

For the purposes of this document and instrument MI 3281 WR Analyser, the following definitions apply.

Index	Unit	Description
RH	[Ω]	Winding resistance of high voltage winding (H) of single phase transformer
RX	[Ω]	Winding resistance of low voltage winding (X) of single phase transformer
10	[Ω]	RH: Winding resistance of high voltage side (H) of three phase transformer, measured between H1 and H0 RX: Winding resistance of low voltage side (X) of three phase transformer, measured between X1 and X0
20	[Ω]	RH: Winding resistance of high voltage side (H) of three phase transformer, measured between H2 and H0 RX: Winding resistance of low voltage side (X) of three phase transformer, measured between X2 and X0
30	[Ω]	RH: Winding resistance of high voltage side (H) of three phase transformer, measured between H3 and H0 RX: Winding resistance of low voltage side (X) of three phase transformer, measured between X3 and X0
12	[Ω]	RH: Winding resistance of high voltage side (H) of three phase transformer, measured between H1 and H2 RX: Winding resistance of low voltage side (X) of three phase transformer, measured between X1 and X2
23	[Ω]	RH: Winding resistance of high voltage side (H) of three phase transformer, measured between H2 and H3 RX: Winding resistance of low voltage side (X) of three phase transformer, measured between X2 and X3
31	[Ω]	RH: Winding resistance of high voltage side (H) of three phase transformer, measured between H3 and H1 RX: Winding resistance of low voltage side (X) of three phase transformer, measured between X3 and X1
A	[Ω]	RH: Phase A winding resistance of high voltage side (H) of three phase transformer
a	[Ω]	RX: Phase a winding resistance of low voltage side (X) of three phase transformer
B	[Ω]	RH: Phase B winding resistance of high voltage side (H) of three phase transformer
b	[Ω]	RX: Phase b winding resistance of low voltage side (X) of three phase transformer
C	[Ω]	RH: Phase C winding resistance of high voltage side (H) of three phase transformer
c	[Ω]	RX: Phase c winding resistance of low voltage side (X) of three phase transformer

Designation of the terminals:
- H - terminal for high voltage transformer windings (H);
- X - terminal for low voltage transformer winding (X).

4 Instrument description

4.1 Instrument casing

The instrument is housed in a plastic box that maintains the protection class defined in the general specifications.

4.2 Operator's panel

The operator's panel is shown below.
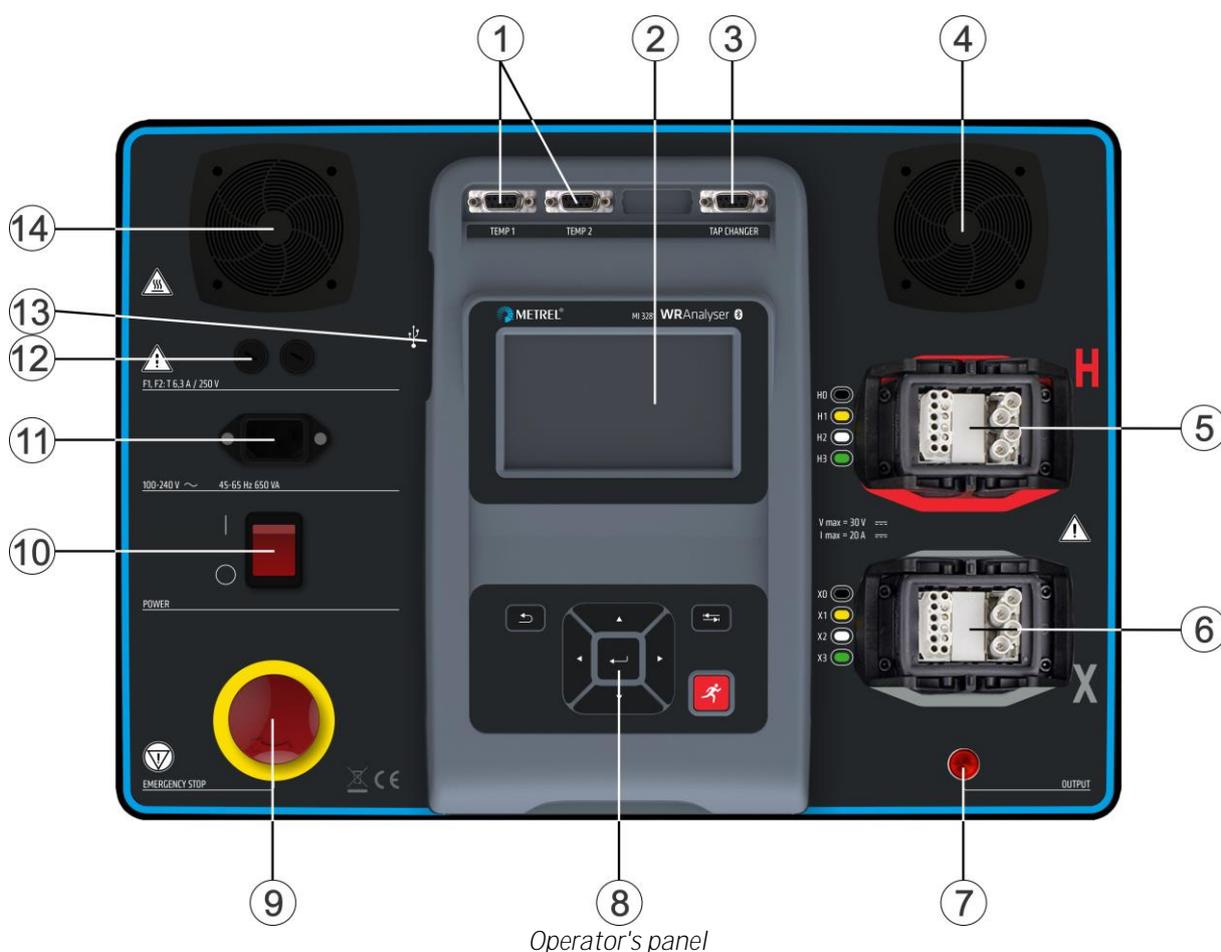
Operator's panel

1	TEMP 1, TEMP 2	Temperature sensor terminals 1 and 2 (DB-9) (not supported)
2		Colour TFT display with touch screen
3	TAP CHANGER	Remote / Tap changer terminal (DB-9)
4		Air intake ventilation opening
5	H	Test terminal H (high voltage side of a transformer)
6	X	Test terminal X (low voltage side of a transformer)
7	OUTPUT	Test operation indicator
8		Keypad (see section *General meaning of keys*)

9	EMERGENCY STOP	Emergency stop switch
10	POWER	Power on / off switch
11		Mains supply connector
12		Fuses (2 x T6.3 A / 250 V)
13	USB	Communication port (standard USB connector - type B)
14		Air outlet ventilation opening

Warnings!

- Maximum allowed voltage between any test terminal and ground is 50 V!
- Use original test accessories only!

5 Accessories

The accessories consist of standard and optional accessories. Optional accessories can be delivered upon request. See *attached* list for standard configuration and options or contact your distributor or see the *METREL* home page: https://www.metrel.si.

5.1 Standard set

	Code	Application notes
1 x Instrument WR Analyser	MI 3281	
1 x H-side test cable with leads (5 m)	A 1715	
1 x X-side test cable with leads (5 m)	A 1716	
8 x Large Kelvin test crocodiles	A 1593	
1 x Tap changer control cable	A 1813	

Other accessories:
- Mains cable
- USB cable
- Bag for accessories
- PC SW Metrel ES Manager
- Instruction manual
- Calibration certificate

5.2 **Optional accessories**

See the attached sheet for a list of optional accessories that are available on request from your distributor.

6 Instrument operation

The MI 3281 WR Analyser instrument can be manipulated via a keypad or touch screen.

6.1 **General meaning of keys**
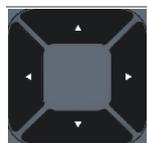
	Cursor keys are used to: • select appropriate option; • decrease, increase the selected parameter.
	Enter key is used to: • confirm selected option.
	Escape key is used to: • return to previous menu without changes; • abort measurement. • instrument hard reset (hold key for 6 s or more).
	Tab key is used to: • expand column in control panel.
	Run key is used to: • start and stop the measurements.
	Emergency stop switch is used to: • immediately stop the measurement in case of any emergency.

6.2 **General meaning of touch gestures**

	Tap (briefly touch surface with fingertip) is used to: • select appropriate option; • confirm selected option; • start and stop measurements.
	Swipe (press, move, lift) up/ down is used to: • scroll content in same level; • navigate between views in same level.
	Long press (touch surface with fingertip for at least 1 s) is used to: • select additional keys (virtual keyboard).
	Tap Escape icon is used to: • return to previous menu without changes; • abort measurements.

6.3 **Virtual keyboard**

Virtual keyboard - keypad

Options

shift	Toggle case between lowercase and uppercase. Active **only when alphabetic characters' keyboard layout selected.**
←	Backspace Clears last character or all characters if selected. (If held for 2 s, all characters are selected).
↵	Enter confirms new text.
12#	Activates numeric / symbols layout.
ABC	Activates alphabetic characters.
eng	English keyboard layout.
GR	Greek keyboard layout.
RU	Russian keyboard layout.
↰	Returns to the previous menu without changes.

6.4 **Display and sound**

6.4.1 Time indication

08:26	Time indication (hh:mm).

6.4.2 Messages

In the message field warnings and messages are displayed.

▶	Conditions on the input terminals allow starting the measurement; consider other displayed warnings and messages.

▶	Conditions on the input terminals do not allow starting the measurement, consider displayed warnings and messages.
▶	Start the measurement step.
■	Stop the measurement.
▶▶	Accept the measuring result and proceed to next measurement step.
💾	Result(s) can be stored.
💬	Add / view comment.
☰	Opens menu for changing parameters and limits.
📝	Plot edit.
⇧	Next tap / increase graph range.
⇩	Previous tap / decrease graph range.
⇦	Previous screen view / move cursor left.
⇨	Next screen view / move cursor right.
?	Opens help screen.
🔍	Views results of measurement.
✔	Pass ticker in Visual test.
✖	Fail ticker in Visual test.
☐	Clear ticker in Visual test.
●	Checked ticker in Visual test.
◀◀◀	Expands control panel / open more options.
⏳	Measurement is running, consider displayed warnings.
⚡✗	No connection. At least H or X one testing clip is not connected to the **transformer or at least one winding has resistance greater than 5 kΩ.**
🌡	Thermal shutdown detected. Instrument is over-heating.
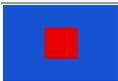
STOP	Emergency stop switch has been pressed during the measurement.

Warning! **Instrument is connected to an IT earthing / centre tapped system or PE is not connected.** **Some measurements will not be available.** **Would you like to proceed?** **YES** **NO**	IT earthing / centre tapped system or PE is not connected In start-up procedure, instrument check the PE connection. Possible causes: • Instrument is connected to a IT earthing or centre tapped system. Select YES to confirm. • Instrument is not connected to a PE. Select No, to enter instrument main menu. Measurements will not be available.

Emergency Stop **The emergency switch has been pressed!**	Emergency switch has been pressed In case of any emergency, operator shall immediately press emergency stop switch. Instrument will safely shut down all current generators and safely discharge the transformer.

Emergency Stop **The emergency switch has been released!** **OK**	Emergency switch has been released After releasing the emergency stop button, second conformation is needed. Select OK to continue.

Warning! **Thermal shutdown detected. Wait for instrument to cool down.**	Thermal shutdown detected Instrument overheating is detected. Instrument will safely shut down all current generators and safely discharge the transformer. Wait for the instrument to cool down.

Contact check fail **No connection on kelvin clamp. Possible fault on: H0, H1,** **OK**	Contact check fail Contact check, before the measurement, has detected bad or no connection. Consider possible faults that are suggested on display.

Connection check fail **No connection on kelvin clamp. Possible fault on: H_side** **OK**	Connection check fail Connection check, before the measurement, has detected bad or no connection. Consider possible faults that are suggested on display.

Message window

✔	PASS measurement result indication.
✘	FAIL measurement result indication.

6.4.3 Help screens

?	Opens help screen.

Help menus are available in all functions. The Help menu contains schematic diagrams for illustrating proper connection of the instrument to the test object. After selecting the measurement to be performed, tap on question mark in order to view the associated Help menu.

👆 on 〈 〉	Selects previous / next help screen.
↩ ↩	Exits help menu.

Examples of help screens for single phase transformer and for three phase transformer.
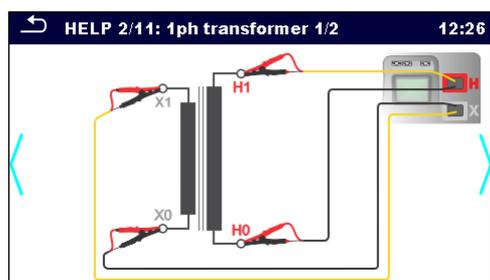
Help screen – Connection of 1 phase transformer
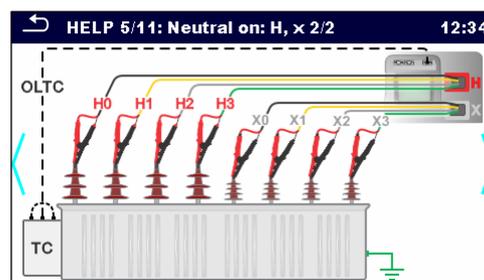
Help screen – Connection of 3 phase transformer with TAP changer

7 Main menu

7.1 **Instruments main menu**

From the instrument Main Menu four main operation menus can be selected.
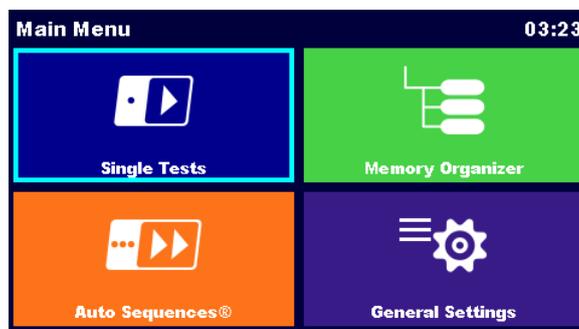
Main menu

Single Tests	Menu for selecting single tests
Auto Sequences®	Menu for selecting Auto sequences
Memory Organizer	Menu for working with structured test objects and measurements
General Settings	Menu for setup of the instrument

8 General Settings

In the General Settings menu general parameters and settings of the instrument can be viewed or set.

General Settings menu

Options in General Settings menu

Language	Language selection
Date / Time	Setting date and time
Workspace Manager	Managing project files
Auto Seq. groups	Manipulating lists of Auto Sequence®
User accounts	Managing user accounts
Profiles	Instrument Profiles
Settings	Setting different system and measuring parameters
Bluetooth init.	Bluetooth initialization
Initial Settings	Factory settings
About	Instrument data

8.1 **Language**

In this menu the language of the instrument can be set.

Language selection menu

8.2 **Date and time**

In this menu date and time of the instrument can be set.

Date / Time menu

8.3 **User Accounts**

The instrument has a User Accounts system. Following actions can be managed:
- Setting if signing in to work with the instrument is required or not.
- Adding and deleting new users, setting their user names and passwords.
- Setting the password for allowing Blackbox operation. See Blackbox operation for more information.

Default passwords

'ADMIN'	The default account manager password
Second account manager password	This password is delivered with the instrument and always unlocks the Account manager
Empty (disabled)	Default password for Blackbox operation

Note
- If a user account is set and the user is signed in the user's name will be stored for each measurement.

	Sign in as user: Select User, Sign in, change user Password. Sign in as administrator: Select Account manager, set account manager Password.
	User sign out: select Sign out Change user password (individual users can change their password): Select Change password, set new password. Account manager sign out: is automatic by exiting the Account manager menu.

8.4 **Instrument profiles**

In this menu the instrument profile can be selected from the available ones.
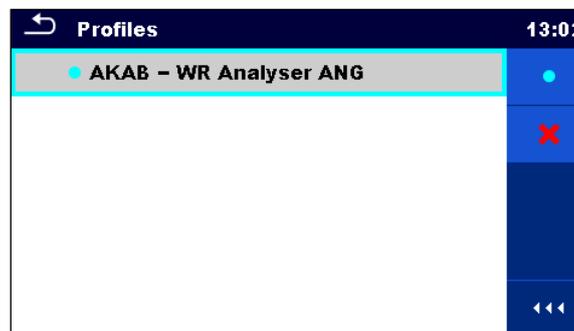
Profile selection menu

The instrument uses different specific system and measuring settings regarding to the scope of work or country it is used. These specific settings are stored in instrument profiles.
By default, each instrument has at least one profile activated. Proper licence keys must be obtained to add more profiles to the instruments.
If different profiles are available, they can be selected in this menu.

Options

	Loads the selected profile. The instrument will restart automatically with new profile loaded.
	Deletes the selected profile.
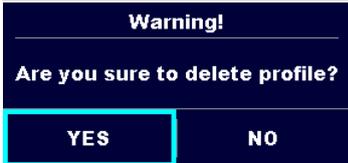
Warning! **Are you sure to delete profile?** **YES**	**NO**	Before deleting the selected profile user is asked for confirmation.
◀◀◀	Expands control panel / open more options.

8.5 **Settings**

In this menu different general parameters can be set.
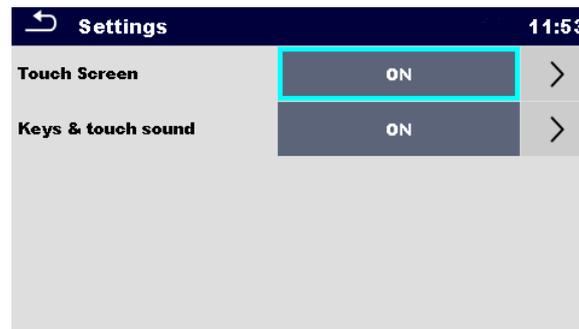
Settings menu

	Available selection	Description
Touch screen	[ON, OFF]	Enables / disables operation with touch screen.
Keys & touch sound	[ON, OFF]	Enables / disables sound when using keys and touch screen.

8.6 **Bluetooth initialization**

In this menu the Bluetooth module can be reset.
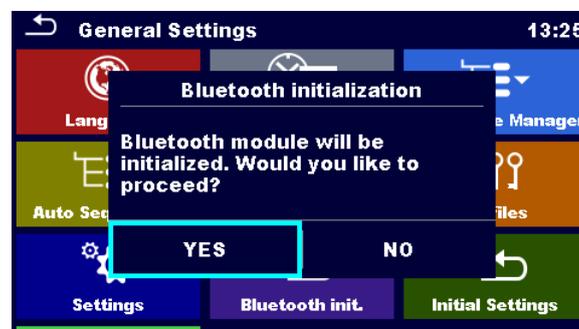
Bluetooth initialization menu

8.7 **Initial Settings**

In this menu the instrument settings, measurement parameters and limits can be set to initial (factory) values.
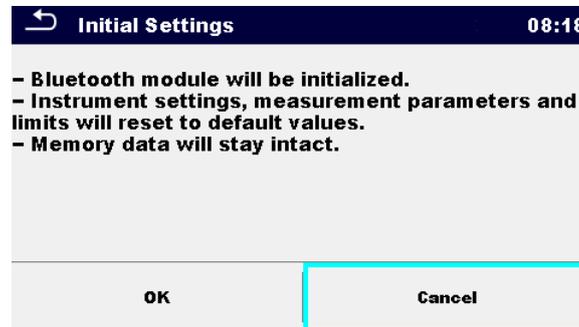
Initial Settings confirmation screen

Warning!
Following customized settings will be lost when setting the instruments to initial settings:
- Measurement limits and parameters.
- Parameters and settings in General settings menu.
- Applying the initial settings will re-boot the instrument.

Notes
Following customized settings will stay:
- Profile settings.
- Data in memory.

8.8 **About**

In this menu instrument data (name, serial number, firmware (FW) and hardware (HW) version, FW profile, hardware documentation (HD) version and date of calibration) can be viewed.

About screen

8.9 **Auto Sequence® groups**

Auto Sequences® are preprogrammed sequences of measurements. The Auto Sequences can be pre-programmed on PC with the Metrel ES Manager software and uploaded to the instrument. On the instrument parameters and limits of individual single test in the Auto Sequence can be changed / set.

8.9.1 Auto Sequence groups menu

In Auto Sequence groups menu lists of Auto Sequences are displayed. Only one list can be opened in the instrument at the same time. The list selected in the Auto Sequence groups menu will be opened in the Auto Sequence main menu.
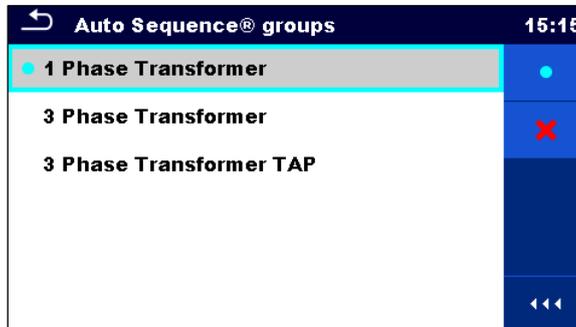
Auto Sequence groups menu

8.9.2 Operations in Auto Sequence groups menu:

Options

●	Opens the selected list of Auto Sequence. Previously selected list of Auto Sequences will be closed automatically.
✖	Deletes the selected list of Auto Sequences.
◀◀◀	Opens options in control panel / expands column.

8.9.3 Selecting a list of Auto Sequences

Procedure
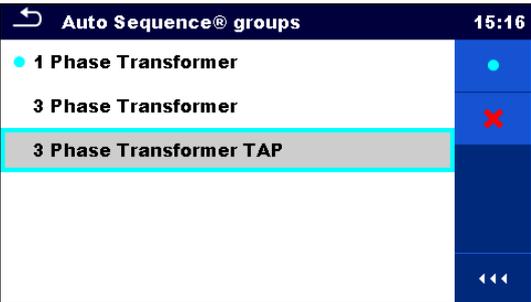
①		A list of Auto Sequences can be selected from the Auto Sequence groups menu.
②	●	Enters option for selecting a list.
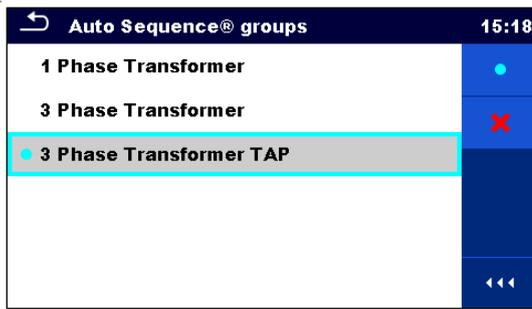
	Auto Sequence® groups 15:18 1 Phase Transformer 3 Phase Transformer ● 3 Phase Transformer TAP	Selected list of Auto Sequence is marked with a blue dot. Note Previously selected list of Auto Sequence is closed automatically.

8.9.4   Deleting a list of Auto Sequences

Procedure
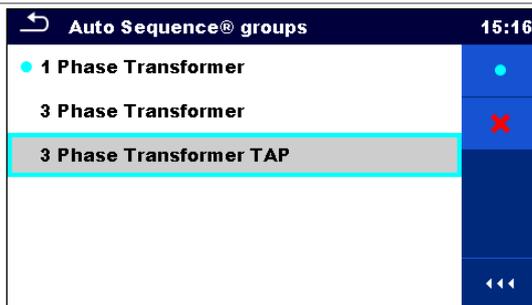
①	**Auto Sequence® groups** 15:16 ● 1 Phase Transformer 3 Phase Transformer 3 Phase Transformer TAP	A list of Auto Sequence to be deleted can be selected from the Auto Sequence groups menu.
②	✖	Enters option for deleting a list.
	Auto Sequence® groups 15:21 ● 1 Phase Transformer **Warning!** 3 Pha **Are you sure you want to remove this Auto Sequence® group?** 3 Pha **YES** NO	Before deleting the selected list of Auto Sequence the user is asked for confirmation.
③	**Auto Sequence® groups** 15:23 ● 1 Phase Transformer 3 Phase Transformer	A list of Auto Sequence is deleted.
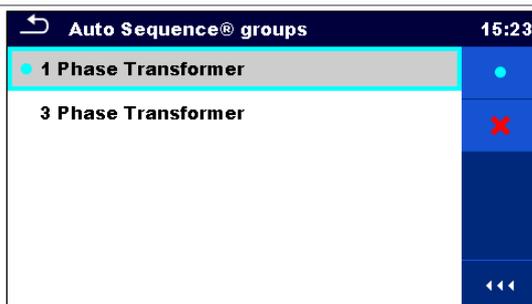
8.10 **Workspace manager**

The Workspace Manager is intended to manage with different Workspaces and Exports that are stored into internal data memory.

8.10.1 Workspaces and Exports

The works with MI 3281 can be organized and structured with help of Workspaces and Exports. Exports and Workspaces contain all relevant data (measurements, parameters, limits, structure objects) of an individual work.

Workspaces are stored on internal data memory on directory WORKSPACES, while Exports are stored on directory EXPORTS. Export files can be read by Metrel applications that run on other devices. Exports are suitable for making backups of important works. To work on the instrument an Export should be imported first from the list of Exports and converted to a Workspace. To be stored as Export data a Workspace should be exported first from the list of Workspaces and converted to an Export.

8.10.2 Workspace Manager main menu

In Workspace manager Workspaces and Exports are displayed in two separated lists.
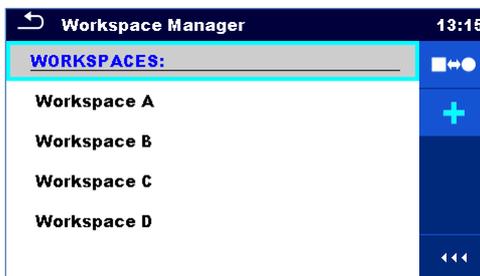
Workspace Manager menu - Header selected	*Workspace Manager menu - Workspace selected*
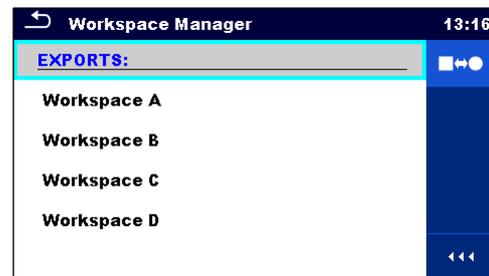
Options

WORKSPACES:	List of Workspaces.
■↔●	Displays a list of Exports.
✚	Adds a new Workspace.
EXPORTS:	List of Exports.
■↔●	Displays a list of Workspaces.

8.10.3 Operations with Workspaces

Only one Workspace can be opened in the instrument at the same time. The Workspace selected in the Workspace Manager will be opened in the Memory Organizer.
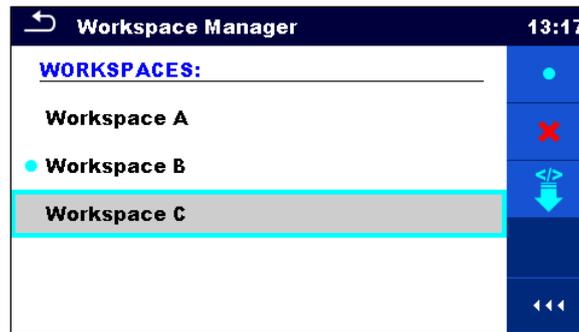
Workspaces menu

Options

●	Marks the opened Workspace in Memory Organizer. Opens the selected Workspace in Memory Organizer.
✖	Deletes the selected Workspace.
✚	Adds a new Workspace.
</> ⬇	Exports a Workspace to an Export.

8.10.4 Operations with Exports
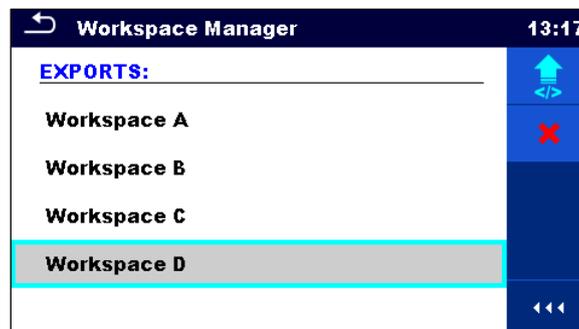
Exports menu

Options

✖	Deletes the selected Export.
⬆ </>	Imports a new Workspace from Export.

8.10.5 Adding a new Workspace

Procedure
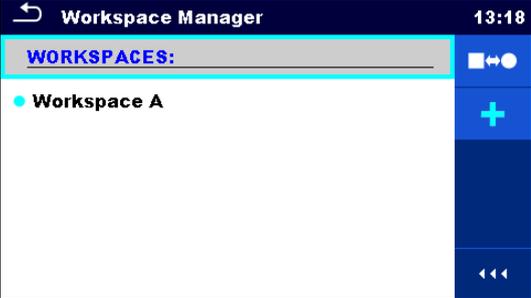
①		New Workspaces can be added from the Workspace Manager screen.
②		Enters option for adding a new Workspace.
		Keypad for entering name of a new Workspace is displayed after selecting New.
③		After confirmation a new Workspace is added in the list in Main Workspace Manager menu.
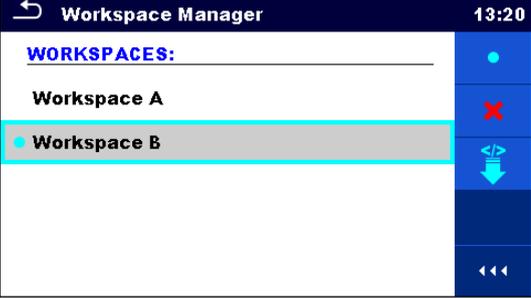
8.10.6 Opening a Workspace

Procedure
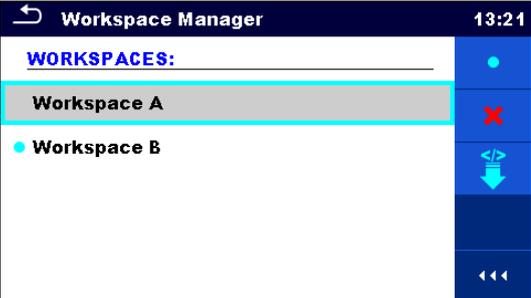
①		Workspace can be selected from a list in Workspace manager screen.
②		Opens a Workspace in Workspace manager.
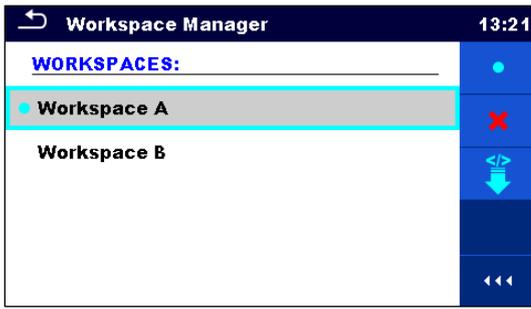
		The opened Workspace is marked with a blue dot. The previously opened Workspace will close automatically.

8.10.7 Deleting a Workspace / Export

Procedure
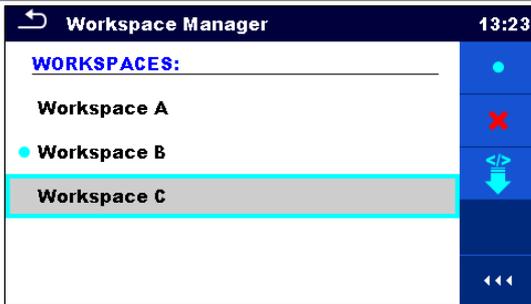
①		Workspace / Export to be deleted should be selected from the list of Workspaces / Exports. **Opened workspace can't be deleted.**
②		Enters option for deleting a Workspace / Export.
		Before deleting the selected Workspace / Export the user is asked for confirmation.
③		Workspace / Export is removed from the Workspace / Export list.
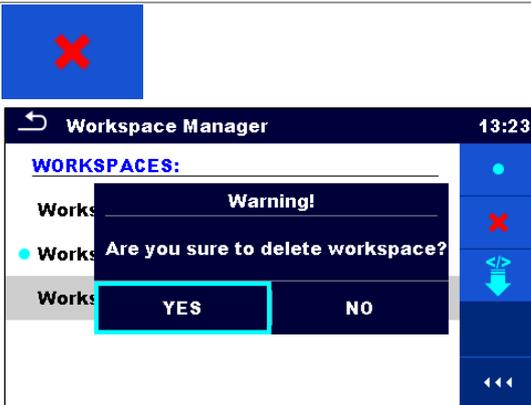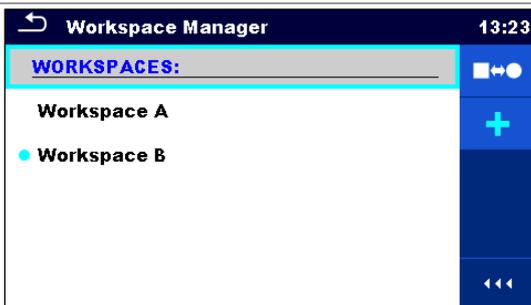
8.10.8 Importing a Workspace
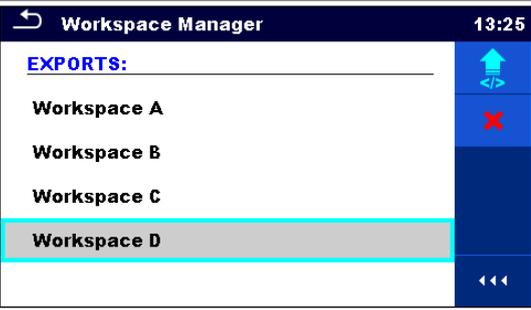
①	**Workspace Manager** 13:25 — EXPORTS: Workspace A, Workspace B, Workspace C, **Workspace D**	Select an Export file to be imported from Workspace Manager Export list.
②	(import icon)	Enters option Import.
	Workspace Manager 13:25 — EXPORTS: Workspace... **Import to workspace?** Workspace D **YES NO** Workspace D	Before the import of the selected file the user is asked for confirmation.
③	**Workspace Manager** 13:15 — WORKSPACES: Workspace A, Workspace B, Workspace C, Workspace D	The Imported Export file is added to the list of Workspaces.
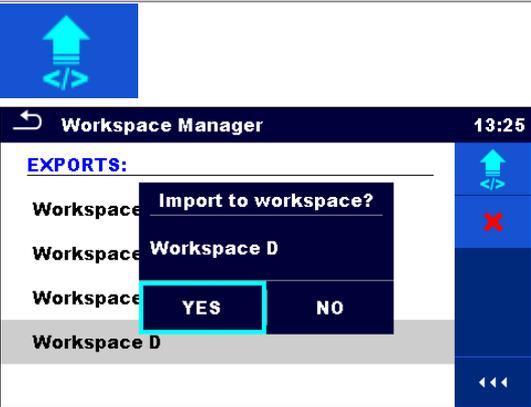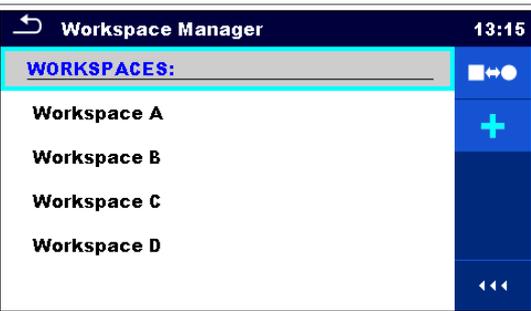
Note
- If a Workspace with the same name already exists the name of the imported Workspace will be changed (name_001, name_002, name_003…). |

8.10.9 Exporting a Workspace
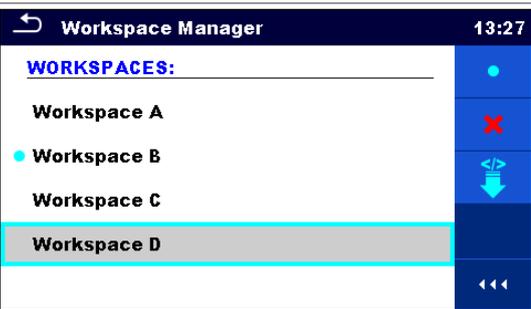
①	**Workspace Manager** 13:27 — WORKSPACES: Workspace A, ● Workspace B, Workspace C, **Workspace D**	Select a Workspace from Workspace manager list to be exported to an Export file.
②	(export icon)	Enters option Export.

Before exporting the selected Workspace, the user is asked for confirmation.
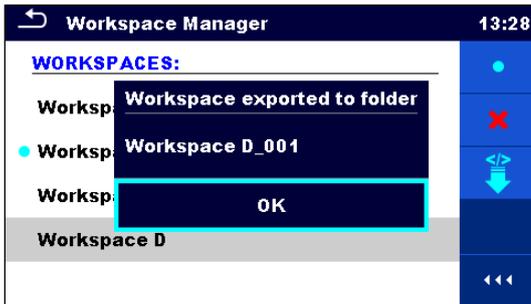
Workspace is exported to Export file and is added to the list of Exports.

Note
- If an Export file with the same name already exists the name of the Export file will be changed (name_001, name_002, name_003, ...).
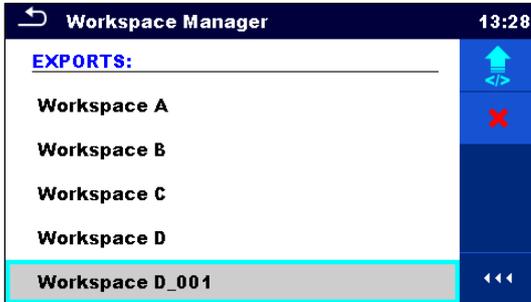
9 Memory Organizer

Memory Organizer is a tool for storing and working with test data.

9.1 **Memory Organizer menu**

WR Analyser instrument has a multi-level structure. The hierarchy of Memory organizer in the tree is shown below. The data is organized according to the Project, Location or Client and object (Transformer). For more information, refer to chapter *Structure objects*.

Default tree structure and its hierarchy:
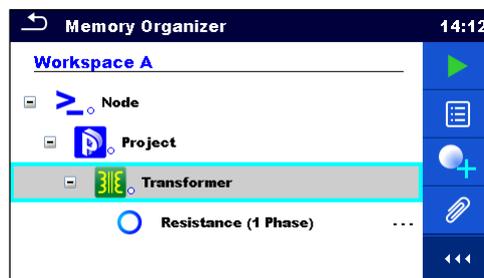
Memory Organizer - Tree structure and its hierarchy

9.1.1 Measurement statuses

Each measurement has:
- Name,
- Results,
- Main result status (Pass or Fail or no status),
- Limits and parameters.

A measurement can be a Single test or an Auto Sequence® test.

Statuses of single tests

🟢	Passed finished single test with test results.
🔴	Failed finished single test with test results.
🔵	Finished single test with test results and no status.
⚪	Empty single test without test results.

Overall statuses of Auto Sequence®

🟢 or ✅	At least one single test in the Auto Sequence® passed and no single test failed.

🔴 or ❌	At least one single test in the Auto Sequence® failed.
🔵 or ➖	At least one single test in the Auto Sequence® was carried out and there were no other passed or failed single tests.
⭕ or ➖	Empty Auto Sequence® with empty single tests.

9.1.2 Structure items

Each Structure item has:
- an icon,
- a name and,
- parameters.

Optionally they can have:
- an indication of the status of the measurements under the Structure and a comment or a file attached.

Structure item in tree menu

9.1.3 Measurement status indication under the Structure item

Overall status of measurements under each structure item /sub-item can be seen without spreading tree menu. This feature is useful for quick evaluation of test status and as guidance for measurements.

Options

Project	There are no measurement results under selected structure item. Measurements should be made.	
Project	One or more measurement result(s) under selected structure item has failed. Not all measurements under selected structure item have been made yet.	
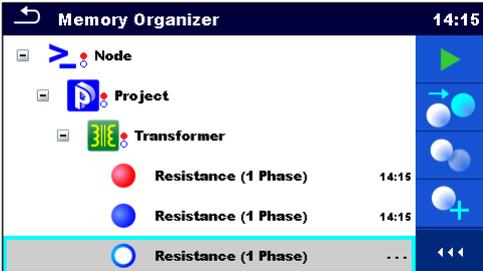
	All measurements under selected structure item are completed but one or more measurement result(s) has failed.	
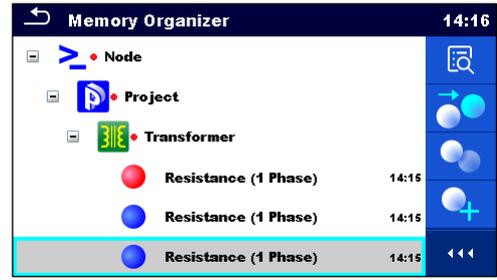
Note

- There is no status indication if all measurement results under each structure item /sub-item have passed or if there is an empty structure item / sub-item (without measurements).

9.1.4 Selecting an active Workspace in Memory Organizer

Memory Organizer and Workspace Manager are interconnected, so an active Workspace can be selected also in the Memory Organizer menu.

Procedure
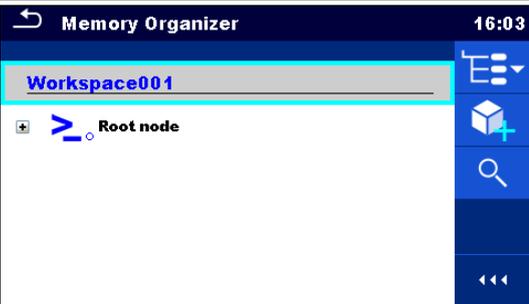
①		Tap on the active Workspace header in Memory Organizer menu.
②		Select List of Workspaces in Control panel.
③		Choose desired Workspace from a list of Workspaces.
④		Use Select button to confirm selection.
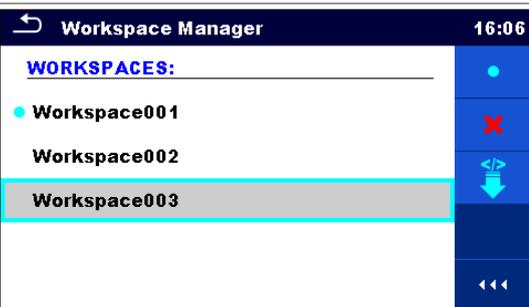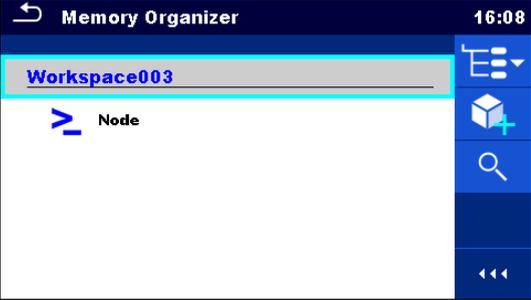
⑤	**Memory Organizer** 16:08 Workspace003 > Node	New Workspace is selected and displayed on the screen.

9.1.5 Adding Nodes in Memory Organizer

Structural Elements (Nodes) are used to ease organization of data in the Memory Organizer. One Node is a must; others are optional and can be created or deleted freely.

Procedure
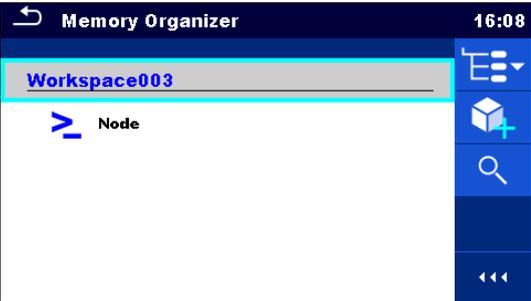
①	**Memory Organizer** 16:08 Workspace003 > Node	Tap on the active Workspace header in Memory Organizer menu.
②		Select Add Structure in Control panel.
③	**Add New** 16:11 → > Node **Create**	Press "Create" to confirm.
④	**Memory Organizer** 16:13 Workspace003 > Node > Node	New Structure element (Node) is added.
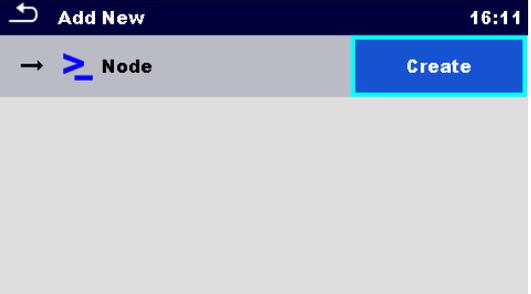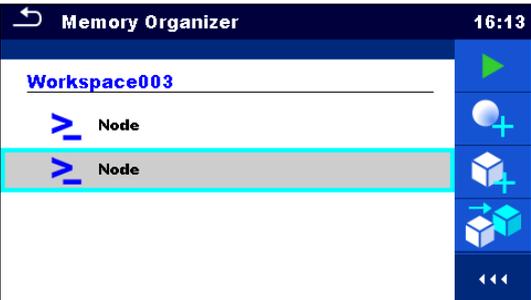
9.1.6 Operations in Tree menu

In the Memory organizer different actions can be taken with help of the control panel at the right side of the display. Possible actions depend on the selected element in the organizer.

9.1.6.1 Operations on measurements (finished or empty measurements)
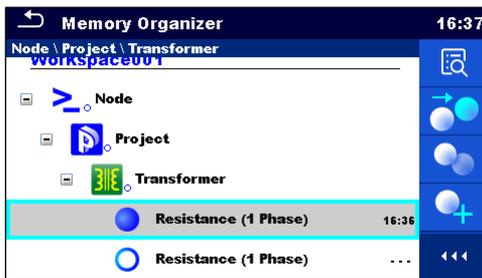
Memory Organizer - Finished measurement selected
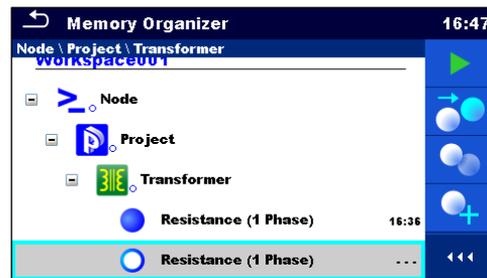
Memory Organizer - Empty measurement selected

Options

	Views results of measurement. The instrument goes to the measurement memory screen.
	Starts a new measurement. The instrument goes to the measurement start screen.
	Saves a measurement. Saving of measurement on a position after the selected (empty or finished) measurement.
	Clones the measurement. The selected measurement can be copied as an empty measurement under the same Structure item. Refer to chapter *Clone a measurement* for more information.
	Copy & Paste a measurement. The selected measurement can be copied and pasted as an empty **measurement to any location in structure tree. Multiple "Paste" is** allowed. Refer to chapter *Copy & Paste a measurement* for more information.
	Adds a new measurement. The instrument goes to the Menu for adding measurements. Refer to chapter *Add a new measurement* for more information.
	Views and edit comments. The instrument displays comment attached to the selected measurement or opens keypad for entering a new comment.
	Deletes a measurement. Selected Measurement can be deleted. User is asked for confirmation before the deleting. Refer to chapter *Delete a measurement* for more information.

9.1.6.2 Operations on Structure items

The structure item must be selected first.
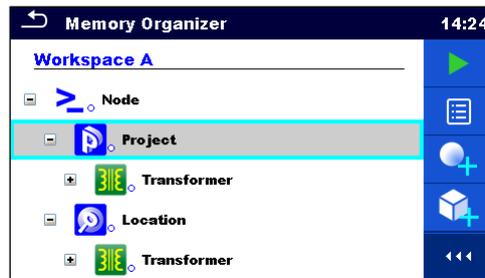
Selected structure item in the Tree menu

Options

▶	Starts a new measurement. Type of measurement (Single test or Auto Sequence) should be selected first. After proper type is selected, the instrument goes to Single Test or Auto Sequence selection screen. Refer to chapters *Selection modes* and *Selection of Auto Sequence®.*
🖫	Saves a measurement. Saving of measurement under the selected Structure project.
🗏	View / edit parameters and attachments. Parameters and attachments of the Structure items can be viewed or edited. Refer to chapter *View / Edit parameters and attachments of a Structure* for more information.
⦿₊	Adds a new measurement. The instrument goes to the menu for adding measurement into structure. Refer to chapter *Add a new measurement* for more information.
⬓₊	Adds a new Structure item. A new Structure item can be added. Refer to chapter *Add a new Structure item* for more information.
📎	Attachments. Name and link of attachment is displayed.
⬓➙⬓	Clones a Structure. Selected Structure can be copied to same level in structure tree (clone). Refer to chapter *Clone a Structure item* for more information.
⬓⬓ ⬓⬓	Copies & Paste a Structure. Selected Structure can be copied and pasted to any allowed location in **structure tree. Multiple "Paste" is allowed. Refer to chapter** *Copy & Paste a Structure item* for more information.
✂⬓ ⬓⬓	Cut & Paste a Structure. Selected Structure with child items (sub-structures and measurements) can be moved to any allowed location in structure tree. Refer to chapter *Cut & Paste a Structure item with sub-items* for more information.

[icon]	Views and edit comments. The instrument displays comment attached to the selected Structure item or opens keypad for entering a new comment.
[icon]	Deletes a Structure item. Selected Structure item and sub-items can be deleted. User is asked for confirmation before the deleting. Refer to chapter *Delete a Structure item* for more information.
[icon]	Renames a Structure item. Selected Structure item can be renamed via keypad. Refer to chapter *Rename a Structure item* for more information.

9.1.6.3 View / Edit parameters and attachments of a Structure

The parameters and their content are displayed in this menu. To edit the selected parameter, tap on it or press tab key followed by enter key to enter menu for editing parameters.

Procedure

①	[screenshot: Memory Organizer 17:20, Node, Workspace, Node, Project 1-1-2015 "This is a sample comment added to the Structure...", Project 1-2-2015]	Select structure item to be edited.
②	[icon]	Select Parameters in Control panel.
③	[screenshot: Memory Organizer / Parameters 09:57, Project 1-1-2015, Name (designation) of project: Project 1-1-2015, Description (of project)]	Example of Parameters menu. In menu for editing parameters the **parameter's value can be selected from a** dropdown list or entered via keypad. Refer to chapter *Instrument operation* for more information about keypad operation.
②a	[icon]	Select Attachments in Control panel.
③a	[screenshot: Memory Organizer / Attachments 17:22, Sample attachment.jpg]	Attachments. The name of attachment can be seen. Operation with attachments is not supported in the instrument.
②b	[icon]	Select Comments in Control panel.
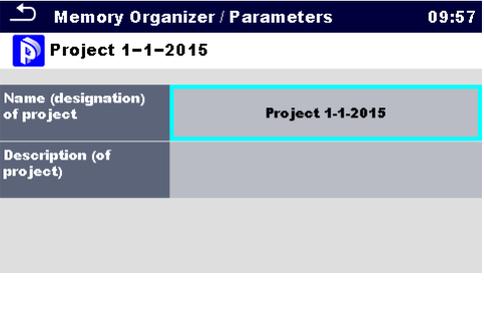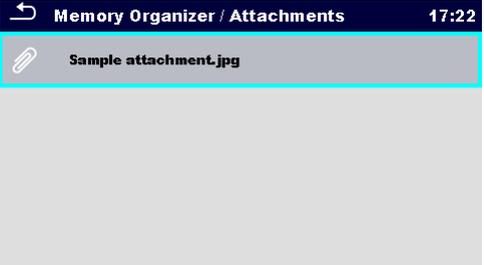
③b	Comment: Project 1−1−2015 17:25 This is a sample comment added to the Structure item. Press the 'ENTER' button or tap the screen to start editing	View or edit comments. Complete comment (if exists) attached to the structure item can be seen on the screen. Press Enter key or tap on screen to open keypad for entering a new comment.

9.1.6.4 Add a new Structure item

This menu is intended to add new structure item in the tree menu. A new structure item can be selected and then added in the tree menu.

Procedure

①	Memory Organizer 09:03 Workspace 1−0 ≥ Node	Default initial structure.
②	(Add Structure icon)	Select Add Structure in Control panel.
③	Add New 09:40 → Project Create Name (designation) of project Project Description (of project)	Add a new structure item menu.
③a	→ Project	Tap on a structure type selection window.
	Element type 09:45 → Project → Location → Client ↓ ≥ Node	A list of available structure items is displayed. Select one from a list. Arrow indicates the position where structure item will be inserted. → Child item to the currently selected structure item. ↓ Structure item located in the same level.
③b	Name (designation) of project Project Description (of project)	In menu for editing name and parameters the parameter's value can be selected from a drop-down list or entered via keypad.

④	Create	Create new structure item.
⑤		New structure item added.
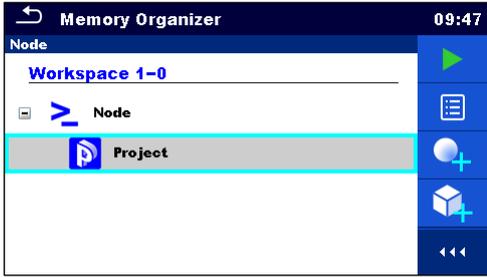
9.1.6.5 Add a new measurement

In this menu new empty measurements can be set and then added in the structure tree. The type of measurement, measurement function and its parameters are first selected and then added under the selected Structure item.

Procedure
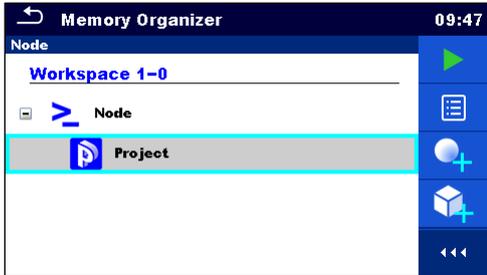
①		Select level in structure where measurement will be added.
②		Select Add measurement in Control panel.
③		Add new measurement menu.
④a	type: Single Tests	Type of test can be selected from this field. Options: Single Tests, Auto Sequences®. Tap on field or press the enter key to modify.
④b	measurement: Resistance (1 Phase)	Last added measurement is offered by default. To select another measurement tap on field or press enter to open menu for selecting measurements.
④c	params & limits: 1, X, 1 A, 10 s, Disable	Select parameter and modify it as described earlier. Refer to chapter *Setting parameters and limits of single tests* for more information.
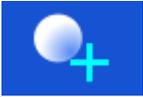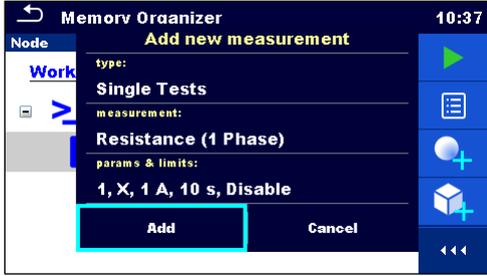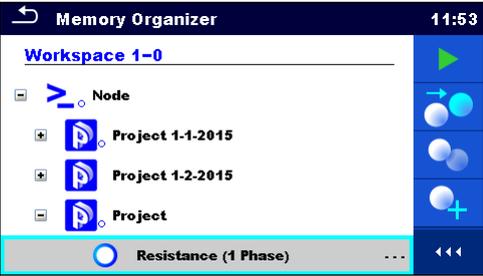
⑤	**Add** / **Cancel**	Adds the measurement under the selected Structure item in the tree menu. Returns to the structure tree menu without changes.
⑥	Memory Organizer screen	New empty measurement is added under the selected Structure item.

9.1.6.6 Clone a Structure item

In this menu selected structure item can be copied (cloned) to same level in the structure tree. Cloned structure item have same name as original.

Procedure

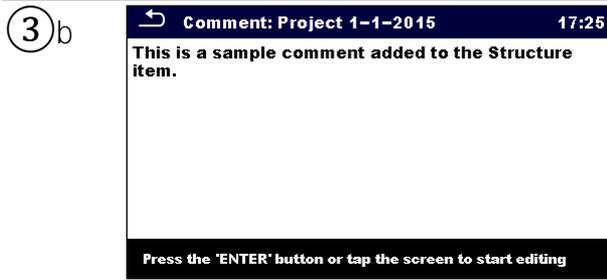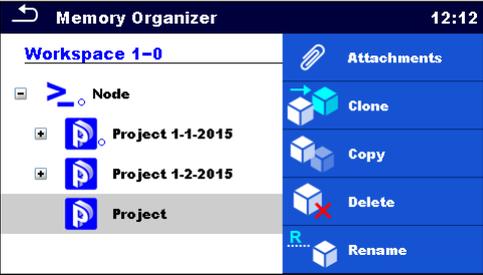|		
①	Memory Organizer screen with Attachments, Clone, Copy, Delete, Rename menu	Select the structure item to be cloned.
②	Clone icon	Select Clone in Control panel.
③	Clone: Project menu with Include structure parameters, Include structure attachments, Include sub structures, Include sub measurements, Clone / Cancel	The Clone Structure menu is displayed. Sub-elements of the selected structure item can be marked or un-marked for cloning. Refer to chapter *Cloning and Pasting sub-elements of selected structure item* for more information.
④	**Clone** / **Cancel**	Selected structure item is copied (cloned) to same level in the structure tree. Cloning is cancelled. No changes in the Structure tree.
⑤	Memory Organizer screen	The new cloned structure item is displayed.

9.1.6.7 Clone a measurement

By using this function a selected empty or finished measurement can be copied (cloned) as an empty measurement to the same level in the structure tree. Parameters and limits of cloned measurement are the same as they are set in original measurement. Its parameters / limits can be changed before measurement is started.

Procedure

①		Select the measurement to be cloned.
②		Select Clone in Control panel.
③		A new empty measurement is displayed.

9.1.6.8 Copy & Paste a Structure item

In this menu selected Structure item can be copied and pasted to any allowed location in the structure tree.

Procedure

①		Select the structure item to be copied.
②		Select Copy in Control panel.
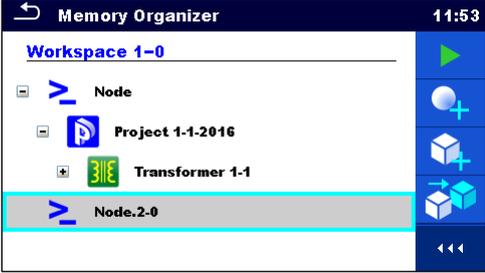
③		Select location where structure item should be copied.
④		Select Paste in Control panel.
⑤		The Paste structure menu is displayed. Before copying it can be set which sub-elements of the selected structure item will be copied too. Refer to chapter *Cloning and Pasting sub-elements of selected structure item* for more information.
⑥		The selected structure item and elements are copied (pasted) to selected position in the tree structure. Returns to the tree menu without changes.
⑦		The new structure item is displayed. Note • The Paste command can be executed one or more times.
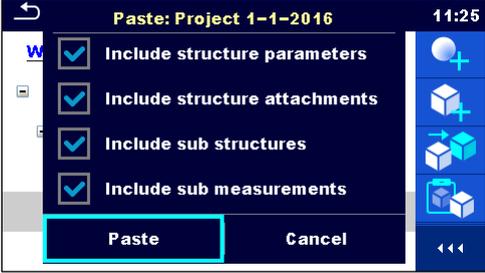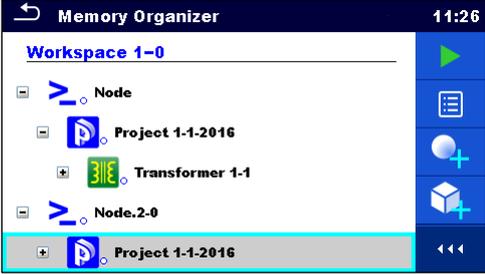
9.1.6.9 Cloning and Pasting sub-elements of selected structure item

When structure item is selected to be cloned, or copied & pasted, additional selection of its sub-elements is needed. The following options are available:

Options

	Parameters of selected structure item will be cloned / pasted too.
	Attachments of selected structure item will be cloned / pasted too.
	Structure items in sub-levels of selected structure item (sub-structures) will be cloned / pasted too.
	Measurements in selected structure item and sub-levels (sub-structures) will be cloned / pasted too.

9.1.6.10   Copy & Paste a measurement

In this menu selected measurement can be copied to any allowed location in the structure tree.

Procedure
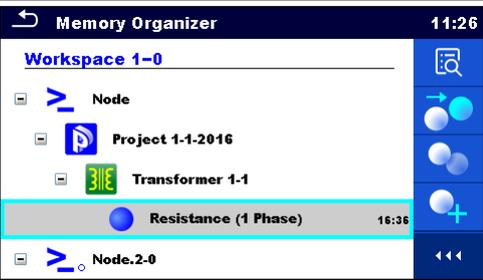
①	Memory Organizer 11:26 **Workspace 1-0** Node Project 1-1-2016 Transformer 1-1 Resistance (1 Phase) 16:36 Node.2-0	Select the measurement to be copied.
②		Select Copy in Control panel.
③	Memory Organizer 11:27 Project 1-1-2016 Transformer 1-1 Resistance (1 Phase) 16:36 Node.2-0 Project 1-1-2016 Transformer 1-1	Select the location where measurement should be pasted.
④		Select Paste in Control panel.
⑤	Memory Organizer 11:30 Transformer 1-1 Resistance (1 Phase) 16:36 Node.2-0 Project 1-1-2016 Transformer 1-1 Resistance (1 Phase) ...	A new (empty) measurement is displayed in selected Structure item. Note • The Paste command can be executed one or more times.

9.1.6.11   Cut & Paste a Structure item with sub-items

In this menu selected Structure item with sub-items (sub-structures and measurements) can be cut and pasted (moved) to any allowed location in the structure tree.

Procedure
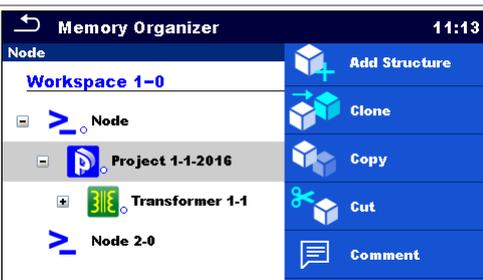
①	Memory Organizer 11:13 Node **Workspace 1-0** Node Project 1-1-2016 Transformer 1-1 Node 2-0 Add Structure Clone Copy Cut Comment	Select the structure item to be moved.

②		Select Cut in Control panel.
③		Select location where structure item (with sub-structures and measurements) should be moved.
④		Select Paste in Control panel.
⑤		The structure item (with sub-structures and measurements) is moved to selected new location and deleted from previous location in the tree structure.
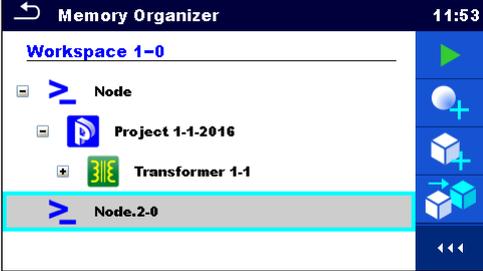
9.1.6.12   Delete a Structure item

In this menu selected Structure item can be deleted.

Procedure
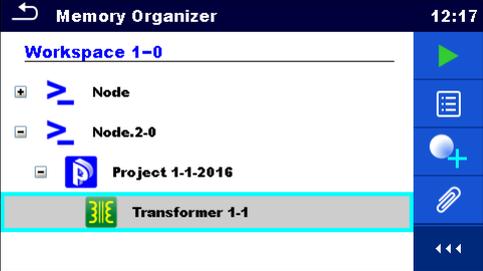
①		Select the structure item to be deleted.
②		Select Delete in Control panel.
③		A confirmation window will appear.
④		Selected structure item and its sub-elements are removed.
		Returns to the tree menu without changes.
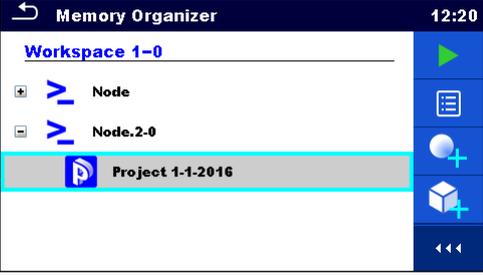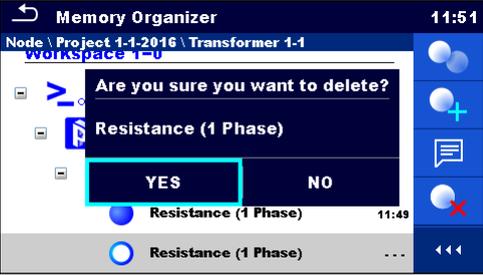
⑤	Memory Organizer screen showing Workspace 1-0 with Node and Node.2-0, Project 1-1-2016 highlighted	Structure without deleted structure item.

9.1.6.13   Delete a measurement

In this menu selected measurement can be deleted.

Procedure

①	Memory Organizer screen showing Node \ Project 1-1-2016 \ Transformer 1-1 with Resistance (1 Phase) highlighted	Select a measurement to be deleted.
②	Delete icon	Select Delete in Control panel.
③	Confirmation window "Are you sure you want to delete? Resistance (1 Phase)" with YES / NO	A confirmation window will appear.
④	YES	Selected measurement is deleted.
	NO	Returns to the tree menu without changes.
⑤	Memory Organizer screen showing structure with Resistance (1 Phase)	Structure without deleted measurement.

9.1.6.14   Rename a Structure item

In this menu selected Structure item can be renamed.

Procedure
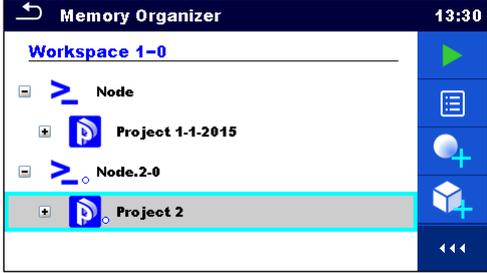
①		Select the structure item to be renamed.
②		Select Rename in Control panel. Virtual keypad will appear on screen. Enter new text and confirm. Refer to chapter *Virtual keyboard* for keypad operation.
③		Structure item with the modified name.
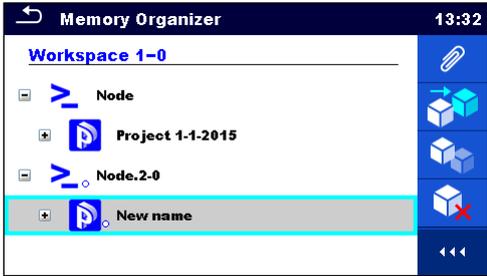
9.1.6.15 Recall and Retest selected measurement

Procedure

①		Select the measurement to be recalled.
②		Select Recall results in Control panel.
③		Measurement is recalled. Parameters and limits can be viewed but cannot be edited.
④		Select Retest in Control panel.
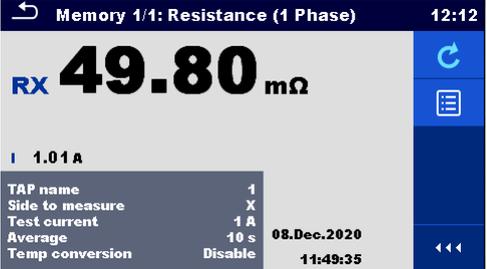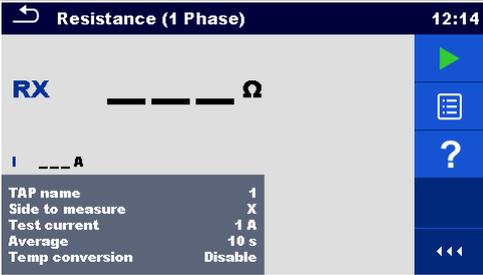
⑤	**↩ Resistance (1 Phase)** 12:14 **RX** **— — —** Ω I ___ A TAP name 1 Side to measure X Test current 1 A Average 10 s Temp conversion Disable	Measurement retest starting screen is displayed.
⑤a	**↩ Parameters & Limits** 12:15 TAP name [1] ❯ Side to measure ❮ [X] ❯ Test current ❮ [1 A] ❯ Average ❮ [10 s] ❯ Temp conversion [Disable] ❯	Parameters and limits can be viewed and edited.
⑥	▶	Select Run in Control panel to retest the measurement.
⑦	**↩ Resistance (1 Phase)** 12:18 **RX 19.88** mΩ I 1.01 A TAP name 1 Side to measure X Test current 1 A Average 10 s Temp conversion Disable	Results / sub-results after re-run of recalled measurement.
⑧	💾	Select Save results in Control panel.

	↩ Memory Organizer 12:20
	 Node \ Project 1-1-2016 \ Transformer 1-1
	 Workspace 1-0
	 ⊟ **≥ Node**
	     ⊟ 🅟 **Project 1-1-2016**
	        ⊟ ▤ **Transformer 1-1**
	           ● Resistance (1 Phase) 11:49
	           ● Resistance (1 Phase) 12:17
		Retested measurement is saved under same structure item as original one. Refreshed memory structure with the new performed measurement is displayed.

9.1.7 Searching in Memory Organizer

In Memory organizer it is possible to search for different structure items and parameters.

Procedure

①	**↩ Memory Organizer** 12:57
	
	 Workspace 1-0
	 ⊟ **≥。 Node**
	     ⊟ 🅟 **Project 1-1-2016**
	        ⊟ ▤ **Transformer 1-1**
	           ● Resistance (1 Phase) 11:49
	           ● Resistance (1 Phase) 12:17
		Search function is available from the active workspace directory line.
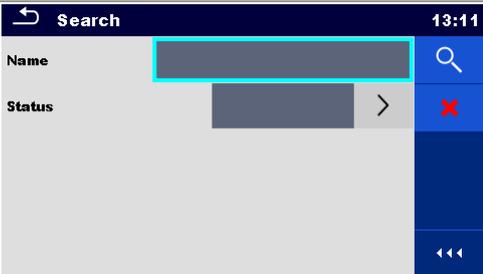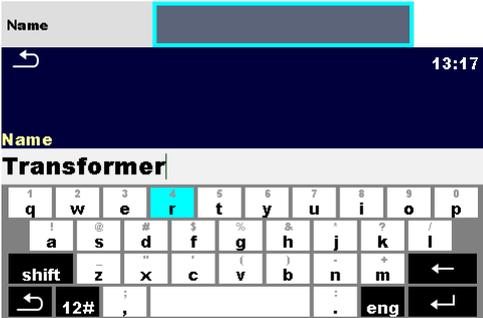
②	[search icon]	Select Search in Control panel to open Search setup menu.
③	[Search setup menu screen showing Name and Status fields]	The parameters that can be searched for are displayed in the Search setup menu.
③a	[Name field with on-screen keypad showing "Transformer"]	The search can be narrowed by entering a text in the Name field. Strings can be entered using the on-screen keypad.
③b	[Status selection screen showing Pass, Fail, Empty, No status]	The search can be narrowed on base of statuses. Note • If searching by status, instrument will display all structure items that include one or more measurements with searched status.
③c	[red X icon]	Clear all search filters.
④	[search icon]	Searches trough the Memory Organizer for structure items according to the set filter. The results are shown in the search results screen.
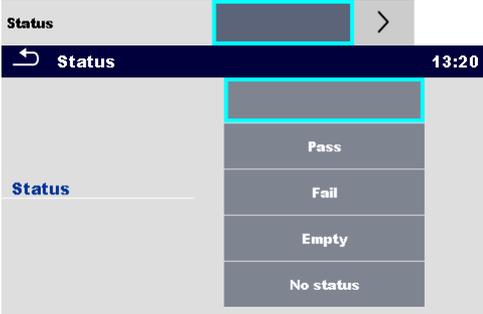
[Search results screen - Page 2/3 with list: Transformer 1-56, Transformer 2-44, Transformer 2-45, Transformer 1-32, Transformer 3-2]
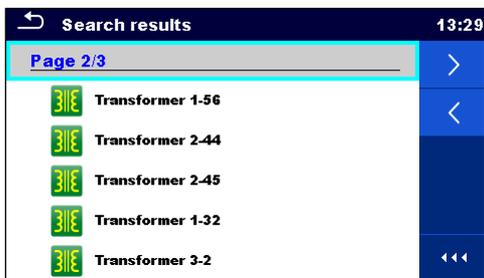
Search result screen - Header selected

[Search results screen - Page 2/3 with Transformer 1-56 highlighted: Transformer 1-56, Transformer 2-44, Transformer 2-45, Transformer 1-32, Transformer 3-2]
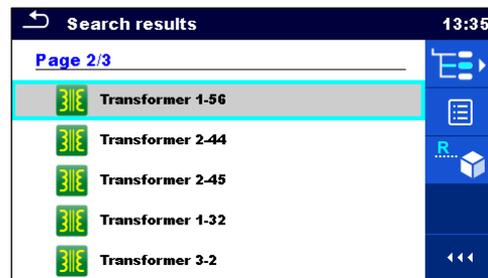
Search result screen - Structure item selected

Options

>	Next page (if available).
<	Previous page (if available).
	Goes to location in Memory Organizer.
	View / edit parameters. Parameters of the Structure items can be viewed or edited. Refer to chapter *View / Edit parameters and attachments of a Structure* for more information.
	Attachments. Name and link of attachment is displayed.
	Views comment. The instrument displays comment attached to the selected structure item.
R	Renames the selected Structure item. Refer to chapter *Rename a Structure item* for more information.

Note
- Search result page consist of up to 50 results.

10 Single tests

Single measurements and tests can be selected in the main Single tests menu or in Memory organizer's main and sub-menus.

10.1 Selection modes

In Single tests main menu three modes for selecting single tests are available.

Options

		Groups
		The single tests are divided into groups of similar tests.
		Last used
		Last 9 made different single tests are displayed.
		All
		A single test can be selected from a list of all single tests. The single tests are always displayed in the same (default) order.
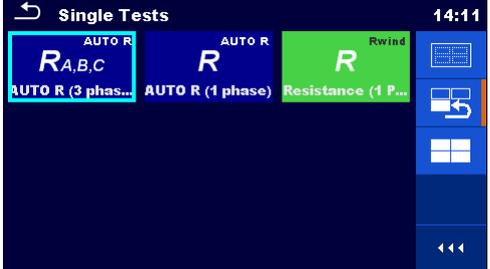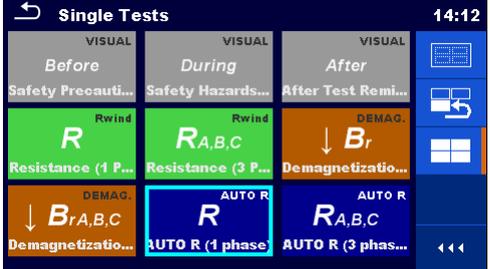
10.1.1 Single test screens

In the Single test screens measuring results, sub-results, limits and parameters of the measurement are displayed. In addition, on-line statuses, warnings and other info are displayed.
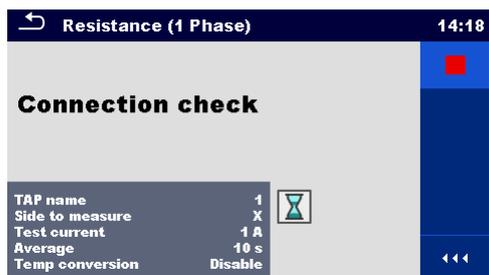
Example of Single test measuring screen
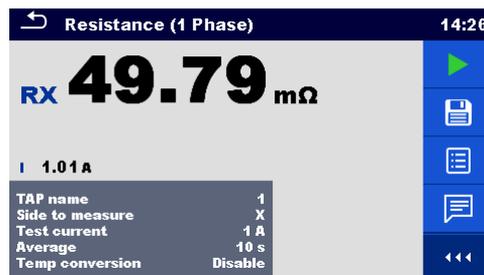
Example of Single test result screen

Single test screen organization

	Main line: • ESC touch key • function name • clock
	Control panel (available options)
	Parameters (white) and limits (red)
	Result field: • main result(s) • sub-result(s) • PASS / FAIL indication • number of screens
	Warning symbols and message field

10.1.2 Single test start screen
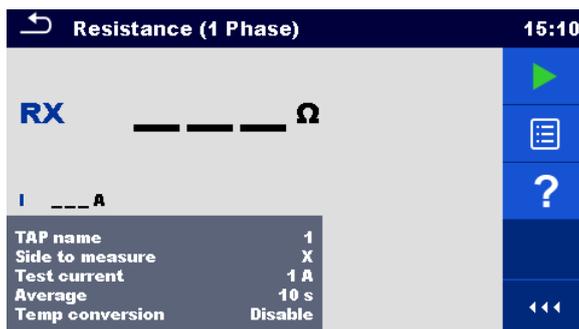
Example of Single test start screen

Options (before test, screen was opened in Memory organizer or Single test main menu):

▶ or 🏃	Starts a new measurement.
🗒 👆 on [parameters]	Opens menu for changing parameters and limits of selected measurement. Refer to chapter *Setting parameters and limits of single tests* for more information how to change measurement parameters and limits.
⬅	Opens previous screen.
➡	Opens next screen.
?	Opens help screens.

10.1.3 Setting parameters and limits of single tests

Procedure
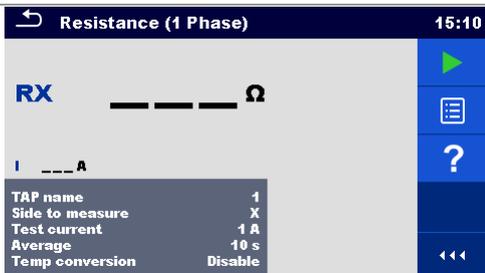
①		Select the test or measurement. The test can be entered from: - Single tests menu or - Memory organizer menu once the empty measurement was created under selected structure.
②	🗒	Select Parameters in Control panel.

	TAP name 1 Side to measure X Test current 1 A Average 10 s Temp conversion Disable on	Shortcut to Parameters & Limits menu.
③	**Parameters & Limits** 12:15 TAP name [1] ＞ Side to measure ＜ X ＞ Test current ＜ 1 A ＞ Average ＜ 10 s ＞ Temp conversion Disable ＞	Select parameter to be edited or limit to be set.
	on ＜ ＞ or	Set parameter / limit value.
③a	on [1] or ↵	Enter Set value menu.
④	⤺ or ⤺	Accepts the new parameters and limit values.

10.1.4 Setting parameters through scrollable list

Most of parameters are settable through scrollable list.

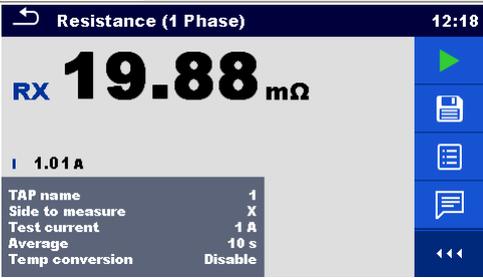|		
	Resistance (1 Phase) 15:10 ▶ RX — — — Ω ▤ ? I ___ A TAP name 1 Side to measure X Test current 1 A Average 10 s Temp conversion Disable ◀◀◀	Select the test or measurement. The test can be entered from: • Single tests menu or • Memory organizer menu once the empty measurement was created in selected object structure.
	▤ TAP name 1 Side to measure X Test current 1 A Average 10 s Temp conversion Disable on	Select Parameters in Control panel.
	Parameters & Limits 12:15 TAP name [1] ＞ Side to measure ＜ X ＞ Test current ＜ 1 A ＞ Average ＜ 10 s ＞ Temp conversion Disable ＞	Select parameter to be edited or limit to be set.

on `1` or ←	Enter Set value menu.
TAP name 12:37 1 2 **3** 4 5	Set parameter value by selecting it from the list.
on `3` or ←	Accepts new parameter / limit value.
← ←	Return to single test start screen.
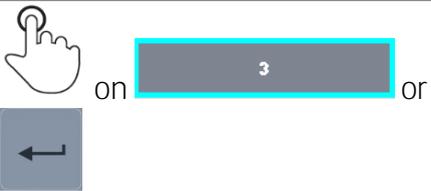
10.1.5 Setting parameters through keyboard

Some parameters are settable through keyboard and they can have custom value:
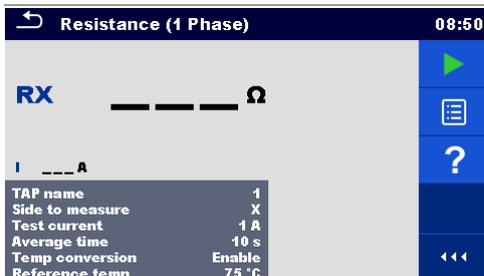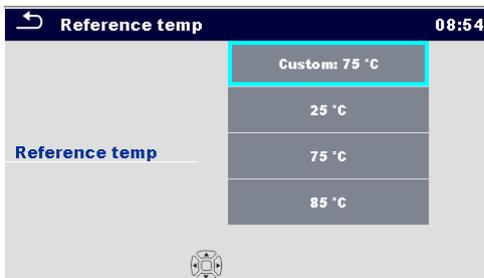
Resistance (1 Phase) 08:50 RX ___ ___ ___ Ω I ___A TAP name 1 Side to measure X Test current 1 A Average time 10 s Temp conversion Enable Reference temp 75 °C	Select the test or measurement. The test can be entered from: • Single tests menu or • Memory organizer menu once the empty measurement was created in selected object structure.
TAP name 1 Side to measure X Test current 1 A Average time 10 s Temp conversion Enable on Reference temp 75 °C	Select Parameters in Control panel.
Reference temp 08:54 Custom: 75 °C 25 °C Reference temp 75 °C 85 °C	Select parameter to be edited.
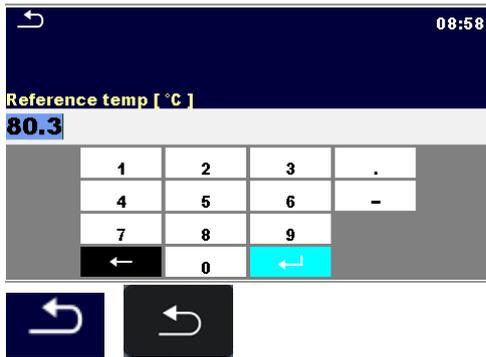
Press ← to clear the field.

Press ↵ to confirm new entered value.

Return to single test start screen.

10.1.6 Single test screen during test
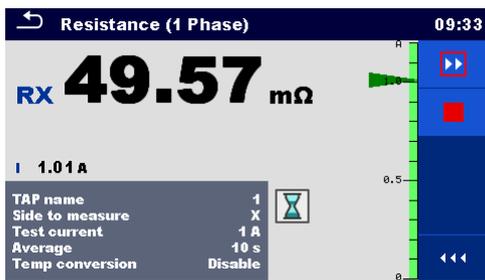
Example of Single test screen during measurement
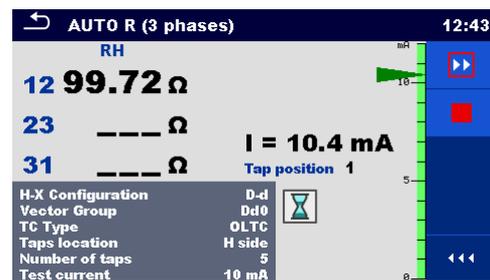
Example of Single test screen during test

Options (when test is running):

◼	Stops / aborts the measurement.
🏃	
↩	
⤺	
▶▶	Proceeds to next step within the measurement (if measurement consists of multiple steps).
🏃	
▶	Starts the next step measurement (if measurement consists of multiple steps).
🏃	
⇧	Increase Tap position value.
⇩	Decrease Tap position value.

10.1.7 Single test result screen
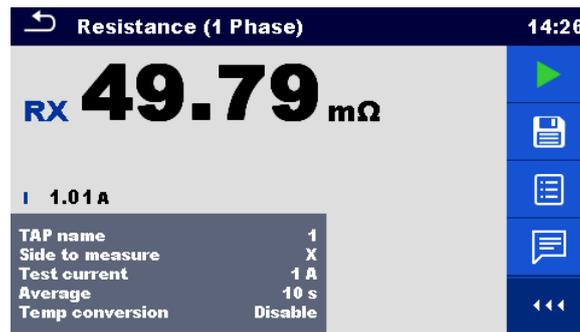
Example of Single test result screen

Options (after measurement is finished)

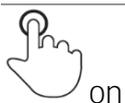|	
▶	Starts a new measurement.
🏃 (red)	
💾	Saves the result.
	A new measurement was selected and started from a Structure item in the structure tree:
	• the measurement will be saved under the selected Structure item.
	A new measurement was started from the Single test main menu:
	• saving under the last selected Structure item will be offered by default. The user can select another Structure item or create a new Structure item.
	• By pressing the 💾 key in Memory organizer menu the measurement is saved under selected location.
	An empty measurement was selected in structure tree and started:
	• the result(s) will be added to the measurement. The measurement **will change its status from 'empty' to 'finished'.**
	An already carried out measurement was selected in structure tree, viewed and then restarted:
	• a new measurement will be saved under the selected Structure item.
☷ 👆 on [TAP name 1 / Side to measure X / Test current 1 A / Average 10 s / Temp conversion Disable]	Opens menu for changing parameters and limits of selected measurements. Refer to chapter *Setting parameters and limits of single tests* for more information how to change measurement parameters and limits.
💬	Adds comment to a single test.

⬅	Opens previous screen.
➡	Opens next screen.
⬆	Opens result screen at increased Tap position value.
⬇	Opens result screen at decreased Tap position value.
(directional pad)	Same functionality as virtual arrow keys.
📝	Enables Plot edit. Refer to chapter *Graph view* for more information on options.
?	Opens help screens.

10.1.8 Graph view
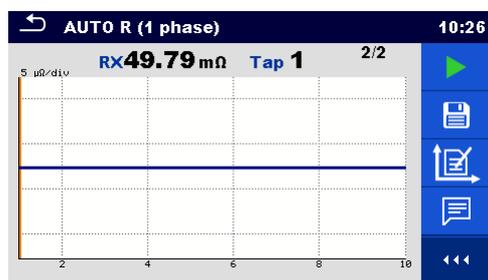
Graph view
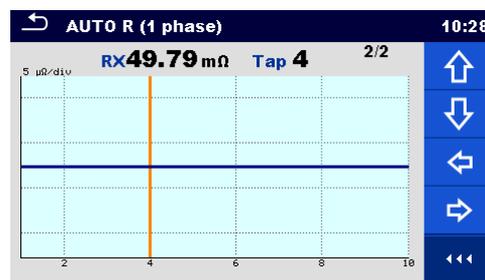
Graph view - Cursor selected

Options

📝	Plot edit. Enables Control panel options for editing graphs.
⬆ ⬇	Increases / decreases scale factor (y-axis)
(directional pad)	

	Moves cursor to the previous / next Tap position (x-axis).
	Selects cursor position (x-axis).
	Exits from editing graphs.

10.1.9 Recall single test result screen

Example of Single test memory screen

Options

	Retest. Enters starting screen for a new measurement.
	Opens menu for viewing / changing parameters and limits of selected measurements. Refer to chapter *Setting parameters and limits of single tests* for more information how to change measurement parameters and limits.
	Opens previous / next screen (if result consist of multiple screens).
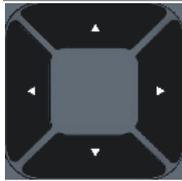
	Change Tap position. Opens results screen at selected Tap position.

10.1.10 Single test (Visual Test) screens

Visual Test can be treated as a special class of tests. Items to be visually checked are displayed. In addition on-line statuses and other information are displayed.
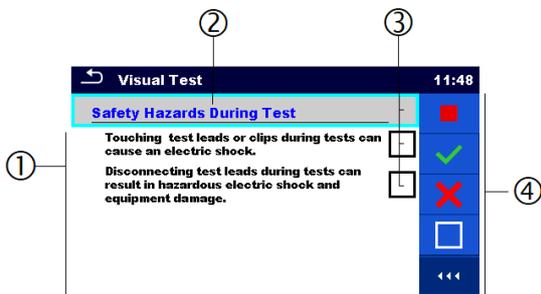
Visual test

Legend

1   Visual test item /sub-item
2   Visual test name
3   Status fields
4   Options

10.1.11 Single test (Visual Test) start screen
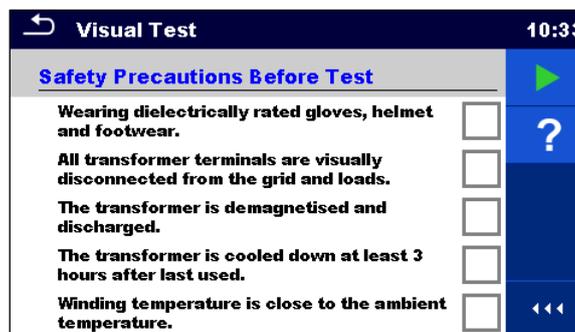
Visual test start screen

Options (before Visual Test, screen was opened in Memory organizer or from Single test main menu)

▶	Starts the Visual Test
🏃	
?	Opens help screens.

10.1.12 Single test (Visual Test) screen during test
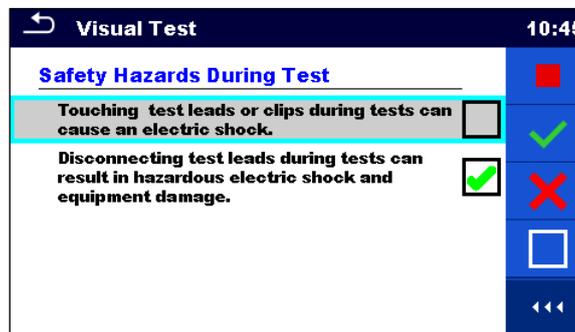
Visual test screen during test

Options (during test)

Safety Hazards During Test / Touching test leads or clips during tests can cause an electric shock. ☐	Selects item (complete Visual test, group of items or particular item).
✔	Applies a pass to the selected item or group of items.
✘	Applies a fail to the selected item or group of items.
☐	Clears status in selected item or group of items.
●	Applies a status that item or group of items was checked.
👆 on ☐	A status can be applied (toggle between options).
■	Goes to the result screen.
↰	
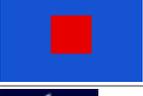
⬑

Rules for automatic applying of statuses
- The parent item(s) can automatically get a status on base of statuses in child items.
    - The fail status has highest priority. A fail status for any item will result in a fail status in all parent items and an overall fail result.
    - If there is no fail status in child items, the parent item will get a status only if all child items have a status.
    - Pass status has priority over checked status.
- The child item(s) will automatically get a status on base of status in the parent item.
    - All child items will get the same status as applied to the parent item.

Notes
- Visual tests and Visual test items can have different status types. Some Visual tests don't have the "checked" status.
- Only Visual tests with overall statuses can be saved.

10.1.13 Single test (Visual Test) result screen
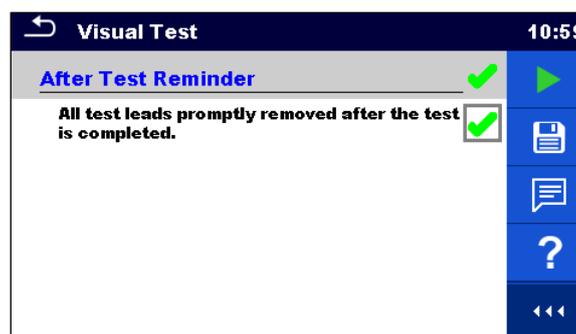
Example of Visual test result screen

Options (after Visual Test is finished)

▶	Starts a new Visual Test.
💾	Saves the result. A new Visual Test was selected and started from a Structure item in the structure tree: • The Visual Test will be saved under the selected Structure item. A new Visual Test was started from the Single test main menu: • Saving under the last selected Structure item will be offered by default. The user can select another Structure item or create a new Structure item. By pressing the 💾 key in Memory organizer menu the Visual Test is saved under selected location. An empty Visual Test was selected in structure tree and started:

- The result(s) will be added to the Visual Test. The Visual Test will change it**s status from 'empty' to 'finished'.**

An already carried out Visual Test was selected in structure tree, viewed and then restarted:

A new measurement will be saved under the selected Structure item.

📝	Add comment to Visual test.
❓	Opens help screens.

10.1.14 Single test (Visual Test) memory screen
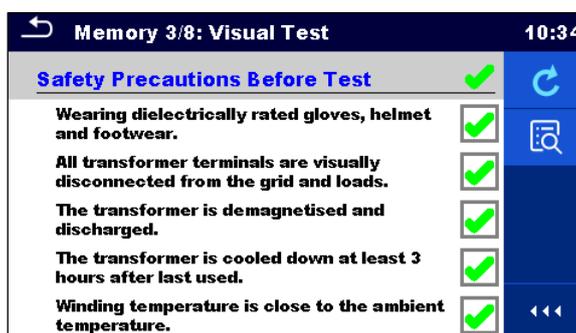
Example of Visual test memory screen

Options

↻	Retest. Starts new Visual test.
↵	
🔍	Opens menu for viewing Visual test results.

11 Tests and Measurements

11.1 **Visual tests**

Visual tests are used as guidance to maintain safety standards prior testing the transformer. To use those visual tests please select VISUAL under Single tests. Visual tests are prepared to make all safety checks before starting, during and after the transformer tests.
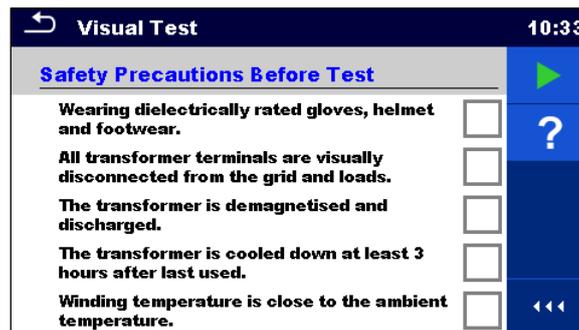
Visual test start screen

Options

✔	Pass
✖	Fail
☐	Clear
⬤	Checked

Safety Precautions Before Test

No.	Description	Values
1	Wearing dielectrically rated gloves, helmet and footwear. Comment: To protect the user from electric shock it is necessary for him/her to wear all necessary protection equipment.	Pass/Fail/Clear/Checked
2	All transformer terminals are visually disconnected from the grid and loads. Comment: Before starting the measurement, it is necessary to visually check on all terminals, if the transformer is disconnected from the grid and all connected loads. Pay attention that the load can become a voltage source.	Pass/Fail/Clear/Checked
3	The transformer is demagnetized and discharged. Comment: Eliminate all reasons that transformer can start to generate voltage for whatever reason.	Pass/Fail/Clear/Checked

4	The transformer is cooled down at least 3 hours after last used. Comment: When measuring winding resistance this must be done at known temperature, which is ambient temperature. This is especially important for large transformers.	Pass/Fail/Clear/Checked
5	The winding temperature is close to the ambient temperature. Comment: If transformer is small, you can leave it disconnected long enough for winding temperature to reach the ambient temperature.	Pass/Fail/Clear/Checked
6	Connect all unused test leads to ground. Comment: Some of three phase transformers have only 6 terminals, so 2 unused test leads must be connected to ground.	Pass/Fail/Clear/Checked

Safety Hazards During Test

No.	Description	Values
1	Touching test leads or clips during testing can cause electric shock. Comment: To protect the user from electric shock it is necessary for him/her to wear all necessary protection equipment.	Pass/Fail/Clear/Checked
2	Disconnecting test leads during testing can results in hazardous electric shock and equipment damage. Comment: Before starting the measurement, it is necessary to visually check on all terminals, if the transformer is disconnected from the grid and all connected loads. Pay attention that the load can become a voltage source.	Pass/Fail/Clear/Checked

After Test Reminder

No.	Description	Values
1	All test leads promptly removed after the test is completed. Comment:	Pass/Fail/Clear/Checked

Visual Test procedure:
- Select Visual function.
- Start the Visual Test.
- Perform the Visual Test.
- Apply appropriate ticker(s) to items.
- End Visual Test.
- Save results (optional).
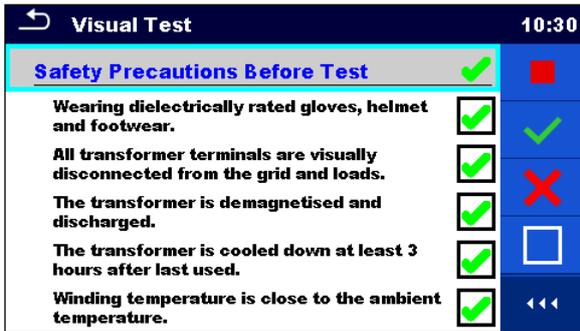
Visual test screen during test
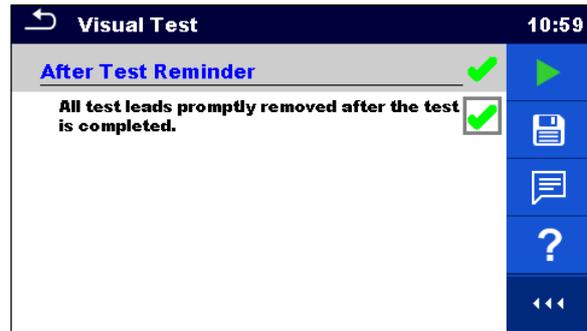
Example of Visual test result screen

11.2 **Winding resistance**

The MI 3281 WR Analyzer is able to measure winding resistances of any voltage transformer type, by applying a user selectable, stable DC test current up to 20 A, to the selected winding(s). It supports the fully automatic measurement of all eight windings of a three-phase transformer with only one wiring. The winding resistance measurements are divided into two groups based on the transformer type as presented in the table below.

Winding resistance measurement	Measuring results	Side to measure	Transformer type
Resistance (1 phase)	RH, RX	H, X, Both	Single-phase transformer
Resistance (3 phases)	R_{10}, R_{20}, R_{30} R_{12}, R_{23}, R_{31} R_A, R_B, R_C R_a, R_b, R_c	H, X, Both	Three-phase transformer

11.2.1   Single-phase transformers

Winding resistance of a single-phase transformer can be measured by selecting single test Resistance (1 Phase). Single-phase transformer winding resistance testing is divided into two parts: winding resistance measurement of a high voltage winding (*H*) and/ or of a low voltage winding (*X*) regarding to parameter *Side to measure*. The complete test can be made by setting parameter *Side to measure* to *Both*.

To measure high voltage side winding resistance of a single-phase transformer, connect H-side test cable to H test connector and/ or to measure low voltage side winding resistance of a single-phase transformer, connect X-side test cable to X test connector on the MI 3281 WR Analyser. For single-phase transformer winding resistance measurement, only H0 black , H1 yellow wire terminals (high voltage side) and/ or X0 black , X1 yellow wire terminals (low voltage side) are required. Use Kelvin test crocodiles and connect each pair of coloured wire terminals to each crocodile. Use Kelvin test principle (one wire should be connected to terminal on one handle, the second wire should be connected to terminal on the other handle of Kelvin test crocodile. Orientation is not relevant. Connect Kelvin test crocodiles to the transformer according to the figure below.
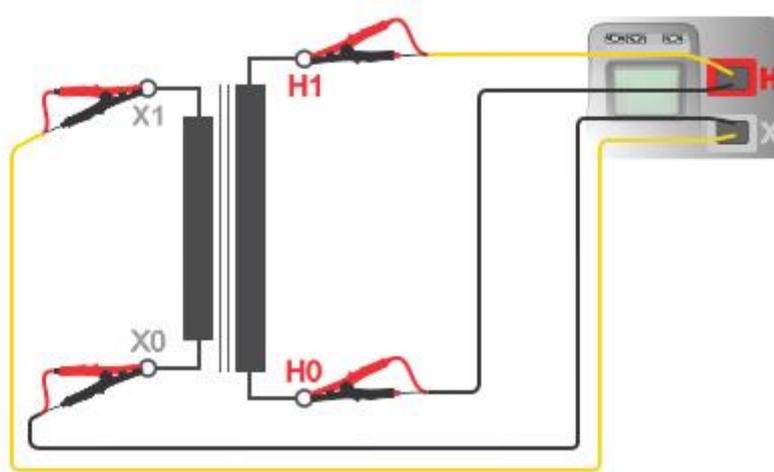
Measuring connection of a 1-phase transformer

According to the application (transformer type or size) adequate test current should be selected (10 mA to 20 A). Stability of the test results can be improved with higher test current and with higher averaging.

During the measurement, a stable DC test current *I* is injected to the selected winding (H or X) or to the both windings at the same time (H and X). After detecting steady state of winding **current, the voltage is measured and resistance is calculated by Ohm's law.**

$$R_H = \frac{V_{H1m} - V_{H0m}}{I_{dc}} \qquad R_X = \frac{V_{X1m} - V_{X0m}}{I_{dc}}$$

Where:

V_{H1m} - V_{H0m}	High voltage winding (H) voltage
V_{X1m} - V_{X0m}	Low voltage winding (X) voltage
I_{dc}	Test DC current
R_H	High voltage winding (H) resistance
R_X	Low voltage winding (X) resistance

Measurement can be started from the Resistance (1 phase) measurement window, which is presented below. Before carrying out a test the following parameters (Tap name, Side to measure, Test Current, Average and Temp conversion parameters – Reference temp, Measured temp, Winding material and Material temp) can be edited.
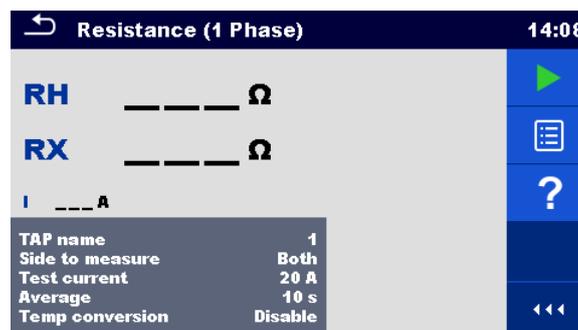
Resistance (1 Phase) start screen

Test parameters for single-phase transformer winding resistance measurement

TAP name	Set TAP name: **-, 1 ... 32**
Side to measure	Set windings to measure: H, X, Both[1]
Test current	Set test current: 10 mA, 100 mA, 1 A, 5 A, 10 A, 15 A, 20 A
Average[2]	Set averaging: 5 s, 10 s, 30 s
Temp conversion	Temperature conversion: Disable, Enable
Reference temp	(If Temp conversion enabled) Reference temperature: 25 °C, 75 °C, 85 °C, Custom value
Measured temp	(If Temp conversion enabled) Measured temperature: Custom value
Winding material	(If Temp conversion enabled) Transformer winding material: Copper, Aluminium, Custom
Material temp	(If Temp conversion enabled and Winding material set to custom) Material reference temperature: Custom value

[1] When Side to measure is set to Both, the same test current is injected to both windings, at the same time. Winding resistance is measured sequentially in two steps.
[2] Pre-defined value is 10 s.

Single-phase transformer winding resistance measurement procedure without temperature conversion

- Connect H-side test cable to H socket and/or X-side test cable to X socket on MI 3281 WR Analyser.
- Connect Kelvin test crocodiles to coloured wire terminals. Only H terminals with H0 black , H1 yellow wires and/or X terminals with X0 black , X1 yellow wires are required for single-phase transformer winding resistance measurement. Each wire terminal should be connected to separate handle terminal of Kelvin test crocodiles.
- Connect Kelvin test crocodiles to the required transformer winding(s). See connection figure above.
- Use Carbine clips with strings to secure test cables and Kelvin test crocodiles against accidental disconnection (optional).
- Select Resistance (1 Phase) test function.
- Set *TAP name* (if measuring multiple TAP transformer).
- Set *Side to measure*. Set according to the test connection.
- Set *Test current*.
- Set *Average*.
- Set *Temp conversion* to disable.
- Press the Run key to start the measurement.
- After Connection test, test results are displayed on the screen. Wait until the measurement automatically stops and discharge is finished.
- Save results (optional).
- Disconnect in reverse order.

During testing of the transformer, instantaneous current is shown on the screen. The measurement screen is displaying current results, when the measurement is in progress. When parameter *Side to measure* is set to Both, the same current is injected to high voltage

and low voltage winding at the same time. Transformer is therefore charged only once while the measurement time is reduced. Both winding resistances are measured sequentially in two steps.
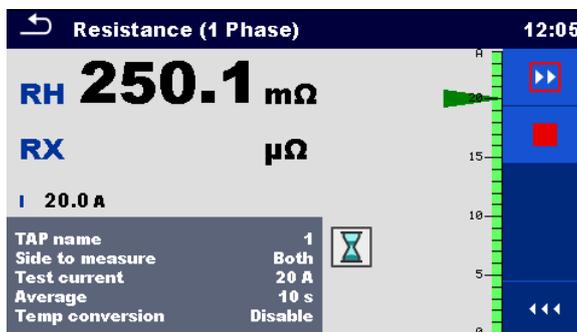
Resistance (1 Phase) screen during measurement

When the measurement is completed, the results are presented on the measurement screen.
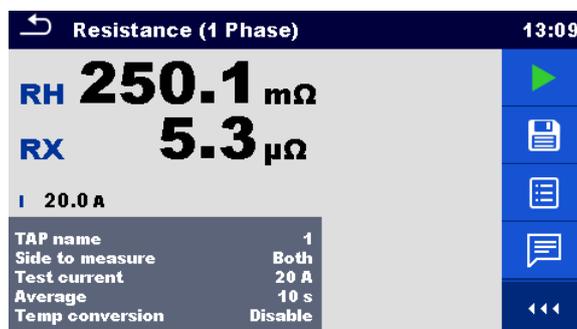
Example of Resistance (1 Phase) result screen

Warning!
- Do not disconnect test leads during testing. Wait until results are shown on the screen and discharge is finished. Removing test crocodiles prior that can result in high voltage spike, potentially hazardous electric shock and a permanent damage of testing equipment.

Notes
- Consider displayed warnings and messages, when starting the measurement!
- Test current should not be set to more than 10 % of transformers winding rated current.
- Autotransformer windings should be connected and measured separately.

11.2.1.1 Temperature conversion

Cold winding resistances can be converted to a standard temperature. Conversion is accomplished by:

$$R_s = R_m \frac{T_s + T_k}{T_m + T_k}$$

Where:

R_s	RH, RX	Converted resistance at the desired temperature (T_s) in Ω
R_m	RH, RX (without Temp conversion)	**Measured resistance in Ω**
T_s	Reference temp	Desired reference temperature in °C
T_m	Measured temp	Temperature at which resistance was measured in °C
T_k	Material temp	is 234.5 °C for copper winding, 225 °C for aluminium winding or user custom defined in °C

Single-phase transformer winding resistance measurement procedure with temperature conversion

- Connect H-side test cable to H socket and/or X-side test cable to X socket on MI 3281 WR Analyser.
- Connect Kelvin test crocodiles to coloured wire terminals. Only H terminals with H0 black , H1 yellow wires and/or X terminals with X0 black , X1 yellow wires are required for single-phase transformer winding resistance measurement. Each wire terminal should be connected to separate handle terminal of Kelvin test crocodiles.
- Connect Kelvin test crocodiles to the required transformer winding(s). See connection figure above.
- Use Carbine clips with strings to secure test cables and Kelvin test crocodiles against accidental disconnection (optional).
- Select Resistance (1 Phase) test function.
- Set *TAP name* (if measuring multiple TAP transformer).
- Set *Side to measure.* Set according to the test connection.
- Set *Test current*.
- Set *Average*.
- Set Temp conversion to Enable (additional parameters will appear).
- Set Reference temp, Measured temp, Winding material and Material temp (if Winding material is set to custom).
- Press the Run key to start the measurement.
- After Connection test, test results are displayed on the screen. Wait until the measurement automatically stops and discharge is finished.
- Save results (optional).
- Disconnect in reverse order.

When the measurement is completed, the results are presented on the measurement screen. The presented winding resistance(s) is/are already converted to a desired reference temperature.
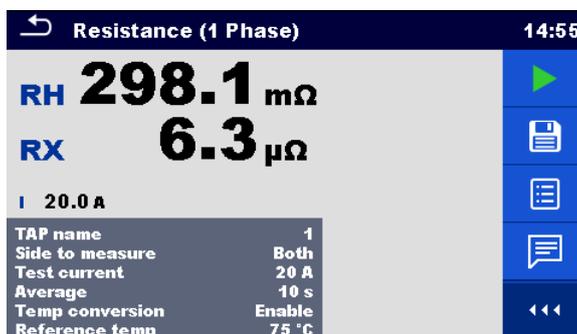
Example of Resistance (1 Phase) measurement with temperature conversion

Warning!
- Do not disconnect test leads during testing. Wait until results are shown on the screen and discharge is finished. Removing test crocodiles prior that can result in high voltage spike, potentially hazardous electric shock and a permanent damage of testing equipment.

Notes
- Consider displayed warnings and messages when starting the measurement!
- Test current should not be set to more than 10 % of transformers winding rated current.
- Autotransformer windings should be connected and measured separately.

11.2.2 Three-phase transformers

Winding resistance of three-phase transformer can be measured by selecting three-phase winding resistance measurement - Resistance (3 Phases). Measurement parameterization must start with selection of the IEC *Vector Group*, which is fundamental parameter. Make sure it is set correctly or the results will be wrong or misleading. The *Vector Group* selection is divided into two sections. First select *H-X Configuration*, which will ease the further selection by limiting the amount of choices for specific *Vector Group*.

MI 3281 WR Analyser is using single current source so all winding resistance of the transformer are measured sequentially in the following order: R_{10}, R_{20} and R_{30} or R_{12}, R_{23} and R_{31}, dependent on the selected Vector Group. Measurements can be selected with *Side to Measure* parameter (*H* side only, *X* side only or *Both* sides). Test current can be manually selected with *Test current* parameter (10 mA to 20 A). It is recommended to test with the highest test current possible, considering not to exceed 10 % of rated transformer winding current. Set *Average* parameter. Higher averaging can improve results stability.

During testing of transformer, instantaneous winding resistance and current are shown on the screen. When the whole transformer is tested, the additional phase resistances are calculated and shown on the separate screen.

All winding resistances can also be converted to desired reference temperature if *Temp conversion* parameter is enabled and additional parameters are set.

Parameter	Description	Values	Unit
H-X Configuration	Select Configuration of transformer	D-d, D-y, D-z, Y-y, Y-d, Y-z, Y-a, Z-a	-
D-d	Select D-d the Vector Group (if used)	Dd0, Dd2, Dd4, Dd6, Dd8, Dd10	-
D-y	Select D-y the Vector Group (if used)	Dy1, Dyn1, Dy5, Dyn5, Dy7, Dyn7, Dy11, Dyn11	-
D-z	Select D-z the Vector Group (if used)	Dz0, Dzn0, Dz2, Dzn2, Dz4, Dzn4, Dz6, Dzn6, Dz8, Dzn8, Dz10, Dzn10	-
Y-y	Select Y-y the Vector Group (if used)	Yy0, YNy0, Yyn0, YNyn0, Yy6, YNy6, Yyn6, YNyn6	-
Y-d	Select Y-d the Vector Group (if used)	Yd1, YNd1, Yd5, YNd5, Yd7, YNd7, Yd11, YNd11	-
Y-z	Select Y-z the Vector Group (if used)	Yz1, Yzn1, Yz5, Yzn5, Yz7, Yzn7, Yz11, Yzn11	-
Y-a	Select Y-a the Vector Group (if used)	Ya0, YNa0	-
Z-a	Select Z-a the Vector Group (if used)	ZNa1, Za1, Zna5, Za5, ZNa7, Za7, ZNa11, Za11	-
TAP name	TAP name or tap position	-,1 ... 32	-
Side to measure	Side of the transformer to be measured	H: high voltage windings only X. low voltage windings only Both: high and low voltage windings	-
Test current H	Test current for high voltage winding (H) resistance measurement	10 m, 100 m, 1, 5, 10, 15, 20	A
Test current X	Test current for low voltage winding (X) resistance measurement	10 m, 100 m, 1, 5, 10, 15, 20	A
Average	Averaging of test results	5, 10, 30	s
Temp conversion	Select temperature conversion	Disable, Enable	-
Reference temp	Set reference temperature (available only if Temp conversion is enabled)	25, 75, 85, Custom value	°C
Measured temp	Set measured temperature (available only if Temp conversion is enabled)	Custom value	°C
Winding material	Select Winding material (available only if Temp conversion is enabled)	Copper, Aluminium, Custom	-
Material temp	Set material temperature (available only if Temp conversion is enabled and	Custom value	°C

Parameter	Description	Values	Unit
	Winding material is set to Custom)		

11.2.2.1 Testing, connection and results

To measure high voltage side winding resistance of a three-phase transformer, connect H-side test cable to H test connector and/or to measure low voltage side winding resistance of a three-phase transformer, connect X-side test cable to X test connector on the MI 3281 WR Analyser. For three-phase transformer winding resistance measurement, H0 black , H1 yellow , H2 white and H3 green wire terminals (high voltage side) and/or X0 black , X1 yellow , X2 white and X3 green wire terminals (low voltage side) are required. Use Kelvin test crocodiles and connect each pair of coloured wire terminals to each crocodile. Use Kelvin test principle (one wire should be connected to terminal on one handle, the second wire should be connected to terminal on the other handle of Kelvin test crocodile. Orientation is not relevant. Connect Kelvin test crocodiles to the transformer according to the figure below.

Measuring connection of a 3-phase transformer

Measurement can be started from the Resistance (3-phases) measurement window. Before carrying out a test the following parameters (H-X Configuration, Vector Group, TAP name, Side to measure, Test Current H and/or X, Average and Temp conversion parameters - Reference temp Measured temp, Winding material and Material temp) can be edited.
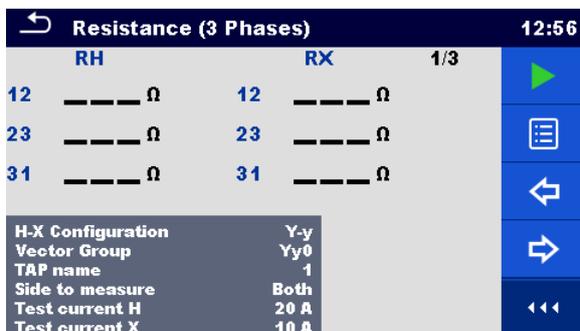
Resistance (3 Phases) start screen - Resistances view
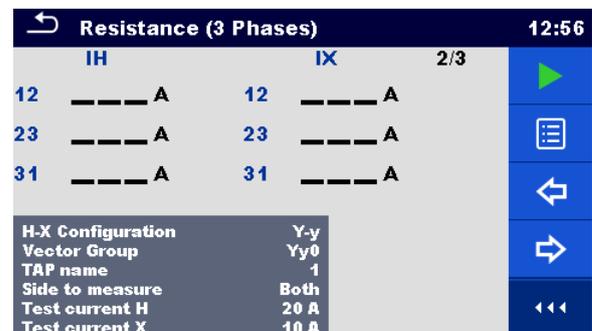
Resistance (3 Phases) start screen – Currents view
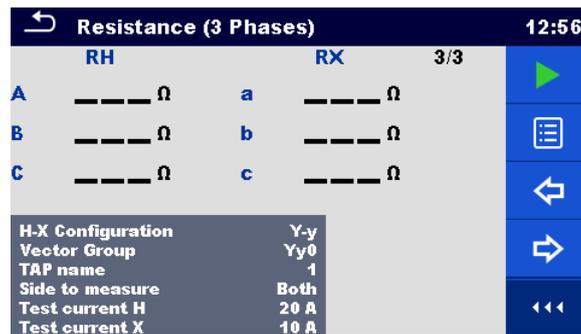
Resistance (3 Phases) start screen – Phase resistances view

Test parameters for three-phase transformer winding resistance measurement

H-X Configuration	Set Configuration of transformer: *D-d*, *D-y*, *D-z*, *Y-y*, *Y-d*, *Y-z*, *Y-a or Z-a*
Vector Group	Set Vector Group: (See *Vector groups* for details)
TAP name	Set TAP name: -, **1 … 32**
Side to measure	Set side of transformer to be measured: H, X or Both
Test current H	Set test current (H-side): 10 mA, 100 mA, 1 A, 5 A, 10 A, 15 A, 20 A
Test current X	Set test current (X-side): 10 mA, 100 mA, 1 A, 5 A, 10 A, 15 A, 20 A
Average[1]	Set averaging: 5 s, 10 s, 30 s
Temp conversion	Temperature conversion: Disable, Enable
Reference temp	(If Temp conversion enabled) Reference temperature: 25 °C, 75 °C, 85 °C, Custom value
Measured temp	(If Temp conversion enabled) Measured temperature: Custom value
Winding material	(If Temp conversion enabled) Transformer winding material: Copper, Aluminium, Custom
Material temp	(If Temp conversion enabled and Winding material set to Custom) Material reference temperature: Custom value

[1] Pre-defined value is 10 s.

Three-phase transformer winding resistance measurement procedure without temperature conversion

- Connect H-side test cable to H socket and/or X-side test cable to X socket on MI 3281 WR Analyser.
- Connect Kelvin test crocodiles to coloured wire terminals. H terminals with H0 black, H1 yellow, H2 white and H3 green wires (high voltage side) and/or X terminals with X0 black, X1 yellow, X2 white and X3 green wires (low voltage side) are required for three-phase transformer winding resistance measurement. Each wire terminal should be connected to separate handle terminal of Kelvin test crocodiles.
- Connect Kelvin test crocodiles to the transformer windings, according to the relevant Vector group.
- Use Carbine clips with strings to secure test cables and Kelvin test crocodiles against accidental disconnection (optional).
- Select Resistance (3 Phases) test function.
- Set parameters *H-X Configuration* and *Vector Group.*
- Set parameter *TAP name* (if measuring multiple TAP transformer).

- Set parameter *Side to measure.* Set according to the test connection.
- Set parameters *Test current H and/or Test current X.*
- Set parameter *Average.*
- Set *Temp conversion* to Disable.
- Press the Run key to start the measurement.
- After Connection test, winding resistance measurements are caried out in a sequential order, starting with R_{10} or R_{12} (H-side) and ended with R_{30} or R_{31} (X-side), as defined in test parameters. Wait until the measurement stops automatically or proceed with steps manually, when result is stabilised. After the whole transformer is tested, the phase resistances R_A, R_B, R_C and/or R_a, R_b, R_c are calculated and displayed on the separate screen. Wait until discharge is finished.
- Use left/right arrow keys to switch between multiple measurement result screens (optional).
- Save results (optional).
- Disconnect in reverse order.

Three-phase transformer winding resistances measurement procedure with temperature conversion
- Connect H-side test cable to H socket and/or X-side test cable to X socket on MI 3281 WR Analyser.
- Connect Kelvin test crocodiles to coloured wire terminals. H terminals with H0 black , H1 yellow , H2 white and H3 green wires (high voltage side) and/or X terminals with X0 black , X1 yellow , X2 white and X3 green wires (low voltage side) are required for three-phase transformer winding resistance measurement. Each wire terminal should be connected to separate handle terminal of Kelvin test crocodiles.
- Connect Kelvin test crocodiles to the transformer windings, according to the relevant Vector group.
- Use Carbine clips with strings to secure test cables and Kelvin test crocodiles against accidental disconnection (optional).
- Select Resistance (3 Phases) test function.
- Set parameters *H-X Configuration* and *Vector Group.*
- Set parameter *TAP name* (if measuring multiple TAP transformer).
- Set parameter *Side to measure.* Set according to the test connection.
- Set parameters *Test current H and/or Test current X.*
- Set parameter *Average.*
- Set *Temp conversion* to Enable. Additional parameters will appear. (Refer to chapter *Temperature conversion* for more information.)
- Set *Reference temp*, *Measured temp*, *Winding material* and *Material temp* (if *Winding material* is set to Custom).
- Press the Run key to start the measurement.
- After Connection test, winding resistance measurements are caried out in a sequential order, starting with R_{10} or R_{12} (H-side) and ended with R_{30} or R_{31} (X-side), as defined in test parameters. Wait until the measurement stops automatically or proceed with steps manually, when result is stabilised. After the whole transformer is tested, the

phase resistances R_A, R_B, R_C and/or R_a, R_b, R_c are calculated and displayed on the separate screen. Wait until discharge is finished.

- Use left/right arrow keys to switch between multiple measurement result screens (optional).
- Save results (optional).
- Disconnect in reverse order.

Resistance (3 Phases) view during measurement - Resistances screen

After the measurement is done, the results are presented on three measurement result screens. First screen represents winding resistances, second screen represents test currents and third screen represents calculated phase winding resistances. To navigate between screens, use left/right arrow keys or scroll down Control panel menu on the right side and tap on "Left" or "Right" icon. If temperature conversion was enabled, all winding resistances are already converted to a desired reference temperature.
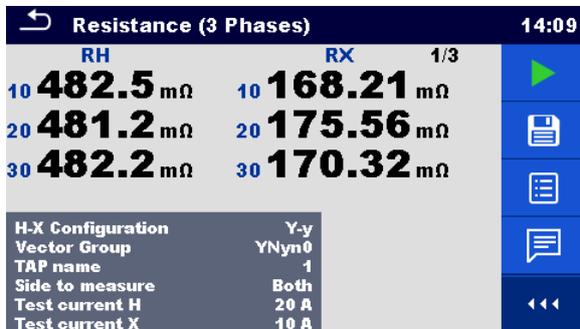
Example of Resistance (3 Phases) result screen - Resistances view
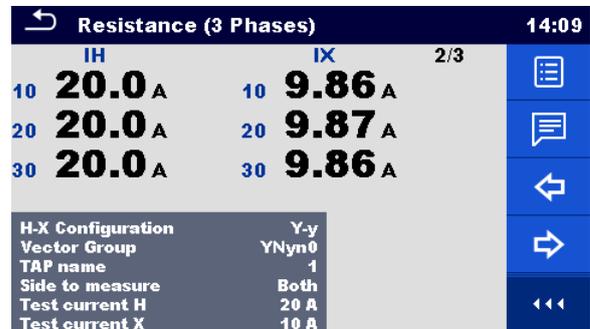
Example of Resistance (3 Phases) result screen - Currents view
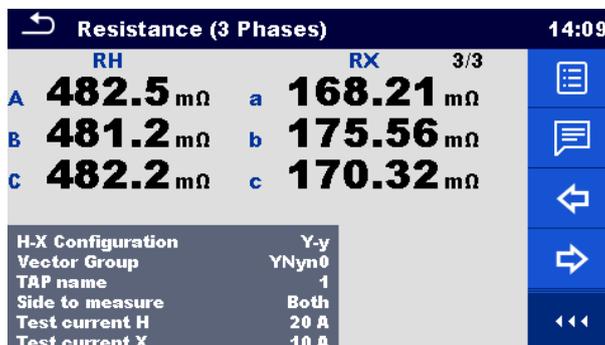
Example of Resistance (3 Phases) result screen – Phase resistances view

Warning!
- Do not disconnect test leads during testing. Wait until results are shown on the screen and discharge is finished. Removing test crocodiles prior that, can result in high voltage spike, potentially hazardous electric shock and a permanent damage of testing equipment.

Notes
- Consider displayed warnings and messages when starting the measurement!
- Test current should not be set to more than 10 % of transformers winding rated current.

11.3 **Winding resistance with tap changer**

MI 3281 WR Analyser supports the winding resistance measurement of single-phase or three-phase transformers with OLTC (On Load Tap Changer). Automatic measurement of OLTC or manual measurement of NLTC (No-Load Tap Changer) transformers are supported by the instrument.
All cold winding resistances can be converted to a user-defined standard temperature.

11.3.1   Single-phase transformers with tap changer

Winding resistances of a single-phase transformer with tap changer can be measured by selecting single test function AUTO R (1 phase). Advantage of this test is that all winding resistances at different tap positions are included in a single measurement and graphical representation of test results is included. There are two measurement modes to measure winding resistances of a single-phase transformer, that depends on a *TC type* (Tap Changer type): OLTC mode, where instrument automatically changes transformer tap positions and NLTC mode, where user has to manually change tap positions. Tap changer can be installed on a high voltage winding (*H*) or on a low voltage winding (*X*) side, regarding to parameter *Taps location*. Only one side of a transformer can be measured in a single test. According to the application (transformer type or size) adequate *Test current* should be selected (10 mA to 20 A). *Average* parameter should be set. Stability of the test results can be improved with higher test current and with higher averaging.
To measure high voltage side winding resistances of a single-phase transformer, at different tap positions, connect H-side test cable to H test connector and to measure low voltage side winding resistances of a single-phase transformer, at different tap positions, connect X-side test cable to X test connector on the MI 3281 WR Analyser. For AUTO R (1 phase) measurement, only H0 black and H1 yellow wire terminals (high voltage side) or X0 black and X1 yellow wire terminals (low voltage side) are required. Use Kelvin test crocodiles and connect each pair of coloured wire terminals to each crocodile. Use Kelvin test principle (one wire should be connected to terminal on one handle, the second wire should be connected to terminal on the other handle of Kelvin test crocodile. Orientation is not relevant. Connect Kelvin test crocodiles to the transformer according to the figure below.

Measuring connection of a 1-phase transformer with Tap changer

Measurement can be started from the AUTO R (1 phase) measurement window, which is presented below. Before carrying out a test the following parameters (TC type, Taps location, Number of taps, Test current, Average, and Temp conversion parameters – Reference temp, Measured temp, Winding material and Material temp) can be edited.

AUTO R (1 Phase) start screen

Test parameters for single-phase transformer winding with taps

TC type	Tap changer type: OLTC, NLTC
Taps location	Set location of a tap changer: H side, X side
Number of taps	Number of tap changer positions: 2 ... **32**
Test current	Set test current: 10 mA, 100 mA, 1 A, 5 A, 10 A, 15 A, 20 A
Average[1]	Set average time: 5 s, 10 s, 30 s
Temp conversion	Temperature conversion: Disable, Enable
Reference temp	(If Temp conversion enabled) Reference temperature: 25 °C, 75 °C, 85 °C, Custom value
Measured temp	(If Temp conversion enabled) Measured temperature: Custom value
Winding material	(If Temp conversion enabled) Transformer winding material: Copper, Aluminium, Custom
Material temp	(If Temp conversion enabled and Winding material set to Custom) Material reference temperature: Custom value

[1] Pre-defined value is 10 s.

11.3.1.1 Single-phase transformers with OLTC

When parameter *TC type* is set to OLTC (On Load Tap Changer), the instrument will automatically change tap position and winding resistances will be measured at each tap. OLTC Parameter *Number of taps* defines number of taps that will be automatically tested. Instrument will start winding resistance measurement at tap position 1, thus the user shall manually set OLTC to tap 1 before the start of the measurement.
When measuring winding resistances with tap changer in OLTC mode, Tap changer control cable should be connected to MI 3281 WR Analyser terminal (TAP CHANGER) and to OLTC control unit.
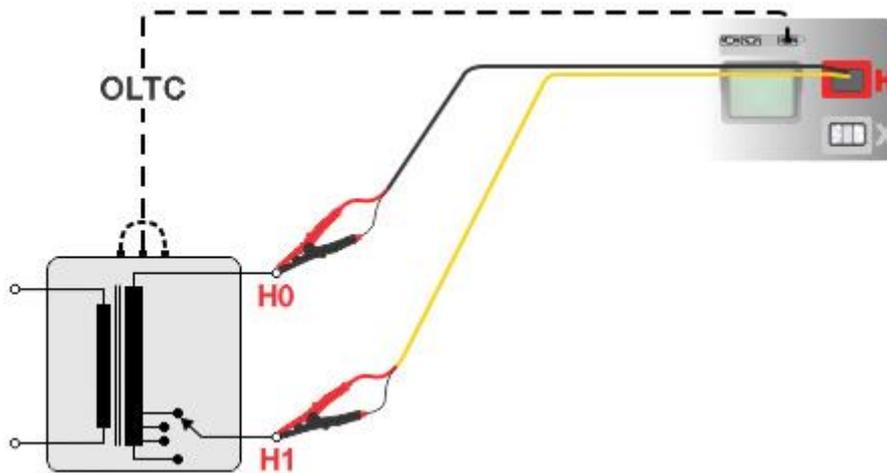
Connecting a 1-phase transformer with OLTC / NLTC to MI 3281

Single-phase transformer with tap changer winding resistance measurement procedure - OLTC

- Prior the measurement, manually set the OLTC to position 1.
- Connect H-side test cable to H socket or X-side test cable to X socket on MI 3281 WR Analyser.
- Connect Kelvin test crocodiles to coloured wire terminals. Only H terminals with H0 black , H1 yellow wires or X terminals with X0 black , X1 yellow wires are required for single-phase transformer winding resistance measurement. Each wire terminal should be connected to separate handle terminal of Kelvin test crocodiles.
- Connect Kelvin test crocodiles to the required transformer winding(s). See connection figure above.
- Use Carbine clips with strings to secure test cables and Kelvin test crocodiles against accidental disconnection (optional).
- Connect Tap changer control cable to WR Analyser MI 3281 TAP CHANGER terminal and to the Tap changer control unit terminals.
- Select AUTO R (1 Phase) test function.
- Set *TC type* to OLTC.
- Set *Taps location.*
- Set *Number of taps.*
- Set *Test current.*
- Set *Average.*

- Set *Temp conversion* to Disable or Enable. (Refer to chapter *Temperature conversion* for more information.)
- Press the Run key to start the measurement.
- After Connection test, test results are displayed on the screen. Wait until measurements at all tap positions automatically stops and discharge is finished.
- Save results (optional).
- Disconnect in reverse order.
- After the measurement OLTC will remain in last set position. Set OLTC position accordingly.

During the test, the measurement screen is displaying instantaneous results of winding resistances for each tap position and instantaneous current. Last measured results for each tap are kept for analysis. Transformer is charged only once and all tap positions are tested sequentially from tap position 1 up to user defined number of taps. After completing the measurement, the test results are presented on the measurement screens on two pages. Page one is a list of winding resistance measurements for each tap position and page two is a chart of winding resistance vs tap position. Both pages are shown in figures below. To toggle between results (at different tap positions) **press "Up"** or **"Down" keys or** scroll down the Control panel and tap on up or down virtual keys. To switch between result list and chart, **press "Left"** or **"Right" keys or** scroll down the Control panel and tap on left or right keys. Tap on chart set cursor position, that can be used for detailed analysis. If temperature conversion was enabled, the winding resistances are already converted to a desired reference temperature.

AUTO R (1 Phase) result screen - Resistance list view
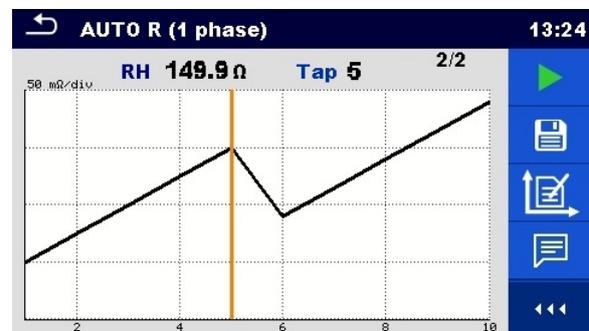
AUTO R (1 Phase) result screen - Chart view

Warning!
- Do not disconnect test leads during testing. Wait until results are shown on the screen and discharge is finished. Removing test crocodiles prior that can result in high voltage spike, potentially hazardous electric shock and a permanent damage of testing equipment.

Notes
- Consider displayed warnings and messages, when starting the measurement!
- Test current should not be set to more than 10 % of transformers winding rated current.

11.3.1.2 Single-phase transformers with NLTC

When parameter *TC type* is set to NLTC (No Load Tap Changer), the instrument will measure winding resistances of transformer taps manually. Instrument will not control tap changer. Tap positions on transformer has to be manually changed prior to each sub-measurement. Parameter *Number of taps* defines number of all taps that can be tested. Advantage of this test is that sequence of measurements at different tap positions is not specified, and can be tested randomly. Test results will be sorted automatically, according to the tap number from 1 to last tap.

Single-phase transformer with tap changer winding resistance measurement procedure - NLTC

- Connect H-side test cable to H socket or X-side test cable to X socket on MI 3281 WR Analyser.
- Connect Kelvin test crocodiles to coloured wire terminals. Only H terminals with H0 black , H1 yellow wires or X terminals with X0 black , X1 yellow wires are required for single-phase transformer winding resistance measurement. Each wire terminal should be connected to separate handle terminal of Kelvin test crocodiles.
- Connect Kelvin test crocodiles to the required transformer winding(s). See connection figure in chapter *Single-phase transformers with OLTC*.
- Use Carbine clips with strings to secure test cables and Kelvin test crocodiles against accidental disconnection (optional).
- Select AUTO R (1 Phase) test function.
- Set *TC type* to NLTC.
- Set *Taps location.*
- Set *Number of taps.*
- Set *Test current.*
- Set *Average.*
- Set *Temp conversion* to Disable or Enable. (Refer to chapter *Temperature conversion* for more information.)
- Press the Run key to initiate the measurement.
- Wait for Connection check to pass.
- Set tap position on the instrument with up and down keys and press Run key for winding resistance measurement at selected tap position.
- Wait until measurement at selected tap position automatically stops and discharge is finished.
- Switch tap position on the tap changer.
- Set new tap position on the instrument with up and down keys and press Run key for winding resistance measurement at new tap position.
- Wait until measurement at selected tap position automatically stops and discharge is finished.
- Repeat procedure for all tap positions.
- Stop the measurement. (Press ESC key or TAB key followed by ENTER key, when all taps are tested.)
- Save results (optional).
- Disconnect in reverse order.

Warnings!
- Do not disconnect test leads during testing. Wait until results are shown on the screen and discharge is finished. Removing test crocodiles prior that can result in high voltage spike, potentially hazardous electric shock and a permanent damage of testing equipment.
- Do not change the tap position during the active measurement. Always wait until the instrument is done with the discharge.

Notes
- Consider displayed warnings and messages, when starting the measurement!
- Test current should not be set to more than 10 % of transformers winding rated current.

11.3.2   Three-phase transformers with tap changer

Winding resistance of a three-phase transformer with tap changer can be measured by selecting single test function AUTO R (3 phases). Advantage of this test is that all winding resistances at different tap positions are included in a single measurement and graphical representation of test results is also included. *H-X Configuration* and *Vector group* parameters should be set according to the transformer specifications. Wrong setting can lead to false and misleading results. There are two measurement modes to measure winding resistances of a three-phase transformer, that depends on a *TC type* (Tap Changer type): OLTC mode, where instrument automatically changes transformer tap positions and NLTC mode, where user has to manually change tap positions. Tap changer can be installed on a high voltage winding (*H*) or on a low voltage winding (*X*) side, regarding to parameter *Taps location*. Only one side of a transformer can be measured in a single test. *Number of taps* should be set according to tap changer specifications. According to the application (transformer type or size) adequate *Test current* should be selected (10 mA to 20 A) and *Average* parameter should be set. Stability of the test results can be improved with higher test current and with higher averaging.

To measure high voltage side winding resistance of a three-phase transformer with tap changer, connect H-side test cable to H test connector or to measure low voltage side winding resistance of a three-phase transformer with tap changer, connect X-side test cable to X test connector on the MI 3281 WR Analyser. For three-phase transformer winding resistance measurement, H0 black , H1 yellow , H2 white and H3 green wire terminals (high voltage side) or X0 black , X1 yellow , X2 white and X3 green wire terminals (low voltage side) are required. Use Kelvin test crocodiles and connect each pair of coloured wire terminals to each crocodile. Use Kelvin test principle (one wire should be connected to terminal on one handle, the second wire should be connected to terminal on the other handle of Kelvin test crocodile. Orientation is not relevant. Connect Kelvin test crocodiles to the transformer according to the figure below.

For OLTC mode, Tap changer control cable should be connected to the MI 3281 WR Analyser and to the tap changer control unit.
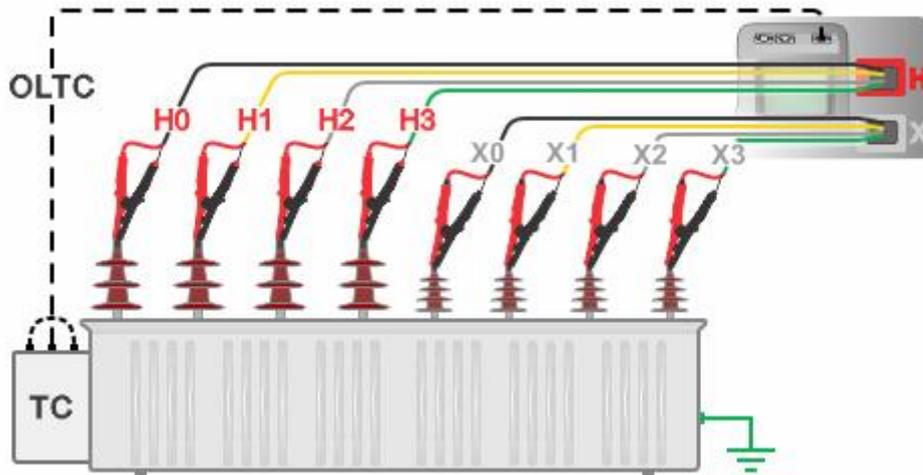
Measuring connection of a 3-phase transformer with Tap changer

Measurement can be started from the AUTO R (3 phases) measurement window, which is presented below. Before carrying out a test the following parameters (H-X Configuration, Vector Group, TC type, Taps location, Number of taps, Test Current, Average and Temp conversion parameters – Reference temp, Measured temp, Winding material and Material temp) can be edited.
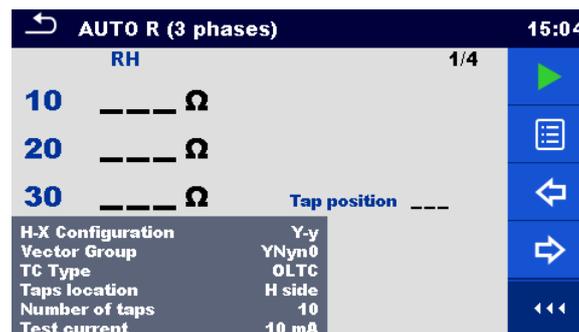
AUTO R (3 Phases) start screen

Test parameters for single-phase transformer winding with taps

H-X Configuration	Set Configuration of transformer: *D-d*, *D-y*, *D-z*, *Y-y*, *Y-d*, *Y-z*, *Y-a or Z-a*
Vector Group	Set Vector Group: (See *Vector groups* for details)
TC type	Tap changer type: OLTC, NLTC
Taps location	Set location of a tap changer: H side, X side
Number of taps	Number of tap changer positions: 2 … **32**
Test Current	Set test current: 10 mA, 100 mA, 1 A, 5 A, 10 A, 15 A, 20 A
Average[1]	Set average time: 5 s, 10 s, 30 s
Temp conversion	Temperature conversion: Disable, Enable
Reference temp	(If Temp conversion enabled) Reference temperature: 25 °C, 75 °C, 85 °C, Custom value
Measured temp	(If Temp conversion enabled) Measured temperature: Custom value
Winding material	(If Temp conversion enabled) Transformer winding material: Copper, Aluminium, Custom

Material temp	(If Temp conversion enabled and Winding material set to Custom) Material reference temperature: Custom value

[1] Pre-defined value is 10 s.

11.3.2.1 Three-phase transformers with OLTC

When parameter *TC type* is set to OLTC (On Load Tap Changer), the instrument will automatically change tap position and winding resistances will be measured at each tap and on all three windings respectively. Parameter *Number of taps* defines total number of taps that will be automatically tested (on each winding). Instrument will start winding resistance measurement at tap position 1, thus the user shall manually set OLTC to tap 1 before the start of the measurement.

When measuring winding resistances with tap changer in OLTC mode, Tap changer control cable should be connected to MI 3281 WR Analyser terminal (TAP CHANGER) and to OLTC control unit.

Connecting a 3-phase transformer with OLTC / NLTC to MI 3281

Three-phase transformer with tap changer winding resistance measurement procedure - OLTC

- Prior the measurement, manually set the OLTC to position 1.
- Connect H-side test cable to H socket or X-side test cable to X socket on MI 3281 WR Analyser.
- Connect Kelvin test crocodiles to coloured wire terminals. H terminals with H0 black, H1 yellow, H2 white and H3 green wires (high voltage side) or X terminals with X0 black, X1 yellow, X2 white and X3 green wires (low voltage side) are required for three-phase transformer winding resistance measurement. Each wire terminal should be connected to separate handle terminal of Kelvin test crocodiles.
- Connect Kelvin test crocodiles to the transformer windings, according to the relevant Vector group.
- Use Carbine clips with strings to secure test cables and Kelvin test crocodiles against accidental disconnection (optional).
- Connect Tap changer control cable to WR Analyser MI 3281 TAP CHANGER terminal and to the Tap changer control unit terminals.
- Select AUTO R (3 Phases) test function.

- Set parameters *H-X Configuration* and *Vector Group.*
- Set *TC type* to OLTC.
- Set parameter *Taps location.* Set according to the test connection.
- Set parameter *Number of taps.*
- Set parameter *Test current.*
- Set parameter *Average.*
- Set *Temp conversion* to Disable or Enable. (Refer to chapter *Temperature conversion* for more information.)
- Press the Run key to start the measurement.
- After Connection test, winding resistance measurements are caried out in a sequential order, starting with R_{10} or R_{12} (H or X-side) at tap position 1 and ended with R_{30} or R_{31} (H or X-side) at highest tap position, as defined in test parameters and flow chart below. Wait until the measurement stops automatically or proceed with steps manually, when result is stabilised. After the whole transformer is tested, the phase resistances R_A, R_B, R_C or R_a, R_b, R_c are calculated and displayed on the separate screen. Wait until discharge is finished.
- Use left/right arrow keys to switch between multiple measurement result screens: winding resistances, winding currents, phase winding resistances and chart view. (optional)
- Save results. (optional)
- Disconnect in reverse order.
- After the measurement OLTC will remain in last set position. Set OLTC position accordingly.

Measurement sequence (presented in the figure below) starts at winding A and tap 1 (user has to set tap-changer in tap position 1 prior to the measurement). Instrument charges winding A and all tap positions are tested sequentially from tap position 1 up to user defined number of taps. After the measurement, discharge of winding A is performed. Next, instrument charges winding B and all tap positions are tested sequentially from user defined number of taps down to tap position 1. After the measurement, discharge of winding B is performed. At last, instrument charges winding C and all tap positions are tested sequentially from tap position 1 up to user defined number of taps. After the measurement discharge of winding C is performed.
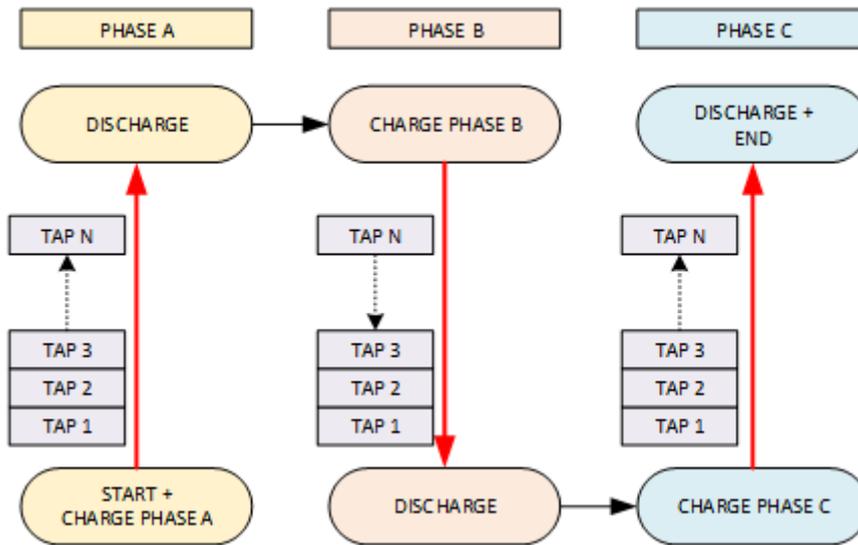
AUTO R (3 phases) OLTC measurement - flow chart

After completing the measurement, the test results are presented on four result pages. First result page represents multiple screens with winding resistances for each tap position, page two represents multiple screens with measurement currents for each tap position, page three represents multiple screens with calculated phase winding resistances for each tap position and page four represents single chart screen with view of winding resistances vs tap position for all three winding resistances. To toggle between tap positions scroll down the Control panel and tap on up and down keys. To toggle between results (at **different tap positions) press "Up" or "Down" keys or scroll down the Control panel and tap on up or down virtual keys. To switch between result pages, press "Left" or "Right" keys or** scroll down the Control panel and tap on left or right keys. Tap on chart set cursor position, that can be used for detailed analysis. If temperature conversion was enabled, the winding resistances and phase winding resistances are already converted to a desired reference temperature.

AUTO R (3 Phase) result screen - Resistance list view

AUTO R (3 Phase) result screen - Current list view

AUTO R (3 Phase) result screen – Phase resistance list view
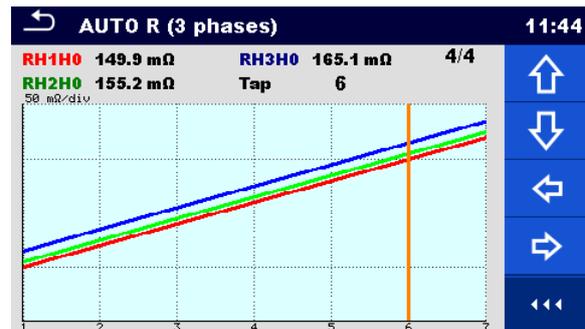
AUTO R (3 Phase) result screen - Chart view

Warning!
- Do not disconnect test leads during testing. Wait until results are shown on the screen and discharge is finished. Removing test crocodiles prior that can result in high voltage spike, potentially hazardous electric shock and a permanent damage of testing equipment.

Notes
- Consider displayed warnings and messages when starting the measurement!
- Test current should not be set to more than 10 % of transformers winding rated current.

11.3.2.2   Three-phase transformers with NLTC

When parameter *TC type* is set to NLTC, the instrument will measure winding resistances of transformer taps manually. Instrument will not control tap changer. Tap positions on transformer has to be manually changed prior to each sub-measurement. Parameter *Number of taps* defines number of all taps that can be tested. Advantage of this test is that sequence of measurements at different tap positions is not specified, and can be tested randomly. Test results will be sorted automatically, according to the tap number from 1 to last tap.

Three-phase transformer with tap changer winding resistance measurement procedure - NLTC
- Connect H-side test cable to H socket or X-side test cable to X socket on MI 3281 WR Analyser.
- Connect Kelvin test crocodiles to coloured wire terminals. H terminals with H0 black , H1 yellow , H2 white and H3 green wires (high voltage side) or X terminals with X0 black , X1 yellow , X2 white and X3 green wires (low voltage side) are required for three-phase transformer winding resistance measurement. Each wire terminal should be connected to separate handle terminal of Kelvin test crocodiles.
- Connect Kelvin test crocodiles to the transformer windings, according to the relevant Vector group.
- Use Carbine clips with strings to secure test cables and Kelvin test crocodiles against accidental disconnection (optional).
- Select AUTO R (3 Phases) test function.
- Set parameters *H-X Configuration* and *Vector Group.*
- Set *TC type* to NLTC.

- Set parameter *Taps location.* Set according to the test connection.
- Set parameter *Number of taps.*
- Set parameter *Test current.*
- Set parameter *Average.*
- Set *Temp conversion* to Disable or Enable. (Refer to chapter *Temperature conversion* for more information.)
- Press the Run key to initiate the measurement.
- Wait for Connection check to pass.
- Set tap position on the instrument with up and down keys and press Run key for winding resistance measurement at selected tap position.
- Wait until all measuring steps are completed, measuring results are calculated and discharge is finished.
- Switch tap position on the tap changer.
- Set new tap position on the instrument with up and down keys and press Run key for winding resistance measurement at new tap position.
- Wait until all measuring steps for new tap are completed, measuring results for new tap are calculated and discharge is finished.
- Repeat procedure for all tap positions.
- Stop the measurement. (Press ESC key, or TAB key followed by ENTER key, when all taps are tested.)
- Use left/right arrow keys to switch between four measurement result pages: winding resistances, winding currents, phase winding resistances, and chart view. (optional)
- Save results. (optional)
- Disconnect in reverse order.

Warnings!
- Do not disconnect test leads during testing. Wait until results are shown on the screen and discharge is finished. Removing test crocodiles prior that can result in high voltage spike, potentially hazardous electric shock and a permanent damage of testing equipment.
- Do not change the tap position during the active measurement. Always wait until the instrument is done with the discharge.

Notes
- Consider displayed warnings and messages when starting the measurement!
- Test current should not be set to more than 10 % of the winding rated current.

11.4 **Demagnetization**

Winding resistance measurements on a single-phase transformers or three-phase transformers uses DC current that magnetize the core of a transformer. Transformers with magnetized core causes high inrush currents in normal operation, so this should be avoided. Therefore, it is recommended to demagnetize the transformer core after all winding resistance measurements are completed.
MI 3281 WR Analyser can demagnetize single-phase transformers as well as three-phase transformers using initial demagnetization currents from 1 A to 20 A. Demagnetization

routine starts by applying initial DC demagnetization current on transformer winding that is sequentially reduced and its polarity reversed up to very low currents.

11.4.1 Single-phase demagnetization

Core demagnetization of a single-phase transformer can be performed by selecting test function Demagnetization (1 phase). Single-phase transformer core can be demagnetized using high voltage winding (H) or low voltage winding (X) regarding to parameter *Side to measure*. Initial *Test current* should be selected for the routine. For the core demagnetization using high voltage side of a single-phase transformer, connect H-side test cable to H test connector and for the core demagnetization using low voltage side of a single-phase transformer, connect X-side test cable to X test connector on the MI 3281 WR Analyser. Only H0 `black`, H1 `yellow` wire terminals (high voltage side) or X0 `black`, X1 `yellow` wire terminals (low voltage side) are required for demagnetization of a single-phase transformer. Use Kelvin test crocodiles and connect each pair of coloured wire terminals to each crocodile. Use Kelvin test principle (one wire should be connected to terminal on one handle, the second wire should be connected to terminal on the other handle of Kelvin test crocodile. Orientation is not relevant. Connect Kelvin test crocodiles to the transformer as described in figure below.
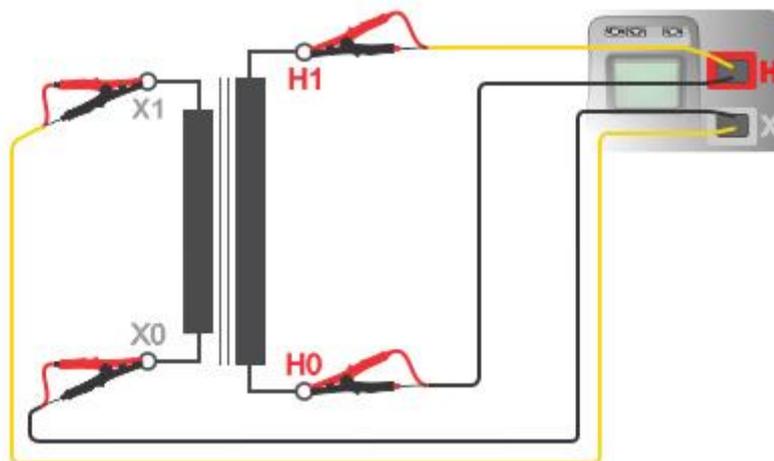
Demagnetization - Connection of a 1-phase transformer to MI 3281

Single-phase transformer's core demagnetization can be performed from Demagnetization (1 phase) window. Before carrying out the routine the following parameters (Side to measure, Test current) can be edited.
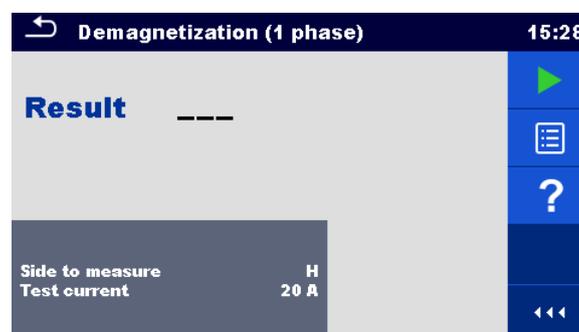
Demagnetization (1 phase) start screen

Test parameters for single-phase transformer demagnetization

Side to measure	Set transformer side for demagnetization routine: H, X
Test current	Set initial demagnetization current: 1 A, 5 A, 10 A, 15 A, 20 A

Single-phase transformer core demagnetization

- Connect H-side test cable to H socket or X-side test cable to X socket on MI 3281 WR Analyser.
- Connect Kelvin test crocodiles to coloured wire terminals. Only H terminals with H0 black, H1 yellow wires or X terminals with X0 black, X1 yellow wires are required for single-phase transformer demagnetization. Each wire terminal should be connected to separate handle terminal of Kelvin test crocodiles.
- Connect Kelvin test crocodiles to the required transformer winding(s). See connection figure above.
- Use Carbine clips with strings to secure test cables and Kelvin test crocodiles against accidental disconnection.
- Select test function Demagnetization (1 Phase).
- Set parameter *Side to measure.*
- Set parameter *Test current.*
- Press the Run key to start the routine.
- Wait until the test result is displayed on the screen and discharge is finished.
- Save results (optional).
- Disconnect in reverse order.

During the demagnetization routine, progress screen represents demagnetization current.
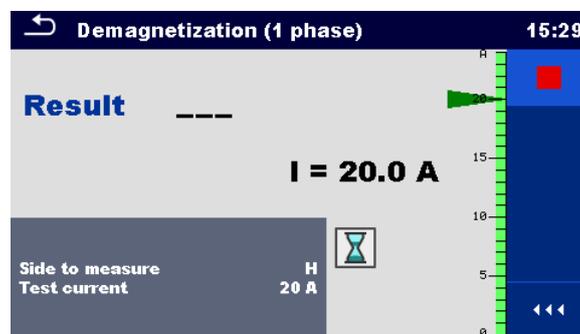
Demagnetization (1 Phase) - Progress indication

After the demagnetization routine is completed, result is presented as "Pass ". If the demagnetization was stopped by the user or interrupted in any other way, the result would be "Fail".

Demagnetization (1 Phase) - Result screen

Warning!

- Do not disconnect test leads during testing. Wait until results are shown on the screen and discharge is finished. Removing test crocodiles prior that can result in high voltage spike, potentially hazardous electric shock and a permanent damage of testing equipment.

Notes

- Consider displayed warnings and messages when starting the measurement!
- It is recommended, that the selected *Test current* is the same as it was during the winding resistance measurements.
- Demagnetization with currents less than 1 A are not supported.

11.4.2 Three-phase demagnetization

Demagnetization of the three-phase transformers can be performed by selecting test function Demagnetization (3 phases). Three-phase transformer core can be demagnetized using high voltage winding (H) or low voltage winding (X) regarding to parameter *Side to measure*. Initial *Test current* should be selected for the routine. For three-phase transformer core demagnetization, H0 black , H1 yellow , H2 white and H3 green wire terminals (high voltage side) or X0 black , X1 yellow , X2 white and X3 green wire terminals (low voltage side) are required. Use Kelvin test crocodiles and connect each pair of coloured wire terminals to each crocodile. Use Kelvin test principle (one wire should be connected to terminal on one handle, the second wire should be connected to terminal on the other handle of Kelvin test crocodile. Orientation is not relevant. Connect Kelvin test crocodiles to the transformer according to the figure below.
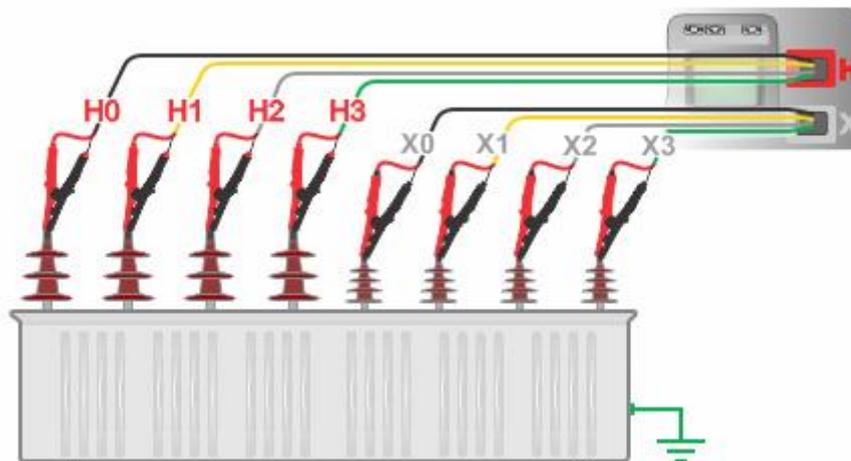
Demagnetization - Connection of a 3-phase transformer to MI 3281

Three-phase transformer's core demagnetization can be performed from Demagnetization (3 phases) window. Before carrying out the routine the following parameters (H-X Configuration, Vector Group, Side to measure, Test current) can be edited.
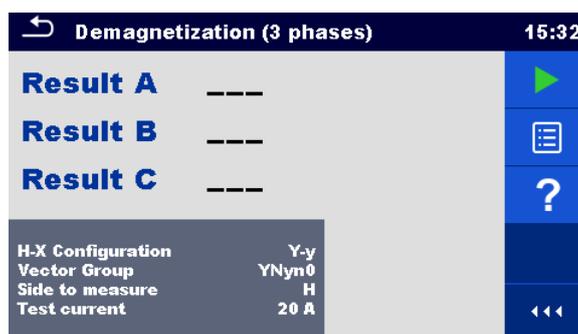
Demagnetization (3 Phases) start screen

Test parameters for three-phase transformer demagnetization

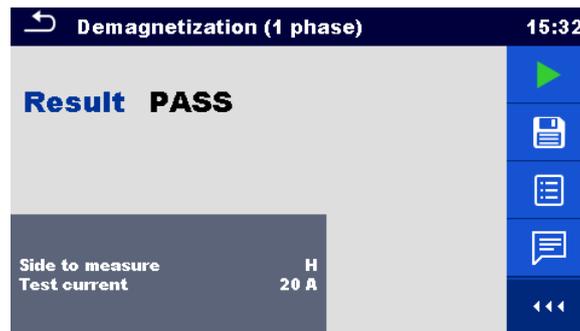| H-X Configuration	Set Configuration of transformer: *D-d, D-y, D-z, Y-y, Y-d or Y-z*
Vector Group	Set Vector Group: (See *Vector groups* for details)
Side to meas.	Set transformer side for demagnetization routine: H, X
Test current	Set initial demagnetization current: 1 A, 5 A, 10 A, 15 A, 20 A

Three-phase transformer core demagnetization
- Connect H-side test cable to H socket or X-side test cable to X socket on MI 3281 WR Analyser.
- Connect Kelvin test crocodiles to coloured wire terminals. H terminals with H0 black, H1 yellow, H2 white and H3 green wires (high voltage side) or X terminals with X0 black, X1 yellow, X2 white and X3 green wires (low voltage side) are required for three-phase transformer core demagnetization. Each wire terminal should be connected to separate handle terminal of Kelvin test crocodiles.
- Connect Kelvin test crocodiles to the transformer windings, according to the relevant Vector group.

- Use Carbine clips with strings to secure test cables and Kelvin test crocodiles against accidental disconnection.
- Select test function Demagnetization (3 phases).
- Set parameters *H-X Configuration* and *Vector Group.*
- Set parameter *Side to measure.*
- Set parameter *Test current.*
- Press the Run key to start the routine.
- Wait until all test results are displayed on the screen and discharge is finished.
- Save results (optional).
- Disconnect in reverse order.

During the demagnetization routine, progress screen represents demagnetization current. Demagnetization routine is sequential for each phase of three-phase transformer.
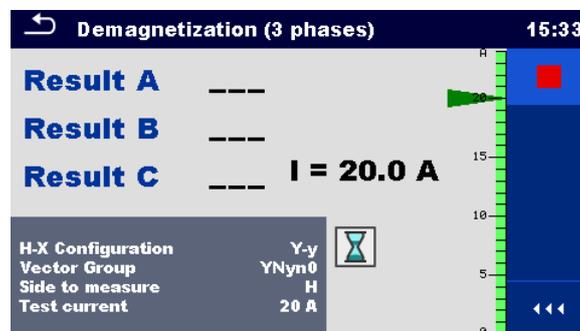
Demagnetization (3 Phases) - Progress indication

After the demagnetization routine is done, result is presented as "Pass ". If the demagnetization was stopped by the user or interrupted in any other way, the result would be "Fail".

*Demagnetization (1 Phase) - Result screen*

Warning!
- Do not disconnect test leads during testing. Wait until results are shown on the screen and discharge is finished. Removing test crocodiles prior that can result in high voltage spike, potentially hazardous electric shock and a permanent damage of testing equipment.

Notes
- Consider displayed warnings and messages when starting the measurement!
- It is recommended, that the selected *Test current* is the same as it was during the winding resistance measurements.
- Demagnetization with currents less than 1 A is not supported.

12 Auto Sequences®

Pre-programmed sequences of measurements can be carried out in Auto Sequences menu. The sequence of measurements, their parameters and flow of the sequence can be programmed. The results of an Auto Sequence can be stored in the memory together with all related information.

Auto Sequences can be pre-programmed on PC with the Metrel ES Manager software and uploaded to the instrument. On the instrument, parameters and limits of individual single test in the Auto Sequence can be changed / set.

12.1 **Selection of Auto Sequences®**

The Auto Sequence list from Auto Sequence groups menu should be selected first. Refer to chapter *Auto Sequence® groups* for more details.

12.1.1 Selecting an active Auto Sequence® group in Auto Sequences® menu

Auto Sequences and Auto Sequence groups menus are interconnected so an active Auto Sequence group can also be selected in the Auto Sequences menu.

Procedure
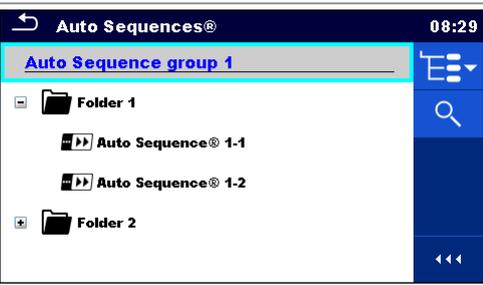
①		Tap on the active Auto Sequence group header in Auto Sequences menu.
②		Opens a list of Auto Sequence groups in Control panel.
③		Selects desired Auto Sequence group from a list of groups.
④		Confirms a new selection.
⑤		New Auto Sequence group is selected and all Auto Sequences within that group are displayed on the screen.
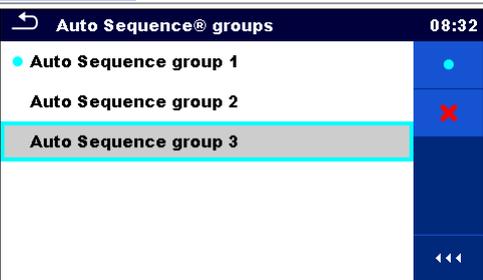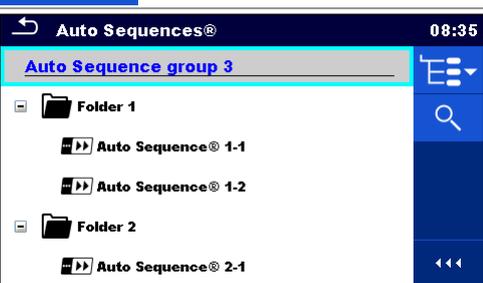
12.1.2 Searching in Auto Sequences® menu

In Auto Sequences menu it is possible to search for AutoSequences on base of their Name or Short code.

Procedure

①		Search function is available from the active Auto Sequence group header line.
②		Select Search in Control panel to open Search setup menu.
		The parameters that can be searched for are displayed in the Search setup menu.
③a		The search can be narrowed by entering a text in the Name and Short code fields. Text can be entered by using on-screen keypad.
③b		Clears all filters. Sets filters to default value.
④		Searches through the active Auto Sequence group according to the set filters. The results are shown in the Search results screen, presented in figures below.
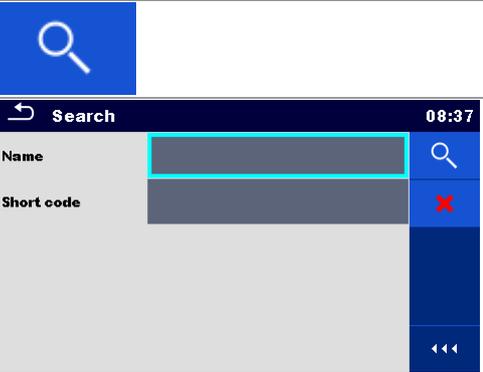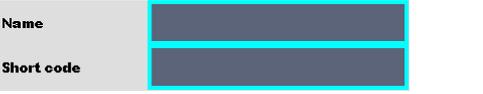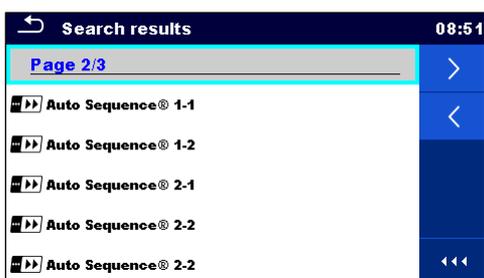
Search results screen - Header selected
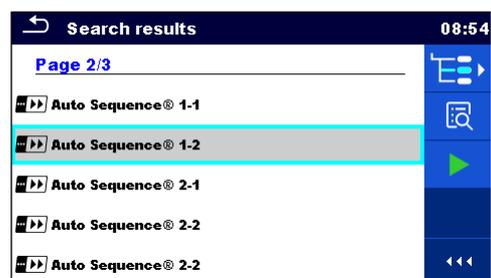
Search results screen - Auto Sequence selected

Options

>	Next page.
<	Previous page.
(icon)	Goes to location in Auto sequences menu.
(icon)	Goes to Auto Sequence view menu.
▶	Starts the selected Auto Sequence.

Note
- Search result page consist of up to 50 results.

12.1.3 Organization of Auto Sequences® in Auto Sequences® menu

The Auto Sequences to be carried out can be selected from the Main Auto sequences menu. This menu can be organized in a structural manner with folders, sub-folders and Auto Sequences. Auto Sequence in the structure can be the original Auto Sequence or a shortcut to the original Auto sequence.
Auto Sequences marked as shortcuts and the original Auto Sequences are coupled. Changing of parameters or limits in any of the coupled Auto sequences will influence on the original Auto Sequence and all its shortcuts.
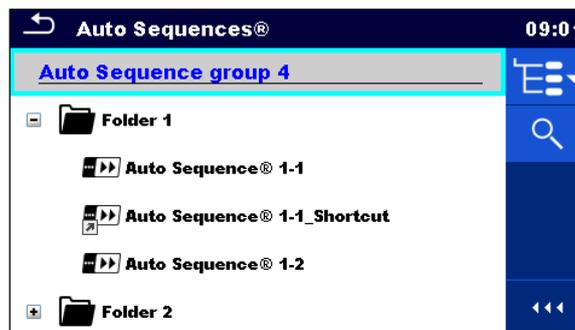
Example of organized Auto sequences in main Auto Sequences menu

Options

(icon)	The original Auto Sequence.
(icon)	A shortcut to the original Auto Sequence.
▶	Starts the selected Auto Sequence. The instrument immediately starts the Auto Sequence.

	Enters menu for more detail view of selected Auto Sequence. This option should also be used if the parameters / limits of the selected Auto Sequence have to be changed.

12.2 **Organization of an Auto Sequence®**

An Auto Sequence is divided into three phases:
- Before starting the first test the Auto Sequence view menu is shown (unless it was started directly from the Main Auto Sequence menu). Parameters and limits of individual measurements can be set in this menu.
- During the execution phase of an Auto Sequence, pre-programmed single tests are carried out. The sequence of single tests is controlled by pre-programmed flow commands.
- After the test sequence is finished the Auto Sequence result menu is shown. Details of individual tests can be viewed and the results can be saved to Memory organizer.

12.2.1 Auto Sequence® view menu

In the Auto Sequence view menu, the header and the single tests of selected Auto Sequence are displayed. The header contains the name and description of the Auto Sequence. Before starting the Auto Sequence, test parameters / limits of individual measurements can be changed.

Auto Sequence view menu (header is selected)

Legend

1 Single test
2 Header
3 Auto Sequence® name
4 Description of Auto Sequence®
5 Options
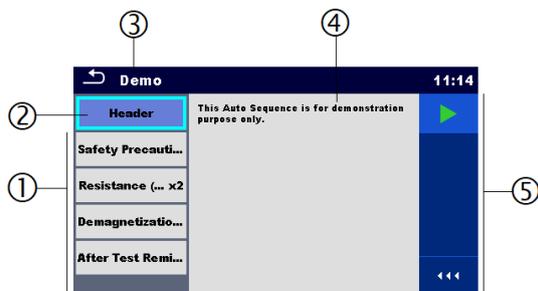
Auto Sequence view menu - Header selected

Options

	Starts the Auto Sequence.

12.2.1.1Auto Sequence® view menu (measurement is selected)

Auto Sequence view menu (measurement is selected)
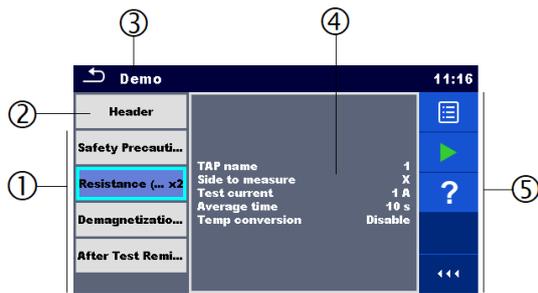
Legend

1 Single tests
2 Header
3 Auto Sequence® name
4 Parameters and limits of selected single test
5 Options

Auto Sequence view menu - Measurement selected

Options

	Selects single test.
	Opens menu for changing parameters and limits of selected measurements. Refer to chapter *Setting parameters and limits of single tests* for more information how to change measurement parameters and limits.
	Starts the Auto Sequence.

Indication of Loops

The attached 'x2' at the end of single test name indicates that a loop of single tests is programmed. This means that the marked single test will be carried out as many times as the **number behind the 'x'** indicates. It is possible to exit the loop before, at the end of each individual measurement.

12.2.2 Step by step executions of Auto Sequences®

While the Auto Sequence is running, it is controlled by pre-programmed flow commands. Examples of actions controlled by flow commands are:
- pauses during the test sequence
- buzzer (Pass / Fail sound after the tests)
- proceeding of test sequence in regard to measured results

The actual list of flow commands is available on chapter *Description of flow commands*.
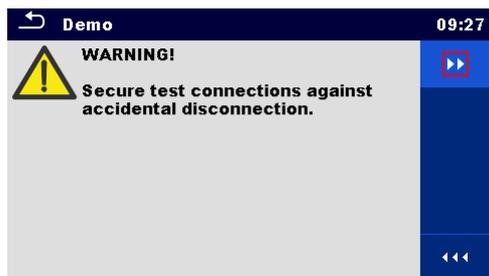
Auto Sequence - Example of a pause with message
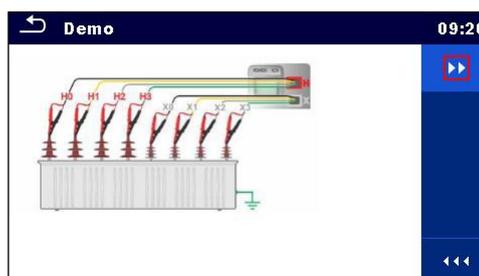
Auto Sequence - Example of a pause with picture

Auto Sequence - Example of a finished measurement with options for proceeding

Options (during execution of an Auto Sequence)

▶▶	Proceeds to the next step in the test sequence.
↻	Repeats the measurement. Displayed result of a single test will not be stored.
■	Ends the Auto Sequence and goes to Auto Sequence result screen.
⟳✗	Exits the loop of single tests and proceeds to the next step in the test sequence.
▤	View parameters and limits of a measurement.
👆 on [TAP name 1 / Side to measure X / Test current 1 A / Average 10 s / Temp conversion Disable]	
🗩	Adds comment. The instrument opens keypad for entering a comment to a current measurement.

Note
- The offered options in Control panel depends on the selected single test, its result and the programmed test flow.

12.2.3 Auto Sequence® result screen

After the Auto Sequence is finished, the Auto Sequence result screen is displayed. At the left side of the display the single tests and their statuses in the Auto Sequence are shown. In the middle of the display the header of the Auto Sequence is displayed. At the top the overall Auto Sequence status is displayed. Refer to chapter *Measurement statuses* for more information.

Auto Sequence result screen
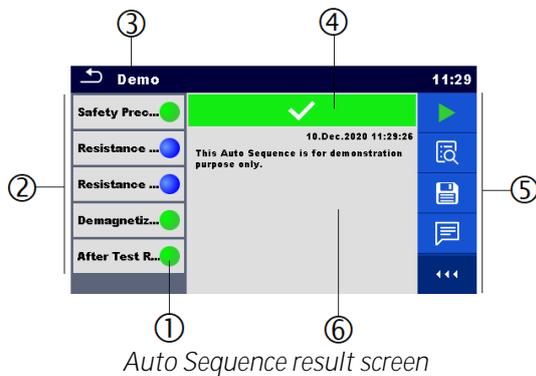
Legend

1 Status of single tests
2 Single tests
3 Auto Sequence® name
4 Overall status of Auto Sequence®
5 Options
6 Description and time-stamp of Auto Sequence®

Options

▶	Starts a new Auto Sequence.
🔍	View results of individual measurements. The instrument goes to menu for viewing details of the Auto Sequence.
💾	Saves the Auto Sequence results. A new Auto Sequence was selected and started from a Structure item in the structure tree: • The Auto Sequence will be saved under the selected Structure item. A new Auto Sequence was started from the Auto Sequence main menu: • Saving under the last selected Structure item will be offered by default. The user can select another Structure item or create a new Structure item. By pressing 💾 in Memory organizer menu the Auto Sequence is saved under selected location. An empty measurement was selected in structure tree and started: • The result(s) will be added to the Auto Sequence. The Auto **Sequence will change its overall status from 'empty' to 'finished'.** An already carried out Auto Sequence was selected in structure tree, viewed and then restarted: • A new Auto Sequence will be saved under the selected Structure item.
💬	Adds comment. The instrument opens keypad for entering a comment to Auto Sequence result.

Options in menu for viewing details of Auto Sequence results

	Details of selected single test in Auto Sequence are displayed.
	View parameters and limits of selected single test.
on	

TAP name	1
Side to measure	X
Test current	1 A
Average	10 s
Temp conversion	Disable

	Adds comment to selected single test result. View / edit comment to selected single test result, when recalled from memory.
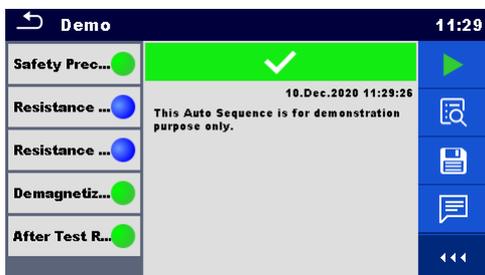
Details of menu for viewing details of Auto Sequence results
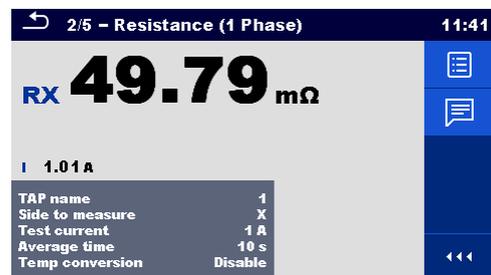
Details of single test in Auto Sequence result menu

12.2.4 Auto Sequence® memory screen

In Auto Sequence memory screen details of the Auto Sequence can be viewed and a new Auto Sequence can be restarted.
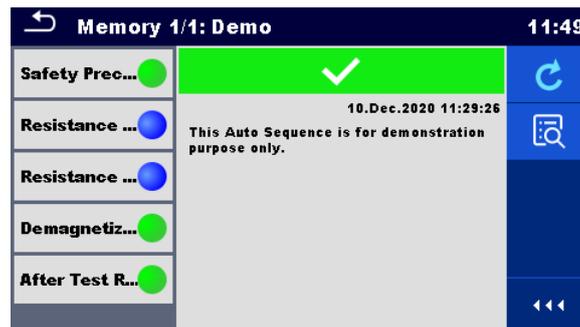
Auto Sequence memory screen

Options

	Retest the Auto Sequence.
	Enters menu for viewing details of the Auto Sequence.

13 Communication

The instrument can communicate with the Metrel ES Manager PC software. The following action is supported:
- Saved results and Tree structure from Memory organizer can be downloaded and stored to a PC.
- Tree structure and Auto Sequences® from Metrel ES Manager PC software can be uploaded to the instrument.

Metrel ES Manager is PC software running on Windows 8.1, Windows 10, and Windows 11. There are two communication interfaces available on the instrument: USB and Bluetooth.

How to establish an USB link:
- Connect a PC USB port to the instrument USB connector using the USB interface cable.
- Switch on the PC and the instrument.
- Run the Metrel ES Manager software.
- **Set the desired communication port. (COM port is identified as "USB Serial Port".)**
- If not visible, make sure to install the correct USB driver (see notes).
- The instrument is prepared to communicate with the PC over USB.

Bluetooth communication
The internal Bluetooth module enables easy communication via Bluetooth with PC and Android devices.

How to configure a Bluetooth link between instrument and PC:
- Switch On the instrument.
- On PC configure a Standard Serial Port to enable communication over Bluetooth link between instrument and PC.
- Run the Metrel ES Manager software.
- Set the configured communication port.
- The instrument is prepared to communicate with the PC over Bluetooth.

Notes
- USB drivers should be installed on PC before using the USB interface. Refer to USB installation instructions available on installation CD or download the drivers from the http://www.ftdichip.com website (MI 3281 is using the FT232RL chip).
- The name of correctly configured Bluetooth device must consist of the instrument type plus serial number, eg. MI 3281-12345678I.

14 Maintenance

Unauthorized persons are not allowed to open the MI 3281 WR Analyser instrument. There are no user replaceable components inside the instrument.

14.1 **Cleaning**

Regularly inspect and clean air intake and air outlet ventilation openings. Use dry vacuum cleaner. To clean the surface of the instrument, use a soft cloth slightly moistened with soapy water or alcohol. Then leave the instrument to dry totally before use.

Warnings!
- Do not use liquids based on petrol or hydrocarbons!
- Do not spill cleaning liquid over the instrument!

14.2 **Periodic calibration**

It is essential that the test instrument is regularly calibrated in order that the technical specification listed in this manual is guaranteed. We recommend an annual calibration. Only an authorized technical person can do the calibration. Please contact your dealer for further information.

14.3 **Fuses**

There are two fuses accessible from front panel:

- F1, F2   T 6.3 A / 250 V (32 mm × 6.3 mm) / 1500 A: intended for instrument mains power supply circuit protection.

If the instrument does not respond after connection to mains supply (with power switch in ON position), disconnect the mains supply and accessories and then check the fuses. For position of fuses see figure in chapter ***Operator's panel***.

Warnings!
- Switch off the instrument and disconnect all test accessories and mains cord before replacing the fuses.
- Replace blown fuse with the same type.

14.4 **Service**

For repairs under warranty, or at any other time, please contact your distributor.

14.5 **Upgrading the instrument**

The instrument can be upgraded from a PC via the USB communication port. This enables to keep the instrument up to date even if the standards or regulations change. The firmware upgrade requires internet access and can be carried out from the Metrel ES Manager software with a help of special upgrading software – FlashMe that will guide you through the upgrading procedure. For more information, refer to Metrel ES Manager Help file.

Note
- See chapter *Communication* for details on USB driver installation.

15 Technical specifications

15.1 **Winding resistance**

Measurement principle: ....Voltage / Current measurement

Winding resistance (H, X) - RH, RX, R_{10}, R_{20}, R_{30}, R_{12}, R_{23}, R_{31}

Test current	Measuring range	Resolution	Uncertainty
20 A, 15 A, 10 A	10.0 μΩ ... 1999.9 μΩ	0.1 μΩ	±0.25 % Rdg ±0.1 % Range
	2.000 mΩ ... 19.999 mΩ	1 μΩ	
	20.00 mΩ ... 199.99 mΩ	10 μΩ	
	200.0 mΩ ... 1999.9 mΩ	100 μΩ	
5 A, 1 A	0.100 mΩ ... 19.999 mΩ	1 μΩ	±0.25 % Rdg ±0.1 % Range
	20.00 mΩ ... 199.99 mΩ	10 μΩ	
	200.0 mΩ ... 1999.9 mΩ	100 μΩ	
	2.000 Ω ... 19.999 Ω	1 mΩ	
100 mA	1.00 mΩ ... 199.99 mΩ	10 μΩ	±0.25 % Rdg ±0.1 % Range
	200.0 mΩ ... 1999.9 mΩ	100 μΩ	
	2.000 Ω ... 19.999 Ω	1 mΩ	
	20.00 Ω ... 199.99 Ω	10 mΩ	
10 mA	10.0 mΩ ... 1999.9 mΩ	100 μΩ	±0.25 % Rdg ±0.1 % Range
	2.000 Ω ... 19.999 Ω	1 mΩ	
	20.00 Ω ... 199.99 Ω	10 mΩ	
	200.0 Ω ... 999.9 Ω	100 mΩ	
	1.000 kΩ ... 9.999 kΩ	1 Ω	±2 % Rdg ±2 % Range

Resistance display range:
@ 20 A, 15 A, 10 A ....0.0 μΩ ... 1999.9 mΩ
@ 5 A, 1 A...0.000 mΩ ... 19.999 Ω
@ 100 mA ....0.00 mΩ ... 199.99 Ω
@ 10 mA ....0.0 mΩ ... 9.999 kΩ

Uncertainty (R_A, R_B, R_C, R_a, R_b, R_c) ....calculated value
(consider uncertainty of R_{10}, R_{20}, R_{30}, R_{12}, R_{23}, R_{31})
Test current accuracy: ±15 % (smoothed DC).

R definition ....winding resistance
Test mode...single
Test method...4-wire
Test voltage shape ....DC voltage (current)

Open-terminal test voltage .... < 30 Vdc
Max. short-circuit test current .... ≈ **20 A**

Automatic range selection .... yes
Automatic test current selection .... no
Automatic discharge .... yes

15.2 **General data**

Mains power supply .... 100 V_{AC} ... 240 V_{AC}, 45 Hz ... 65 Hz, 650 VA
Over-voltage category .... 300 V CAT II

Protection classification........................ Class I
Max. transient over-voltage .... 1500 V

Pollution degree 2
Degree of protection............................. IP 65 (case closed), IP 40 (case open)
Operation .... Outdoor use

Dimensions (w * h * d) .... 47 cm x 19 cm x 37 cm
Weight .... ≈**9.3 kg, (without accessories)**

Visual warnings .... yes
Emergency stop switch .... yes
Display .... 4.3'' (10.9 cm) 480 × 272 pixels TFT colour display
with touch screen

EMC:
Emission .... Class A
Immunity .... Industrial environment

Reference conditions:
Reference temperature range .... 25 °C ± 5 °C
Reference humidity range .... **40 %RH ... 60 %RH**

Operation conditions:
Working temperature range .... **-10 °C ... 40 °C**
Maximum relative humidity .... **80 %RH (0 °C ... 40 °C), non**-condensing
Working nominal altitude .... up to 4000 m

Storage conditions:
Temperature range................................ **-10 °C ... 70 °C**
Maximum relative humidity .... 90 %RH (**-10 °C ... 40 °C**)
80 %RH (40 °C ... 60 °C)

USB communication:
USB slave communication...................... galvanic separated
Baud rate .... 115200 bit/s

Connector...standard USB connector - type B

Bluetooth communication:
Baud rate:...115200 bit/s
Bluetooth module ....class 1

Data:
Memory...>1 GBit
PC software...yes

Fuses:
F1, F2...T 6.3 A / 250 V, (32 mm x 6.3 mm) / 1500 A

Specifications are quoted at a coverage factor of k = 2, equivalent to a confidence level of approximately 95 %.
Accuracies apply for 1 year in reference conditions. Temperature coefficient outside these limits is 0.2 % of measured value per °C, and 1 digit.

16 Appendix A – Structure items

Structure items used in Memory Organizer and relations between them:

or

or

Symbol	Default name	Parameters
	Node	/
	Project	Name (designation) of project, Description (of project);
	Location	Name (designation) of location, Address of location (*Organization, Name, Address, Telephone, Mobile, Fax, Email, Location number, Postcode*), Description of location;
	Client	Name of client, Client (*Organization, Name, Address, Telephone, Mobile, Fax, Email, Client number, Postcode*);
	Transformer	Name, Description, Serial number, Year of production, Nominal voltage, Nominal power, Location, Winding material, Coolant type, Reason for testing (*Periodic, Routine, Malfunction*), Weather condition (*Sunny, Cloudy, Rainy, Snowy, Foggy*), Temperature, Humidity, Next inspection, Comment;

17 Appendix B – Vector groups

17.1 **Vector groups of three-phase transformer**

Configuration, phase relationship, and vector diagrams are necessary to understand in details, in order to obtain correct and credible results.

A detailed explanation and description of terminal markings, phase relationship, and vector diagrams are contained in specification: C57.12.70 American National Standard Terminal Markings and Connections for Distribution and Power Transformers.

The tables on the following pages are guidelines for connecting and testing three-phase transformers.

17.1.1   IEC vector groups

The vector group column is the IEC vector group coding. The number indicates the phase displacement in increments of 30° of the low side winding (X or LV) to the high side (H or HV) winding. For example a D-Y transformer with a Vector group number of 1 would have a phase displacement of 1 x 30° or 30°. The low voltage side (LV) winding has a lagging displacement with respect to the high voltage side (HV) winding.

Phase tested:
The transformer phase that is being tested

H winding & X winding:
The transformer connections that are selected for testing

Example: Dd0, **phase "A" would require H1 & H3 to be tested** and **phase "a" would require X1 & X3 to be tested.**

Markings on transformer terminals can vary with different nomenclature of transformer terminals:

HV (high voltage side):
- H1/ 1U / A
- H2/ 1V / B
- H3/ 1W / C
- H0 / 1N / N

LV (low voltage side):
- X1/ 2U / a
- X2/ 2V / b
- X3/ 2W / c
- X0 / 2N / n

See charts below for more details:

No.	Vector Group	H winding connection	X winding connection	No.	Vector Group	H winding connection	X winding connection
1	Dd0			8	Dyn1		
2	Dd2			9	Dy5		
3	Dd4			10	Dyn5		
4	Dd6			11	Dy7		
5	Dd8			12	Dyn7		
6	Dd10			13	Dy11		
7	Dy1			14	Dyn11		

No.	Vector Group	H winding connection	X winding connection	No.	Vector Group	H winding connection	X winding connection
15	Dz0			22	Dzn6		
16	Dzn0			23	Dz8		
17	Dz2			24	Dzn8		
18	Dzn2			25	Dz10		
19	Dz4			26	Dzn10		
20	Dzn4			27	Yy0		
21	Dz6			28	Yyn0		

No.	Vector Group	H winding connection	X winding connection	No.	Vector Group	H winding connection	X winding connection
29	YNy0			36	YNd1		
30	YNyn0			37	Yd5		
31	Yy6			38	YNd5		
32	Yyn6			39	Yd7		
33	YNy6			40	YNd7		
34	YNyn6			41	Yd11		
35	Yd1			42	YNd11		

No.	Vector Group	H winding connection	X winding connection	No.	Vector Group	H winding connection	X winding connection
43	Yz1			47	Yz7		
44	Yzn1			48	Yzn7		
45	Yz5			49	Yz11		
46	Yzn5			50	Yzn11		

18 Appendix C – Programming of Auto Sequences® on Metrel ES Manager

The Auto Sequence® Editor is a part of the Metrel ES Manager software. In Auto Sequence® Editor, Auto Sequences can be pre-programmed and organized in groups, before uploaded to the instrument.
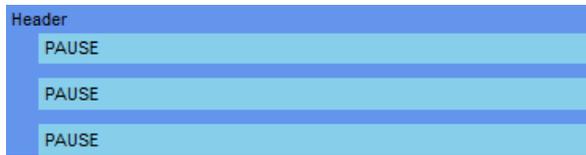
18.1 **Auto Sequence Editor® workspace**

To enter Auto Sequence® **Editor's workspace, select** ![Auto Sequence® Editor] in Home Tab of Metrel ES Manager PC SW. Auto Sequence® Editor workspace is divided in four main areas. On the left side ❶, structure of selected Auto Sequence® group is displayed. In the middle part of the workspace ❷, the elements of the selected Auto Sequence are shown. On the right side, list of available single tests ❸ and list of flow commands ❹ are shown.
Single test area contains three tabs; Measurements, Inspections, and Custom inspections. Custom inspections and their tasks are programmed by user, see chapter *Custom Inspections programming* for procedure.
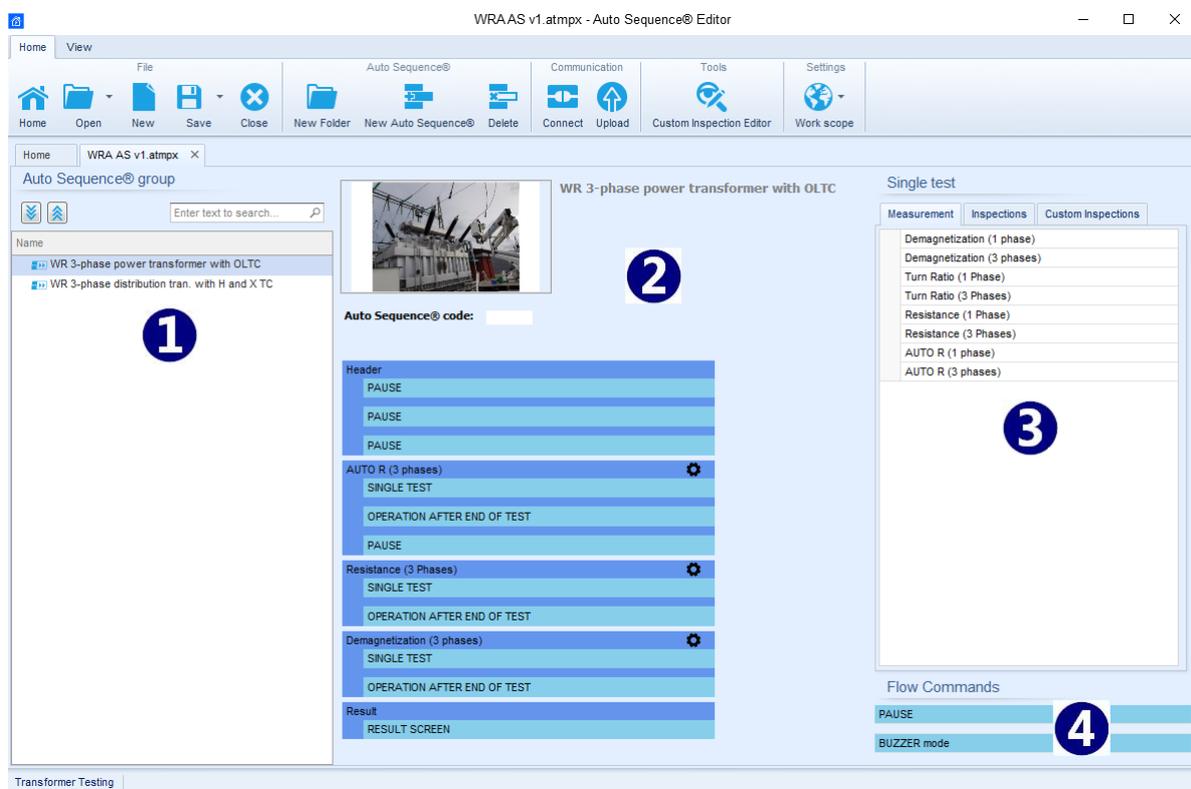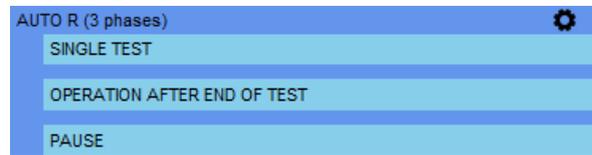

Auto Sequence Editor workspace

An Auto Sequence ❷ begins with Name, Description and Image, followed by the first step (Header), one or more measuring steps and ends with the last step (Result). By inserting appropriate Single tests ❸ and Flow commands ❹ and setting their parameters, arbitrary Auto Sequences can be created.

Header	
PAUSE	
PAUSE	
PAUSE	

Example of an Auto Sequence header

AUTO R (3 phases)	⚙
SINGLE TEST	
OPERATION AFTER END OF TEST	
PAUSE	

Example of a measurement step

| Result |
|---|
| RESULT SCREEN |

Example of an Auto Sequence result part

18.2 **Managing groups of Auto Sequences®**

The Auto Sequences® can be divided into different user defined groups of Auto Sequences®. Each Auto Sequence® Group is stored in a file. More files can be opened simultaneously in Auto Sequence editor.
Within Auto Sequence® Group, tree structure can be organized, with folders / sub-folders containing Auto Sequences®. The tree structure of currently active Auto Sequence® Group is displayed on the left side of the Auto Sequence® Editor workspace, see below.
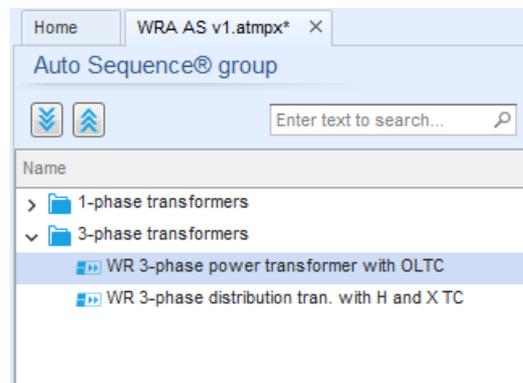
Auto Sequence group - tree organization

Operation options on Files and Auto Sequence® Groups are available from menu bar at the top of Auto Sequence® Editor workspace.

File operation options

🏠	Opens starting Auto Sequence Editor screen.
📂 ▾	Opens a file (Auto Sequence® Group).
📄	Creates a new file (Auto Sequence® Group).

💾 ▾	Saves / Saves as the opened Auto Sequence® Group to a file.
❌	Closes the file (Auto Sequence® Group).

Auto Sequence® Group view options

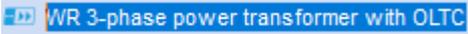|	
⏬	Expands all folders / sub-folders / Auto Sequences.
⏫	Collapses all folders / sub-folders / Auto Sequences.
🔍	Searches by name within the Auto Sequence Group.

Auto Sequence® Group operation options (also available by right clicking on Folder or Auto Sequence®)

📂	Adds a new folder / subfolder to the group
➕	Adds a new Auto Sequence to the group.
➖	Deletes: • the selected Auto Sequence • the selected folder with all sub-folders and Auto Sequences

Right click on the selected Auto Sequence® or Folder opens menu with additional possibilities:

✏️	Auto sequence®: Edit Name, Description and Image. Folder: Edit folder name
📋	Auto Sequence®: Copy to clipboard Folder: Copy to clipboard including sub-folders and Auto Sequences®
📋	Auto Sequence®: Paste it to selected location Folder: Paste it to selected location
🔗	Auto Sequence®: Creates a shortcut to selected Auto Sequence®

Double click on the object name allows name edit

DOUBLE CLICK	Auto Sequence® name: Edit Auto Sequence® name WR 3-phase power transformer with OLTC Folder name: Edit folder name 3-phase transformers
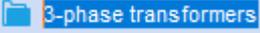
Drag and drop of the selected Auto Sequence® or Folder / Sub-folder moves it to a new location

| DRAG & DROP	**"Drag and drop" functionality is equivalent to "cut" and "paste" in a single move.** ➡️ move to folder ↪️ insert

18.2.1 Auto Sequence® Name, Description and Image editing

When EDIT function is selected on Auto Sequence®, menu for editing presented in figure below appear on the screen.
Editing options are:
- Name: Edit or change the name of Auto Sequence®
- Description: Any text for additional description of Auto Sequence® can be entered.
- Image: Image presenting Auto Sequence® measuring arrangement can be entered or deleted.

|	
...	Enters menu for browsing to Image location.
✗	Deletes the Image from Auto Sequence®.
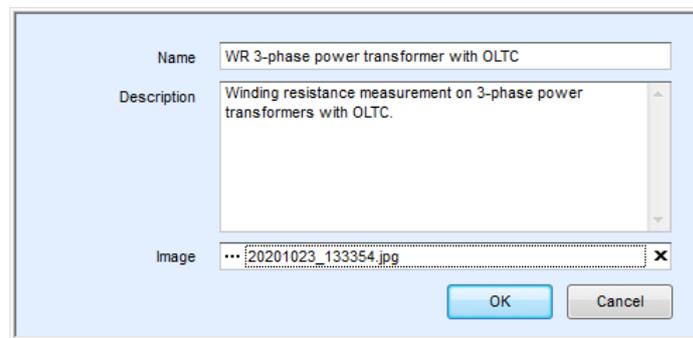
Editing the Auto Sequence Name, Description and Image

18.2.2 Search within selected Auto Sequence® group

When 🔍 function is selected, Search menu as presented on figure below appear on the screen. By entering the text into search box and click on the search 🔍 icon, found results are automatically highlighted with orange colour background. Search functionality is implemented in Folders, Sub-folders and Auto Sequences® of selected Auto Sequence® Group.

Search text can be cleared by selecting the Clear ⊗ button.
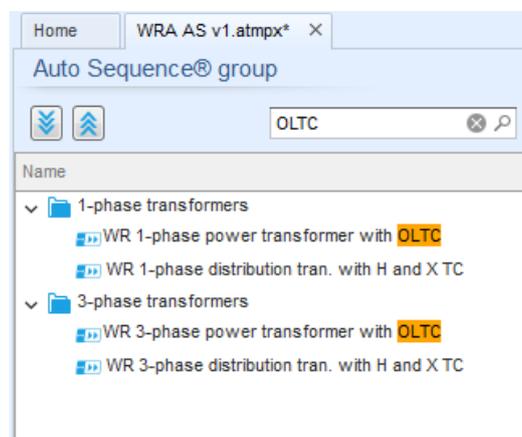
Example of Search result within Auto Sequence group

18.3 **Elements of an Auto Sequence®**

18.3.1 Auto Sequence® steps

There are three kinds of Auto Sequence® steps.

Header
The Header step is empty by default.
Flow commands can be added to the Header step.

Measurement step
The Measurement step contains a Single test and the Operation after end of test flow command by default. Other Flow commands can be added optionally.

Result
The Result step contains the Result screen flow command by default. Other Flow commands can also be added to the Result step.

18.3.2 Single tests

Single tests are the same as in Metrel ES Manager Measurement menu.
Limits and parameters of the measurements can be set. Results and sub-results can't be set.

18.3.3 Flow commands

Flow commands are used to control the flow of measurements. Refer to chapter *Description of flow commands* for more information.

18.3.4 Number of measurement steps

Often the same measurement step has to be performed on multiple points on the device under test. It is possible to set how many times a Measurement step will be repeated. All carried out individual Single test results are stored in the Auto Sequence® result as if they were programmed as independent measuring steps.

18.4 **Creating / modifying an Auto Sequence®**

If creating a new Auto Sequence® from scratch, the first step (Header) and the last step (Result) are offered by default. Measurement steps are inserted by the user.

Options

Adding a measurement step	By double clicking on a Single test a new measurement step will appear as the last of measurement steps. It can also be dragged and dropped on the appropriate position in the Auto sequence®.
Adding flow commands	Selected flow command can be dragged from the list of Flow commands and dropped on the appropriate place in any Auto Sequence® step.

Changing position of flow command within measurement step	By a click on an element and use of 🔼 🔽 keys.
Viewing / changing parameters of flow commands or single tests.	By a double click on the element.
Setting number of measurement step repetitions	By setting a number in the ⚙ field.

Right click on the selected measurement step / flow command

	Copy – Paste before
Copy	A measurement step / flow command can be copied and pasted above selected location on the same or on another Auto Sequence.
Delete	
Paste Before	Copy – Paste after
Paste After	A measurement step / flow command can be copied and pasted under selected location on the same or on another Auto Sequence.
	Delete
	Deletes the selected measurement step / flow command.

18.5 **Description of flow commands**

Double click on inserted Flow Command opens menu window, where text or picture can be entered, external commands can be activated and parameters can be set. Flow commands Operation after end of test and Results screen are entered by default, others are user selectable from Flow Commands menu.

Pause
A Pause command with text message or picture can be inserted anywhere in the measuring steps. Warning icon can be set alone or added to text message. Arbitrary text message can be entered in prepared field Text of menu window.

Pause type	Show text and/or warning (☑ check to show warning icon)
	Show picture (⋯ browse for image path)
Duration	Number in seconds, infinite (no entry)

Buzzer mode
Passed or failed measurement is indicated with beeps.
- Pass – double beep after the test
- Fail – single long beep after the test
Beep happens right after single test measurement.

State	On – enables Buzzer mode
	Off – disables Buzzer mode

Operation after end of test

This flow command controls the proceeding of the Auto Sequence® in regard to the measurement results.

Operation after end of test • pass • fail • no status	The operation can be individually set for the case the measurement passed, failed or ended without a status.	
	Manual	The test sequence stops and waits for appropriate command (Enter key) to proceed.
	Auto	The test sequence automatically proceeds.

Result screen
This flow command controls the proceeding after the Auto Sequence has ended.

| ☑ Auto Save	Auto Sequence results are automatically stored in the momentary workspace. A new Node with the date (month and year) will be created. Under the node, Auto sequence® results will be stored. Up to 100 Auto Sequence® results can be automatically stored under the same node. If more results are available, they are split to multiple nodes. Local Save Flow setting is disabled by default. Note • This flow command is active only if Auto Sequence® is started from the Auto Sequence® Main menu (not from the Memory organizer).

18.6 **Custom Inspections programming**

Arbitrary set of tasks dedicated to specific user defined Inspections can be programmed with application Custom Inspection Editor tool, accessible from Auto Sequence® Editor workspace. Custom Inspections are stored in dedicated file *.indf with user defined name. For application of Custom Inspections as a single test within Auto Sequence® group, appropriate file containing specific Custom Inspections should be opened first. Custom inspections can only be run within Auto Sequences and can't be run as Single tests.

18.6.1 Creating and editing Custom Inspections

Custom Inspection Editor workspace is entered by selecting [Custom Inspection Editor] icon from Auto Sequences® main menu. It is divided in two main areas, as presented on figure below:

- ❶ Custom inspection Name and Scope of inspection (Visual or Functional)
- ❷ Name of Custom Inspection Item tasks and Type of possible Item statuses (Pass / Fail / Checked / Empty)
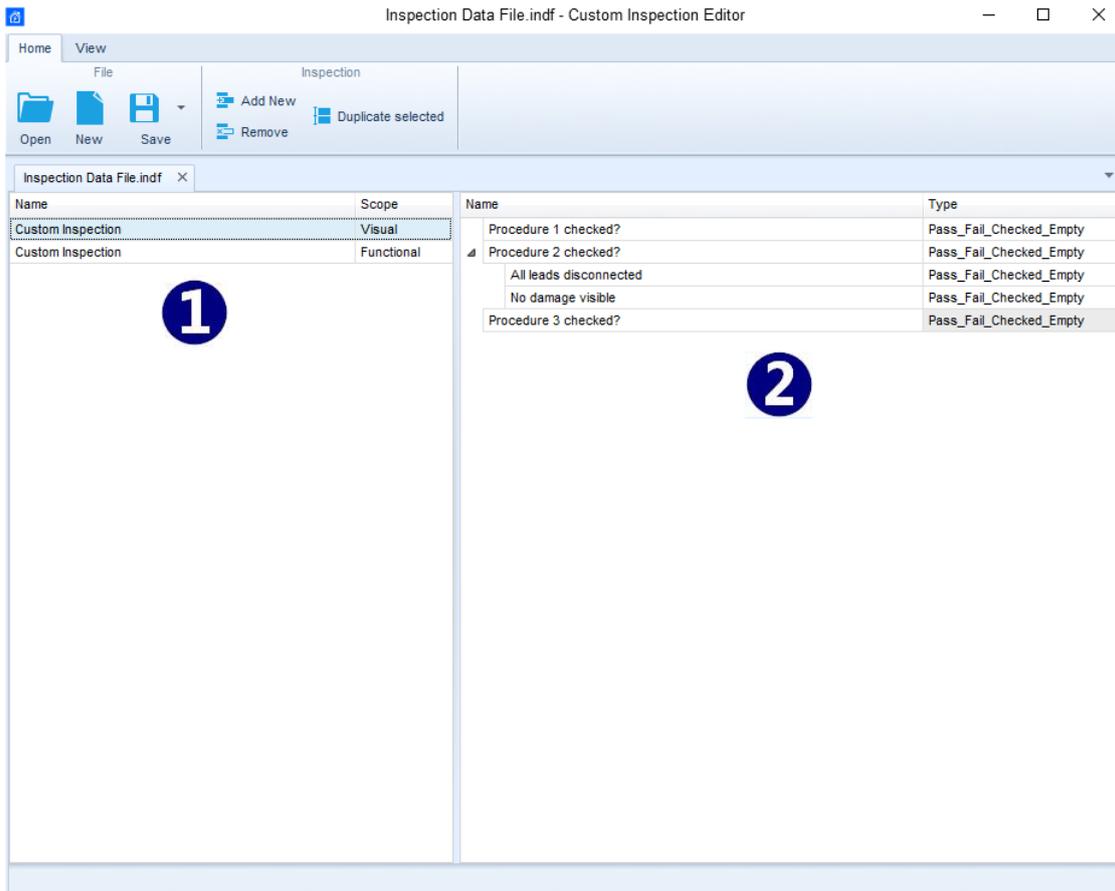
Custom Inspection Editor workspace

Custom Inspection Editor main menu options:

|	
	Opens existing Custom Inspection Data file. By selecting, menu for browsing to location of *.indf file containing one or more Custom Inspections data appear on the screen. Selected file is opened in dedicated tab marked with file name.
	Creates a new Custom Inspection Data file. New tab with empty workspace is opened. Default name of the new tab is *Inspection Data File*; it could be renamed during Save procedure.
	Saves / Saves as a Custom Inspection Data file opened on active tab. Menu for browsing to the folder location and editing of file name is opened. Browse to the location, confirm overwriting, if file already exists or edit file name tosave it as a new Custom Inspection Data file.
	Adds New Custom Inspection. New inspection with default name *Custom Inspection* and default scope *Visual* appear on the editor workspace. It contains one Item task with default name *Custom Inspection* and default Type *Pass_Fail_Checked_Empty*. default Name and Type can be edited - changed.
	Removes selected Custom Inspection.

To select inspection, click to the inspection Name field. To remove it, select icon from Editor main menu. Before removal, user is asked to confirm deletion.

	Duplicates selected Custom Inspection. Selected Custom Inspection including *Scope* and all Custom Inspection items and sub-items, or only selected Custom Inspection Item or sub-item including *Type* can be duplicated.

Edit Name and Scope of Inspection
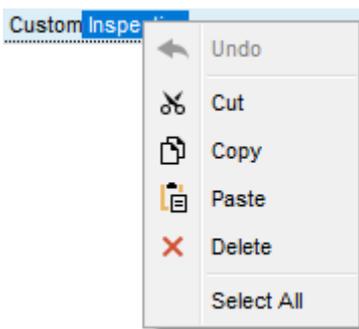
Inspection Name edit

Click to the Inspection Name field to start editing it. Drag cursor, with left mouse button pressed, to select letters and words. Position cursor and double-click to select word of the name. Actions could be performed with keyboard also.
Press right mouse button to activate Edit menu and select appropriate action as presented on the left figure. Menu is case sensitive; options currently not available are greyed out.
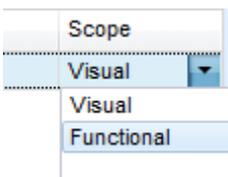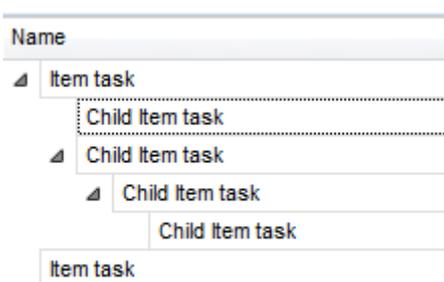

Inspection Scope edit

Click to Inspection Scope field to open selection menu presented on left figure.
Options are:

- Visual is intended for observation of test object
- Functional allows functional test of observed object

Edit Item task structure of Inspection

Item tasks of the selected Inspection are listed in Name column on the right side of Editor workspace. Each Item task can have Child Item tasks, Child Item can have its own Child Item tasks and so on. Arbitrary tree structure of Item tasks and sub-tasks can be built as presented on the left figure.
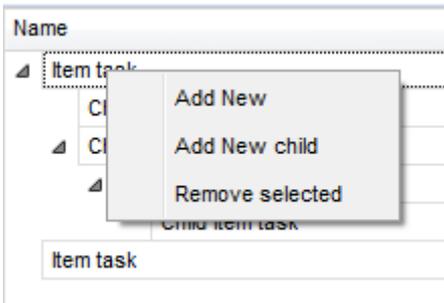

ADD New Item task procedure:

Position Cursor above Item task Name and apply right mouse click to select Item task and open menu with options:

- Add New: new Item task is added on the top tree level
- Add New child: new child Item task is added under selected Item

- Remove selected: delete selected Item task with all sub-tasks

Default name of New Item task is *Custom Inspection*, default Type is *Pass_Fail_Checked_Empty* and both can be edited - changed.
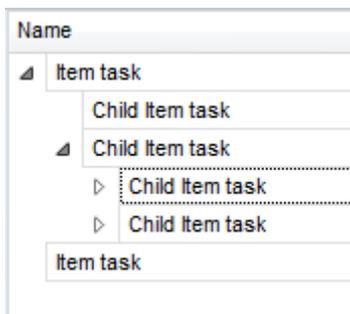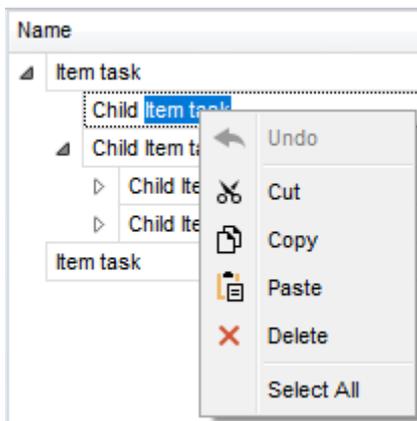
Item tasks containing Child Item tasks are marked with triangle in front of their name.

Click on Triangle mark:

◢ collapse Item task tree structure

▷ expands Item task tree structure

Edit Name and Type of Item task

Edit Name of Item task

Click to the Item task Name field to start editing it. Drag cursor, with left mouse button pressed, to select letters and words. Position cursor and double-click to select word of the name. Actions could be performed with keyboard also. Press right mouse button to activate Edit menu and select appropriate action as presented on the left figure. Menu is case sensitive; options currently not available are greyed out.
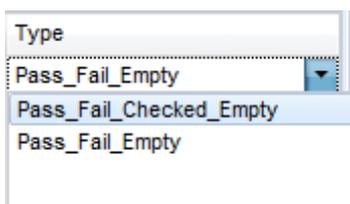
Edit Type of Item task

Click to Item Type field to open selection menu presented on left figure.
Options are:
- Pass_Fail_Checked_Empty: Pass, Fail, Checked, Empty, statuses enabled (default)
- Pass_Fail_Empty: Pass, Fail, Empty, statuses enabled

18.6.2 Applying Custom Inspections

Custom Inspections can be applied in Auto Sequences®. Direct assignment of Custom Inspection to the Metrel ES Manager structure items is not possible.
After custom created Inspection Data file is opened, available inspections are listed in Custom Inspections tab of Single test area of Auto Sequence® Editor, see chapter *Auto Sequence Editor® workspace* for details.
Custom Inspection is added to Auto sequence as a Single test, see chapter *Creating / modifying an Auto Sequence®* for details.

Opening / Changing Inspection Data File
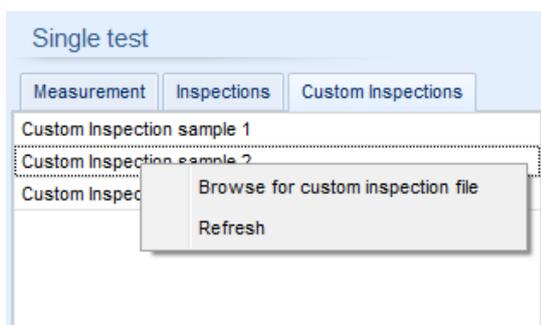
	Position cursor within Custom inspections List area and apply mouse right click to open Option menu: • Browse for custom inspection file: menu for browsing to folder location of new Inspection Data file is opened • Refresh: refresh content of already opened Inspection Data file
	After confirmation of selection, new Inspection Data file is opened and list of available Custom Inspections is changed. Note • If Metrel ES Manager Workscope is changed, opened Inspection Data file remains active and available Custom Inspections remains the same.

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