

CP SB1

User Manual



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

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

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

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About this manual

This User Manual provides detailed information on how to use the *CP SB1* transformer switch box safely, properly and efficiently. The *CP SB1* User Manual contains important safety instructions for working with the *CP SB1*, gets you familiar with operating the *CP SB1*, and provides typical application examples. Following the instructions in this User Manual will help you to prevent danger, repair costs and possible down time due to incorrect operation.

The *CP SB1* User Manual always has to be available at the site where the *CP SB1* is used. It must be read and observed by all users of the *CP SB1*.

Reading the *CP SB1* User Manual alone does not release you from the duty of complying with all national and international safety regulations relevant to working with the *CPC 100* and *CP SB1*. The regulation EN 50191 "The Erection and Operation of Electrical Test Equipment" as well as all the applicable regulations for accident prevention in the country and at the site of operation have to be fulfilled.

Operator qualifications and safety standards

Working on overhead lines is extremely dangerous. Testing and measuring with the *CP SB1* must be carried out only by qualified, skilled and authorized personnel. Before starting to work, clearly establish the responsibilities. Personnel receiving training, instructions, directions, or education on the *CP SB1* must be under constant supervision of an experienced operator while working with the equipment.

Testing and measuring with the *CP SB1* must comply with the relevant national and international safety standards listed below:

- EN 50191 (VDE 0104) "Erection and Operation of Electrical Equipment"
- EN 50110-1 (VDE 0105 Part 100) "Operation of Electrical Installations"
- IEEE 510 "IEEE Recommended Practices for Safety in High-Voltage and High-Power Testing"

Moreover, additional relevant laws and internal safety standards have to be followed.

Conventions and symbols used

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



DANGER

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



WARNING

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



CAUTION

Minor or moderate injury may occur if the appropriate safety instructions are not observed.

NOTICE

Equipment damage or loss of data possible

Related documents

The following documents complete the information covered in the CP SB1 User Manual:

Title	Description
CPC 100 User Manual	Contains information on how to use the <i>CPC 100</i> test system and relevant safety instructions.
CPC 100 Reference Manual	Contains detailed hardware and software information on the <i>CPC 100</i> including relevant safety instructions.

1 Safety rules

Before operating the *CP SB1* transformer switch box, read the following safety rules carefully. If you do not understand some safety rules, contact OMICRON electronics before proceeding. The *CP SB1* is designated for use with the *CPC 100* test system. Therefore, observe the safety rules both in this User Manual and in the *CPC 100* User/Reference Manual when working with the *CP SB1*.

Depending on the application and the device under test, specific safety instructions must be observed. Very often, the danger coming from the device under test is even higher than the danger from the *CP SB1* itself. For application-specific safety instructions, see 4.1 "Safety instructions for connecting the *CP SB1* to power transformers" on page 19.

Maintenance and repair is only permitted by qualified experts either at the factory or certified external repair centers.

1.1 General

Always observe the five safety rules:

- ▶ Disconnect completely
- ▶ Secure against re-connection
- ▶ Verify that the installation is dead
- ▶ Carry out grounding and short-circuiting
- ▶ Provide protection against adjacent live parts

1.2 Operating the measurement setup

Only personnel qualified in electrical engineering and trained by OMICRON electronics are authorized to operate the *CP SB1*. Before starting the work, clearly establish the responsibilities.

Personnel receiving training, instructions, directions, or education on the *CPC 100* or *CP SB1* must be under constant supervision of an experienced operator while working with the equipment.

The operator is responsible for the safety requirements during the whole test.

In principle, the safety instructions that apply to the *CPC 100* and its accessories (refer to "Safety Instructions for *CPC 100* and its Accessories" in the *CPC 100* Reference Manual) also apply to the *CP SB1*. Following, only safety instructions that exclusively apply to the *CP SB1* are listed. Before performing tests using high voltage, please read the following:

- ▶ Do not use the test equipment without a good connection to substation ground.
- ▶ Keep clear from zones in which high voltages may occur. Set up a barrier or establish similar adequate means.

- ▶ Make sure to position the *CP SB1* in the high-voltage area.

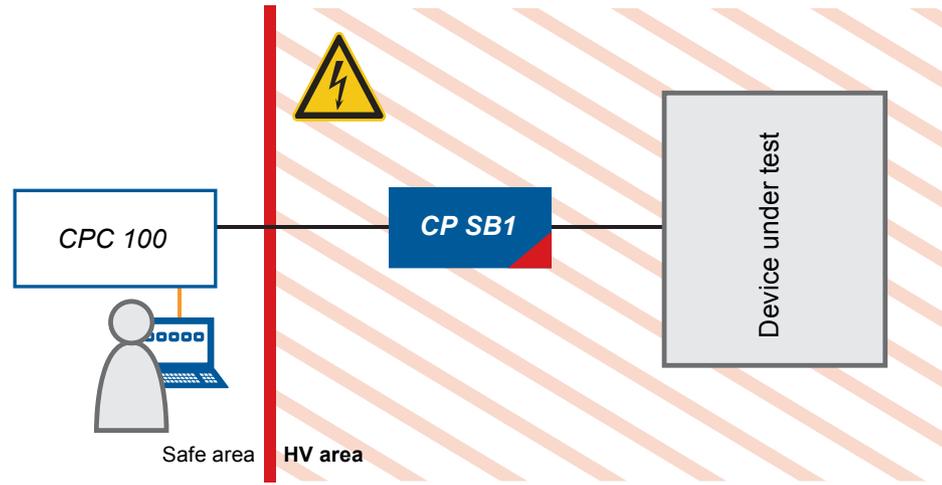


Figure 1-1 Safe area and high-voltage area with *CPC 100* and *CP SB1*

- ▶ Pay attention to the national and the international standards for the safe operation of high-voltage test equipment (EN 50191, IEEE 510).
- ▶ Never touch any terminal without a visible ground connection!
- ▶ Before connecting or disconnecting test objects and/or cables, turn off the *CPC 100* by either the POWER ON/OFF switch or the Emergency Stop button. Never connect or disconnect a test object while the outputs are active.
- ▶ Even if you switched off the *CPC 100*, wait until the red I/O warning light is fully extinguished. As long as this warning light is lit, there is still voltage and/or current potential on one or more of the outputs.
- ▶ Make sure that the test object's terminals that are to be connected to the *CP SB1* or *CPC 100* do not carry any voltage potential. During a test, the only power source for a test object may be the *CPC 100*.
- ▶ Do not insert objects (for example screwdrivers, etc.) into any input/output socket.
- ▶ When measuring the ratio of power transformers make sure that the test voltage is connected to the corresponding high-voltage winding, and the voltage of the low-voltage winding is the one that is measured. Accidentally mixing up the windings can generate life-threatening voltages within the transformer.
For example: feeding a voltage of 300 V to the low-voltage winding of a power transformer that has a ratio of 400000 V : 30000 V, induces a voltage of 4000 V in the transformer's primary winding.
- ▶ Do not operate the *CP SB1* under ambient conditions that exceed the temperature and humidity limits listed in 5 "Technical data" on page 56.
- ▶ Make sure to position the test equipment on dry, solid ground.
- ▶ Do not operate the *CP SB1* in the presence of explosives, gas or vapors.
- ▶ Opening the *CP SB1* invalidates all warranty claims.

- ▶ If the *CP SB1* or any add-on device or accessory does not seem to function properly, do not use it anymore. Please call the OMICRON electronics hotline.
- ▶ Before handling the *CP SB1* or *CPC 100* in any way, connect them with a solid connection of at least 6 mm² cross-section to equipotential ground. Ground the *CP SB1* as close as possible to the *CPC 100*.

1.3 DC output to test objects with a high inductance

When using the DC Output to test power transformers with a high inductance, observe the following safety instructions:

- ▶ Use the **TRTapCheck** (tap changer winding resistance and on-load tap changer interruption check) test card only.
- ▶ As long as the *CPC 100* software shows the on-screen message "Switch off in progress", NEVER connect or disconnect test objects and/or cables.
- ▶ The message "Switch off in progress" notifies you that, while the *CPC 100* is deactivating, the connected external inductance (this means the test object) still "feeds" voltage potential back into the 6 A DC output.
- ▶ The existence of this voltage potential at the 6 A DC output is also indicated by a lit LED - even if the *CPC 100* is switched off.
- ▶ If a test object with a high inductance was connected to the *CPC 100*, short-out the test object additionally before disconnecting any cables.

1.4 High-voltage outputs

All AC and DC output sockets of the *CP SB1* can carry life-hazardous voltage potential and provide life-hazardous currents. Therefore:

- ▶ While connecting cables to the *CP SB1* outputs or other conducting parts that are not protected against accidental contact, press the Emergency Stop button on the *CPC 100* front panel, and keep it pressed as long as an output signal is not absolutely necessary for the test.
- ▶ When connecting cables to the front panel input/output sockets, use wires with 4 mm safety "banana" connectors and plastic housing.
- ▶ For the connection between the *CPC 100* and *CP SB1* only use the specially manufactured cables supplied by OMICRON electronics (see 2.4 "*CP SB1* delivery" on page 14).

Note: One end of the high-voltage cable has a coaxial safety plug that is certified for a voltage level of 2 kV AC. The other end is equipped with a safety banana plug that is insulated with a shrink tube.

- ▶ When the *CPC 100* is activated, consider this part of the cable to be a hazard of electric shock.
- ▶ Do not stand right next to or directly underneath a connection point because the clamps may fall off and touch you. This is a physical and an electrical hazard.

- ▶ The red warning light on the *CPC 100* front panel indicates hazardous voltage and/or current levels at the *CPC 100* outputs (red light "I" on or flashing). The green warning light indicates that the *CPC 100* outputs are not activated.

Note: If none or both warning lights are on, the unit is defective and must not be used anymore.

1.5 Static charges

Static charges on transformer windings may be induced by test potentials. While the voltage may not be significant enough to cause any damage, it can be a source for serious accidents due to falls caused by reflex action.

Connect the windings to ground as described in the *CPC 100* Reference Manual.

1.6 Orderly measures

The CP SB1 User Manual or alternatively the e-book in PDF format has always to be available on site where the *CP SB1* is being used. It must be read and observed by all users of the *CP SB1*.

The *CP SB1* may be used only as described in 4 "Application" on page 19. Any other use is not in accordance with the regulations. The manufacturer and/or distributor is not liable for damage resulting from improper usage. The user alone assumes all responsibility and risk.

Following the instructions provided in this User Manual is also considered part of being in accordance with the regulations.

1.7 Disclaimer

If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

1.8 Compliance Statement

Declaration of Conformity (EU)

The equipment adheres to the guidelines of the council of the European Community for meeting the requirements of the member states regarding the electromagnetic compatibility (EMC) directive, the low voltage directive (LVD) and the RoHS directive.

FCC Compliance (USA)

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

Declaration of Compliance (Canada)

This Class A digital apparatus complies with Canadian ICES-003.

Cet appareil numérique de la classe A est conforme à la norme NMB-003 du Canada.

2 Hardware information

2.1 Designated use

The *CP SB1* is a transformer switch box designated for automatically measuring the ratio and winding resistance, and testing the tap changer of three-phase power transformers. It is an accessory to the *CPC 100*. Automatic control of the On-Load Tap Changer (OLTC) is included. Testing of power transformers over all taps and all phases is fully automated. Therefore, no rewiring is required. The *CP SB1* is controlled from the *CPC 100* via its serial interface. The results are recorded in the *CPC 100* with the ratio and tap changer test cards, and can be analyzed with the computer tool set (*CPC 100 Excel File Loader*).

2.2 Block diagram of the *CP SB1*

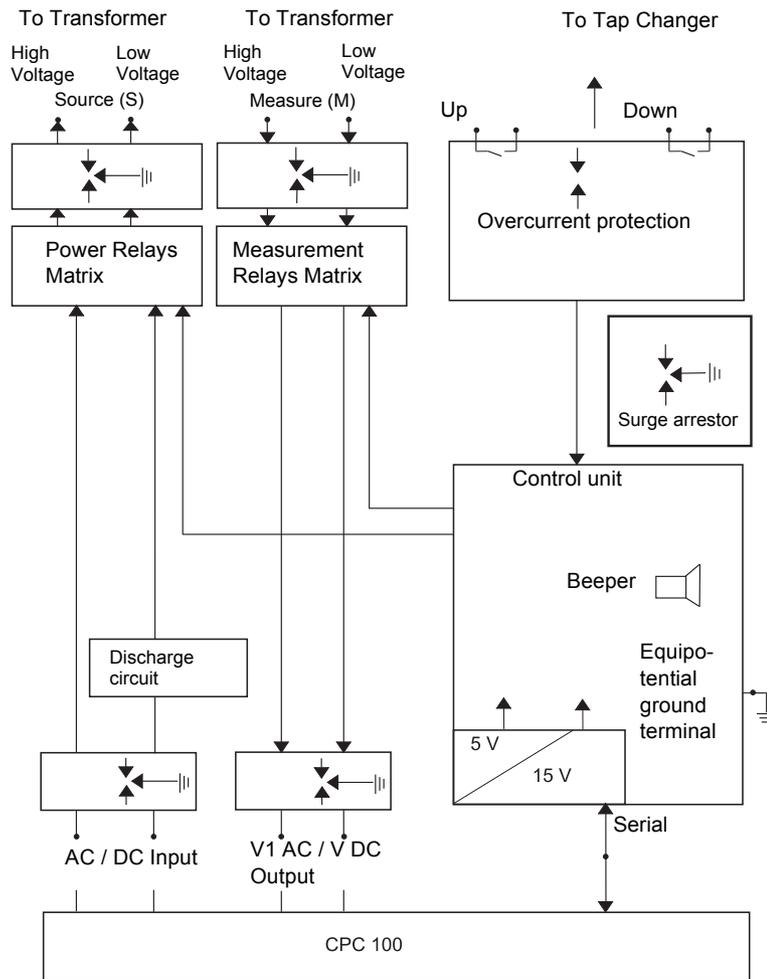


Figure 2-1 Circuit diagram of the *CP SB1*

2.3 Functional components of the CP SB1

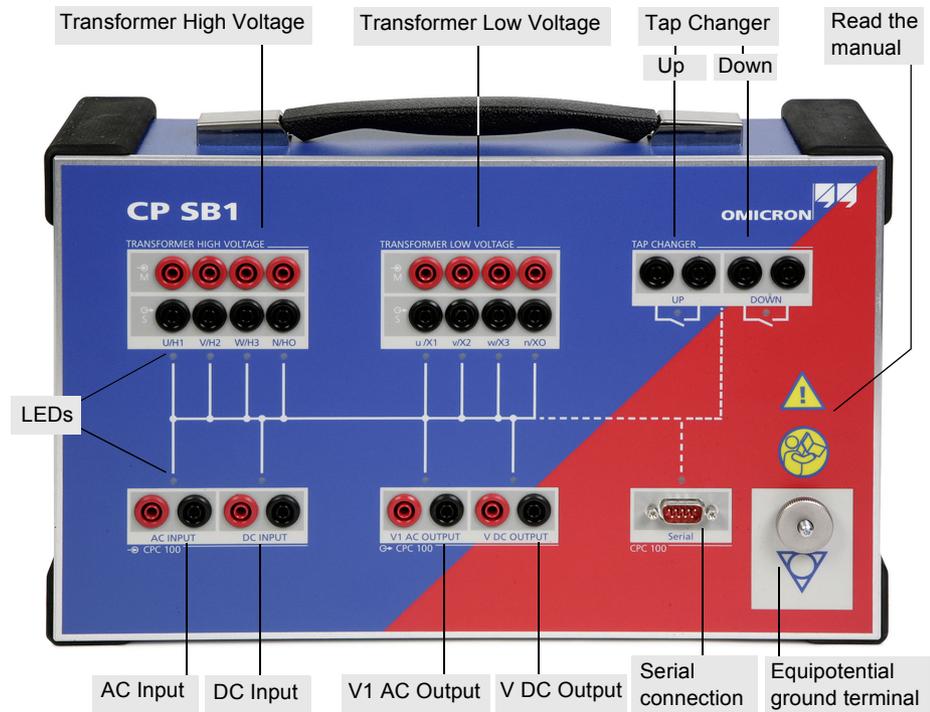


Figure 2-2 Front panel

The front panel of the *CP SB1* provides the following functional components:

- Transformer High Voltage:
 - Outputs (**S**ource) for the input of current or voltage on the individual phases of the transformer
 - Inputs (**M**easure) for the voltage measurement

Note: The inputs and outputs of the respective connections (U/H1, V/H2, W/H3, N/H0) are connected to the transformer using Kelvin clamps.
- Transformer Low Voltage:
 - Outputs (**S**ource) for the input of current or voltage on the individual phases of the transformer
 - Inputs (**M**easure) for the voltage measurement

Note: The inputs and outputs of the respective connections (u/X1, v/x2, w/x3, n/X0) are connected to the transformer using Kelvin clamps.
- Tap Changer: Two potential-free contacts for switching the tap changer
- AC input for connection to the 2 KV AC output of the *CPC 100*
- DC input for connection to the 6 A DC output and I AC/DC input of the *CPC 100*
- AC output for connection to the V1 AC input of the *CPC 100*
- DC output for connection to the V DC input of the *CPC 100*

- Serial interface for the *CPC 100* (**TRRatio** and **TRTapCheck** test cards) to control the *CP SB1*
- Equipotential ground terminal for grounding the *CP SB1* close to the position of the operating staff

2.4 CP SB1 delivery

The following items are included in the *CP SB1* delivery:

Table 2-1 CP SB1 delivery

Accessories		Description
1x Transport case		To transport the entire equipment
1x Data cable 3 m grey		Connection from the <i>CP SB1</i> to the <i>CPC 100</i>
2x Connection cable 8 pole 15 m/2.5 mm ²		Connection from the <i>CP SB1</i> to the transformer via Kelvin clamps
1x Grounding cable 6 m		Connection from the <i>CP SB1</i> 's equipotential ground terminal to the substation ground
Connecting cables with safety plugs 2 m 3x red and 3x black		Connection from the <i>CPC 100</i> to the <i>CP SB1</i> 's DC input, V1 AC output and V DC output

Table 2-1 CP SB1 delivery (continued)

Accessories		Description
4x Coaxial cable 2 pole 6 m		Extension of the 8-pole connection cable for the high-voltage side of large transformers
2x Coaxial cable 2 pole 15 m		Connection to tap changer
1x Three-lead cable		To shorten the transformer's phases on the CP SB1
2x Elastic rope with cable clamp and hook		Pull relief, protecting the high- and low-voltage cables against disconnection
8x Kelvin clamps black		Connection to bushings
6x Flexible terminal adapter		Connection to tap changer

2.5 Recycling



This test set (including all accessories) is not intended for household use. At the end of its service life, do not dispose of the test set with household waste!

For customers in EU countries (incl. European Economic Area)

OMICRON test sets are subject to the EU Waste Electrical and Electronic Equipment Directive 2012/19/EU (WEEE directive). As part of our legal obligations under this legislation, OMICRON offers to take back the test set and ensure that it is disposed of by authorized recycling agents.

For customers outside the European Economic Area

Please contact the authorities in charge for the relevant environmental regulations in your country and dispose the OMICRON test set only in accordance with your local legal requirements.

3 Operation

3.1 Measurement setup

The measurement setup consists of the *CPC 100* test system and the *CP SB1* transformer switch box.

3.2 Operating principle

The *CP SB1* is a transformer switch box whose relays are controlled by the serial interface of the *CPC 100* test system. Potential-free relay contacts control the AC tap changer of the transformer under test. With the switch box, you can measure the winding resistance (current up to 6 A) and ratio on three-phase transformers (output voltage limited to 300 V/150 V). Automatic control of the OLTC is included. The *CP SB1* consists of a relay switching matrix with which you can conduct automatic testing.

An integrated logic which is controlled by the *CPC 100* controls the relays and the OLTC. The *CP SB1* has two outputs to operate the tap changer together with an optimized "Auto Keep Result" algorithm within the **TRTapCheck** test card. Both **TRRatio** and **TRTapCheck** test cards can record the results of all three phases with a single test card. The switch box automatically switches to the next phase after testing of a phase is completed.

You can conduct the transformer ratio test and the time-consuming tap changer resistance test over all taps and all three phases without rewiring. For special measurements and single-phase transformers, the operation mode can be set to manual. In this case, use banana cables between the connections to the transformer and the *CPC 100* of the *CP SB1*.

An acoustic signal (intermittent beep) indicates if the discharge is in progress. A double beep informs the user when a correct connection has been established. An intermittent beep with a longer interval sounds in case of firmware download.

For the ratio measurement, the voltage is always injected into the high-voltage side of the transformer. The winding resistance can be measured on the high- or low-voltage side. Manual mode is possible for both **TRTapCheck** and **TRRatio**.

- For detailed information about all available tests refer to the *CPC 100* User and Reference Manuals.

3.3 Test cards

The *CP SB1* comprises the following test cards:

- **TRRatio** to measure the ratio, see 4.4 "TRRatio test card" on page 21
 - **TRTapCheck** to test the tap changer of power transformers and the winding resistance, see 4.5 "TRTapCheck test card" on page 44
 - **Vector Group Check** to automatically determine the transformer's vector group, see 4.6 "Vector Group Check test card" on page 51
 - **Demagnetization** to demagnetize the transformer core, see 4.6.1 "Demagnetization test card" on page 51
- For detailed information about test cards, test procedures and templates refer to the chapters listed above and the CPC 100 User and Reference Manuals.

4 Application

4.1 Safety instructions for connecting the *CP SB1* to power transformers

4.1.1 Before starting

- ▶ Before operating the *CP SB1*, always observe the five general safety rules as described in 1.1 "General" on page 7.

4.1.2 Connecting the measurement setup to power transformers

WARNING



Death or severe injury caused by high voltage or current possible

- ▶ Position the *CP SB1* in the high-voltage area and do not enter this area during the entire measurement.

1. Connect the *CPC 100* and *CP SB1* using the delivered grounding cable.
2. Connect the grounding cable of the *CP SB1* at a safe grounding point at the transformer.

Note: Do not operate the test equipment without safe connection to ground.

3. Make sure that all high-voltage connections of the transformer are removed.
4. Make sure that all bushings of the transformer are connected to ground.
5. Switch off the power supply of the tap changer.
6. Connect the Kelvin clamps to the bushings.
7. Connect the cables to the Kelvin clamps. Make sure that the cables face upwards and that each color is connected to a different phase.



Figure 4-1 Kelvin clamp on a bushing

8. Connect the cables from the Kelvin clamps' voltage sense outputs to the *CP SB1*'s transformer inputs. Observe the color code.
9. Make sure to measure the voltage to ground at the terminals of the tap changer. If no voltage is measured, connect the flexible terminal adapters to the "up" and "down" terminals of the tap changer.
10. Connect the cables ("up", "down") to the *CP SB1*.
11. Connect the *CP SB1* to the *CPC 100* according to 2.3 "Functional components of the *CP SB1*" on page 13.
12. Switch on the power supply of the tap changer.
13. Remove the grounding connections from all bushings.
14. Start the measurement according to 4.4.3 "Performing measurements with TRRatio" on page 27 and 4.5.3 "Performing winding resistance measurements" on page 48.

4.2 Template usage

With the *CPC 100 Excel File Loader* you can load XML files generated with the *CPC 100* into Microsoft Excel templates for post-processing. The *CPC 100 Excel File Loader* is installed with the setup disk. After the installation, a shortcut to open the *CPC 100 Start Page* appears on your desktop, where you can start the *Excel CPC 100 File Loader*. Templates are pairs of XML documents and Microsoft Excel templates designed by OMICRON electronics or end users for designated applications. The XML templates are predefined test procedures, often with comments, that run on the *CPC 100* and guide the user through the test. Once completed, the XML file is saved on the *CPC 100*. The file is then loaded into the corresponding Microsoft Excel template. There the results are post-processed and a final test report is generated. The template pairs facilitate and speed testing with the *CPC 100* and the evaluation of results.

Complete the following steps to run a test procedure according to a template:

1. Upload the XML template for the intended application from the computer to the *CPC 100*.
2. Open the template on the *CPC 100*.
3. Run the test procedure according to the template.
4. After completing the test procedure, save the test in a new file.
5. Open the corresponding Microsoft Excel template on the *CPC 100 Start Page*. A Microsoft Excel workbook appears.
6. Click the **Load XML-File** button and open the *.xml file saved on your *CPC 100* that is available under the *OMICRON Devices* tree.
7. After all worksheets are filled with data, the test results are calculated.

4.3 Test cards



- ▶ To select a test card, press **Insert Card** in the Test Card View.
- ▶ Use the context-dependent **Up/Down** menu keys to the right, or the handwheel, to browse through the structure. On Transformer, press **Enter**.



- ▶ Alternatively, press the accelerator key to open the **Insert a new test card** dialog box.
- ▶ Highlight the test card of your choice either by navigating with the handwheel or by using the context-dependent **Up/Down** menu keys, and then press **Enter**.

Note: The test card **TRRatio** (per Tap) employs the frequency-selective measurement method, which is used to filter out interferences usually present in substations.

- ▶ To learn more about the frequency-selective measurement, refer to "The Frequency-Selective Measurement" in the *CPC 100* Reference Manual.

4.4 TRRatio test card

Use the **TRRatio** test card to measure the ratio of power transformers by injecting AC voltage from **AC OUTPUT** into the transformer's high-voltage side. The maximum voltage for Y and D transformers is limited to 300 V, and for YN transformers to 150 V.

The *CPC 100* measures both the voltage it applies to **AC OUTPUT** and the transformer's low-voltage side at **V1 AC**. From these values, it calculates the ratio and its deviation from the nominal ratio in percent.

In addition, the excitation current and its phase angle is measured. Moreover, the phase angle between the high-voltage and the low-voltage side is measured.

Furthermore, you can use the **TRRatio** test card to measure a power transformer's ratio for each single tap changer position.

4.4.1 "Test settings for TRRatio" on page 22 shows the V_{prim} and V_{sec} settings on the **TRRatio** test card for different connections of the transformer under test.

Settings

Pressing the **Settings** menu key opens the **Settings** page. The **Settings** page of the **TRRatio** test card has another functionality as on other test cards.

Time needed to switch from one tap to the next

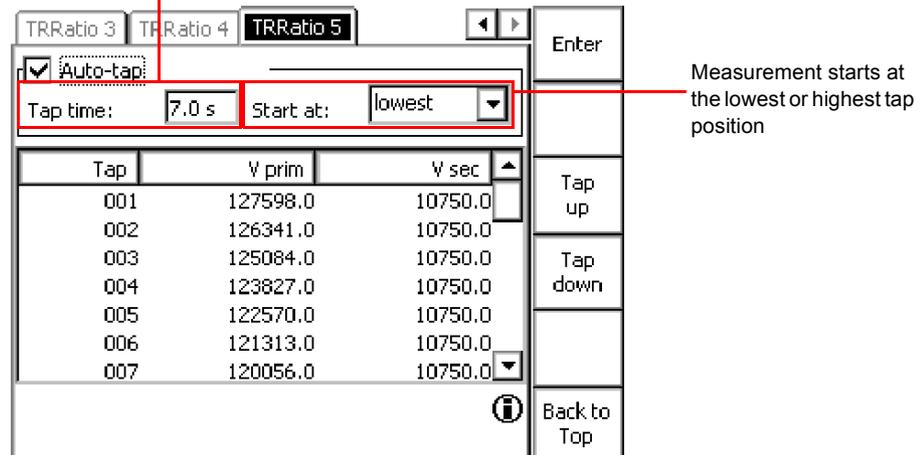


Figure 4-3 Settings page of the **TRRatio** test card

Note: The **Settings** page opens automatically if the **Auto-tap** operation mode is activated.

For proper **Auto-tap** operation, the **Tap time** and **Start at** settings need to be adjusted. The **Tap time** is the time needed to switch from one tap to the next. **Start at** defines the initial position of the tap. With the **Tap up / Tap down** softkeys you can move the tap changer manually. Move the tap changer to the highest or lowest tap, depending on your setting before measurement.

Tap up

Tap down

The **Settings** page allows adding the transformer's ratio per tap as follows:

- ▶ After pressing the **Add Tap** menu key first enter the Tap Number, Vprim and Vsec.
- ▶ Add the next tap by pressing the **Add Tap** menu key and enter the corresponding Vprim and Vsec values. Pressing the **Add Tap** menu key repeatedly adds more taps with a step calculated from the values of the preceding taps. The tap entries apply equally to all phases.
- ▶ After adding all taps, press the **Main Page** menu key to transfer the data to the main page.

Note: After the transformer's ratio was specified on the **Settings** page, you can save the data by pressing the **Save As Default** menu key. Then, for each new test card these tap values will be retained.

Automatic Tap Fill

The **Settings** page of the **TRRatio** test card offers an offline **Auto-tap fill** function. It automatically fills in the nominal ratio table of the **TRRatio** test card for symmetric tap changers.

Number of taps with the specified nominal ratio in the middle of the symmetrical tap scheme

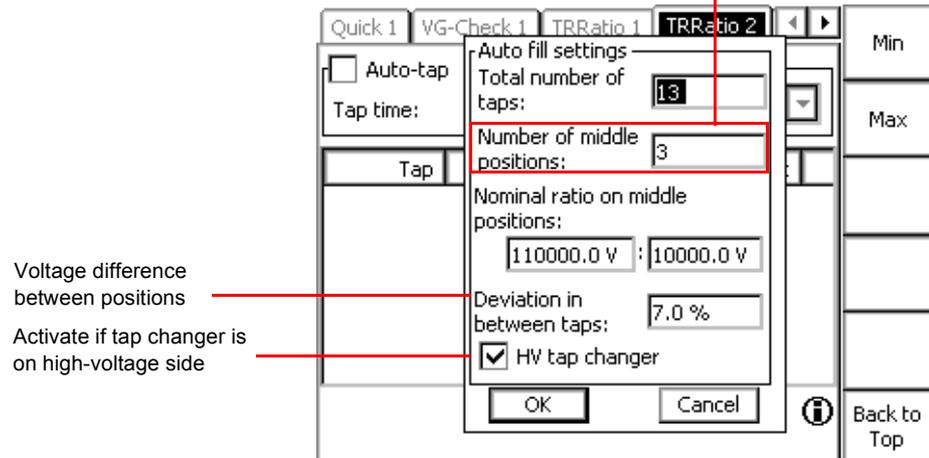


Figure 4-4 Auto fill settings window

The total number of taps minus the middle positions defines the number of taps above and below the middle position(s). To determine the voltage for each tap position, the nominal ratio of the middle position(s) and the deviation percentage are needed and the HV tap changer check box needs to be activated if applicable.

To set up the different measurements, use the **A**, **B**, and **C** keys to the right:

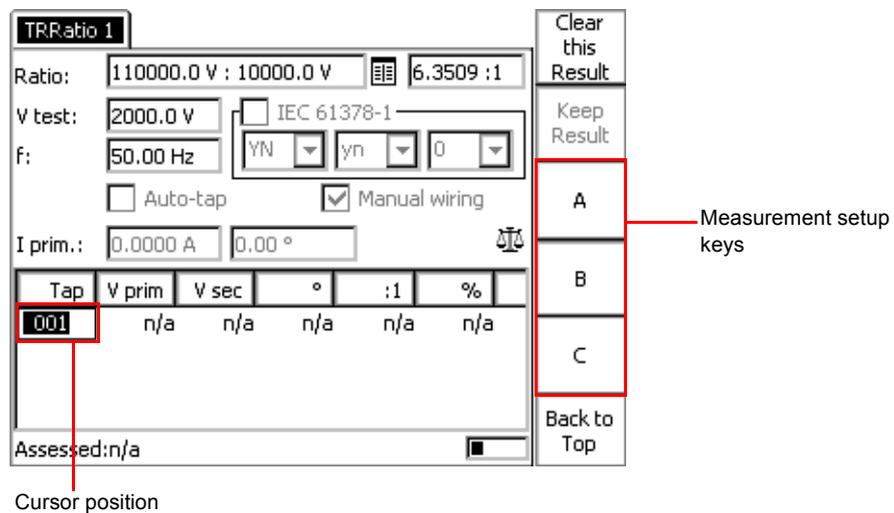


Figure 4-5 Setting up the different measurements

Note: The context-dependent keys to the right will only appear if the cursor is positioned in the result line.

The **TRRatio** test card displays the measurement results in two display fields and a table:

Iprim:	<p>Primary current from 2 kV AC output, measured by the <i>CPC 100</i> internally</p> <p>If the focus is on the table, scrolling through the lines will change this display accordingly, depending on the selected line.</p> <p>The ° shows the phase angle of the primary current relative to V_{prim} nominal.</p>
Tap (in table):	Displays the transformer tap identifier and tap number for the measurements in the respective line of the table.
Vprim:	Actual voltage injected from AC OUTPUT into the transformer's high-voltage side
Vsec:	<p>Actual voltage measured at V1 AC from the transformer's low-voltage side.</p> <p>The ° shows the phase angle of the secondary voltage relative to V_{prim} nominal.</p> <p>Note: Even on transformers such as Yd5, only phase angles like 0° or 180° can be found using a single phase test set because a transformer can change the phase angle only by "mixing" different phases.</p>
Ratio :1	Calculated ratio value from the measured values V_{prim} / V_{sec}
%:	The % shows the deviation of the actual ratio from the nominal ratio in %.

4.4.2 Measurement setup for TRRatio

The measurement setup in connection with the **TRRatio** test card is shown below.

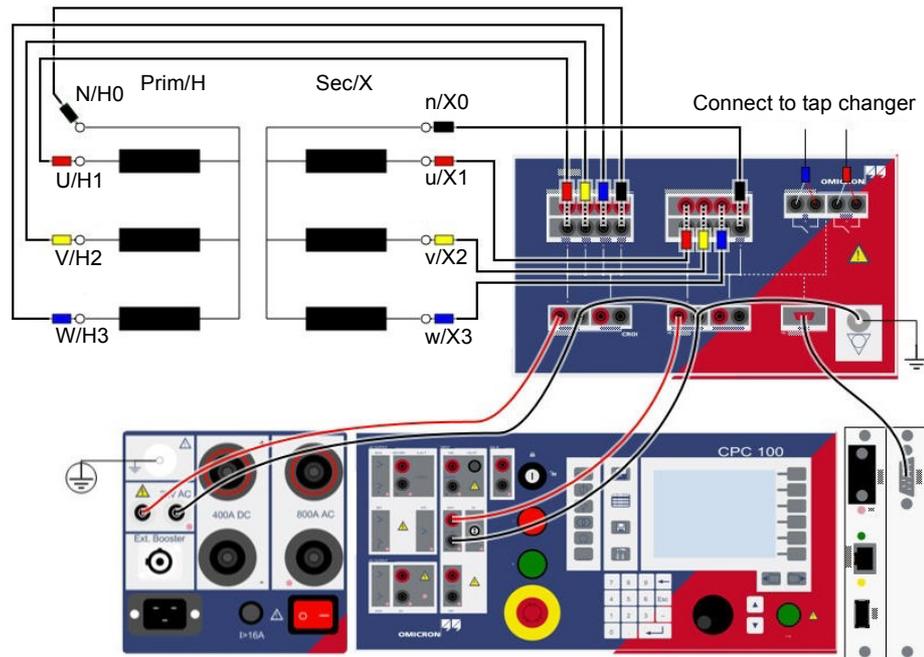


Figure 4-6 Measurement setup for **TRRatio**

4.4.3 Performing measurements with TRRatio

The *CP SB1* can be operated in four different modes, depending on the way you like to test and operate the tap changer. These modes also apply to the **TRTapCheck** test card.

Auto-tap	Manual wiring	Mode	Description
<input checked="" type="checkbox"/>	<input type="checkbox"/>	Fully automatic mode	The tap changer, phase switches and the measurement procedure are controlled by the <i>CPC 100</i> . The test runs fully automatically through all the taps and phases, and is completed automatically. There is no need to save the individual measurement results manually.
<input type="checkbox"/>	<input type="checkbox"/>	Half-automatic mode	If the tap changer is not connected, the <i>CP SB1</i> performs a half-automatic test. The procedure is the same as for the manual mode. The only difference is that the phases can be switched without deactivating the <i>CPC 100</i> .
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Extended manual mode	The tap changer is controlled by the <i>CPC 100</i> , and measurements are performed automatically. However, you are able to manually wire the connections. Therefore, the phases cannot be switched automatically.
<input type="checkbox"/>	<input checked="" type="checkbox"/>	Manual mode	Manual wiring is required, and the taps have to be switched manually.

Fully automatic test

Complete the following steps to perform a fully automatic test:

1. Select **Auto-tap** operation, deselect **Manual wiring** (default).
2. On the **Settings** page, define **Tap time**, **Start at** and the tap table. In case the nominal ratios are not known, select **n/a**.
3. Select **Vector group**, **Vtest** and **frequency**.
4. Press the **I/O** (test start/stop) push button to start the test.
5. The test voltage increases in a ramp characteristic from 0 V to **Vtest** within 1 second. Then, the first set of measurements is taken.
6. The *CPC 100* deactivates when the test is completed.



Note: In fully automatic mode, an interrupted test will be resumed at the current tap position.

Manual or half-automatic test



Complete the following steps to perform a manual or half-automatic test:

1. Define the parameters first on the **Settings** page, then on the main page and press the **I/O** (test start/stop) push button to start the test.
2. The test voltage increases in a ramp characteristic from 0V to V_{test} within 1 second.
3. Save the test results of the first tap by pressing **Keep Result**. This adds the measured values to the first line of the table.
4. While passing through the power transformer's tap changer positions, press **Keep Result** for each single position. This adds new lines to the table holding the measured values.
5. When all test points are measured, press the **I/O** (test start/stop) push button to stop the test. V_{test} decreases in a ramp characteristic within 1 second, and the last unsaved line, that is, the line that was not saved by pressing **Keep Result**, will be discarded.

Note: The maximum voltage between the connectors is 300 Veff AC. Depending on the configuration of your transformer, the voltage between the connectors might be higher than the injected voltage.

Table 4-1 Different vector groups

IEC 60076 vector group	Winding connection		Measurement	Transformer high-voltage side	Transformer low-voltage side	Measured turn ratio	
	HV / H	LV / X					
Dd0	$V/H2$ U/H1 W/H3	$v/X2$ u/X1 w/X3	A	U-V / H1-H2	u-v / X1-X2	1	
				B	V-W / H2-H3	v-w / X2-X3	
				C	W-U / H3-H1	w-u / X3-X1	

Table 4-1 Different vector groups (Continued)

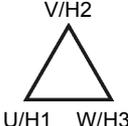
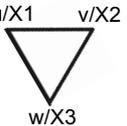
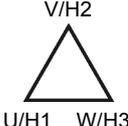
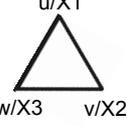
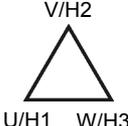
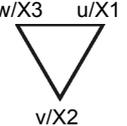
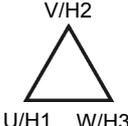
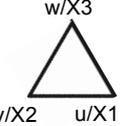
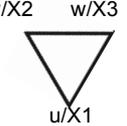
IEC 60076 vector group	Winding connection		Measurement	Transformer high-voltage side	Transformer low-voltage side	Measured turn ratio
	HV / H	LV / X				
Dd2			A	U-V / H1-H2	w-v / X3-X2	1
			B	V-W / H2-H3	u-w / X1-X3	
			C	W-U / H3-H1	v-u / X2-X1	
Dd4			A	U-V / H1-H2	w-u / X3-X1	1
			B	V-W / H2-H3	u-v / X1-X2	
			C	W-U / H3-H1	v-w / X2-X3	
Dd6			A	U-V / H1-H2	v-u / X2-X1	1
			B	V-W / H2-H3	w-v / X3-X2	
			C	W-U / H3-H1	u-w / X1-X3	
Dd8			A	U-V / H1-H2	v-w / X2-X3	1
			B	V-W / H2-H3	w-u / X3-X1	
			C	W-U / H3-H1	u-v / X1-X2	
Dd10			A	U-V / H1-H2	u-w / X1-X3	1
			B	V-W / H2-H3	v-u / X2-X1	
			C	W-U / H3-H1	w-v / X3-X2	

Table 4-1 Different vector groups (Continued)

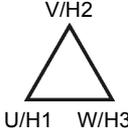
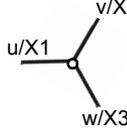
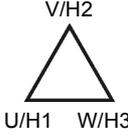
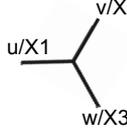
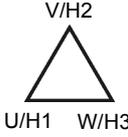
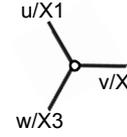
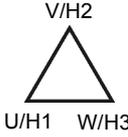
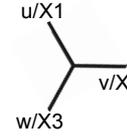
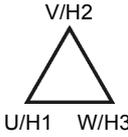
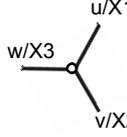
IEC 60076 vector group	Winding connection		Measurement	Transformer high-voltage side	Transformer low-voltage side	Measured turn ratio
	HV / H	LV / X				
Dyn1			A	U-V / H1-H2	n-v / X0-X2	$1*\sqrt{3}$
			B	V-W / H2-H3	n-w / X0-X3	
			C	W-U / H3-H1	n-u / X0-X1	
Dy1			A	U-(V+W) / H1-(H2+H3)	u-v / X1-X2	$\sqrt{3}/2$
			B	V-(U+W) / H2-(H1+H3)	v+w / X2-X3	
			C	W-(U+V) / H3-(H1+H2)	w-u / X3-X1	
Dyn3			A	U-V / H1-H2	w-n / X3-X0	$1*\sqrt{3}$
			B	V-W / H2-H3	u-n / X1-X0	
			C	W-U / H3-H1	v-n / X2-X0	
Dy3			A	U-(V+W) / H1-(H2+H3)	w-v / X3-X2	$\sqrt{3}/2$
			B	V-(U+W) / H2-(H1+H3)	u-w / X1-X3	
			C	W-(U+V) / H3-(H1+H2)	v-u / X2-X1	
Dyn5			A	U-V / H1-H2	n-u / X0-X1	$1*\sqrt{3}$
			B	V-W / H2-H3	n-v / X0-X2	
			C	W-U / H3-H1	n-w / X0-X3	

Table 4-1 Different vector groups (Continued)

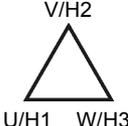
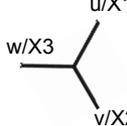
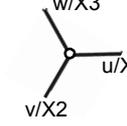
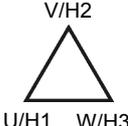
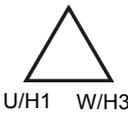
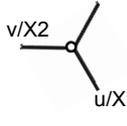
IEC 60076 vector group	Winding connection		Measurement	Transformer high-voltage side	Transformer low-voltage side	Measured turn ratio
	HV / H	LV / X				
Dy5			A	$U-(V+W) / H1-(H2+H3)$	$w-u / X3-X1$	$\sqrt{3}/2$
			B	$V-(U+W) / H2-(H1+H3)$	$u-v / X1-X2$	
			C	$W-(U+V) / H3-(H1+H2)$	$v-w / X2-X3$	
Dyn7			A	$U-V / H1-H2$	$v-n / X2-X0$	$\sqrt{3}$
			B	$V-W / H2-H3$	$w-n / X3-X0$	
			C	$W-U / H3-H1$	$u-n / X1-X0$	
Dy7			A	$U-(V+W) / H1-(H2+H3)$	$v-u / X2-X1$	$1*\sqrt{3}/2$
			B	$V-(U+W) / H2-(H1+H3)$	$w-v / X3-X2$	
			C	$W-(U+V) / H3-(H1+H2)$	$u-w / X1-X3$	
Dyn9			A	$U-V / H1-H2$	$n-w / X0-X3$	$\sqrt{3}$
			B	$V-W / H2-H3$	$n-u / X0-X1$	
			C	$W-U / H3-H1$	$n-v / X0-X2$	

Table 4-1 Different vector groups (Continued)

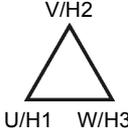
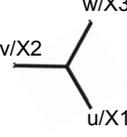
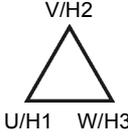
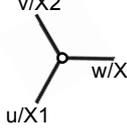
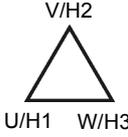
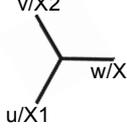
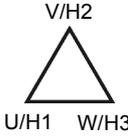
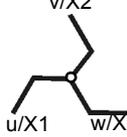
IEC 60076 vector group	Winding connection		Measurement	Transformer high-voltage side	Transformer low-voltage side	Measured turn ratio
	HV / H	LV / X				
Dy9			A	$U-(V+W) / H1-(H2+H3)$	$v-w / X2-X3$	$1*\sqrt{3}/2$
			B	$V-(U+W) / H2-(H1+H3)$	$w-u / X3-X1$	
			C	$W-(U+V) / H3-(H1+H2)$	$u-v / X1-X2$	
Dyn11			A	$U-V / H1-H2$	$u-n / X1-X0$	$\sqrt{3}$
			B	$V-W / H2-H3$	$v-n / X2-X0$	
			C	$W-U / H3-H1$	$w-n / X3-X0$	
Dy11			A	$U-(V+W) / H1-(H2+H3)$	$u-w / X1-X3$	$1*\sqrt{3}/2$
			B	$V-(U+W) / H2-(H1+H3)$	$v-u / X2-X1$	
			C	$W-(U+V) / H3-(H1+H2)$	$w-v / X3-X2$	
Dzn0			A	$U-(V+W) / H1-(H2+H3)$	$u-n / X1-X0$	1.5
			B	$V-(U+W) / H2-(H1+H3)$	$v-n / X2-X0$	
			C	$W-(U+V) / H3-(H1+H2)$	$w-n / X3-X0$	

Table 4-1 Different vector groups (Continued)

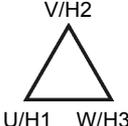
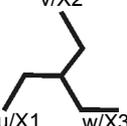
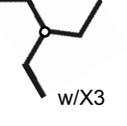
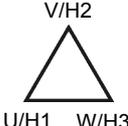
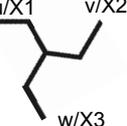
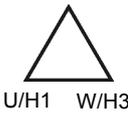
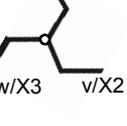
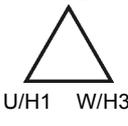
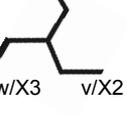
IEC 60076 vector group	Winding connection		Measurement	Transformer high-voltage side	Transformer low-voltage side	Measured turn ratio
	HV / H	LV / X				
Dz0			A	U-V / H1-H2	u-v / X1-X2	1
			B	V-W / H2-H3	v-w / X2-X3	
			C	W-U / H3-H1	w-u / X3-X1	
Dzn2			A	$U-(V+W) / H1-(H2+H3)$	n-v / X0-X2	1.5
			B	$V-(U+W) / H2-(H1+H3)$	n-w / X0-X3	
			C	$W-(U+V) / H3-(H1+H2)$	n-u / X0-X1	
Dz2			A	U-V / H1-H2	w-v / X3-X2	1
			B	V-W / H2-H3	u-w / X1-X3	
			C	W-U / H3-H1	v-u / X2-X1	
Dzn4			A	$U-(V+W) / H1-(H2+H3)$	w-n / X3-X0	1.5
			B	$V-(U+W) / H2-(H1+H3)$	u-n / X1-X0	
			C	$W-(U+V) / H3-(H1+H2)$	v-n / X2-X0	
Dz4			A	U-V / H1-H2	w-u / X3-X1	1
			B	V-W / H2-H3	u-v / X1-X2	
			C	W-U / H3-H1	v-w / X2-X3	

Table 4-1 Different vector groups (Continued)

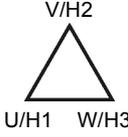
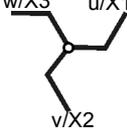
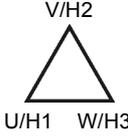
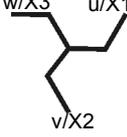
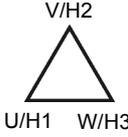
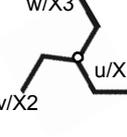
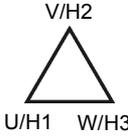
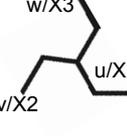
IEC 60076 vector group	Winding connection		Measurement	Transformer high-voltage side	Transformer low-voltage side	Measured turn ratio
	HV / H	LV / X				
Dzn6			A	$U-(V+W) / H1-(H2+H3)$	$n-u / X0-X1$	1.5
			B	$V-(U+W) / H2-(H1+H3)$	$n-v / X0-X2$	
			C	$W-(U+V) / H3-(H1+H3)$	$n-w / X0-X3$	
Dz6			A	$U-V / H1-H2$	$v-u / X2-X1$	1
			B	$V-W / H2-H3$	$w-v / X3-X2$	
			C	$W-U / H3-H1$	$u-w / X1-X3$	
Dzn8			A	$U-(V+W) / H1-(H2+H3)$	$v-n / X2-X0$	1.5
			B	$V-(U+W) / H2-(H1+H3)$	$w-n / X3-X0$	
			C	$W-(U+V) / H3-(H1+H2)$	$u-n / X1-X0$	
Dz8			A	$U-V / H1-H2$	$v-w / X2-X3$	1
			B	$V-W / H2-H3$	$w-u / X3-X1$	
			C	$W-U / H3-H1$	$u-v / X1-X2$	

Table 4-1 Different vector groups (Continued)

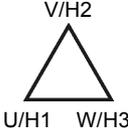
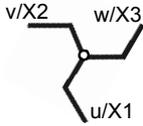
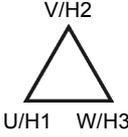
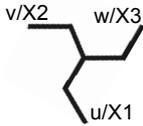
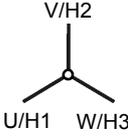
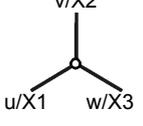
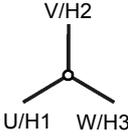
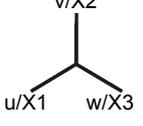
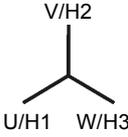
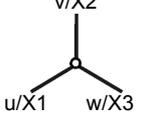
IEC 60076 vector group	Winding connection		Measurement	Transformer high-voltage side	Transformer low-voltage side	Measured turn ratio
	HV / H	LV / X				
Dzn10			A	$U-(V+W) / H1-(H2+H3)$	$n-w / X0-X3$	1.5
			B	$V-(U+W) / H2-(H1+H3)$	$n-u / X0-X1$	
			C	$W-(U+V) / H3-(H1+H2)$	$n-v / X0-X2$	
Dz10			A	$U-V / H1-H2$	$u-w / X1-X3$	1
			B	$V-W / H2-H3$	$v-u / X2-X1$	
			C	$W-U / H3-H1$	$w-v / X3-X2$	
YNyn0			A	$U-N / H1-H0$	$u-n / X1-X0$	1
			B	$V-N / H2-H0$	$v-n / X2-X0$	
			C	$W-N / H3-H0$	$w-n / X3-X0$	
YNy0			A	$U-V / H1-H2$	$u-v / X1-X2$	1
			B	$V-W / H2-H3$	$v-w / X2-X3$	
			C	$W-U / H3-H1$	$w-u / X3-X1$	
Yyn0			A	$U-V / H1-H2$	$u-v / X1-X2$	1
			B	$V-W / H2-H3$	$v-w / X2-X3$	
			C	$W-U / H3-H1$	$w-u / X3-X1$	

Table 4-1 Different vector groups (Continued)

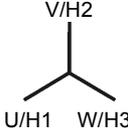
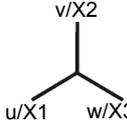
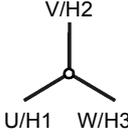
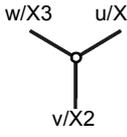
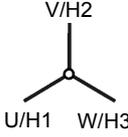
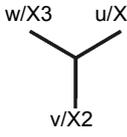
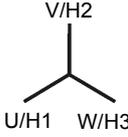
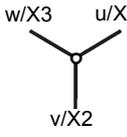
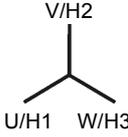
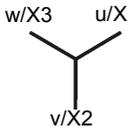
IEC 60076 vector group	Winding connection		Measurement	Transformer high-voltage side	Transformer low-voltage side	Measured turn ratio
	HV / H	LV / X				
Yy0			A	U-V / H1-H2	u-v / X1-X2	1
			B	V-W / H2-H3	v-w / X2-X3	
			C	W-U / H3-H1	w-u / X3-X1	
YNyn6			A	U-N / H1-H0	n-u / X0-X1	1
			B	V-N / H2-H0	n-v / X0-X2	
			C	W-N / H3-H0	n-w / X0-X3	
YNy6			A	U-V / H1-H2	v-u / X2-X1	1
			B	V-W / H2-H3	w-v / X3-X2	
			C	W-U / H3-H1	u-w / X1-X3	
Yyn6			A	U-V / H1-H2	v-u / X2-X1	1
			B	V-W / H2-H3	w-v / X3-X2	
			C	W-U / H3-H1	u-w / X1-X3	
Yy6			A	U-V / H1-H2	v-u / X2-X1	1
			B	V-W / H2-H3	w-v / X3-X2	
			C	W-U / H3-H1	u-w / X1-X3	

Table 4-1 Different vector groups (Continued)

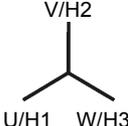
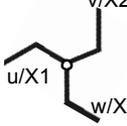
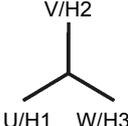
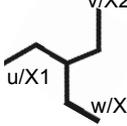
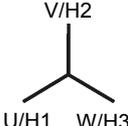
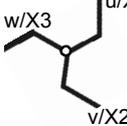
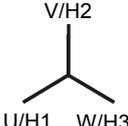
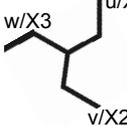
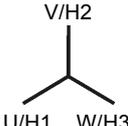
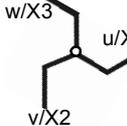
IEC 60076 vector group	Winding connection		Measurement	Transformer high-voltage side	Transformer low-voltage side	Measured turn ratio
	HV / H	LV / X				
Yzn1			A	U-V / H1-H2	n-v / X0-X2	$1*\sqrt{3}$
			B	V-W / H2-H3	n-w / X0-X3	
			C	W-U / H3-H1	n-u / X0-X1	
Yz1			A	U-(V+W) / H1-(H2+H3)	u-v / X1-X2	$\sqrt{3}/2$
			B	V-(U+W) / H2-(H1+H3)	v-w / X2-X3	
			C	W-(U+V) / H3-(H1+H2)	w-u / X3-X1	
Yzn5			A	U-V / H1-H2	n-u / X0-X1	$1*\sqrt{3}$
			B	V-W / H2-H3	n-v / X0-X2	
			C	W-U / H3-H1	n-w / X0-X3	
Yz5			A	U-(V+W) / H1-(H2+H3)	w-u / X3-X1	$\sqrt{3}/2$
			B	V-(U+W) / H2-(H1+H3)	u-v / X1-X2	
			C	W-(U+V) / H3-(H1+H2)	v-w / X2-X3	
Yzn7			A	U-V / H1-H2	v-n / X2-X0	$\sqrt{3}$
			B	V-W / H2-H3	w-n / X3-X0	
			C	W-U / H3-H1	u-n / X1-X0	

Table 4-1 Different vector groups (Continued)

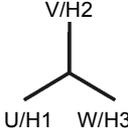
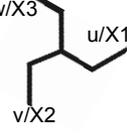
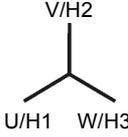
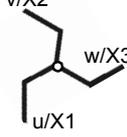
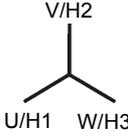
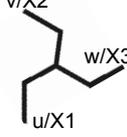
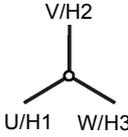
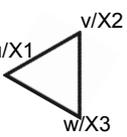
IEC 60076 vector group	Winding connection		Measurement	Transformer high-voltage side	Transformer low-voltage side	Measured turn ratio
	HV / H	LV / X				
Yz7			A	$U-(V+W) / H1-(H2+H3)$	$v-u / X2-X1$	$1*\sqrt{3}/2$
			B	$V-(U+W) / H2-(H1+H3)$	$w-v / X3-X2$	
			C	$W-(U+V) / H3-(H1+H2)$	$u-w / X1-X3$	
Yzn11			A	$U-V / H1-H2$	$u-n / X1-X0$	$\sqrt{3}$
			B	$V-W / H2-H3$	$v-n / X2-X0$	
			C	$W-U / H3-H1$	$w-n / X3-X0$	
Yz11			A	$U-(V+W) / H1-(H2+H3)$	$u-w / X1-X3$	$1*\sqrt{3}/2$
			B	$V-(U+W) / H2-(H1+H3)$	$v-u / X2-X1$	
			C	$W-(U+V) / H3-(H1+H2)$	$w-v / X3-X2$	
YNd1			A	$U-N / H1-H0$	$u-v / X1-X2$	$1/\sqrt{3}$
			B	$V-N / H2-H0$	$v-w / X2-X3$	
			C	$W-N / H3-H0$	$w-u / X3-X1$	

Table 4-1 Different vector groups (Continued)

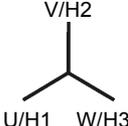
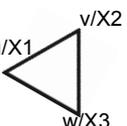
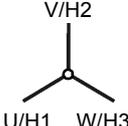
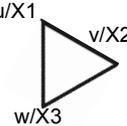
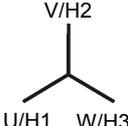
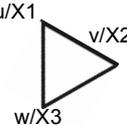
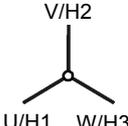
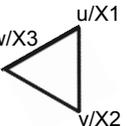
IEC 60076 vector group	Winding connection		Measurement	Transformer high-voltage side	Transformer low-voltage side	Measured turn ratio
	HV / H	LV / X				
Yd1			A	$U-(V+W) / H1-(H2+H3)$	$u-v / X1-X2$	$\sqrt{3}/2$
			B	$V-(U+W) / H2-(H1+H3)$	$v-w / X2-X3$	
			C	$W-(U+V) / H3-(H1+H2)$	$w-u / X3-X1$	
YNd3			A	$U-N / H1-H0$	$w-v / X3-X2$	$1/\sqrt{3}$
			B	$V-N / H2-H0$	$u-w / X1-X3$	
			C	$W-N / H3-H0$	$v-u / X2-X1$	
Yd3			A	$U-(V+W) / H1-(H2+H3)$	$w-v / X3-X2$	$\sqrt{3}/2$
			B	$V-(U+W) / H2-(H1+H3)$	$u-w / X1-X3$	
			C	$W-(U+V) / H3-(H1+H2)$	$v-u / X2-X1$	
YNd5			A	$U-N / H1-H0$	$w-u / X3-X1$	$1/\sqrt{3}$
			B	$V-N / H2-H0$	$u-v / X1-X2$	
			C	$W-N / H3-H0$	$v-w / X2-X3$	

Table 4-1 Different vector groups (Continued)

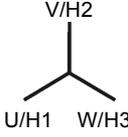
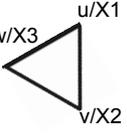
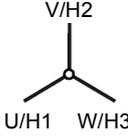
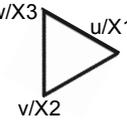
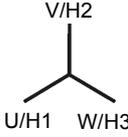
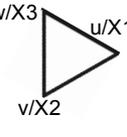
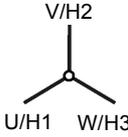
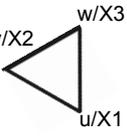
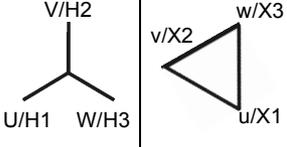
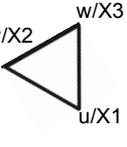
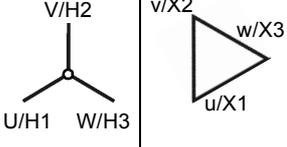
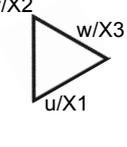
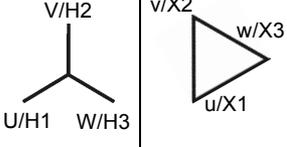
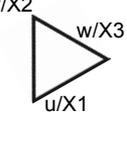
IEC 60076 vector group	Winding connection		Measurement	Transformer high-voltage side	Transformer low-voltage side	Measured turn ratio
	HV / H	LV / X				
Yd5			A	$U-(V+W) / H1-(H2+H3)$	$w-u / X3-X1$	$\sqrt{3}/2$
			B	$V-(U+W) / H2-(H1+H3)$	$u-v / X1-X2$	
			C	$W-(U+V) / H3-(H1+H2)$	$v-w / X2-X3$	
YNd7			A	$U-N / H1-H0$	$v-u / X2-X1$	$1/\sqrt{3}$
			B	$V-N / H2-H0$	$w-v / X3-X2$	
			C	$W-N / H3-H0$	$u-w / X1-X3$	
Yd7			A	$U-(V+W) / H1-(H2+H3)$	$v-u / X2-X1$	$1^*\sqrt{3}/2$
			B	$V-(U+W) / H2-(H1+H3)$	$w-v / X3-X2$	
			C	$W-(U+V) / H3-(H1+H2)$	$u-w / X1-X3$	
YNd9			A	$U-N / H1-H0$	$v-w / X2-X3$	$1/\sqrt{3}$
			B	$V-N / H2-H0$	$w-u / X3-X1$	
			C	$W-N / H3-H0$	$u-v / X1-X2$	

Table 4-1 Different vector groups (Continued)

IEC 60076 vector group	Winding connection		Measurement	Transformer high-voltage side	Transformer low-voltage side	Measured turn ratio
	HV / H	LV / X				
Yd9			A	$U-(V+W) / H1-(H2+H3)$	$v-w / X2-X3$	$1*\sqrt{3}/2$
			B	$V-(U+W) / H2-(H1+H3)$	$w-u / X3-X1$	
			C	$W-(U+V) / H3-(H1+H2)$	$u-v / X1-X2$	
YNd11			A	$U-N / H1-H0$	$u-w / X1-X3$	$1/\sqrt{3}$
			B	$V-N / H2-H0$	$v-u / X2-X1$	
			C	$W-N / H3-H0$	$w-v / X3-X2$	
Yd11			A	$U-(V+W) / H1-(H2+H3)$	$u-w / X1-X3$	$1*\sqrt{3}/2$
			B	$V-(U+W) / H2-(H1+H3)$	$v-u / X2-X1$	
			C	$W-(U+V) / H3-(H1+H2)$	$w-v / X3-X2$	

In the Transformer high-voltage side column, + means that the terminals in the CP SB1 are short circuited.

In the graphics, the \circ symbol means N / H0.

4.4.4 TRRatio according to IEC 61378-1

The IEC 61378-1 is a standard for testing transformers with unconventional vector groups.

- ▶ Activate the **IEC 61378-1** check box to perform a measurement according to this standard. The test is vector-group independent.

The screenshot shows a control panel for the TRRatio test. At the top, there are three tabs: 'Quick 1', 'VG-Check 1', and 'TRRatio 1'. Below the tabs, there are input fields for 'Ratio' (n/a), 'V test' (300.0 V), and 'f' (60.00 Hz). A red line points from the text 'Nominal primary injection voltage' to the 'V test' field, and another red line points from 'Output frequency' to the 'f' field. To the right of these fields, there is a checked checkbox for 'IEC 61378-1' and an unchecked checkbox for 'VG independent'. Below these are checkboxes for 'Auto-tap' (checked) and 'Manual wiring' (unchecked). A table with columns 'Tap', 'V prim', 'V sec', '°', ':1', and '%' contains one row with values 'A 001', 'n/a', 'n/a', 'n/a', 'n/a', and 'n/a'. At the bottom, there is an 'Assessed:n/a' field and a scale icon. On the right side, there are buttons for 'Enter', 'Back to Top', and a small 'IEC' logo.

Figure 4-7 TRRatio test according to IEC 61378-1

With the **IEC 61378-1** check box activated, the *CPC 100* carries out two standard-compliant measurements for each winding and calculates the transformer’s turns ratio and phase shift. The measurement table displays the same values as for the standard **TRRatio** measurement. The magnetization current and phase angle will not be available in this mode.

Note: The **IEC 61378-1** test takes longer than a standard ratio measurement.

4.5 TRTapCheck test card

Use the **TRTapCheck** test card to measure the winding resistance of the individual taps of a power transformer's tap changer, and to check whether the on-load tap changer (OLTC) switches without interruption.

The *CPC 100* injects a constant current from the **6 A DC output** into the power transformer and the current is led via the **IAC/DC** input for measurement. From this current value and the voltage measured by the **V DC input**, the winding resistance is calculated.

The moment the tap is changed, the **IAC/DC** measuring input detects the sudden, very short drop of the current flow. A properly working tap change differs from a malfunctioning one, for example, an interruption during the change, by the magnitude of the ripple and slope values. An interruption will result in much higher ripple and slope values than a properly functioning tap change.

4.5.1 Measurement setup for TRTapCheck

The measurement setup on the high-voltage side in connection with the **TRTapCheck** test card is shown below.

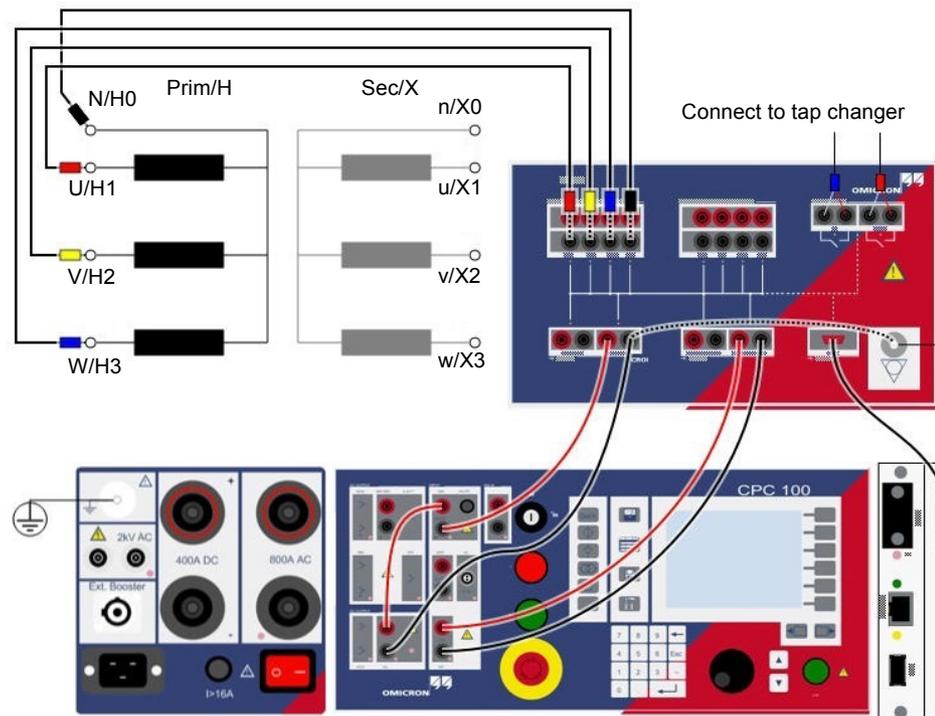


Figure 4-9 Measurement setup for **TRTapCheck** on the high-voltage side

Note: It is not necessary to connect the low-voltage side.

The measurement setup on the low-voltage side in connection with the **TRTapCheck** test card is shown below.

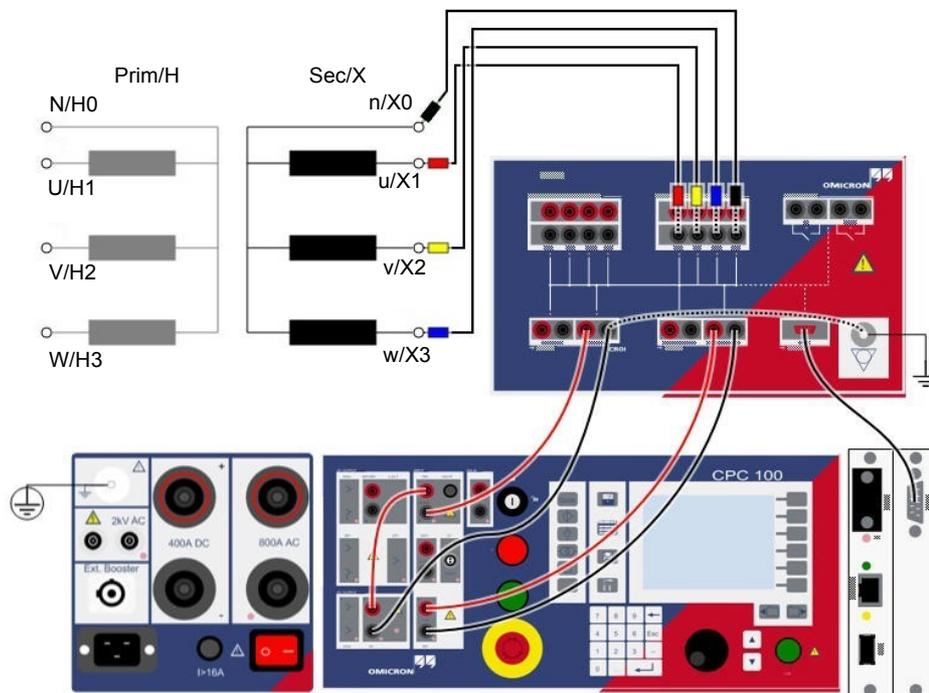


Figure 4-10 Measurement setup for **TRTapCheck** on the low-voltage side

NOTICE

Equipment damage possible

- ▶ When performing a winding resistance measurement on the low-voltage side, disconnect the high-voltage cables first.

4.5.2 Test settings for TRTapCheck

The ripple and slope values are indicated at the **TRTapCheck** test card's measurement table (see Figure 4-13 "Measurement table with relevant columns for winding resistance measurement").

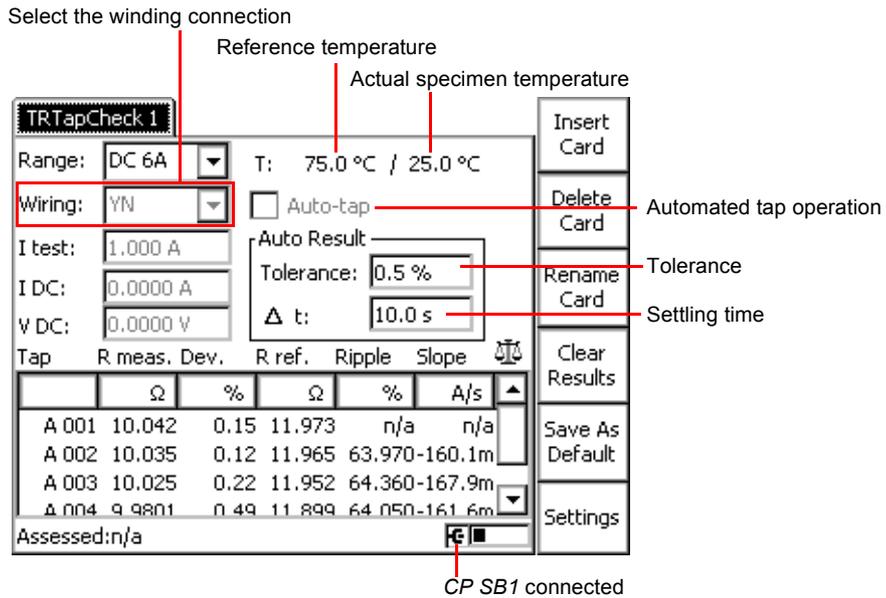


Figure 4-11 TRTapCheck test card

Pressing the **Settings** menu key or activating the **Auto-tap** operation mode will open the second page of the **TRTapCheck** test card.

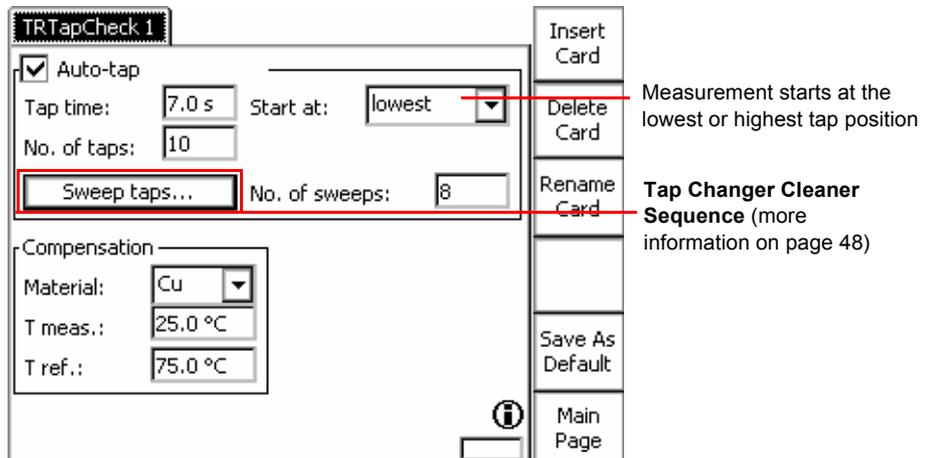


Figure 4-12 Settings page of the TRTapCheck test card

Navigate to the parameter fields, and enter the values according to your test requirements:

Range:	Output range
Itest:	Nominal test current
Wiring:	<ul style="list-style-type: none"> • D, Y, YN: for measurements on the high-voltage side • d, y, yn, z, zn: for measurements on the low-voltage side <p>The measurement is performed where the tap changer is mounted.</p> <ul style="list-style-type: none"> • manual: manual wiring to the <i>CP SB1</i> for special measurements <p>The wiring information can be displayed via the Wiring Info soft key.</p> <p>Note: If the winding connections YN, yn, zn are selected, the measured resistance is always from phase to neutral. Otherwise, the measurement is between the phases.</p>
Tmeas:	Actual specimen temperature
Tref:	<p>This is the reference temperature at which the manufacturer measured the taps' winding resistance values. Generally, this value should be specified in the transformer's data sheet.</p> <p>The winding resistance value at this temperature always represents the nominal resistance value.</p>
Auto-tap:	Automated tap operation mode for performing automatic tap switches
Tap time:	Time needed to switch from one tap to the next
Start at:	Starts the measurement at the lowest or highest position of the tap
No. of taps:	Indicates the number of taps of the transformer
Tolerance:	Tolerance of the deviation in percent
Δt :	Settling time

The **TRTapCheck** test card displays the measurement results in two display fields and a table:

IDC:	Actual test current from 6 A DC output measured at IAC/DC input
VDC:	Voltage measured at the 10 V DC input
Tap (in table):	Displays the transformer tap identifier and tap number for the measurements in the respective line of the table.
Rmeas:	Actual resistance, calculated from VDC / IDC
Dev. in %:	Deviation in % between the maximum and the minimum measured values evaluated within the settling time (Δt).

Rref:	Temperature-corrected resistance value, that is, the resistance value at an actual specimen temperature of Tref.
Ripple:	Samples and holds the biggest measured current ripple that occurred in the measuring cycle. It is indicated in % with reference to IDC.
Slope:	Samples and holds the biggest measured steepness of the falling edge of the actual test current that occurred in the measuring cycle.

Tap Changer Cleaner Sequence

The **Tap Changer Cleaner Sequence** is used to sweep all taps before performing a **Winding Resistance** measurement to ensure that the taps are clean. The currently swept tap and the remaining time are displayed during the sequence.

Note: The **Tap Changer Cleaner Sequence** can only be activated if **Auto-tap** is selected. You can only interrupt the sequence by pressing the Emergency Stop button.

4.5.3 Performing winding resistance measurements

For the available modes see 4.4.3 "Performing measurements with TRRatio" on page 27. The only difference in the fully automatic mode is that the *CPC 100* automatically performs the **Auto Keep Result** algorithm.

Press the context-dependent **Keep Result** or **Auto Keep Result** menu keys to save the actual result in the measurement table (only required for manual mode). This adds a new line to the measurement table and the next measurement can be started.



After pressing the **Auto Keep Result** menu key, the *CPC 100* waits until stable results with a deviation less than the defined tolerance (in %) within the defined settling time (Δt) are achieved. After then, a new result line is added and the next measurement starts.

Note: If the *CPC 100* is in **Auto Keep Result** status, the user can end the process by either pressing **Keep Result** or by changing to the **Tolerance** setting and changing the value. The soft key **Set current deviation** resumes the value of the current deviation in the **Tolerance** field.

Note: The manual mode also applies, if you have not purchased a license.

Fully automatic test

To perform a fully automatic test:

1. Select **Auto-tap** operation.
2. Select **Wiring** (vector group), **Itest**, **Tolerance** and Δt .
3. On the **Settings** page, define **Tap time**, **Start at** and **No. of taps**.
4. Press the **I/O** (test start/stop) push button to start the test.
5. The *CPC 100* deactivates when the test is completed.



Note: In fully automatic mode, an interrupted test will be resumed at the current tap position.

Manual or half-automatic test



Complete the following steps to perform a manual or half-automatic test:

1. For a manual test, choose **manual** under **Wiring**. For a half-automatic test, choose the wiring as required.
2. Press the **I/O** (test start/stop) push button to start the test.
3. Press **Keep Result** to save the resistance value of this tap or press **Auto Keep Result**. In this case, the *CPC 100* waits until stable results within the set **Tolerance** and Δt are achieved. After then, a new result line is added showing the number of the next measured tap.
4. At the transformer, set the tap displayed in the current result line.
5. Repeat steps 3 and 4 for all taps you want to measure.
6. Press the **I/O** (test start/stop) push button to stop the test and wait until the transformer windings are discharged.

DANGER

Death or severe injury caused by high voltage or current

- Before disconnecting the transformer under test, ground all transformer connections.

For the winding resistance, the first 4 columns (Tap, Rmeas in Ω , Dev. in % and Rref in Ω) of the measurement table are relevant.

Tap	R meas.	Dev.	R ref.	Ripple	Slope	
	Ω	%	Ω	%	A/s	
A 003	73.22m	0.00	87.30m	97.620-653.2m		
A 004	73.22m	0.00	87.30m	97.650-664.4m		
A 005	73.22m	0.00	87.30m	97.430-665.3m		
A 006	73.22m	0.01	87.30m	97.380-658.9m		

Figure 4-13 Measurement table with relevant columns for winding resistance measurement

Editing the tap number



Tap changer test and measuring the winding resistance

It is possible to edit the tap number during or after a test.

You can publish the results in a report. To do so, change to File Operations.

After the test has been finished, you can delete a result line by selecting the result line you want to delete and pressing the **Clear Results** menu key.

When testing a tap changer, we recommend the following steps:

- Inject the same current value for each phase.
- Perform tests of each phase, start with the lowest tap through to the highest and continue backwards down to the lowest tap again. Measurements may show quite different results depending on the direction of the tap movement and defects can behave differently. An interruption caused by a defective tap changer results in comparatively high measured values for ripple and slope.

For the tap changer test, the last 2 columns of the table are relevant.

Tap	R meas.	Dev.	R ref.	Ripple	Slope	
	Ω	%	Ω	%	A/s	▲
A 003	73.22m	0.00	87.30m	97.620-653.2m		
A 004	73.22m	0.00	87.30m	97.650-664.4m		
A 005	73.22m	0.00	87.30m	97.430-665.3m		
A 006	73.22m	0.01	87.30m	97.380-658.9m		

Figure 4-14 Measurement table with results of tap changer and winding resistance test

Note: During switching between the phases, the transformer is always automatically discharged.

Automated winding resistance measurement without tap changer

A special test is available for the opposite side of where the tap changer is mounted (either high- or low-voltage side). To perform the automated winding resistance measurement without tap changer on all phases, or on a transformer voltage level, where no tap changer is mounted, select the respective winding connection in the **Wiring** dialog box and check **Auto-tap** operation. Set the **No. of taps** to 1 and start the test.

Wiring:

Auto-tap

Tap time: Start at:

No. of taps:

Figure 4-15 Settings for the automated winding resistance test without tap changer

4.6 Vector Group Check test card

Use the **Vector Group Check** to automatically determine the transformer's vector group.

- Before starting the **Vector Group Check**, use the **Demag** test card with the **Wiring** set to **Yd5** or **Dy5** to ensure reliable results.

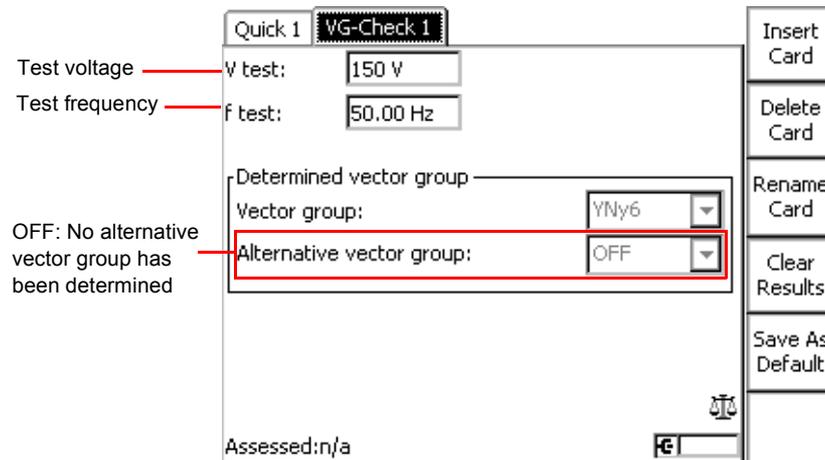


Figure 4-16 Vector Group Check test card

The *CPC 100* energizes the transformer's primary windings and measures the voltages on the secondary terminal. The optimized algorithm reduces the number of measurements. The vector group is determined according to the voltage distributions. In cases where the measurement results apply equally to two vector groups, an alternative group is provided.

- Refer to the *CPC 100* User and Reference Manuals for more information.

4.6.1 Demagnetization test card

- Use the **Demag** test card to demagnetize the transformer core.

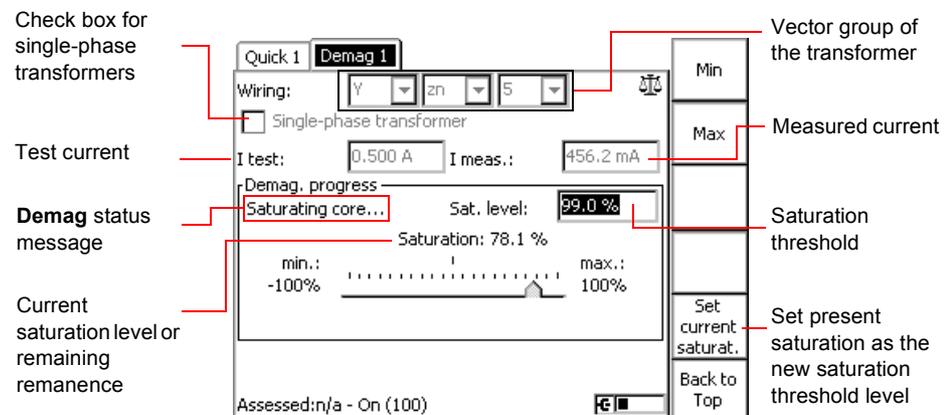


Figure 4-17 Test card during Demag process

Demag status messages:

Wiring check...	Checking for correct wiring
Idle.	Displayed before the process is started
Test was canceled.	Displayed after pushing the Emergency Stop button, confirming an error message or pressing the I/O button again
Saturating core...	Core is being saturated
Discharging...	Core is being discharged
Demagnetizing...	Actual demagnetization cycle in progress
Test stopped.	<i>CPC 100</i> could not complete the demagnetization
Core is demagnetized.	Demag cycle has been successful

► Refer to the *CPC 100* User and Reference Manuals for more information.

4.6.2 Measurement setup for the Demagnetization test card

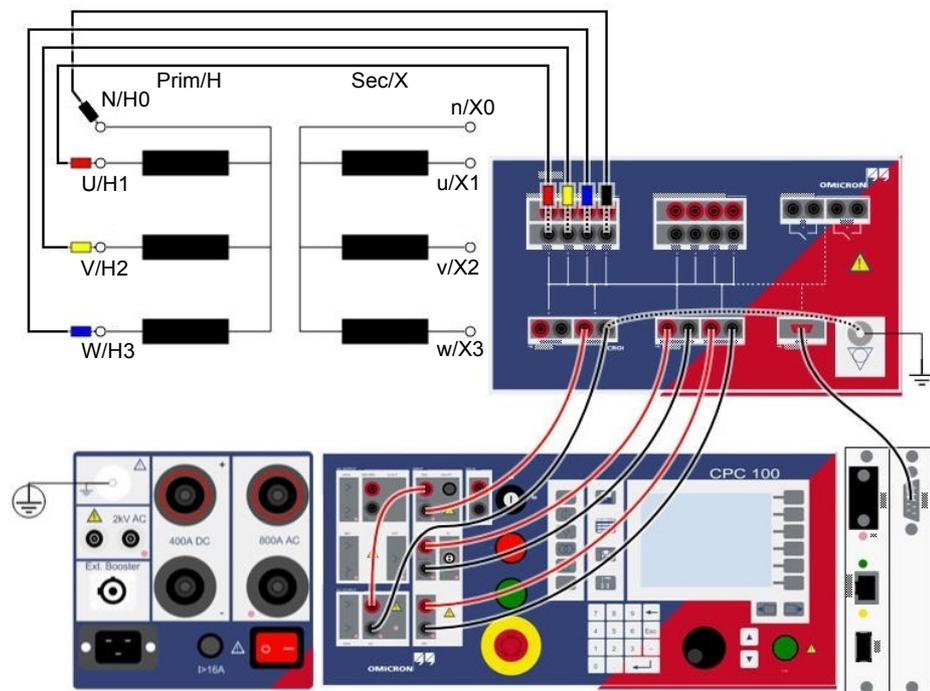
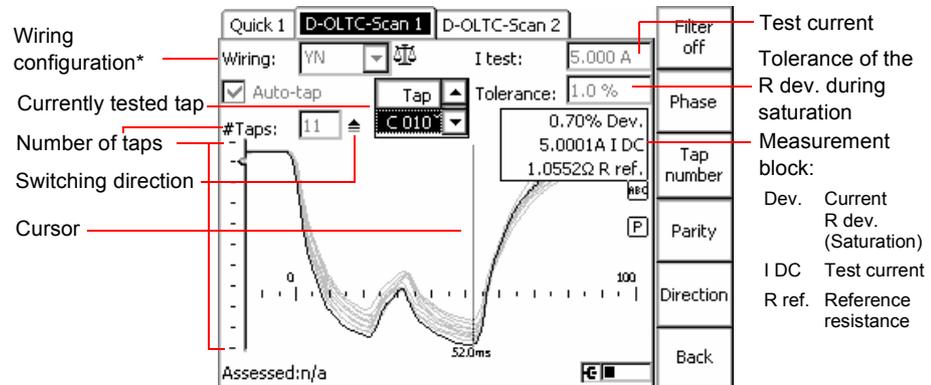


Figure 4-18 Measurement setup for **Demagnetization**

4.7 Dynamic OLTC-Scan (DRM)

- ▶ Use the **Dynamic OLTC-Scan** test card to illustrate the on-load tap changer's transient switching cycle and assess its condition. The winding resistance, ripple and slope are measured in parallel.
- ▶ In the test card, set the transformer's wiring configuration, the number of taps, and the test current. The tolerance can also be adjusted during the test.



* <1> for single-phase transformers

Figure 4-19 Dynamic OLTC-Scan test card

During the test, the following symbols may be displayed:

	Marks the detection phase during which the tap changer has to be actuated. This is either done automatically or manually.
	Time-out: No switching operation has been detected during the Tap time . Only applicable when auto-tap is activated.
	Data corruption: A disturbance has been detected. This result is invalid. ▶ Delete the corrupted data row and the subsequent rows and restart the test from the last valid result.

By default, the test results are displayed in the **Graph** view. In the **Chart** view, the results are displayed as bar charts, and in the **Table** view, Ripple/Slope and the resistance are arranged in a table.

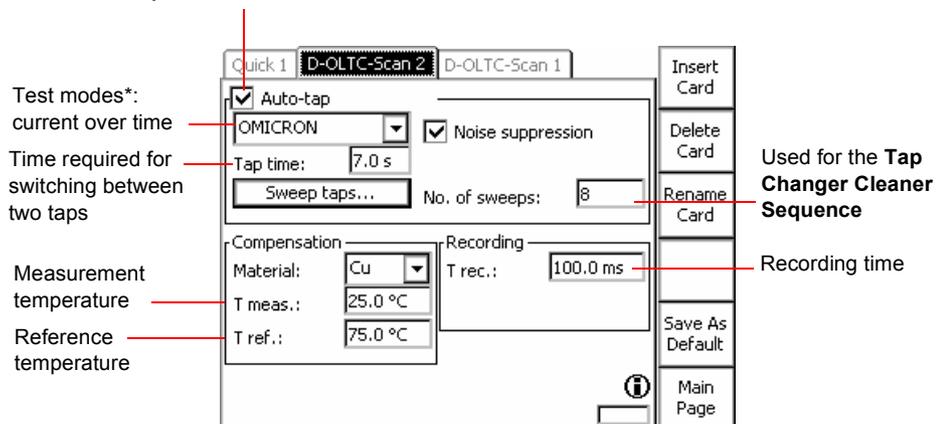
- ▶ Press **View** and use the corresponding context-dependent menu keys to switch from the **Graph** view to the **Chart** view or the **Table** view.
- ▶ Press **Meas. block** to hide/unhide the measurement block.
- ▶ Press **Mark** to place a ★ for later reference
- ▶ Press **Set Current Deviation** to enter the value of the current R dev. in the **Tolerance** field.

- ▶ Press **Filter** and use the corresponding context-dependent menu keys to apply one of the following filters:

Phase:	Only results from the currently selected phase are displayed.
Tap number:	Only results with the same tap number are displayed.
Parity:	Only results from taps with even/odd numbers are displayed.
Direction:	Only results from one direction of OLTC movement (up or down) are displayed.

- ▶ Adjust the test settings on the **Settings** page:

Activate for fully automatic mode



* **Basic**: standard test without dynamic LV shorting
OMICRON: **Basic** mode expanded by dynamic shorting of the transformer's LV side for increased sensitivity

Figure 4-20 **Dynamic OLTC-Scan** settings page

- ▶ Refer to the *CPC 100* User and Reference Manuals for more information.

4.7.1 Measurement setup for the Dynamic OLTC-Scan

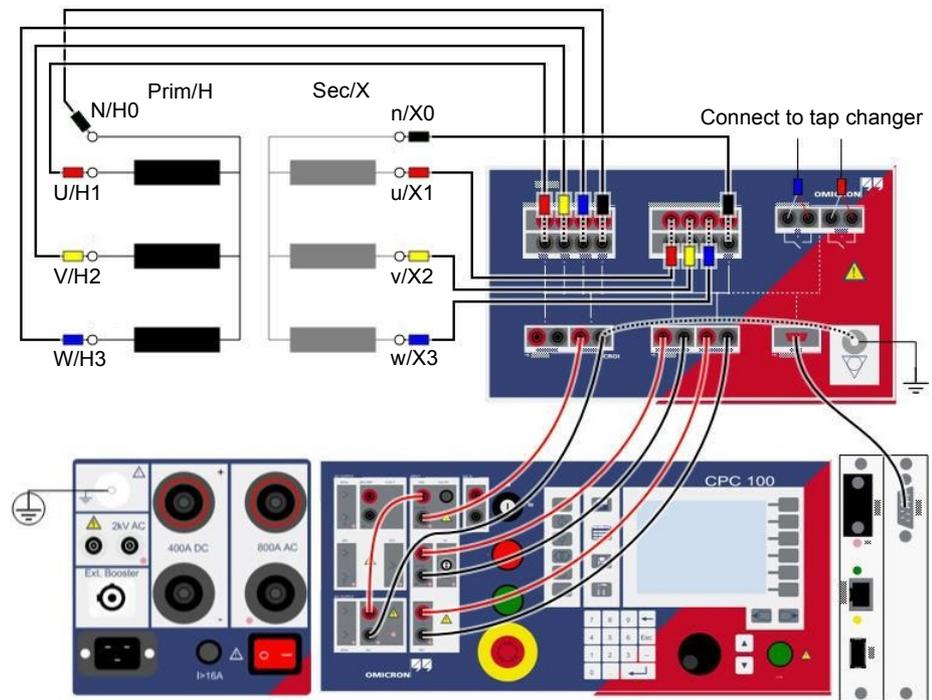


Figure 4-21 Measurement setup for the **Dynamic OLTC-Scan**

5 Technical data

5.1 Specifications

Table 5-1 Specifications

Characteristic	Rating
AC Input / V1 AC Output	max. 300 V _{eff}
DC Input	max. 6 A DC
Transformer High and Low Voltage connections	max. 300 V _{eff} between all connectors and ground
Tap Changer	Two potential-free contacts, short circuit-protected; 0-240 V AC (only AC permitted); Overvoltage Category II; Resistance per contact = max. 4 Ω I continuous = 0.9 A rms
Supply	Via serial interface from <i>CPC 100</i> (+15 V)
Overvoltage protection to case with surge arrestors	All connections to Transformer High and Low voltage side; AC/DC Input; V1 AC / V DC Output

Two different *CPC 100* versions exist, V0 and V1. An upgrade from the version V0 to V1 is possible. For *CPC 100* V1 units you will find the text "V1" in the "Options" field of the nameplate on the right-hand side of your *CPC 100*. Depending on the version, the *CPC 100* is delivered with different processor options and only V1 supports the *CP SB1*. For further information, please refer to the *CPC 100* Reference Manual.

5.2 Environmental conditions

5.2.1 Climate

Table 5-2 Climate

Climate	
Operating temperature	-10 ... +55 °C (+14 ... 131 °F)
Storage and transportation	-20 ... +70 °C (-4 ... 158 °F)
Max. altitude	2000 m

5.3 Mechanical data

Table 5-3 Mechanical data

Weight, Dimensions	
Weight <i>CP SB1</i>	3.5 kg (7.7 lb)
Weight filled transport case	28.5 kg (62.7 lb)
Dimensions W x H x D <i>CP SB1</i>	357 x 235 x 111 mm (14.1 x 9.2 x 4.4")
Dimensions transport case	700 x 450 x 500 mm (27.6 x 17.7 x 19.7")

5.4 Standards

Table 5-4 Standards conformity

EMC, safety		
EMC	IEC/EN 61326-1 (industrial electromagnetic environment) FCC subpart B of part 15, class A	
Safety	IEC/EN/UL 61010-1	
Other		
Shock	IEC/EN 60068-2-27 (15 g / 11 ms, half-sinusoid, 3 shocks in each axis)	
Vibration	IEC/EN 60068-2-6 (frequency range 10 ... 150 Hz; acceleration 2 g continuous (20 m/s ²); 20 cycles per axis)	
Humidity	IEC/EN 60068-2-78, 5 ... 95 % relative humidity; no condensation Tested at 40 °C (104 °F) for 48 hours	
Protection class (housing)	IP20, according to EN 60529	

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