

# CPC 100

## Reference 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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# Preface

## About this reference manual

The purpose of this Reference Manual is to familiarize users with the *CPC 100* and its various application fields. It contains helpful instructions on how to use the *CPC 100* safely, properly, and efficiently.

Following these instructions will help you to prevent danger, repair costs and possible down time due to incorrect operation. Furthermore, it ensures the reliability and life-cycle of the *CPC 100*.

**Note:** The *CPC 100* must be used in observance of all existing safety requirements from national standards for accident prevention and environmental protection.

Reading the *CPC 100* manual alone does not release the user from the duty of complying with all national and international safety regulations relevant for working with the *CPC 100*, for example, the regulation EN50191 "Erection and Operation of Electrical Test Equipment".

The Reference Manual always has to be available at the site where the *CPC 100* is used.

It should be read and used by all people working with the *CPC 100*.

In addition to the Reference Manual and the applicable regulations for accident prevention in the country and at the site of operation, the accepted technical procedures for safe and competent work should be heeded.

## Glossary of symbols and terms

This manual uses different symbols to highlight text passages of special safety and/or operational relevance. These symbols are listed in the following section.

In addition, the glossary lists a number of terms that are frequently used throughout this manual.

### Used symbols



#### **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

## Used terms

<b>Booster</b>	Amplifier; for example the <i>CP CB2</i> current booster option for output currents of up to 2000 A.
<b>Combo box</b>	Component of the software UI. Technical term for the dialog box option that is a text box with an attached list box, for example, a measurement table.
<b>DHCP</b>	<b>D</b> ynamic <b>H</b> ost <b>C</b> onfiguration <b>P</b> rotocol; used to connect the <i>CPC 100</i> to a PC network (refer to "CPC 100 in a network" in chapter 11).
<b>ePC</b>	<b>e</b> mbedded <b>P</b> ersonal <b>C</b> omputer, that is, fully-functional PC with processor, RAM, interfaces, operating system etc. that is embedded into the <i>CPC 100</i> . An ePC, however, does not contain certain features that characterize a PC, such as floppy disk or CD-ROM drive, a hard disk drive or a sound card.
<b>Ethernet</b>	One of the most popular network connection standards (IEEE 802.3), based on the CSMA/CD (Carrier Sense Multiple Access with Collision Detection) model. See also ⇒ NIC...
<b>fs</b>	fs = <b>f</b> ull <b>s</b> cale; used for determining the error value of a measurement range (for an example refer to 15.1 "General" on page 294).
<b>Focus</b>	The term "focus" designates the currently selected (active) part of the software user interface: "the focus is on...", that is, the selected UI part is highlighted or inverted.
<b>IP address</b>	IP = Internet <b>P</b> rotocol address; used to connect the <i>CPC 100</i> to a PC network (refer to "CPC 100 in a network" in chapter 11).
<b>LCD</b>	LCD = <b>L</b> iquid <b>C</b> rystal <b>D</b> isplay. The <i>CPC 100</i> built-in PC monitor is a LCD monitor.
<b>NIC</b>	<b>N</b> etwork <b>I</b> nterface <b>C</b> ard; built-in board that serves as the interface between a device (PC, notebook, <i>CPC 100</i> ) and the "outside world" (PC, network hub, Internet).  The NICs used to interface with the <i>CPC 100</i> are ⇒ Ethernet boards with RJ-45 connectors.
	
	<p>Typical Ethernet network interface card with BNC and RJ-45 connectors</p>
	
	<p>Typical PCMCIA Ethernet network interface card for notebooks with BNC and RJ-45 connectors</p>
	
<b>Offline</b>	Not connected to the <i>CPC 100</i> , for example, "offline test preparation" means: preparing a test with a PC using <i>CPC Editor</i> .

<b>PC Card</b>	PCMCIA network interface card. See also ⇒ NIC...
<b>Press</b>	The term "press" in the context of working with the <i>CPC 100</i> software (for example, press the <b>Insert Card</b> key) means: a) pressing a menu or an accelerator key b) or setting the focus onto a UI element by navigating to it with the handwheel, and pressing the handwheel to execute the <b>Enter</b> function
<b>Quantity</b>	The term "quantity" designates a physical unit, such as Volt (V) or Ampere (A).
<b>rd</b>	rd = <b>reading</b> ; used for determining the error value of a measurement range (For an example, see 15.1 "General" on page 294.)
<b>sel</b>	sel = frequency- <b>selective</b> measurement (see chapter 4.2.1 on page 81)
<b>Test object</b>	The object to be tested by the <i>CPC 100</i> , for example, a current or voltage transformer.
<b>Trigger</b>	A trigger is an "initiator". In this case it is an electrical signal, for example, at <i>CPC 100</i> binary input, whose occurrence causes direct follow-up actions, such as switching off the output signals.
<b>User interface (UI)</b>	Operational surface of a software. A user interface contains all control elements necessary to work with the software.
<b>V0</b>	<i>CPC 100</i> version V0 (see on page 14 of this chapter)
<b>V1</b>	<i>CPC 100</i> version V1 (see on page 14 of this chapter)

## Functionality of the *CPC 100*



### Current transformer (CT)

- testing ratio, polarity (and burden) with injection to current input
- testing ratio, polarity (and burden) with a current clamp
- testing secondary burden
- measuring the excitation curve
- measuring winding resistance
- dielectric withstand voltage test (2kV AC)
- polarity check
- testing ratio and polarity by measuring the voltage ratio
- testing ratio and polarity of a Rogowski coil
- testing ratio and polarity of low-power current transformer
- testing sampled value ratio according to IEC 61850-9-2
- measuring power/dissipation factor & capacitance with the *CP TD* test set



### Voltage transformer (VT)

- testing ratio and polarity
- testing secondary burden
- dielectric withstand voltage test (2kV AC)
- polarity check
- testing ratio & polarity of non-conventional electronic voltage transformers
- testing sampled value ratio according to IEC 61850-9-2
- measuring power/dissipation factor & capacitance with the *CP TD* test set



### Power transformer testing (TR)

- ratio and polarity / tap changer test
- measuring winding resistance
- testing tap changer contacts
- dielectric withstand voltage test (2kV AC)
- Vector group detection
- Demagnetization of a power transformer
- measuring dynamic resistance on tap changers
- measuring power/dissipation factor & capacitance with the *CP TD* test set

## Ω Resistance testing

- measuring contact resistance ( $\mu\Omega$ )
- measuring winding resistance ( $\mu\Omega$  -  $k\Omega$ )
- measuring earth resistance ( $\mu\Omega$  -  $k\Omega$ )
- dielectric withstand voltage test (2kV AC)
- measuring line impedance with the *CP CU1*

## Other applications

- **Ramping**, a programmable ramping generator and determination of thresholds
- **Sequencer** for automatic testing with different states in real time
- **Comment** card to hold a user-defined comment and/or note regarding the actual test procedure.
- **HV resonance** test card for the generation of high voltage by means of a resonance circuit
- **12kV HV** test card with the *CP TD* as high voltage source either independently or with a compensating reactor
- When using the **Amplifier** test card, an input signal fed into a synchronization input drives the high-current output's magnitude, frequency and phase angle.

## Insulation tests (TanDelta)

*CP TD* for on-site insulation tests of high-voltage systems like power and measuring transformers, circuit breakers, capacitors and isolators.

## CPC 100 versions

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 and ePC interface options described below.

CPC 100 Version	Processor	ePC Interfaces				
		PC	Network	USB	Serial	Safety
V0	66 MHz x86 compatible	x	x		x	x
V1	400 MHz RISC CPU	x <sup>1</sup>	x <sup>1</sup>	x	x	x

1. *CPC 100* V1 units are equipped with one socket for connecting the *CPC 100* to both a PC and a network hub.

For detailed information on the ePC interfaces, see 2.1.3 "ePC interfaces" on page 29.

## Related documents

The following documents complete the information covered in the CPC 100 Reference 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 PTM User Manual	Contains information on how to use the <i>Primary Test Manager PTM</i> together with the <i>CPC 100</i> .
CP TD1 User Manual	Contains information on how to use the <i>CP TD1</i> insulation analyzing system and relevant safety instructions.
CP TD12/15 User Manual	Contains information on how to use the <i>CP TD12/15</i> insulation analyzing system and relevant safety instructions.
CP CR500 User Manual	Contains information on how to use the <i>CP CR500</i> compensating reactor and relevant safety instructions
CP CR600 User Manual	Contains information on how to use the <i>CP CR600</i> compensating reactor and relevant safety instructions
CP SB1 User Manual	Contains information on how to use the <i>CP SB1</i> switchbox and relevant safety instructions.
CP CU1 User Manual	Contains information on how to use the <i>CP CU1</i> coupling unit and relevant safety instructions.
CPOL2 User Manual	Contains information on how to use the <i>CPOL2</i> handheld polarity checker and relevant safety instructions.
CPOL3 User Manual	Contains information on how to use the <i>CPOL3</i> handheld polarity checker and relevant safety instructions.
CP RC1 User Manual	Contains information on how to use the <i>CP RC1</i> resonance circuit and relevant safety instructions.
CP RC2 User Manual	Contains information on how to use the <i>CP RC2</i> resonance circuit and relevant safety instructions.

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# 1 Safety instructions for the *CPC 100* and its accessories

- ▶ Before operating the *CPC 100*, read the following safety instructions carefully.
- ▶ If some points of the safety instructions are unclear, please contact OMICRON
- ▶ Do not turn on and do not use the *CPC 100* without understanding the information in this manual.

## 1.1 Principle use according to regulations

- ▶ Use the *CPC 100* and its accessories only in a technically sound condition. Make sure its use is in accordance with the regulations on site and the designated use described in this document.
- ▶ Comply with the workflows described in this document. Avoid interruptions or distractions that could affect safety.
- ▶ If you have a cardiac pacemaker, do not use the *CPC 100*! Before operating the *CPC 100*, make sure there is no person with a cardiac pacemaker in the immediate vicinity.
- ▶ The *CPC 100* is exclusively intended for the application fields specified in detail in 1.4 "Designated use" on page 17.
- ▶ Do not open the *CPC 100* housing.

## 1.2 Operator qualifications and primary responsibilities

- ▶ Only authorized personnel who are qualified, skilled and regularly trained in electrical engineering are allowed to operate the *CPC 100* and its accessories.
- ▶ Personnel receiving training, instructions, directions, or education on *CPC 100* must be under constant supervision of an experienced operator while working with the equipment. The supervising operator must be familiar with the equipment and the regulations on site.

## 1.3 Safety standards and rules

### 1.3.1 Safety standards

Testing with the *CPC* must comply with the internal safety instructions and additional safety-relevant documents.

In addition, observe the following safety standards, if applicable:

- EN 50191 (VDE 0104) "Erection and Operation of Electrical Test 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, observe all applicable regulations for accident prevention in the country and at the site of operation.

Before operating the *CPC* and its accessories, read the safety instructions in this Reference Manual carefully. Do not turn on the *CPC* and do not operate the *CPC* without understanding the safety information in this manual. If you do not understand some safety instructions, contact OMICRON before proceeding.

- ▶ Observe all applicable regulations for accident prevention in the country and on the site of operation.
- ▶ If you do not understand the safety rules, contact OMICRON before proceeding.

### 1.3.2 Safety rules

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.

### 1.3.3 Safety accessories

- ▶ OMICRON offers a range of accessories for added safety during the operation of our test systems. For further information and specifications, refer to the corresponding Supplementary Sheet or contact OMICRON Support (see "Support" on page 335).

### 1.3.4 Safe operation

- ▶ When setting the *CPC 100* into operation, follow the instructions in 2.6 "Putting the *CPC 100* into operation" on page 70.
- ▶ Never use the *CPC 100* without a solid connection to ground with at least 6 mm<sup>2</sup>. Use a ground point as close as possible to the operator.

## 1.4 Designated use

The *CPC 100*, in conjunction with its accessories or as a stand-alone unit, is a multi-purpose primary test set for commissioning and maintaining substation equipment. It performs current transformer (CT), voltage transformer (VT) and power transformer (TR) tests. Furthermore, it is used for contact and winding resistance testing, polarity checks as well as primary and secondary protection relay testing.

The various, partly automated tests are defined and parameterized via the front panel control of a built-in ePC.

## 1.5 Orderly measures

- ▶ The Reference Manual, or alternatively the e-book in PDF format, should always be available on the site where the *CPC 100* is being used.
- ▶ Personnel assigned to use the *CPC 100* should carefully read the Reference Manual - in particular this section on safety instructions - before beginning to work with it. On principle, this also applies to personnel who only occasionally work with the *CPC 100*.

- ▶ The person responsible for the work activity (for example a measurement) must coordinate clear communication with all persons and parties involved in work activities on and around the device under test, especially before injecting voltages or currents. Risks arising from overlapping work activities on the same installation need to be evaluated and clarified beforehand.
- ▶ Unauthorized persons must be prevented from accessing and/or activating the *CPC 100* or any of its accessories.

**Note:** Equipping the *CPC 100* with additional visual and acoustic signaling (*SAA2*) may raise awareness of ongoing test activities.

- ▶ Do not repair, modify, extend, or adapt the *CPC 100* or its accessories.
- ▶ Use the *CPC 100* in conjunction with original accessories only.
- ▶ Only use the *CPC 100* on dry, solid ground.
- ▶ Do not enter the danger zone if the red signal light of the *CPC 100* is on since all outputs can carry dangerous voltage or current.
- ▶ Always obey the five safety rules and follow the detailed safety instructions in the respective user manuals.

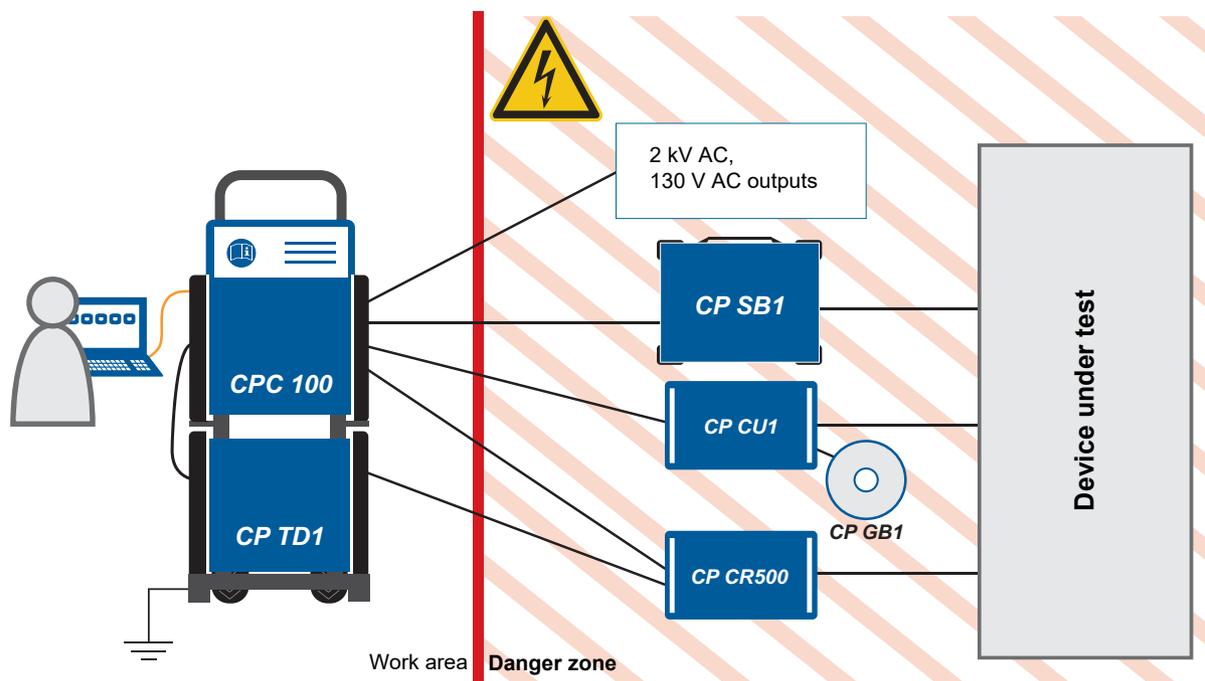


Figure 1-1: Example of the separation of work area and danger zone using different OMICRON devices

## 1.6 General

- ▶ Use dry and clean cables and connectors.
- ▶ Do not connect any cable to the test object without a visible grounding of the test object.
- ▶ Before rewiring, stop the test, press the **Emergency Switching off** button, lock the control unit, and short-circuit and ground the device under test.
- ▶ Never connect or disconnect a test object while the outputs are active.
- ▶ Do not remove any cables from the *CPC 100* during a test.
- ▶ When connecting cables to a control cabinet, be aware of uninsulated live components. Adhere to the safety instructions provided by the manufacturer.
- ▶ Make sure that a test object's terminals that are to be connected to the *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.

At their output sockets and especially in the cables connected to them, in operation the high-current **400A DC** and **800A AC** outputs generate a significant amount of heat (approx. 300 W/m at 800 A).

- ▶ After operation, wait for cables and clamps to cool down before touching them. If in doubt, wear gloves.
- ▶ Never use the test cards **Quick** and **Resistance** to measure the resistance of windings with a high inductance because turning off the DC source results in life-threatening voltage levels. For this kind of measurement only use the special winding resistance test card **RWinding**, **TRTapCheck** or **OLTC-Scan**.

When measuring the ratio of voltage and power transformers make sure that the test voltage is connected to the corresponding primary winding, and the voltage of the secondary 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 100 V to the secondary winding of a voltage transformer that has a ratio of 400,000 V:100 V, induces a voltage of 400,000 V in the transformer's primary winding.

On open secondary windings, life-threatening voltages can be induced!

- ▶ Make sure that when testing a current transformer by feeding a test current into its primary winding, all secondary windings are shorted.
- ▶ Do not operate the *CPC 100* under ambient conditions that exceed the temperature and humidity limits listed at 15 "Technical data" on page 294.
- ▶ Do not operate the *CPC 100* in the presence of explosives, gas or vapors.
- ▶ Opening *CPC 100* or its accessories without authorization invalidates all warranty claims. Any kind of maintenance, calibration or repair on the device itself may only be carried out by persons authorized by OMICRON.
- ▶ If the *CPC 100* or any add-on device or accessory does not seem to function properly, do not use it anymore. Please call the OMICRON hotline.
- ▶ Unwind extension cables from their reel. Otherwise they will overheat.

## 1.7 Grounding

Operating the device without PE and ground connection is life-threatening and not permitted.

- ▶ Only operate the *CPC 100* with a mains power supply connected to protective earth (PE).
- ▶ Make sure that both the PE connection of the power supply and the ground connector of the *CPC 100* have a solid and low-impedance connection to the grounding system on site. This also applies to all other test devices and accessories in the test setup.
- ▶ Make sure that the grounding clamp has a good electrical contact to the grounding system on site and avoid connecting it to corroded or painted surfaces.
- ▶ Make sure that the grounding terminal connections of all grounded devices in use remain intact during the whole measurement procedure, and are not accidentally disconnected.
- ▶ Only use ground and supply cables provided by OMICRON.



Connect the *CPC* grounding terminal to the grounding system on site.

## 1.8 Power supply

Operating the *CPC 100* without PE and ground connection is life-threatening and not permitted.

- ▶ Only operate the *CPC 100* with a mains power supply connected to protective earth (PE).

### Power supply from grounded grids (TN/TT)

Before a measurement is started, the *CPC 100* automatically verifies the PE connection in grounded grids (TN/TT).

- ▶ If this check fails, check the power cord and power supply.

If the error message persists, there is no intact connection to protective earth (PE).

This is life-threatening. In this case measurements are not permitted and cannot be performed.

### Power supply from isolated grids (IT)

An IT grid is a grid structure where none of the active conductors are galvanically connected to ground. In an IT grid, only the PE is connected to ground.

In IT grids, the check fails – even if there is a PE connection. This can be the case when the *CPC 100* is powered by a generator. Since every operation mandates a PE connection for the operation of the *CPC 100*, you need to manually verify this.

If the *CPC 100* is supplied by a generator, the equipotential ground or PE of the generator has to be grounded properly.

- ▶ If this is not possible, measurements are not permitted and cannot be performed.

## Additional information

Instead of supplying the *CPC 100* from phase-neutral (L1-N, A-N), it may also be supplied from phase-phase (for example, L1-L2; A-B).

- ▶ Make sure that the voltage does not exceed 240V AC.
- ▶ Make sure that the power supply is fuse-protected (16 A automatic circuit breaker).
- ▶ Do not use an extension cable on a cable reel to prevent an overheating of the cord; run out the extension cord.
- ▶ Keep extension cables as short as possible to prevent power loss.

If the power supply is  $\leq 190\text{V AC}$ , the *CPC 100* cannot provide the full output power at the **800A AC** output. The same applies when an external current booster is used.

- ▶ Therefore, in order to gain the full output power, provide a sufficient power supply (190 V ... 240 V AC).

The **Ext. Booster** connector is **always** galvanically connected to mains and active.

This also applies when no external booster is selected, the green signal light (0) is on, the outputs are turned off, or the **Emergency Switching off** button is pressed.

- ▶ Handle the **Ext. Booster** connector with extreme caution.
- ▶ Only use booster cables supplied by OMICRON.
- ▶ Do not use booster cables that are frayed or damaged in any way.

## 1.9 Changing fuses

1. Ground the test object, and disconnect it from the *CPC 100*. By disconnecting it you prevent a possibly faulty test object feeding power back into the *CPC 100*.
  2. Turn off the *CPC 100* and unplug the power cord.
  3. Press the **Emergency Switching off** button.  
Wait for about 30 seconds. This time is necessary for the internal electrolytic capacitors to fully discharge.
  4. Locate the blown fuse on the front panel of the *CPC 100*, and replace it:
    - **6.3A T** (6.3 Amps slow-acting wire fuse 5x20 mm) for **AC OUTPUT** in 6A operation mode<sup>1</sup> or for **DC OUTPUT**.
    - **3.15A T** (3.15 Amps slow-acting wire fuse 5x20 mm) for **AC OUTPUT** in 130V operation mode.
    - **10A FF** (10 Amps very-quick-acting wire fuse 5x20 mm) for measuring inputs.
- ▶ Replace with identical fuse type only.

---

1. For detailed information about the difference between the 6A and the 130V operation mode refer to 2.1 "Functional components of the CPC 100" on page 27.

## 1.10 DC output to test objects with a high inductance

- ▶ Only use the dedicated tests for DC measurements on assets with inductive characteristics:

<b>CPC 100 test cards</b>	<b>Primary Test Manager tests</b>
RWinding	DC Winding Resistance
D-OLTC-Scan	Dynamic OLTC Scan
Demag	Demagnetization
TRTapCheck	CT Winding Resistance Sec
	DC Winding Resistance Stator
	DC Winding Resistance Rotor

- ▶ Never open the measuring circuit while current flows.
- ▶ After a measurement, wait until the test device has discharged completely.
- ▶ Ground all terminals of the test object before touching the test setup.
- ▶ Short-circuit the terminals before disconnecting the test leads.
- ▶ Disconnect cables not used for testing both from the test object and the test device.

### 1.10.1 Discharging after tests on objects with a high inductance

After a winding resistance measurement, the *CPC 100* monitors the reduction of the current and voltage levels to zero. During this discharge process, the red signal light flashes.

In the **Demag** test card, the discharging process is displayed as a status message (see 7.8 "Demagnetization" on page 206).

In the other listed tests, a discharge dialog is displayed:

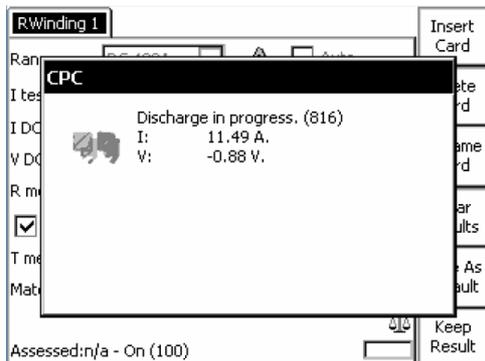
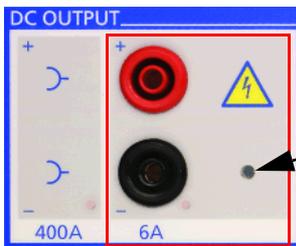


Figure 1-2: Discharge in progress



Indicator light steady-on red: voltage on **6A DC** output > 2 V

**Note:** This indicator light only applies to the **6A DC** output and *does not* include the **400A DC** output.

**Note:** When you disconnect a cable during the discharge process, even low voltage (0.88 V in Figure 1-2 above) presents considerable danger as it suddenly increases to a very high level when the circuit is disconnected.

- ▶ Do not touch or disconnect any part of the test setup until the current and voltage levels have reduced to zero.
- ▶ If the measurement is interrupted due to, for example, an unexpected loss of supply voltage or erroneous behavior of the *CPC 100* do not touch the test setup until the energy has dissipated over time.  
Note that the length of time depends heavily on the asset under test.

## 1.11 High-voltage and high-current outputs

- ▶ Connect only one *CPC 100* output at a time.
- ▶ All AC and DC output sockets of the *CPC 100* can carry dangerous voltage potential and provide dangerous currents. Therefore:



- ▶ While connecting cables to the *CPC 100* high-voltage or high-current outputs or other conducting parts that are not protected against accidental contact, press the **Emergency Switching off** button, and keep it pressed as long as an output signal is not absolutely necessary for the test.

For the high-voltage and high-current output connectors on the left-hand side of the test set (**2kV AC**, **400A DC** and **800A AC**, ext. Booster), only use the specially manufactured cables supplied by OMICRON (refer to 16.4.1 "Assembly instructions for Odu MINI-SNAP plug" on page 329). One end of the high-voltage cable has a coaxial safety plug that is certified for a voltage level of 2kV AC. The other end is equipped with a safety banana plug that is insulated with a shrink tube. When the *CPC 100* is switched on consider this part of the cable a hazard of electric shock!

The **400A DC** or **800A AC** outputs are not switched off by internal relays. Therefore, if a test mode is selected that does not use either one of these two outputs, they are still active.

- ▶ If you do not use the high-current **400A DC** or **800A AC** outputs or the high-voltage **2kV AC** output, disconnect any cable that may be plugged in to these sockets.
  - ▶ Do not stand right next to or directly underneath a connection point because the clamps may fall off and touch you.
  - ▶ The red signal 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 signal light indicates that the *CPC 100* outputs are not activated.

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

- ▶ Both of the high-current output sockets on the left-hand side of the test set (**400A DC** and **800A AC**) usually carry a relatively low-voltage potential.

In case of an internal insulation fault these outputs may carry up to 300 V.

- ▶ Consider these outputs dangerous!
- ▶ Always lock connectors properly.



The counterpart of the high-current sockets are locking connectors.

To lock these connectors safely, insert them carefully until you feel a "click" position. Now they are locked. Confirm this by trying to pull them out. This should not be possible now.

To remove the locking connectors again, unlock them by pushing them in first, and then pull them out.

- ▶ The high-current cables for both the **800A AC** and **400A DC** outputs are equipped with connection clamps at one end. If these connection clamps are attached to a test object's terminal that is situated above your head, make sure the clamp is securely attached. Due to the weight of the cables the clamp may become loose and fall down.

## 1.12 CPC 100 in combination with the CP TD

The *CP TD* (*CP TD1*, *CP TD12* or *CP TD15*) is an optionally available high-precision test system for on-site insulation tests of high-voltage systems like power and measuring transformers, circuit breakers, capacitors and isolators. The *CP TD* works as an add-on device to the *CPC 100* and is described in the *CP TD1* and *CP TD12/15* User Manuals on the *Primary Test Manager* DVD and the *CPC 100 Start Page*.

On principle, the safety instructions that apply to the *CPC 100* and its accessories also apply to the *CP TD*. However, the *CP TD* requires some additional precautions and measures. They are listed in the *CP TD1* and *CP TD12/15* User Manuals.

## 1.13 Handling long cables

- ▶ The entire working environment, including the power supply of the test system, must not extend beyond the perimeter of the substation, except where this is not feasible due to the situation on site.
- ▶ Make sure the *CPC 100*, its cables and the device under test are properly grounded as described in this manual.
- ▶ Before unreeling any power extension cords to supply the *CPC 100*, make sure the respective cable is connected to a mains supply with protective earth (PE).
- ▶ Before unreeling any measurement, communication or interface cables of the *CPC 100*, make sure no cables are connected to an ungrounded device under test.
- ▶ Extra care should be taken that cables are placed as close as possible to ground level (this practice minimizes both electric and magnetic coupling).
- ▶ Any measurement, communication or interface cables of the *CPC 100* shall be placed within an environment, where unauthorized or unintentional human entry are avoided during usage of the *CPC 100* with any means necessary.

## 1.14 Disclaimer

If the equipment is used in a manner not described in the user documentation, the protection provided by the equipment may be impaired.

## 1.15 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.

## 1.16 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.

## 2 Introduction

### 2.1 Functional components of the *CPC 100*

#### 2.1.1 Front panel

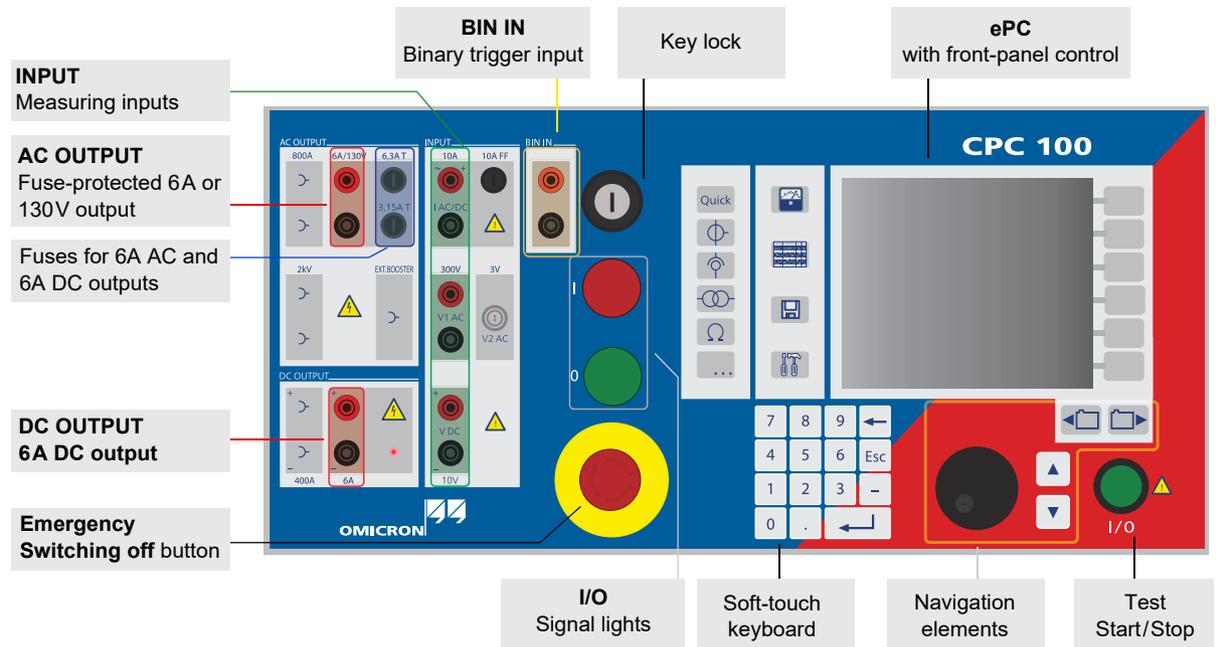


Figure 2-1: *CPC 100* front view

**Note:** With the *CPC 100 V0*, the number of test cards in one test procedure should be limited to 15 to avoid memory problems. The *CPC 100 V1* allows using more test cards in one test procedure but we recommend not using more than 15 test cards or more than 50 test results to keep the tests clearly structured.

## 2.1.2 High-voltage and high-current outputs

When the *CPC 100* outputs high current, observe the allowed duty cycles that may apply to the selected AC output range. For more information please refer to 15.3 "CPC 100 outputs" on page 297.

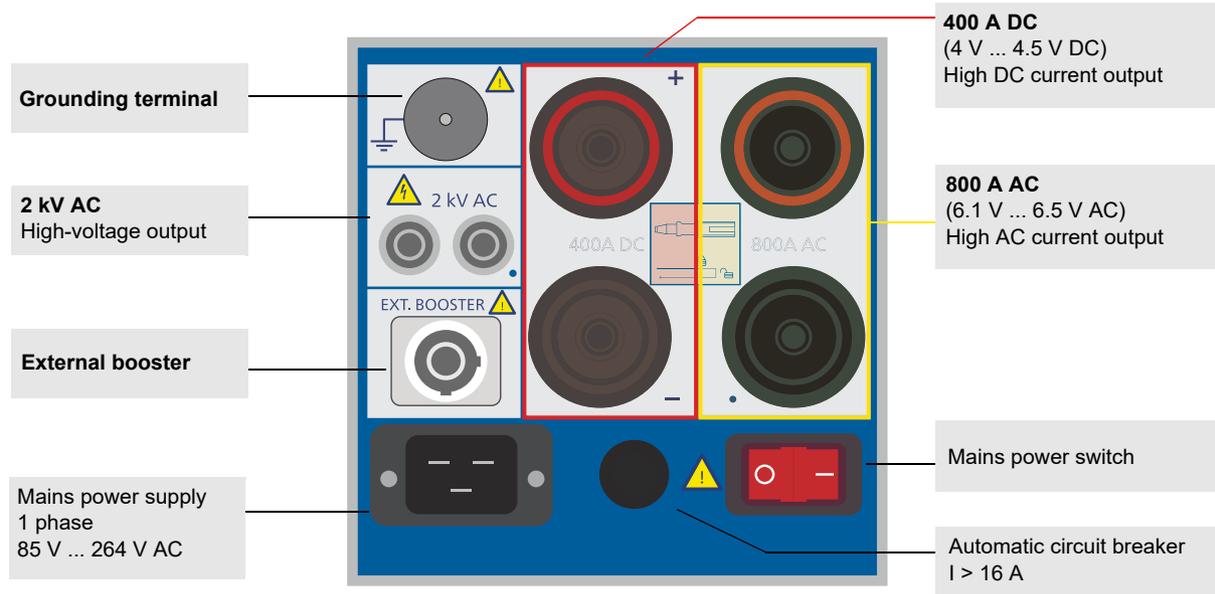


Figure 2-2: High-voltage and high-current outputs on left-hand side of the *CPC 100*

### DANGER



#### Death or severe injury caused by high voltage or current

The **Ext. Booster** connector is **always** galvanically connected to mains. This also applies when no external booster is selected, the green signal light (0) is on, the outputs are turned off or the **Emergency Switching off** button is pressed.

- ▶ Handle the **Ext. Booster** connector with extreme caution.
- ▶ Do not use any other booster cables than the ones supplied by OMICRON.
- ▶ Do not use booster cables that are frayed or damaged in any way.

### 2.1.3 ePC interfaces

The ePC interfaces are located on the right-hand side of the *CPC 100* housing. The PC and network interfaces differ depending on the *CPC 100* version as described below.

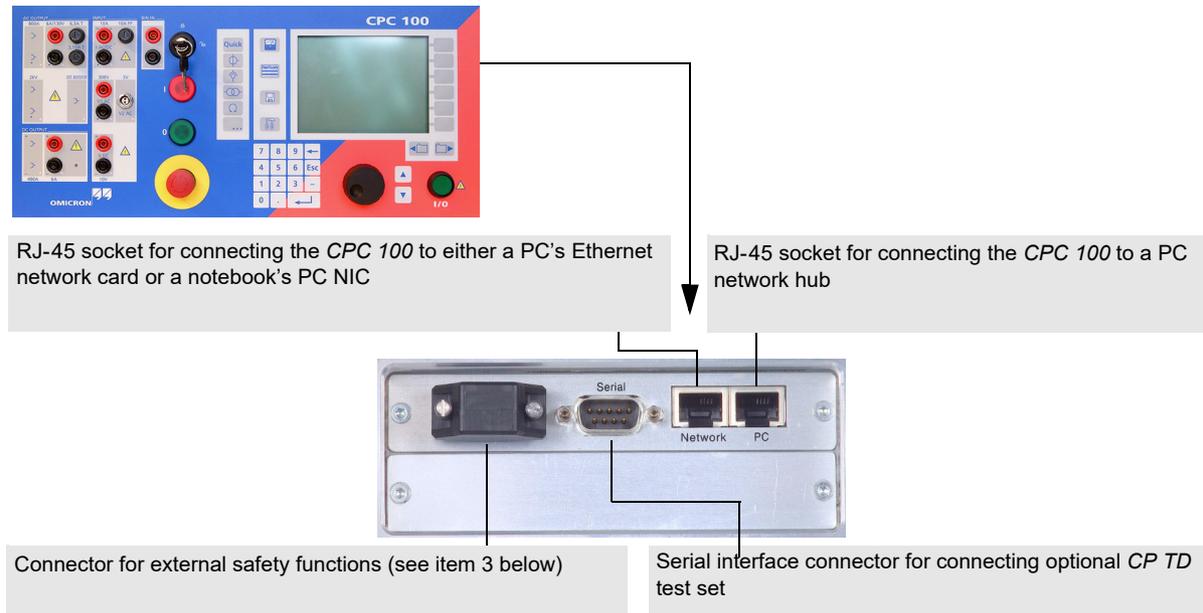


Figure 2-3: ePC interfaces of the *CPC 100 V0*

1. For more information on the PC and network interfaces, see 11 "CPC 100 in a network" on page 274.
2. For the pin assignment of the RS232 serial interface connector, see 15.6 "ePC interfaces" on page 317.
3. The connector for external safety functions allows connecting safety accessories for the *CPC 100*. The attached plug contains a jumper, and as long as it is placed on the connector, the circuit is bridged. If the plug is removed, the emergency switching off is active.

## CPC 100 Reference Manual

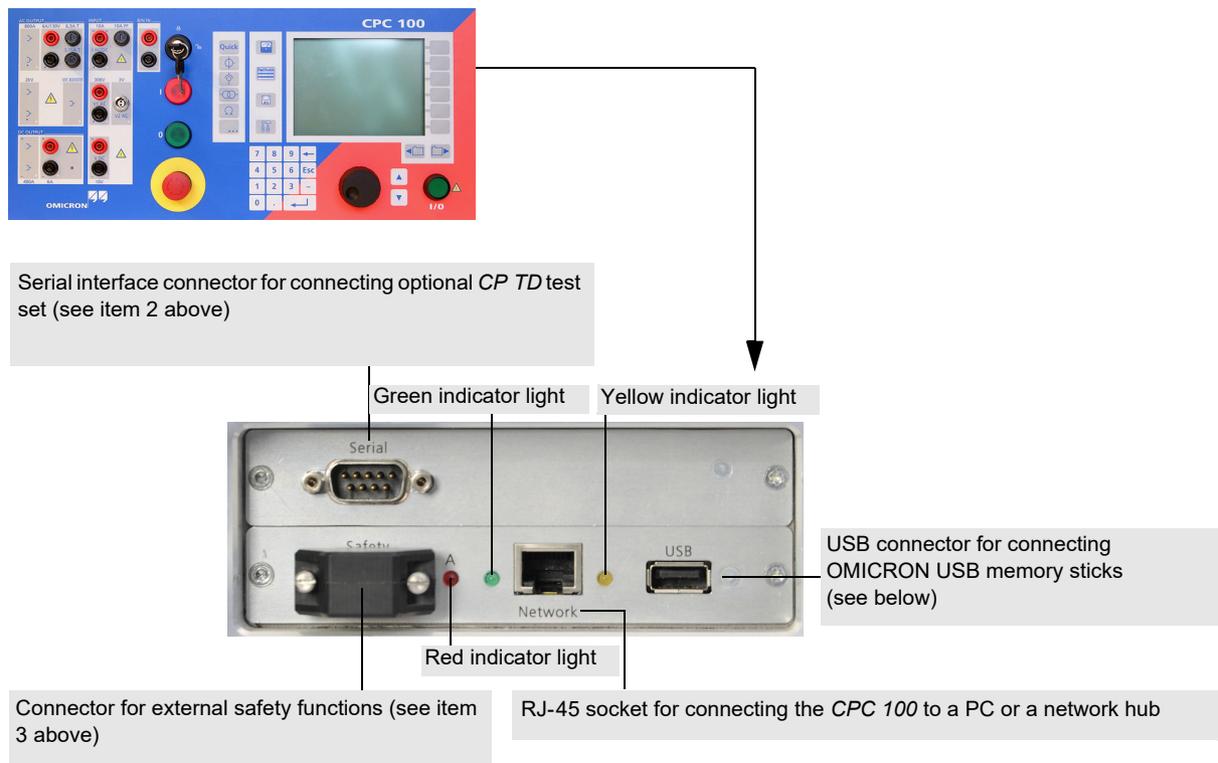


Figure 2-4: ePC interfaces of the *CPC 100 V1*

The *CPC 100 V1* supports the USB interface 1.1 and 2.0 for connecting the USB memory stick shipped with the *CPC 100*.

**Note:** The full functionality is guaranteed only for the stick delivered with the *CPC 100*.

The serial and safety interfaces are identical with the *CPC 100 V0* version (see above). The network interface is an auto-crossover Ethernet connector that can be connected to a network hub or directly to a PC or a notebook.

The *CPC 100 V1* provides the following indicator lights on the ePC interface:

- Green indicator light lights if the *CPC 100* is properly connected to a PC or network.
- Yellow indicator light lights if data is transferred from or to the network.
- Red indicator light serves for diagnosis purposes.

## 2.1.4 Functional components in detail

### AC OUTPUT

Programmable AC current and voltage outputs.

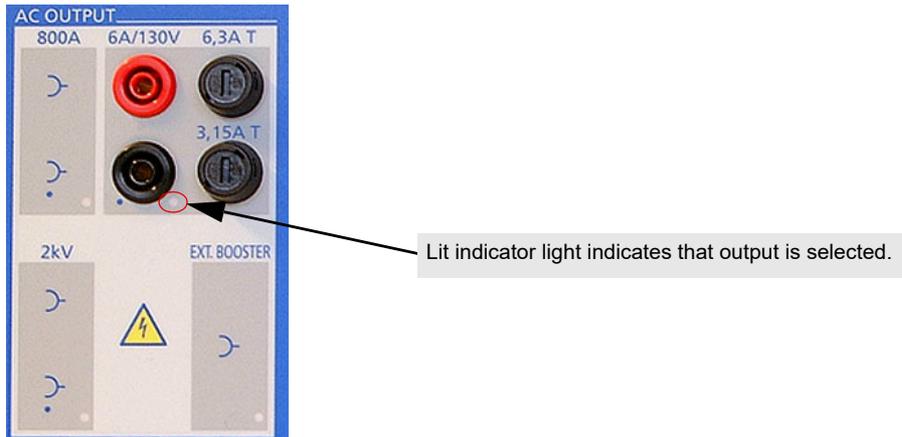


Figure 2-5: Functional group AC OUTPUT

- The front panel output **6A/130V** operates as either a 0 ... 6 A AC or a 0 ... 130 V AC output. The output range and the actual values are set by the software.

In current mode 0 ... 6 A, the maximum output voltage is 55 V (330 VA).

In voltage mode 0 ... 130 V, the maximum output current is 3 A (390 VA).

The **6.3A T** (6.3 Amps slow-acting wire fuse 5x20 mm) protects both the **AC OUTPUT** in 6A current mode and the **DC OUTPUT**.

The **3.15A T** (3.15 Amps slow-acting wire fuse 5x20 mm) protects the **AC OUTPUT** in 130V voltage mode and in the 3A AC current mode.
- The **800A** output sockets are situated at the left-hand side of the *CPC 100* as shown in chapter 2.1.2 on page 28.

They provide an AC current of 0 ... 800 A at a voltage of 6.1 ... 6.5 V. The actual output power (4880 VA max.) is range-dependent. For details refer to 15.3.1 "High-current and high-voltage outputs" on page 297.

The current that flows from this output is measured internally by the *CPC 100*, and displayed on the respective test card.
- The **2kV** output sockets are situated at the left-hand side of the *CPC 100* as shown in chapter 2.1.2 on page 28.

They provide an output voltage of either

  - 0 ... 0.5 kV with a maximum current of 5 A, or
  - 0 ... 1 kV with a maximum current of 2.5 A, or
  - 0 ... 2 kV with a maximum current of 1.25 A.

For details refer to 15.3.1 "High-current and high-voltage outputs" on page 297.

Both the voltage of this output and the current that flows from this output are measured internally by the *CPC 100*, and displayed on the respective test card.

All outputs are overload and short-circuit-proof and protected against external high-voltage signals as well as over-temperature.

**Note:** The length of time a high current or a voltage can be applied may be limited due to a high temperature occurrence of the internal transformer windings and/or heat dissipaters. This high temperature occurrence may even be increased if the *CPC 100* is operated in a hot environment or is exposed to direct sunlight.

We strongly recommend not exceeding the typical duration time  $t_{\max}$  specified for each current and voltage output (refer to 15.3 "CPC 100 outputs" on page 297). If you do, and the *CPC 100* develops too high an internal temperature, the outputs are shut off automatically.

### DC OUTPUT

Programmable DC current output.

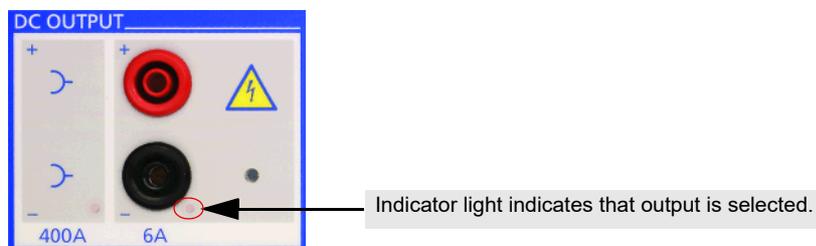


Figure 2-6: Functional group DC OUTPUT

1. The **6A** output provides a DC current of 0 ... 6 A with a maximum output voltage of 60V (360W). The output value is set by the software.

The **6.3A T** (6.3 Amps slow-acting wire fuse 5x20 mm, situated at the front panel's **AC OUTPUT** group) protects both the **AC OUTPUT** in 6A current mode and the **DC OUTPUT**.

2. The **400A** output is situated at the left-hand side of the *CPC 100* as shown at 2.1.2 "High-voltage and high-current outputs" on page 28.

They provide an output current of 0 ... 400 A at a voltage of 4 ... 4.5 V. The actual output power (2600 W max.) depends on the current magnitude. For details refer to 15.3.1 "High-current and high-voltage outputs" on page 297.

The current that flows from this output is measured internally by the *CPC 100*, and displayed on the respective test card.

All outputs are overload and short-circuit-proof and protected against external high-voltage signals as well as over-temperature.

**Note:** The length of time a high current or a voltage can be applied may be limited due to a high temperature occurrence of the internal transformer windings and/or heat dissipaters. This high temperature occurrence may even be increased if the *CPC 100* is operated in a hot environment or is exposed to direct sunlight.

We strongly recommend not exceeding the max. duration time  $t_{\max}$  specified for each current and voltage output (refer to 15.3 "CPC 100 outputs" on page 297). If you do, and the *CPC 100* develops too high an internal temperature, the outputs are shut off automatically.

## INPUT

Analog precision measuring inputs



### 1. **IAC/DC** current measuring input 10A AC and DC

Measuring input for AC and DC current of 0 ... 10 A, depending on the selected test card. AC current is measured in a frequency range of 15 ... 400 Hz.

For both AC and DC current measurement, the software changes automatically between the two measuring ranges 1 A and 10 A. In both ranges the measuring error is  $< \pm 0.2 \%$ .

A **10A FF** (10 Amps very quick-acting wire fuse 6.3x32 mm) protects the 0 ... 10A AC/DC current measuring input.

### 2. **V1 AC** voltage measuring input 300V AC

Measuring input for AC voltage of 0 ... 300V AC voltage is measured in a frequency range of 15 ... 400 Hz.

During measurement, the software changes automatically between the measuring ranges 0.3 V, 3 V, 30 V and 300 V.

For details about the accuracy of the individual ranges, please refer to 15.4.3 "300V V1 AC input" on page 312.

Figure 2-7: Functional group INPUT

### 3. **V2AC** low-level AC voltage measuring input

Measuring input for low-level AC voltage of 0 ... 3 V in a frequency range of 15 ... 400 Hz (for example, for low-power measuring transformers, or to connect a current clamp).

The software changes automatically between the measuring ranges 0.03 V, 0.3 V and 3 V. For details about the accuracy of the individual ranges, please refer to 15.4.4 "3V V2 AC input" on page 314.

**Note:** The **V1 AC** and **V2 AC** inputs are galvanically connected. All other inputs and outputs are separated.

### 4. **VDC** voltage measuring input **10V DC**

Measuring input for DC voltage of 0 ... 10 V. The software changes automatically between the measuring ranges 0.01 V / 0.1 V / 1 V / 10 V.

For details about the accuracy of the individual ranges, please refer to 15.4.5 "10V V DC input" on page 315.

**Note:** This measuring input is also used for resistance measuring ( $\Omega$ -meter) in a range of 0.2  $\Omega$  ... 20 k $\Omega$ .

For more details about  $\Omega$ -measuring refer to "Resistance" in chapter 8.

## BIN IN

Binary input for trigger signal



Binary trigger signal input to be used with a toggling potential-free contact or with voltages up to 300V DC.

The response time of this input is 1 ms, and it is galvanically separated from all other circuits.

Figure 2-8: Functional group BIN IN

## Key lock

The key lock helps you to secure the *CPC 100* against unauthorized operation:



- ▶ When no test is running, turn the key to "locked" position (vertical) and remove it from key lock:

The software does not accept any more entries and/or commands via the soft-touch keyboard and/or the handwheel. The test cannot be started by pushing the **I/O** (test start/stop) push-button.

- ▶ To activate the *CPC 100*, put the key into the key lock and turn it to "unlocked" position (horizontal).

**Note:** Turning the key from "unlocked" to "locked" position while a test is running, stops the ongoing test.

Figure 2-9: Key lock, shown in "enable" position

## Signal lights

The signal lights indicate the operational status of the *CPC 100* as a current/voltage source.

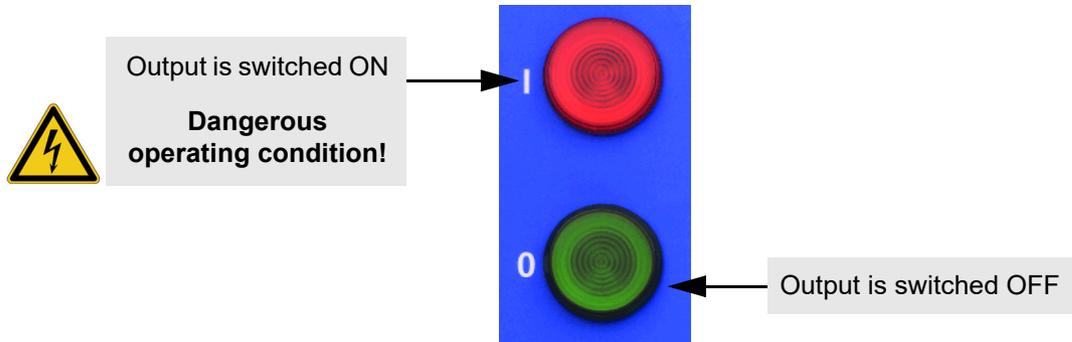


Figure 2-10: Signal lights

	1. Output is switched OFF	Green signal light (0) on	Current/voltage source is inactive/off
	2. Output is switched ON and/or measurement process is active	Red signal light (I) is flashing	<b>Dangerous</b> operating condition 
If the <i>CPC 100</i> is supplied by mains and switched on, and <i>no</i> or <i>both</i> signal lights are on, the unit might be defective. ► Contact OMICRON support (see "Support" on page 335).			<b>Dangerous</b> operating condition 

## Emergency Switching off button



Pressing the **Emergency Switching off** button *immediately* shuts off all current and voltage outputs except for the **Ext. Booster** output.

A running test is terminated, the software does not accept any more entries and/or commands.

Once the reason for the emergency switching off is cleared and the **Emergency Switching off** button released, the test can be re-started by pressing the **I/O** (test start/stop) push-button while in Test Card View.

Figure 2-11: **Emergency Switching off** button

## Ext. Booster

Socket to connect an external booster, for example, the *CP CB2* current booster for output currents of up to 2000 A.

Enable any external booster in the *CPC 100* software on the tab **Options | Device Setup** (refer to "Device Setup" on page 56 of this chapter).

### DANGER



#### Death or severe injury caused by high voltage or current

The **Ext. Booster** connector is **always** galvanically connected to mains. This also applies when no external booster is selected, the green signal light (0) is on, the outputs are turned off or the **Emergency Switching off** button is pressed.

- ▶ Handle the **Ext. Booster** connector with extreme caution.
- ▶ Do not use any other booster cables than the ones supplied by OMICRON.
- ▶ Do not use booster cables that are frayed or damaged in any way.

## 2.2 CPC 100 block diagram (simplified)

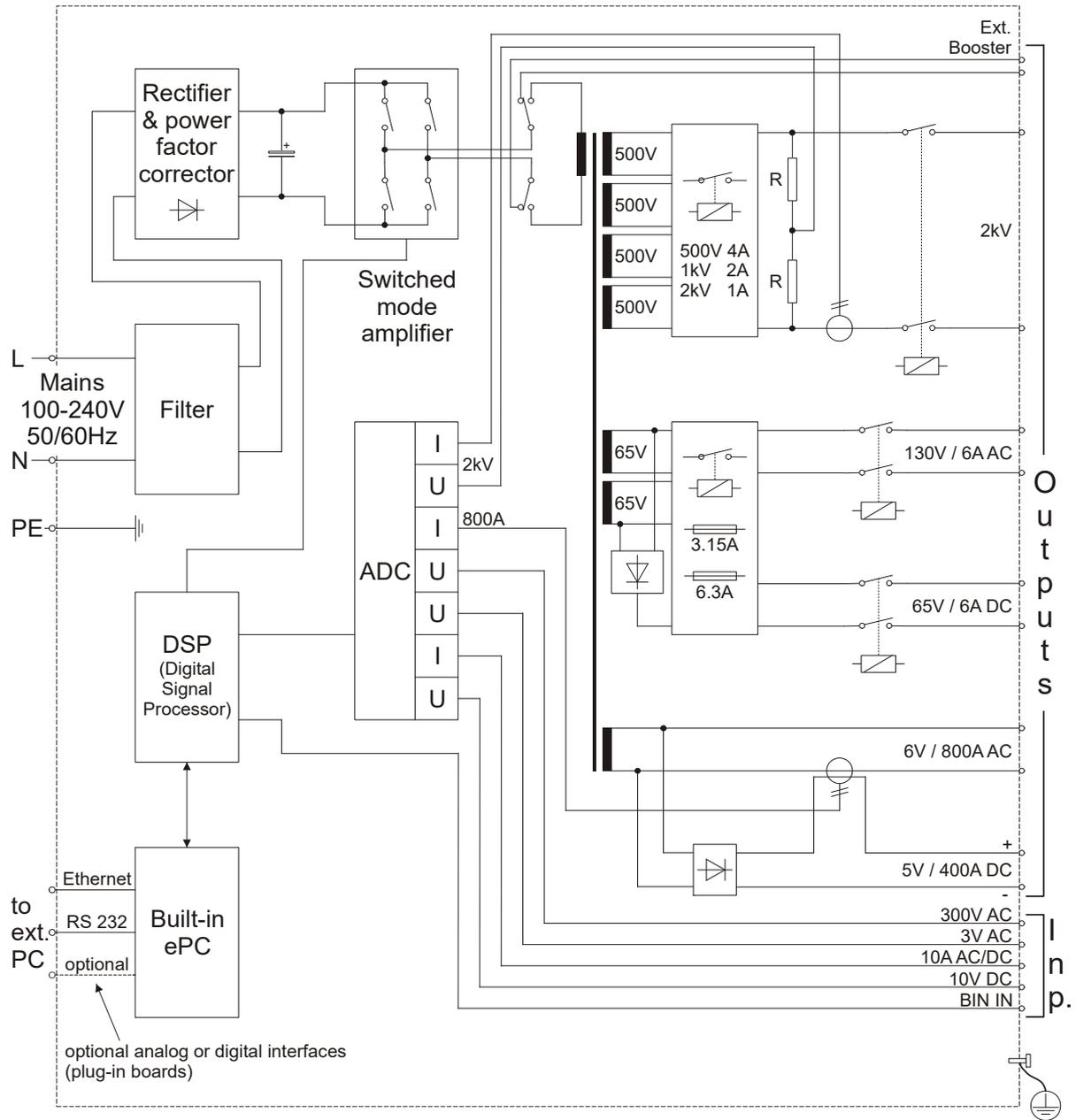


Figure 2-12: Simplified block diagram of the CPC 100

## 2.3 Built-in ePC

The built-in ePC of the *CPC 100* runs under Microsoft Windows CE operating system and provides front panel control.

This section provides a brief overview of the front panel control components.

Section "How to use the CPC 100 software" on page 40 of this chapter describes in detail how to work with the front panel control components, how to set up a test, execute it and save it for later use.

Via the built-in ePC, the *CPC 100* can be accessed from a stand-alone PC, for example, a notebook, via a PC network and via the Internet (refer to "CPC 100 in a network" in chapter 11).

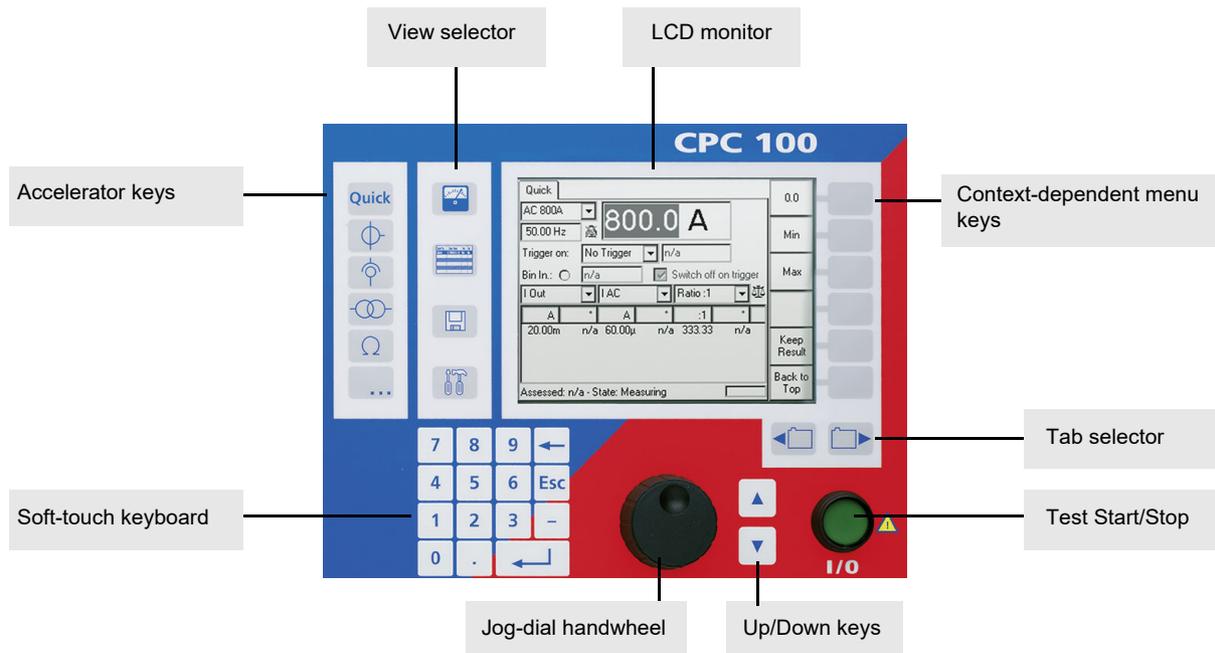


Figure 2-13: The *CPC 100*'s built-in ePC, components overview

### LCD monitor

The monitor is a high-contrast gray-scale graphical LCD display with a resolution of 320x240 pixels.

### Accelerator keys

Add the test card of your choice, for example, Quick, CT, VT... etc. (refer to "Accelerator keys" on page 44 of this chapter).

### View selector

Lets you select the view of your choice, for example, Test Card View, Test Procedure Overview, File Operations or Options (refer to "View selector" on page 43 of this chapter).

### Jog-dial handwheel

Advanced jog-dial handwheel with "click" (**Enter**) function.

In "navigation" mode, turning the handwheel navigates you through the UI elements within one test card. Pressing the **Up/Down** keys has the same effect.

In "data entry" mode, that is, if the focus is set onto a data entry field or a combo box, and the handwheel was pressed to "enter" the field and to enable data entry, turning the handwheel increases/decreases the entry field's value or browses through the preset values of the combo box, respectively.

Pressing the handwheel corresponds to the **Enter** function of the soft-touch keyboard.

Furthermore, the wheel comprises an adaptive acceleration function, that is, if the focus is, for example, set onto a data entry field, fast turning increments/decrements a value in increasingly bigger steps, slow turning in decreasingly smaller steps.

### Up/Down keys

Soft-touch keys supplementing the handwheel. Depending on the current focus in the software user interface, pressing these keys either navigates through the UI elements within one test card, or - if in a data entry field, for example - increments/decrements a value.

Contrary to the handwheel, the **Up/Down** keys change a value in fixed coarse increments /decrements in order to ease a quick approximation to the end value. The fine adjustment is then done with the handwheel.

### Context-dependent menu keys

Soft-touch keys that directly invoke specific commands associated with the currently selected control of the test card and view.

Since their actual functions depend on the selected view, test mode, test card and selected UI element, the menu keys do not hold any specific text. The individual key function is displayed on the monitor with a labelled button symbol right next to the menu key.

### I/O (test start/stop)

If the test parameters are set in the software's Test Card View, the **Emergency Switching off** button is released and the key lock is set to the "unlocked" position, pressing this push-button enables the *CPC 100* outputs and starts a test.

Pressing this push-button a second time stops the test.

#### WARNING



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

Stopping a test does not shut off the *CPC 100* outputs instantaneously. First, the currently running test sequence finishes, then the test execution is stopped.

Most test cards finish the running test sequence with a predefined ramp function.

- ▶ Therefore, in a hazardous situation never press "Stop Test".
- ▶ Instead, use the **Emergency Switching off** button.

### Tab selector

If a test procedure comprises more than one test card, use these keys to change between the single test cards.

## 2.4 How to use the *CPC 100* software

Information about the software version of your *CPC 100* can be found at the **Options** tab **System Info** (refer to "System Info" on page 66 of this chapter).

This section provides an overview of the front panel control components, explains in detail how to navigate with them through the software, how to set up a test, execute it, save it for later use, etc.

**Note:** The subsequent chapters (Quick, CT, VT, Resistance, Transformer...), explaining the various test procedures from a more practice-orientated point of view, are confined to test-relevant issues, and assume that you have read and understood this section.

### 2.4.1 The principles of test cards and test procedures

#### Test cards

The *CPC 100* software comprises a number of test cards. A test card carries out one specific test, for example, measuring a CT excitation curve, or testing the ratio of a voltage transformer.

A test card holds a number of user-definable test settings and - after the test was run - test results.

#### Test card default

Rather than repeatedly filling out blank test cards with frequently used settings, any test card with its actual settings can be made a test card default for that particular type of card, for example, filling out a **CTRatioV** test card with certain values and pressing **Save As Default** makes this card the new **CTRatioV** test card default.

Each card of this type that will later be inserted to a test procedure will already hold these new settings.

**Note:** A test card default contains user-defined settings, not test results.

#### Test procedure

A test procedure contains multiple test cards.

The composition of such a test procedure and the settings of all single test cards can be freely defined by the user. Within a test procedure, each test card and its associated test is executed individually in a user-defined order.

**Note:** With the *CPC 100 V0*, the number of test cards in one test procedure should be limited to 15 to avoid memory problems. The *CPC 100 V1* allows using more test cards in one test procedure but we recommend not using more than 15 test cards to keep the tests clearly structured.

#### Test procedure default

A test procedure with all of its test cards and specific settings - but without test results - can be made the test procedure default.

**Note:** When the *CPC 100* software starts, it automatically loads the test procedure default.

Initially, that is, as long as no user-defined test procedure default is created, the the *CPC 100* software loads one empty **Quick** test card.

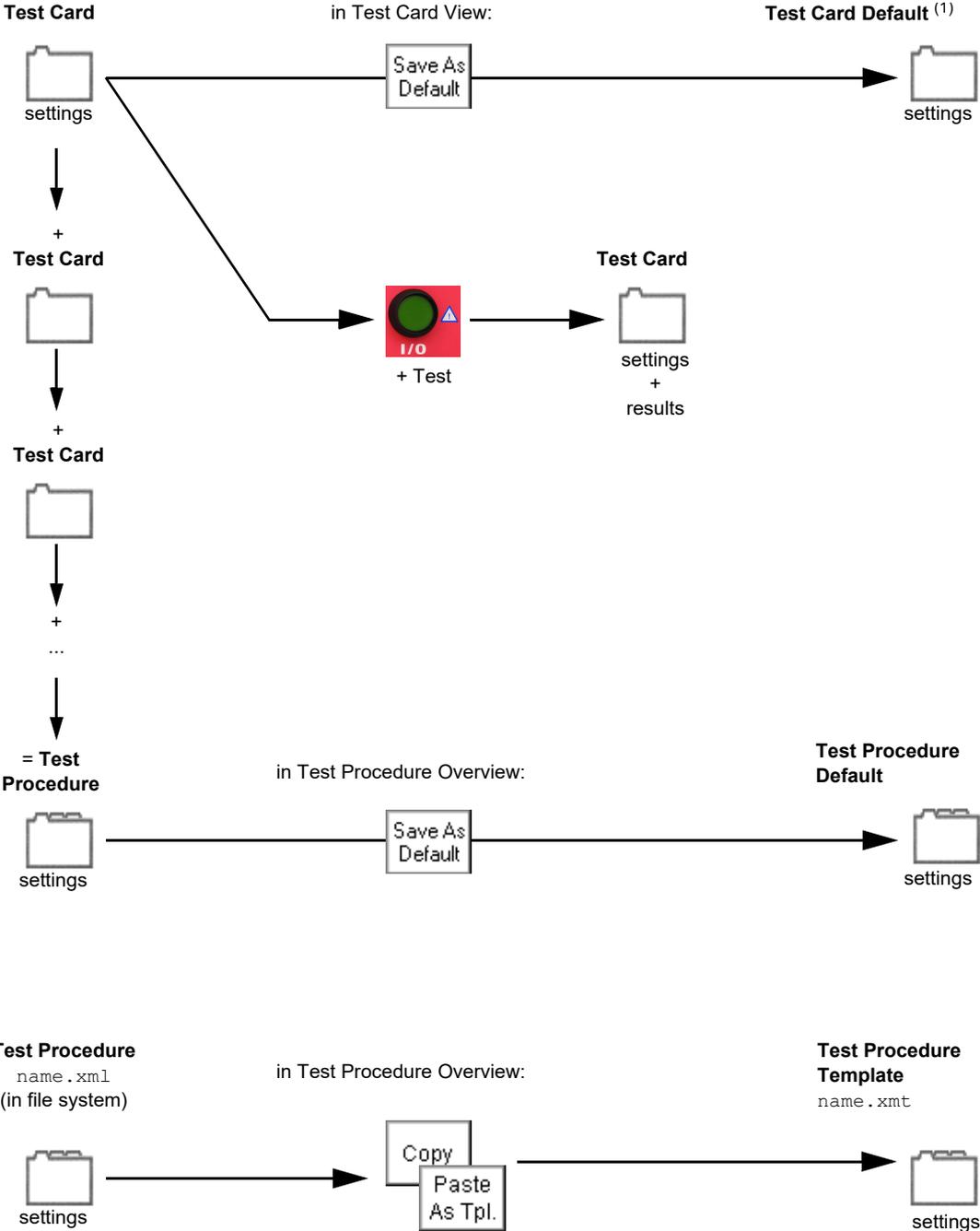
## Report

For archiving or reporting purposes, or later processing, a test procedure with all of its test cards, specific settings and - after the test was run - test results and assessments can be saved. It is then considered a report.

Such a report can later be opened any time in *CPC 100 File Operations* menu.

**Test procedure template**

A report can be copied/pasted to be a test procedure template. In this process, the settings are preserved, however, the test results are deleted.



(1) One Test Card Default for each type of test card

Figure 2-14: The principles of test cards, defaults and test procedures

The following sections emphasize on test cards, defaults and templates in more detail. Also refer to "Creating defaults and templates" on page 67 of this chapter.

## 2.4.2 Starting the software

When the *CPC 100* is switched on, the operating system boots up, and the *CPC 100* software starts automatically.

During the hardware and software initialization phase, the software displays a splash screen.

The *CPC 100* software starts in the Test Card View loading the test procedure default (refer to "The principles of test cards and test procedures" on page 40 of this chapter).

Initially, the test procedure default contains one empty **Quick** test card<sup>1</sup>. However, this default can be customized according to your specific requirements with as many test cards as needed and of all types of your choice.

By creating a user-defined test procedure default, the *CPC 100* starts up loading your most frequently used test cards already containing specific values.

To learn more about defining such a default, refer to "Creating defaults and templates" on page 67 of this chapter.

## 2.4.3 View selector



### Test Card View (default view upon start-up)

View to set up test cards, compose test procedures, enter test settings, define test cards or the test procedure default, start tests etc.



### Test Procedure Overview

Provides an enhanced overview of all test cards of the currently active test procedure. Defines the test procedure default.



### File Operations

Lets you save, load, delete, copy and rename test procedures. Some of these features call up the *Phrase Editor* (described at "The String Editor" in chapter 10).



### Options

Specify general parameters, such as display and regional settings, date and time, decimal symbol, network settings, system information and the device setup.

**Note:** If you are using a current clamp or an external current or voltage booster, specify these devices at the **Options** tab **Device Setup** before you start using them.

---

1. More about Quick at "Getting started with Quick" in chapter 4.

## 2.4.4 Accelerator keys

With the exception of Quick, pressing an accelerator key opens the according **Insert a new test card** dialog box and lets you select the test card of your choice. Pressing Quick opens the **Quick** test card directly.

Quick

**Quick** test card



select from current transformer (CT) test cards



select from voltage transformer (VT) test cards



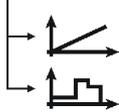
select from power transformer test cards



select from resistance test cards

...

select from other test applications...



- Ramping (primary / secondary protection relay testing)
- Sequencer (primary / secondary protection relay testing)
- Amplifier card (refer to 9.4 "Amplifier" on page 254).
- Comment card (refer to 9.5 "Comment" on page 257).

TanDelta (refer to the CP TD1 or CP TD12/15 User Manual available on the *CPC 100 Toolset* DVD or the *CPC 100 Start Page*).

## 2.4.5 Test card view

The Test Card View displays the test procedures. The *CPC 100* software starts in the Test Card View loading the test procedure default.

A test card inserted to the Test Card View loads the values from the respective test card default. If no test card default has been defined yet by the user, the test card opens with preset default values.



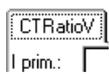
Any test card with its actual settings can be made a test card default for that particular type of card, for example, filling out a **CTRatioV** test card with certain values and pressing **Save As Default** makes this card the new **CTRatioV** test card default.

Each card of this type that will later be inserted to a test procedure will already hold these new settings.

**Note:** A test card default contains user-defined settings, not test results.

The Test Card View comprises a number of context-dependent menu keys. Some examples are given below:

Insert Card	→	Inserts a test card of your choice and places it after the selected test card of the current test procedure.
Delete Card	→	Deletes the current test card from the test procedure.
Rename Card	→	Opens the <i>String Editor</i> . You can rename the current test card to any new name of your choice (max. 15 characters).
Clear Results	→	Clears the results of the current test card, and thus enables the start of a new test.
Save As Default	→	Makes the current test card with all of its settings the new default for that particular type of card.
Demag.	→	Context-dependent menu item (shown here: "Demag.", <b>CTExcitation</b> ).



**Note:** The actual function of the context-dependent menu keys depends on the selected view, test mode, test card and selected UI element.

To make the above listed functions visible, the focus must be set onto the test card tab designation, for example, **CTRatioV**.

### Inserting test cards



The **Insert a new test card** dialog box displays the available tests and their associated test cards in a tree-like structure.

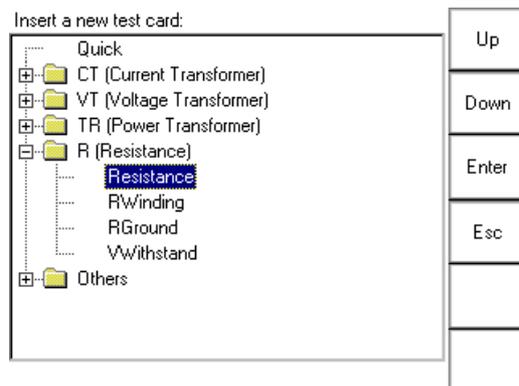


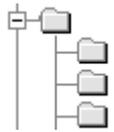
Figure 2-15: Insert a test card

Use the context-dependent **Up/Down** menu keys to the right, or the handwheel, to browse through the structure.

Due to usability reasons, some test cards, such as **Winding Resistance**, **Voltage Withstand Test** or **Polarity Check**, appear in more than one test mode, e.g., **Winding Resistance** appears in **Current Transformer**, **Power Transformer** and **Resistance**.

With regard to their functionality, these test cards are identical.

To expand a collapsed group of tests , for example, CT, set the focus onto this group, and press **Enter** or the handwheel.



The group of tests expands and displays all of its associated test cards.

Browse to the test file of your choice, and when it is highlighted press **Enter**.

This will switch from the **Insert a new test card** dialog to the Test Card View, inserting the test card of your choice after the last selected test card in the Test Card View.

**Note:** Only test cards that are licensed can be inserted.

When you purchased the *CPC 100*, you purchased a license for a number of test cards of your choice. Not licensed test cards are displayed in the **Insert a new test card** dialog, but the attempt to insert one of them to the test procedure results in an according on-screen message.

If you wish further information about licensing, please contact OMICRON.



You can insert as many test cards as needed and of all types of your choice by repeating this process.

**Note:** With the *CPC 100 V0*, the number of test cards in one test procedure should be limited to 15 to avoid memory problems. The *CPC 100 V1* allows using more test cards in one test procedure but we recommend not using more than 15 test cards to keep the tests clearly structured.

If you need more test cards in one test procedure, we recommend not saving all cards in one, for example, the test procedure default, but combining a smaller number of cards to logical groups, and saving these logical groups as test procedure templates with individual names (refer to "Test procedure templates" on page 69 of this chapter).

Pressing **Esc** closes **Insert a new test card**, and brings you back to the previous view without inserting a new test card.

## Setting up a test card

**Note:** Each parameter whose numerical value can be changed in a data entry field has an associated minimum and maximum value as well as a preset number of decimal characters. The parameter value can be changed freely within this min. ... max. range.

Furthermore, each numerical value has a

- fixed precision value that is used as a step size when increased/decreased by means of the handwheel
- a coarse step value that is used as a step size when increased/decreased by pressing the **Up/Down** keys.



Within one test card, to navigate to the UI element of your choice either turn the handwheel or use the **Up/Down** keys at the right-hand side of the handwheel.

A selected UI element is entirely highlighted; it has the focus.

If a data entry field, for example, "I max:" has the focus, press the handwheel to "enter" and enable the field.



Quick 1 CTExcitation 1

I max: 0.50000 A V max: 500.0 V  Auto

50.00 Hz 500 V/W

Noise suppress.

V: n/a

I: n/a

IEC/BS

I knee: n/a V knee: n/a

Assessed:n/a

Insert Card  
Delete Card  
Rename Card  
Clear Results  
Save As Default  
Demag.

As shown above, the value itself is highlighted, the unit is not, and at the value's end a blinking caret (cursor) indicates "ready for data entry".

Now either

- ▶ use the **Up/Down** keys to approximate the value of your choice quickly in coarse predefined steps
- ▶ rotate the handwheel to fine-adjust the value in precision steps
- ▶ type in the value of your choice using the numeric soft-touch keys to the left of the handwheel (refer to Figure 2-16).

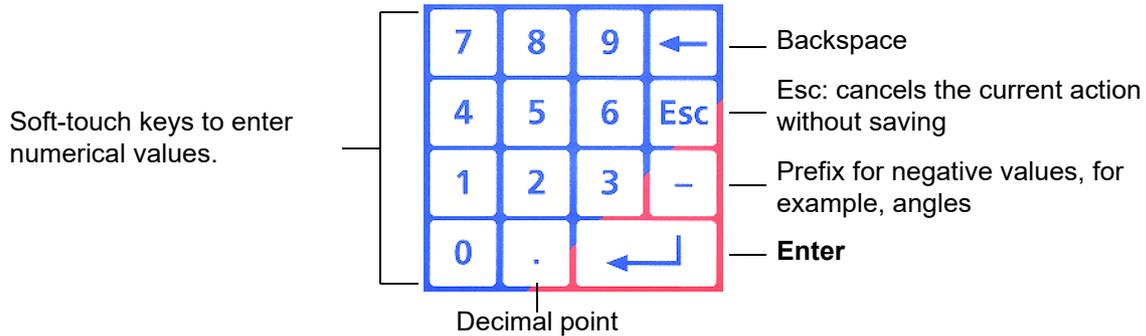


Figure 2-16: Soft-touch keys to enter numerical values

Pressing **Esc** on the soft-touch keyboard while entering a value, discards the entry and restores the previous value.

When ready, press either the handwheel again or the **Enter** key to confirm your entry, and move forward to the next UI element of your choice by turning the handwheel or the **Up/Down** keys.

**Note:** If a number key is pressed with the focus set onto a data entry field, this number is automatically written to the data entry field, and the field is enabled for data entry.

 Pressing the context-dependent menu key **Back to Top** terminates the data entry mode, accepts all current values and sets the focus onto the test card tab designation.

**Combo box**

The same principle applies at a combo box, for example,  :

- ▶ press the handwheel (to "enter" the combo box for selection)
- ▶ and either navigate through the list of available parameters by rotating the handwheel, or by using the **Up/Down** keys.

Pressing **Esc** while scrolling through the list of values closes the combo box and returns to the previous value.

**Check box**

Set the focus onto the check box, for example,  Current clamp for I sec. and press either the **Enter** key or the handwheel to select/clear a check box.

## List box

V	°	A	°	Ω	°
49.950	0.00	72.30m	-42.70	690.87	42.70
30.00m	n/a	2.400m	n/a	12.500	n/a

Assessed: n/a - Measuring

Figure 2-17: Example of a list box

List boxes are differentiated between read-only and editable list boxes:

- In a read-only list box (Figure 2-17), turning the handwheel scrolls from line to line.  
When using the **Up/Down** keys, a read-only list box is treated as one UI element, that is, pressing one of the keys exits the list box, and sets the focus onto the next /previous UI element.
- In an editable list box, turning the handwheel scrolls from table cell to table cell. Press either the handwheel or **Enter** to "enter" a cell and to edit the value.  
When using the **Up/Down** keys, the focus proceeds to the same table cell one line above or below.

## Settings page

 Some test cards include the **Settings** menu key. Pressing the **Settings** menu key opens the **Settings** page.

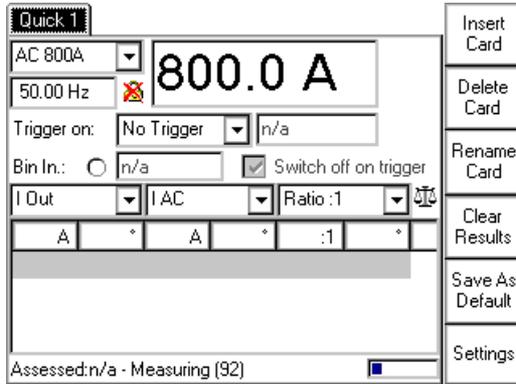


Figure 2-18: Main page with **Settings** menu key

The **Settings** page with the exception of the **TRRatio** test card looks as shown below.

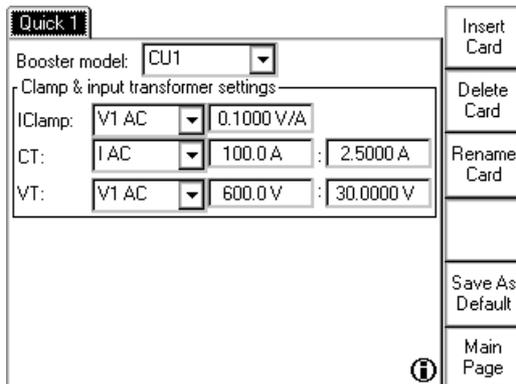


Figure 2-19: **Settings** page

The **Settings** page allows setting the test cards individually. At the **Device Setup** tab in the **Options** view (see "Options" on page 56 of this chapter), the same properties can be set for all test cards of a test procedure. As a rule, do not use the **Settings** page described here but the **Device Setup** tab in the **Options** view to set the test cards. Making different settings for the test cards is rarely a good idea. Set the test cards individually using the **Settings** page only in well-founded cases.

If a test card contains results, the settings cannot be changed. When a file containing results is loaded, the **Settings** page can be used to view the settings of the test procedure.

## Starting a test

**Note:** Tests can only be started and stopped with the I/O (test start / stop) push-button while in the Test Card View.

Each test card represents a separate test, and is started individually.

### Preconditions to start a test

1. The required test card is defined, the test parameters are set.
2. The software is in the Test Card View.
3. The **Emergency Switching off** button is released.
4. The key lock is set to the "unlocked" position.



Pressing the I/O (test start/stop) push-button starts the test. Pressing this push-button a second time stops the test.

### WARNING



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

Stopping a test *does not shut off* the CPC 100 outputs *instantaneously*. First, the currently running test sequence finishes, then the test execution is stopped.

Most test cards finish the running test sequence with a predefined ramp function.

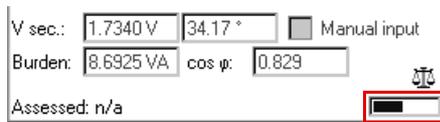
- ▶ Therefore, in an emergency situation never press "Stop Test". Instead, use the **Emergency Switching off** button.

While a test is running, several functions such as changing the test card, changing the view etc., are disabled.



To repeat the test, the test results need to be cleared beforehand. Otherwise the start is blocked.

## Temperature monitoring



Each test card contains a progress bar-like temperature gauge that displays the *CPC 100* actual temperature condition. When the temperature limit is reached, that is before an overheating condition occurs, the output is switched off automatically.

In addition, if an output is activated, both the *CPC 100* current consumption from the power supply and the current emitted at the high-current outputs is monitored and, together with the temperature, displayed by this temperature gauge. The temperature gauge's bar therewith represents an indicator for the remaining time the *CPC 100* can output power.

Just as with over-temperature, if these limit values are exceeded, the output is switched off automatically.

With deactivated outputs, the temperature gauge's bar represents an indicator how much the device has already cooled off.

**Note:** To reach a maximum output time, we suggest to let the *CPC 100* cool off completely before switching it on again.

**Note:** For each line of measurement results there is a separate overload indication top right on the *CPC 100*'s screen (or in the report) explained below.

No overload indication means no overload during that step of the measurement sequence. In the test report, "No" appears in the overload field or column.



Dotted overload indication means that there was an overload during that step of the measurement sequence but not all the time. In the test report, "Yes" appears in the overload field or column.



Solid overload indication means a permanent overload during that step of the measurement sequence. In the test report, "Yes!" appears in the overload field or column.

## 2.4.6 Test procedure overview

Name	Date/Time	Res.	Assess.	
Quick	11/3/01 9:37:51	No	n/a	Insert Card Delete Card Save As Default Clear Results Clear All Results New Test
Comment	11/3/01 9:37:56	No	n/a	
CTRatio	11/3/01 9:47:05	Yes	OK	
CTBurden	11/3/01 9:47:02	Yes	OK	
CTExcitation	11/3/01 9:46:59	Yes	OK	
VWithstand	11/3/01 9:46:54	Yes	OK	

Type: Comment  
Filename: CPC100\CTL1.xml

Figure 2-20: Test Procedure Overview

The Test Procedure Overview lists all test cards of the currently active test procedure in a list box showing the card's name, its creation date and time, whether test results are available and the test card's assessment status.

Insert Card

Pressing **Insert Card** switches to the **Insert a new test card** dialog. After inserting a new test card, the software automatically switches to the Test Card View, inserting the test card of your choice after the last selected test card in the Test Card View.

Pressing **Esc** at **Insert a new test card** brings you back to the previous view without inserting a new test card.

Delete Card

**Delete Card** deletes the currently highlighted test card from the test procedure.

Save As Default

With **Save As Default**, Test Procedure Overview provides a function to save the current test procedure as the test procedure default, that is the default the *CPC 100* software will start with in future.

► To learn more about defaults, refer to section "Creating defaults and templates" on page 67 of this chapter.

Default

Clear Results

Clear All Results

New

Unlike in Test Card View, where all context-dependent menu keys apply for that particular card only, the Test Procedure Overview has an additional menu item that applies for all test cards: whereas **Clear Results** clears the test results of the currently highlighted test card only ("Comment" in Figure 2-20), **Clear All Results** applies to all test cards, that is, clears the results of all cards listed in the Test Procedure Overview.

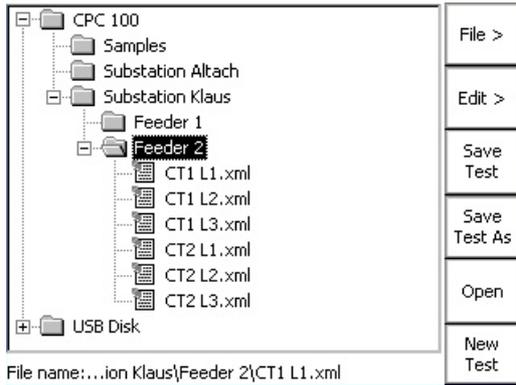
After both **Clear Results** and **Clear All Results**, re-start the test in the Test Card View by pressing the I/O (test start/stop) push-button.

New Test

Automatically switches back to the Test Card View, and opens the test procedure default. If the current test procedure contains unsaved data, you will be asked whether or not you want to save them before you proceed.

## 2.4.7 The CPC 100 file system

The *CPC 100* File Operations resemble the functionality known from, for example, the Windows Explorer. File Operations comprises a **File** and an **Edit** submenu with additional menu items as well as an **Open** and various **Save...** functions.



The highest hierarchical level of the *CPC 100* file system, the "root", is named **CPC 100**. Below this, you can create additional folders in a tree-structure of your choice, save tests in these folders, and carry out file operations, such as open, save, rename, copy, paste etc. For *CPC 100* V1 units with a USB memory stick plugged in, a second tree root **USB Disk** is displayed as shown above.

The *CPC 100* file system differentiates two file types:

-  name.xml      A test procedure with all of its test cards and specific settings. An .xml file may also contain test results and assessments that were stored together with the settings as report in the *CPC 100* file system for archiving purposes.
-  name.xmt      Test procedure template, that is, a user-defined template containing one or more test cards with all of their specific test settings but without test results.

**Note:** The file containing the up-to-date measurements should be saved regularly. If the test unit is switched off, or in case of a power outage, all unsaved measurements will be lost.

## 2.4.8 Navigating through the file system

Select, that is, highlight, a test or a folder using the handwheel or the **Up/Down** keys.

To expand a collapsed folder tree , highlight it, and press either the handwheel or **Enter**.

-       The folder expands and displays its subfolders (if any) and the tests it contains.
-       Browse to the test card of your choice, and when its highlighted press the handwheel or **Enter**.

## 2.4.9 The menus

### Main file operations menu

File >	→	Opens the submenu <b>File</b> (refer to "Submenu File" on page 55)
Edit >	→	Opens the submenu <b>Edit</b> (refer to "Submenu Edit" on page 56)
Save Test	→	Saves the currently open test, that is, the test card(s) previously opened in the Test Card View (refer to Note below).
Save Test As	→	Opens the <i>String Editor</i> . You can save the currently open test under a new name of your choice (15 characters max.).
Open	→	Use the handwheel or the <b>Up/Down</b> keys to select a test, and press <b>Open</b> to open it. Changes to Test Card View.
New Test	→	Closes the current test card(s), changes to Test Card View and opens the test procedure default.

Unlike the other menu items, the two **Save...** functions of the main File Operations menu directly effect the *currently open test*, i.e., the test procedure that was composed in the Test Card View, or the test that was loaded in the *CPC 100* file system beforehand.

Therefore, pressing **Save**, for example, does not save the test that you may have highlighted in the folder tree, but the one that is currently open.

### Submenu File

New Folder	→	Opens the <i>String Editor</i> . You can create a new folder with any name of your choice.
Insert After...	→	Appends the contents of a test file (.xml) or template (.xmt) of your choice to the currently open test.
Delete	→	Deletes the currently selected test or folder from the <i>CPC 100</i> disk space.
Rename	→	Opens the <i>String Editor</i> that enables you to rename the current test to any new name of your choice.
	→	(for future use)
Back	→	Closes the submenu and returns to the main File Operations menu.

## Submenu Edit

Cut	→	Select the test of your choice. Press <b>Cut</b> to put the selected test or folder to the Clipboard. Proceed with <b>Paste...</b>
Copy	→	Select the test of your choice. Press <b>Copy</b> to copy test or folder to the <i>CPC 100</i> Clipboard. Proceed with <b>Paste...</b>
Paste	→	Move to the destination folder of your choice. Press <b>Paste</b> to insert the contents of the <i>CPC 100</i> Clipboard to this folder.
Paste As Tpl.	→	Press <b>Paste As Templ.</b> to make the contents of the <i>CPC 100</i> Clipboard a test procedure template.
	→	(for future use)
Back	→	Closes the <b>Edit</b> submenu and returns to the main File Operations menu.

**Note:** If a folder is cut or copied to the Clipboard, the selection is recursive, that is, all of its subfolders will also be put to the Clipboard.

Cutting or copying a test or folder, and trying to paste it in the same location, opens the *String Editor*. Since a test or folder cannot exist twice under the same name at the same location, determine a new name for it using the *String Editor*.

For more information about the *String Editor*, please refer to "The String Editor" in chapter 10.

## 2.4.10 Options



**Note:** Changes made in the **Options** view are automatically saved when the view is changed (for example when **Options** is left to change to Test Card View).

Alternatively, changes can be saved instantly by pressing **Save Options**.

Upon a power supply loss or an accidental switching off of the *CPC 100*, unsaved changes are lost, and the old values are restored.

## Device Setup

The **Device Setup** tab in the **Options** view allows you to change the settings of all test cards of the test procedure running on the *CPC 100* and all test cards inserted afterwards. The test cards can be instantiated in different ways and for different purposes. Table 2-1: "Instantiation procedures" below displays the instantiation procedures and the associated default values.

Table 2-1: Instantiation procedures

Procedure	Default values
New test card	Booster, clamp and default frequency set in the <b>Options</b> view
New test card saved as default	Booster and clamp set in the <b>Options</b> view
New test procedure from template (*.xmt)	Booster, clamp and frequency remain as defined in the template
New procedure from report (*.xml)	Booster, clamp and frequency remain as defined in the report

Because the settings of a test card containing results cannot be changed, the settings made at the **Device Setup** tab in the **Options** view apply only to new test cards if the currently loaded procedure contains results. To change the settings of a test procedure containing results (for example, after pressing the **Keep Results** menu key or after loading a file), clear the results by pressing the **Clear Results** menu key in all test cards before setting the test procedure in the **Options** view.

We strongly recommend setting the test cards using the **Options** view. In well-founded cases, you can alternatively set a test card individually using the **Settings** menu key (see "Settings page" on page 50 of this chapter).

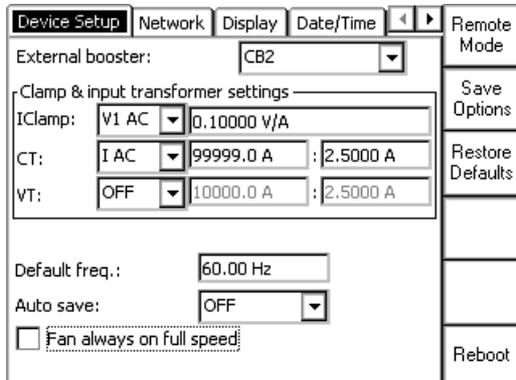


Figure 2-21: Options tab Device Setup

### External booster

The "External booster" combo box allows to set the external booster:

- CB2 for the *CP CB2* current booster
- CU20 for the *CP CU20* coupling unit
- CU1 for the *CP CU1* coupling unit
- CP TR8 for the *CP TR8* inductor (also used for the *MTR2* matching transformer)
- MTR1 for the *MTR1* matching transformer

For the default value associated with different instantiation procedures, see Table 2-1: "Instantiation procedures" on page 56.

### Clamp & input transformer settings

When an input is not connected to the device under test directly but using a current clamp, a CT or a VT, the ratio of these devices can be set here.

The **Clamp & input transformer settings** group box displays and, if required, allows you to change settings for external devices:

- **IClamp** for the current clamp parameters
- **CT** for the transformation ratio of the current transformer
- **VT** for the transformation ratio of the voltage transformer

By default, the transformation ratios of the current and voltage transformers for the selected external device are preset. For the default value associated with different instantiation procedures, see Table 2-1: "Instantiation procedures" on page 56.

**Default freq.**

The "Default freq." data entry field allows you to enter the default frequency. For the default value associated with different instantiation procedures, see Table 2-1: "Instantiation procedures" on page 56.

**Auto Save**

As the name implies, the **Auto Save** feature automatically saves the current test settings in fixed intervals. These intervals can be set in the "Auto Save" box. There are three time intervals available (10, 30 or 60 minutes), and the option **OFF** which disables **Auto Save**.

**Auto Save** saves all actual data to a file named `lastmeas.xml`. So depending on the set time interval, in case of a system crash, `lastmeas.xml` may contain more actual data than the last manually saved test. The file is created during the next booting process.

When **Auto Save** saves test settings, it pops up a dialog notifying you about it.

**Auto Save** works in Test Procedure Overview, File Operations or Options without any restrictions. In Test Card View, **Auto Save** does not work as long as a test is running, or as long as inputs are measured (for example, in **Quick**).

In a case like this, **Auto Save** repeats the attempt to save the test settings in intervals until it succeeds, that is, until the test is finished and it can save the data. After this, **Auto Save** returns to the set time interval.

**Fan always on full speed**

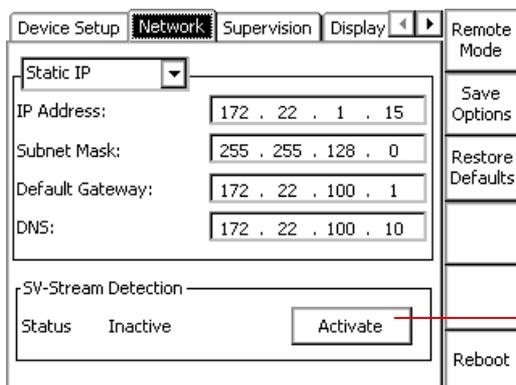
If selected, the *CPC 100* cools down faster. Thus, the duty cycle can be increased.

**Restore Defaults**

**Note:** Pressing the **Restore defaults** menu key resets all user-specific settings made in the *CPC 100* software to factory-defined defaults including:

- the test card defaults
- the test procedure default
- all settings made at the **Device Setup** tab (sets external booster to CB2, sets CT and VT to "OFF", and sets the value in the "Default freq." data entry field to 50 Hz)
- the *String Editor's* template strings (refer to 10.2.1 "Template phrases" on page 273).

**Network**



Activate/deactivate the sampled values stream communication. This is a licensed feature for the SV-Ratio measurement, filtering IEC 61850 messages.

Figure 2-22: Options tab Network

Via the built-in ePC, the *CPC 100* can be accessed from a stand-alone PC, for example, a notebook and via a PC network. At the **Network** tab the communication settings are specified.

In the combo box select between

- DHCP/Auto IP** Configures all communication parameters automatically; the DHCP server will do it for you or it will be done via the Auto IP mechanism.  
The data entry fields for IP address, Subnet Mask, Default Gateway and DNS are read-only, no data can be entered. This is the recommended setting.
- Static IP** Configure the communication parameters manually by entering the values into the data entry fields using the soft-touch keys.

Section "CPC 100 in a network" in chapter 11 explains in detail how to connect the *CPC 100* to either a stand-alone PC or a PC network, and how to configure such a connection.

 Once the communication parameters are configured, press **Save Options** to save them to the Windows Registry.

For a change to come into effect, the *CPC 100* needs to be restarted.

## Supervision

The **Supervision** tab comprises supervision settings around the *CPC 100* test system. The settings you choose in this view serve as a default for all corresponding test cards you set up afterwards.

**Note:** By default and after start-up, the check boxes are selected.

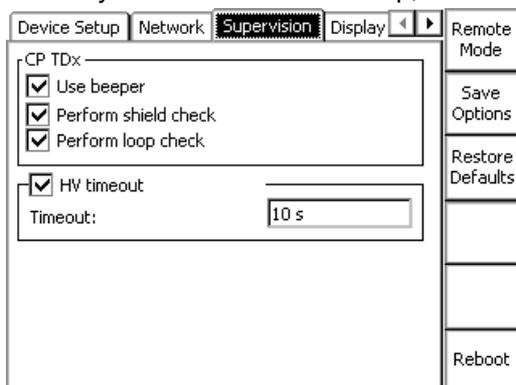


Figure 2-23: Options tab **Supervision**

### Use beeper

If selected, the beeper sounds during the entire test. If cleared, the beeper sounds at the beginning and the end of the test only.

**Perform shield check**

The shield check verifies whether both the high-voltage connector and the grounding terminal are connected to the *CP TD*. In certain cases, for example when strong interferences are present during testing or when compensating reactors (e. g. the *CP CR500* or *CP CR600*) are used, the shield check will prompt a false error message.

**DANGER**



**Death or severe injury caused by high voltage or current**

- ▶ Make sure that **both** the high-voltage connector and the grounding terminal are connected and that the cables and connectors are intact before deactivating the shield check.

**Perform loop check**

The loop check verifies the connection to the device under test. When measuring very low capacities, the resulting weak signal might cause the loop check to falsely state that no device under test is connected.

**DANGER**



**Death or severe injury caused by high voltage or current**

- ▶ Make sure that the device under test is connected and that all cables and connectors are intact before deactivating the loop check.

**HV timeout**

The HV timeout limits by default the total injection cycle by using the 2 kV output with **Quick** in the 1000 V and 2000 V modes to restrict long unintended injection cycles. The status bar of the **Quick** test card displays the time progress and the timeout threshold for the intended output modes in seconds.

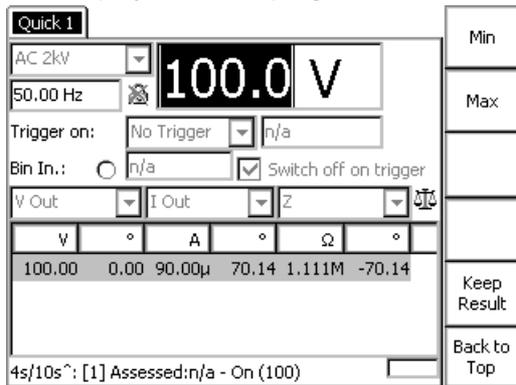


Figure 2-24: **Quick** test card showing the HV timeout information in the status bar

**Note:** Changing the target value or pressing Enter on the keyboard resets the HV timeout.

## Display

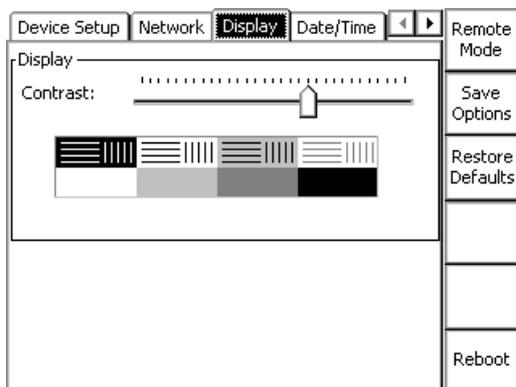


Figure 2-25: Options tab **Display**

The "sliding" regulator brightens or darkens the monitor display and the contrast within it. Adding contrast increases the difference in shading between areas.

## Synchronization

Synchronize up to two slave units (*CPC 100* or *CPC 80*) with a *CPC 100* configured as master unit for testing with the **Quick, Sequencer, Ramping, Amplifier** and **HV Resonance Test System** test cards.

**Note:** Synchronization requires the CPC Sync plug-in card and license, and the *TRC1*. *CPC 100 V0* devices cannot be used for synchronization.

Sync mode:  
▶ Set one **Master** and up to two **Slaves**

▶ Set phase displacement and amplitude factor of **Slaves**.

Synchronization status between the connected devices

Sync status abbreviation displayed in the test cards

Mode: Master

Phase 1: 0.00 ° Amp. corr. 1: 1.00

Phase 2: 0.00 ° Amp. corr. 2: 1.00

Sync state: Slave 1 synced.

Output synchronization with other CPC devices requires the CPC Sync hardware module and the TRC1. Refer to the TRC1 user manual for the correct setup. Set one device as Master and all other devices as Slaves. Use the same outputs on all devices. (229)

[M1]

Figure 2-26: Options tab **Synchronization**

	Displayed on	Status
<b>M1</b>	Master	Slave 1 synchronized
<b>M2</b>	Master	Slave 2 synchronized
<b>M</b>	Master	Both slaves synchronized with master
<b>S</b>	Slave	Status OK
<b>EV</b>	Slave	CPC version mismatch
<b>EO</b>	Slave	Different outputs set on master and slave(s) Set the same outputs on all devices.
<b>ES</b>	All	No <i>TRC1</i> connected
<b>EC</b>	All	Sync cable(s) error/not connected

Available output ranges in the **Quick, Sequencer, Amplifier** and **Ramping** test cards with synchronized *CPC* devices:

- AC 800 A
- CB2 1000 A
- CB2 2000 A
- TR8 200 V
- Output for customized matching transformer

**Note:** The output value depends on the number of synchronized *CPC* devices (for example: 3 *CPC* devices – max. output value:  $800\text{ A} \times 3 = 2400\text{ A}$ ).

**NOTICE****Equipment damage possible**

- ▶ When connecting devices in series, make sure that the insulation of the equipment housing can withstand the maximum applied voltage.

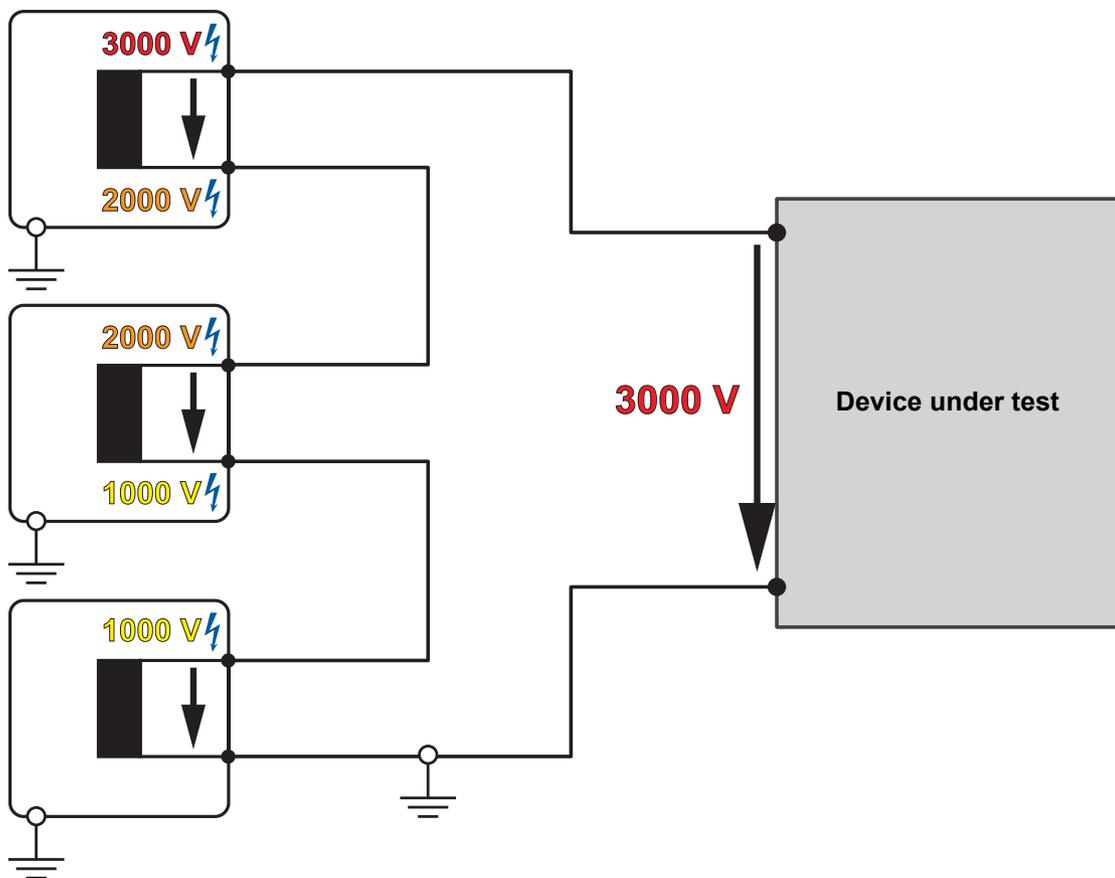


Figure 2-27: Series connection of devices causing increasing voltage stress on the housing insulation

## Date / Time

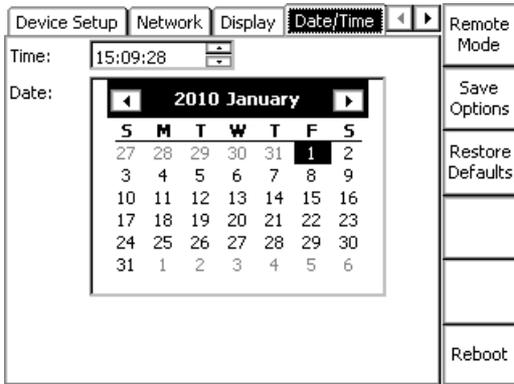


Figure 2-28: Options tab Date/Time

Specify the system’s date and time here.

To set the time

- ▶ put the focus onto the “Time:” field using the handwheel
- ▶ use the **Up / Down** keys to select between hours, minutes and seconds
- ▶ turn the handwheel to increase or decrease the value
- ▶ press the handwheel to acknowledge your entry

Changing the current date and time does not require pressing **Save Options**.

## Regional Settings

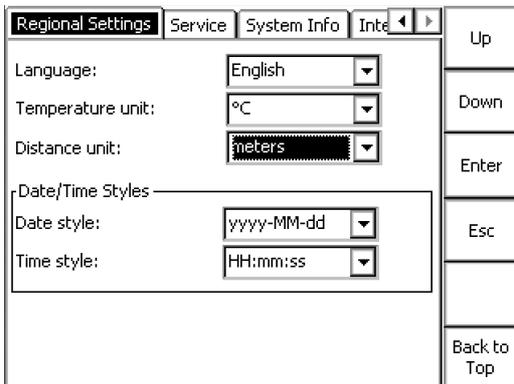


Figure 2-29: Options tab Regional Settings

Choose a regional setting for language, temperature unit, distance unit, date and time style. These settings affect the way the *CPC 100* software displays and sort dates, times, numbers and decimal points.

## Service

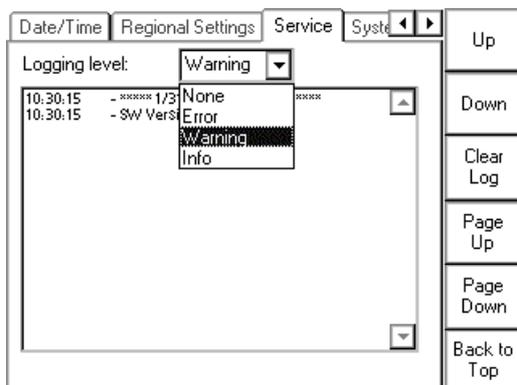


Figure 2-30: Options tab Service

During operation, the *CPC 100* creates a logfile with a user-definable logging level (see below).

Every time the *CPC 100* is switched on, it generates a new logfile, and saves the existing one as the "previous" logfile. This way, the occurrences of the previous and the current session can be viewed.

The logging level specifies the occurrences to be recorded in the logfile:

Logging level	Records
<b>None</b>	nothing
<b>Error</b>	internal errors, hardware errors, operational errors, overload conditions etc.
<b>Warning</b>	uncritical errors such as over-temperature, malfunction etc.
<b>Info</b>	additional operational information about the <i>CPC 100</i> .  This setting is suggested if the operator suspects, for example, an incorrect functioning or an operational malfunction of the <i>CPC 100</i> . This setting records every relevant operational activity of the <i>CPC 100</i> .  The logfile can then be sent to OMICRON for diagnosis.

The default setting is **Warning**.

**Note:** The logging levels are hierarchical, that is, if logging level **Warning** is set, **Errors** are also recorded, or if **Info** is set, the logging levels **Warning** and **Error** also apply.

If the logfile gets quite long, use either the scroll bar or the buttons **Page Up/Page Down** to navigate up and down in the list of logged occurrences.



**Clear Log** deletes all logfile entries and starts recording occurrences anew.

### System Info

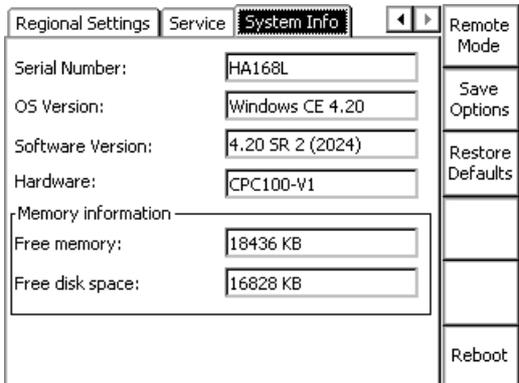


Figure 2-31: Options tab System Info

Displays the following system information:

- Serial Number:** CPC 100 serial number
  - OS Version:** operating system with version
  - Software Version:** CPC 100 software version
  - Hardware:** CPC 100 hardware  
The last two positions indicate the CPC 100 hardware version.
  - Free memory:** currently available free memory (RAM)
  - Free disk space:** free disk space
-

## 2.4.11 Creating defaults and templates

The *CPC 100* software differentiates three types of templates:

1. test card default
2. test procedure default (default upon start-up)
3. test procedure templates.



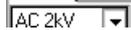
**Note:** Pressing the **Restore Defaults** menu key at the **Options** tab **Device Setup** resets all user-specific settings made in the *CPC 100* software to factory-defined defaults. This includes the test card defaults and the test procedure default.

### Test card default



Rather than repeatedly filling out blank test cards with frequently used settings, any test card with its actual settings can be made a test card default for that particular type of card, for example, filling out a **Quick** test card with values and pressing **Save As Default** makes this card the new **Quick** test card default.

**Note:** The actual function of the context-dependent menu keys depends on the selected view, test mode, test card and selected UI element.



To make the function **Save As Default** visible, the focus must be set onto the test card tab designation, for example, **Quick**.

Each card of this type, here **Quick**, that will later be inserted to a test procedure will already hold these new settings.

**Note:** A test card default contains user-defined settings, not test results.

In the *CPC 100* file system, a test card default is not visible as a "file" (refer to 2.4.7 "The *CPC 100* file system" on page 54).

### Test procedure default

The *CPC 100* software always starts with the test procedure default. Initially, that is, as long as no user-defined test procedure default is created, this default contains one empty **Quick** test card. However, this default can be customized according to your specific requirements with as many test cards as needed and of all types of your choice.

**Note:** With the *CPC 100 V0*, the number of test cards in one test procedure should be limited to 15 to avoid memory problems. The *CPC 100 V1* allows using more test cards in one test procedure but we recommend not using more than 15 test cards to keep the tests clearly structured.

If you need more test cards in one test procedure, we recommend not saving all cards in one, for example, the test procedure default, but combining a smaller number of cards to logical groups, and saving these logical groups as test procedure templates with individual names (refer to "Test Procedure Templates" on page 45 of this chapter).

In the CPC 100 file system, the test procedure default is not visible as a "file" (refer to 2.4.7 "The CPC 100 file system" on page 54).

**Step 3**

Switch to the Test Procedure Overview...

Name	Date/Time	Res.	Assess.
Quick	11/3/01 9:37:51	No	n/a
Comment	11/3/01 9:37:56	No	n/a
CTRatio	11/3/01 9:47:05	Yes	OK
CTBurden	11/3/01 9:47:02	Yes	OK
CTExcitation	11/3/01 9:46:59	Yes	OK
Vwithstand	11/3/01 9:46:54	Yes	OK

Type: Comment  
Filename: CPC100\CTL1.xml

... and press



to make this test procedure the new test procedure default.

**Step 2**

A number of test cards are inserted to the currently open test procedure.

CTRatio 1 | **CTRatio 2** | CTBurden 1 | CTExcitation 1

Range: AC 800A | Auto

I prim.: 200.0 A | I sec.: 5.000 A

I test: 200.0 A | f: 50.00 Hz

I prim.: 199.98 A |  Current clamp I sec.

I sec.: 5.0120 A | 0.15 ° |  Manual input

Ratio: 200.0:5.0125 | 0.250 %

Polarity: OK |  Measure burden

V sec.: 1.7340 V | 34.15 ° |  Manual input

Burden: 8.6492 VA | cos φ: 0.829

Assessed: n/a

**Step 1**



Quick

AC 800A | **800.0 A** | 0.0

50.00 Hz

Trigger on: No Trigger | n/a

Bin In:  n/a |  Switch off on trigger

I Out: IAC | Ratio: 1

30.00m | n/a | 70.00μ | n/a | 428.57 | n/a

Assessed: n/a - Measuring

test card 1

CTRatio 1 | **CTRatio 2** | CTBurden 1 | CTExcitation 1

Range: AC 800A | Auto

I prim.: 200.0 A | I sec.: 5.000 A

I test: 200.0 A | f: 50.00 Hz

I prim.: 199.99 A |  Current clamp I sec.

I sec.: 5.0130 A | 0.10 ° |  Manual input

Ratio: 200.0:5.0133 | 0.265 %

Polarity: OK |  Measure burden

Assessed: n/a

test card 2

CTRatio 1 | CTBurden 1 | **CTExcitation 1** | RWif

I max: 5.00000 A | V max: 100.0 V | Auto

50.00 Hz

Noise suppress.

V: 20.780 V

I: 226.5 mA

IEC/BS

I knee: 116.9 mA | V knee: 18.020 V

Assessed: 2010-02-12 15:25:25

test card 3

Figure 2-32: Creating a user-defined default by customizing the test procedure default



**Step 1:** In the test card view, insert as many test cards as needed to the currently open test procedure default.



**Step 2:** At the *CPC 100* front panel view selector, switch to the Test Procedure Overview.



**Step 3:** Press **Save As Default** to make this test procedure the new test procedure default.

## Test procedure templates

A test procedure template is a user-defined test procedure, and can be created from any test procedure that was saved to the *CPC 100* file system beforehand (a `name.xml` file; refer to 2.4.7 "The *CPC 100* file system" on page 54).

To create a test procedure template from an `.xml` file



- ▶ go to "File Operations"
- ▶ highlight the `name.xml` file of your choice
- ▶ select **Edit | Copy** to copy the test procedure



- ▶ select **Paste As Templ.**
- ▶ a file `name.xmt` is generated.

If this file `name.xmt` already exists, you will be asked whether or not to overwrite the existing file. If you answer this question with **No**, the *String Editor* opens (refer to "The String Editor" in chapter 10).

Give the test procedure template a name of your choice (max. 15 characters), and select **OK**. The file name extension `.xmt` is appended automatically.

In this process, the settings of the original `name.xml` file are taken over to the newly created test procedure template `name.xmt`. The test results, however, are not taken over.

The original file `name.xml` remains unchanged.

## 2.5 Installation of the *CPC 100 Toolset*

The *CPC 100 Toolset* and its installation program Setup Wizard are stored on the *CPC 100 Toolset* DVD. The installation comprises the *CPC 100 Start Page*, *Primary Test Manager*, *CPC Excel File Loader*, Excel Templates (for specific applications), *CPC Editor* (to create and edit *CPC 100* test templates), *OMICRON Device Browser*, *CPC 100 Upgrade Packages*, Manuals and Application Notes, Foxit PDF Reader (redistributable), *OMICRON News*, and Product Application Videos.

To start the installation:

1. Quit all other major programs running on your computer.
2. Insert the *CPC 100 Toolset* DVD into your computer's DVD drive. The Setup Wizard starts automatically displaying the *CPC 100 Toolset* start screen.

**Note:** Should the Setup Wizard not start automatically a few seconds after the DVD has been inserted into the DVD drive, launch the Windows Explorer and double-click `setup.exe` on the *CPC 100 Toolset* DVD.

3. On the start screen, click the language of your choice and follow the on-screen instructions.

**Note:** The selected language affects all subsequent dialog boxes and all installed files.

## 2.5.1 System requirements

Table 2-2: *CPC 100 Toolset* system requirements

Characteristic	Requirement (*recommended)
Operating system	<b>Windows 10 64-bit</b>
CPU	<b>Multicore system with 2 GHz or faster*</b> , single-core system with 2 GHz or faster
RAM	min. 4 GB ( <b>8 GB*</b> )
Hard disk	min. 5 GB of available space
Storage device	DVD-ROM drive
Graphics adapter	Super VGA (1280×768) or higher-resolution video adapter and monitor <sup>1</sup>
Interface	Ethernet NIC <sup>2</sup>
Installed software required for the optional Microsoft Office interface functions	<b>Microsoft Office 365*</b> , Office 2019*, Office 2016, Office 2013

1. We recommend graphics adapter supporting Microsoft DirectX 9.0 or later.

2. The *CPC 100* can be connected with RJ-45 connectors either directly to the computer or to the local network, for example, by using an Ethernet hub.

## 2.6 Putting the *CPC 100* into operation

**Note:** Before setting the *CPC 100* into operation and carrying out a test, it is essential that you have read and understood the section 1 "Safety instructions for the *CPC 100* and its accessories" on page 16. Always be aware that all AC and DC output sockets of the *CPC 100* can carry dangerous voltage potential and provide dangerous currents.

### 2.6.1 Safety aspects

We strongly advise you to obey the following legal safety aspects:

- ▶ Tests with high voltages and currents must only be carried out by authorized and qualified personnel.
- ▶ Personnel receiving training, instructions, directions, or education on high- voltage/current tests must remain under the constant supervision of an experienced operator while working with the equipment. The instructions have to be renewed at least once per year.
- ▶ The instructions must be available in written form and signed by each person assigned to do high-voltage/current tests.

## 2.6.2 Preparations in the substation

Prior to connecting a test object to the *CPC 100*, the following steps need to be carried out by an authorized employee of the utility:

- ▶ Turn off all voltage sources connected to the test object and disconnect all external connections.
- ▶ Protect yourself and your working environment against an accidental re-connection of high voltage by other persons and circumstances.
- ▶ Verify a safe isolation of the test object.
- ▶ Earth-connect and shorten out the test object's terminals using a grounding set.
- ▶ Protect yourself and your working environment with a suitable protection against other (possibly live) circuits.
- ▶ Protect others from accessing the dangerous zone and accidentally touching live parts by setting up a suitable barrier and, if applicable, warning lights.
- ▶ If there is a longer distance between the location of the *CPC 100* and the danger zone (the test object), a second person with an additional **Emergency Switching off** button is required.

## 2.6.3 Basic steps to carry out a test with the *CPC 100*

1. Verify that the substation is prepared accordingly and you comply with all safety regulations.

### WARNING



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

- ▶ Connect the *CPC 100* grounding terminal to the substation ground.
- ▶ Use a wire with a cross-section of  $\geq 6 \text{ mm}^2$ .



Connect the *CPC 100* grounding terminal to substation ground.

2. Make sure that the power switch on the *CPC 100* side panel is turned off. Press the **Emergency Switching off** button.
3. Connect the *CPC 100* to the mains power supply using the provided cable.
4. *With the test object grounded and shorted out*, connect the *CPC 100* to the test object according to your requirements.

5. Set up a barrier to separate the danger zone from the work area (see Figure 1-1: "Example of the separation of work area and danger zone using different OMICRON devices" on page 18).

**WARNING**



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

- ▶ Do not enter the danger zone during measurement.
- ▶ Remain in the work area.
- ▶ Before entering the danger zone, follow step 12 to 15 later in this section.

6. Remove the grounding set from the test object.
7. Turn on the *CPC 100* at its POWER switch at the left-hand side.



The green signal light "0" lights up, showing that the current/voltage source is not active.



8. Set up your test in the *CPC 100* software, and, where applicable, determine whether you want to perform an automatic or a manual test.

The following chapters of this manual comprise an example for each available test.

For a detailed description of how to use the software refer to section "How to use the *CPC 100* software" on page 40 of this chapter.

9. Once all test cards are prepared and the parameters set, make sure the key lock is in position "unlocked" (horizontal). Release the **Emergency Switching off** button.



10. Start the test by pressing the green I/O (test start/stop) push-button on the *CPC 100* front panel.

**Note:**

- A test can only be started in the Test Card View and with all preconditions met (refer to "Starting a test" on page 51 of this chapter).
- If voltages  $\geq 500$  V are to be applied, after pressing the I/O (test start/stop) push-button for the first time a warning message appears on the screen.  
Only after the I/O push-button is pressed a second time, the voltage is applied to the *CPC 100* output.
- An error message (313) appears if no PE connection can be detected on the power supply.

**WARNING**



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

This is a safety-relevant message. If the reason for this message is that the PE is not connected, this can cause injury or possibly death of the operating staff.

- ▶ Make sure that both PE and grounding terminal are connected.



11. If a potentially hazardous voltage and/or current level is fed by the *CPC 100* outputs, the red signal red light "I" starts flashing.

12. After testing, switch off the high voltage or current immediately with the I/O (test start/stop) push-button.

13. If you do not use the *CPC 100* anymore, turn the key to "lock" (vertical) and remove the key to avoid anybody accidentally turning on the high voltage or current.

**Note:** After turning off the high voltage or current observe the signal lights: only when the *CPC 100* green signal light is on and the red one off, switch off the key lock and take off its key.

14. After turning off the *CPC 100* outputs, connect all terminals of the test object to ground and short-circuit them again using a grounding set.

15. Remove the connection between the *CPC 100* and the test object.

**WARNING****Death or severe injury caused by high voltage or current possible**

- ▶ Never touch any metallic terminals and housing components without a visible ground connection!

## 2.7 Cleaning

**WARNING****Death or severe injury caused by high voltage or current possible**

- ▶ Prior to cleaning disconnect the device.
- ▶ To clean one of the devices described in this document, use a cloth dampened with isopropanol alcohol or water.

## 3 Measurement setup

### 3.1 Preparations in the substation



#### DANGER

##### Death or severe injury caused by high voltage or current

Prior to connecting a test object to the *CPC*, the following steps need to be carried out by an authorized employee of the utility.

- ▶ Turn off all external voltage sources connected to the test object.
- ▶ Protect yourself and your working environment against an accidental re-connection of high voltage by other persons and circumstances.
- ▶ Verify a safe isolation of the test object.
- ▶ Ground and short-circuit all terminals of the test object using a grounding set.
- ▶ Protect yourself and your working environment with a suitable protection against other (possibly live) circuits.
- ▶ Disconnect all external connections to the test object.

### 3.2 Basic steps to carry out a test with the *CPC*

#### 3.2.1 Connection

1. Define a work area and a danger zone around the test object and secure this area sufficiently against unauthorized access, for example using a barrier chain and signs. See Figure 1-1: "Example of the separation of work area and danger zone using different OMICRON devices" on page 18.
2. Connect the grounding terminal of the *CPC* to substation ground using the grounding cable delivered with the *CPC*.



#### DANGER

##### Death or severe injury caused by high voltage or current

Operating the *CPC* without PE and ground connection is life-threatening and not permitted.

- ▶ Always comply with the instructions given in 1.7 "Grounding" on page 20.

3. Make sure that the power switch of the *CPC* is turned off.
4. Press the **Emergency Switching off** button.
5. Connect the *CPC* to the mains power supply using the provided cable.
6. Turn on the *CPC* using the power switch.
7. Lock the *CPC* using the key lock and if applicable lock the connected PC.
8. With the test object grounded and short-circuited, connect the *CPC* to the test object according to the applicable wiring diagram.

### 3.2.2 Performing measurements

1. Remove the grounding set from the test object.
2. Unlock the *CPC* and verify the test setup and the settings in the software.
3. Release the **Emergency Switching off** button.
4. Start the test by pressing the green I/O (test start/stop) push-button on the *CPC*'s front panel.

**Note:**

- A test can only be started in the Test Card View and with all preconditions met.
- If voltages  $\geq 500$  V are to be applied, after pressing the I/O (test start/stop) push-button for the first time a warning message appears on the screen.
- Only after the I/O push-button is pressed a second time, the voltage is applied to the *CPC*'s output.
- An error message (313) appears if no PE connection can be detected on the power supply.

**WARNING**



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

This is a safety-relevant message. If the reason for this message is that the PE is not connected, this can cause injury or possibly death of the operating staff.

- ▶ Make sure that both PE and grounding terminal are connected.

5. While the test is running, the red signal light is flashing.
6. To manually end a test, press the I/O (test start/stop) push-button.

**WARNING**



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

Depending on the test, a predefined switch-off cycle is initiated after the test. Therefore, stopping a test manually might not shut off the *CPC* outputs instantaneously. Most tests finish the running test sequence with a predefined ramp function.

- ▶ Therefore, in a hazardous situation never press "Stop Test".
- ▶ Instead, use the **Emergency Switching off** button.

The outputs of the *CPC* are switched off when the red signal light is off and the green signal light is on

**WARNING**



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

This is not an indicator for a safe state as externally generated voltages and/or currents are not within the control of the *CPC*.

- ▶ Never touch any metallic terminals and housing components without a visible ground connection!

7. If you do not use the *CPC* anymore, turn the key to "lock" (vertical) and remove the key – lock the *CPC* to avoid unauthorized operation of the *CPC*.
8. Press the **Emergency Switching off** button.

### 3.2.3 Disconnection

1. Connect all terminals of the test object to ground and short-circuit them using a grounding set.

#### WARNING



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

- ▶ Never touch any metallic terminals and housing components without a visible ground connection!

2. Remove the connection between the *CPC* and the test object.

### 3.3 Cleaning

#### WARNING



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

- ▶ Do not clean *CPC* when connected to the test object.
- ▶ Disconnect the test object, accessories and connection cables before cleaning.

- ▶ Use a cloth dampened with isopropanol alcohol to clean *CPC* and its accessories.

## 4 Getting started with Quick

### 4.1 About Quick

Quick is the most basic mode to operate all of the *CPC 100* outputs in a manual-like mode with front panel control.

The screenshot shows the Quick test card interface. At the top left, there is a 'Quick' tab. Below it, the main display area contains several controls: a dropdown menu set to 'AC 800A', a large digital display showing '800.0 A', a '50.00 Hz' setting with a lock icon, a 'Trigger on:' dropdown set to 'No Trigger', a 'Bin In.' radio button set to 'n/a', and a checked 'Switch off on trigger' checkbox. Below these are 'I Out' and 'I AC' dropdowns, and a 'Ratio: 1' dropdown. A table below these controls shows measurement data for 'A' and 'A' columns. At the bottom left, it says 'Assessed: n/a - Measuring'. On the right side, there is a vertical column of buttons: '0.0', 'Min', 'Max', 'Keep Result', and 'Back to Top'.

A	*	A	*	:1	*
30.00m	n/a	70.00μ	n/a	428.57	n/a

Figure 4-1: **Quick** test card

The *CPC 100* starts in the Test Card View (refer to 2.4.5 "Test card view" on page 44) with the test procedure default. Initially, the test procedure default contains one empty **Quick** test card. However, this template can be customized according to your specific requirements with as many test cards as needed and of all types of your choice.

By creating a user-defined test procedure default, the *CPC 100* starts up loading your most frequently used test cards already containing specific values.

To learn more about defining such a template, refer to 2.4.11 "Creating defaults and templates" on page 67.

**Quick** starts in "measuring" state with de-activated outputs, displaying the measured values in the measurement table of the **Quick** test card.

The measurements as well as the indication of the binary input's signal status (refer to "Bin.In." on page 85 of this chapter) are updated with an interval of approx. 0.5 s.

After having set all necessary parameters (more about this in the following sections), press the I/O (test start/stop) push-button. The **Quick** test card enters the "on" state, the set power output value is switched to the *CPC 100* outputs, the measuring continues.



Pressing the **Quick** test card menu key **Keep Results** saves the currently measured values and "freezes" their display in the measurement table. Both the "measuring" and the "on" state remain active, the measurement continues in a new line of the measurement table.

While in "on" state, pressing the I/O (test start/stop) push-button terminates the test. The *CPC 100* outputs are turned off, and **Quick** returns to the "measuring" mode.

**DANGER**



**Death or severe injury caused by high voltage or current**

Together with the test object's capacitance, the leakage inductance of the *CPC 100*'s internal output transformer forms a series resonant circuit. Especially at frequencies > 50 / 60 Hz this may result in voltage superelevation.

- ▶ When testing capacitive test objects using voltages  $\geq 500$  V, make sure that the test object's capacitance does not exceed 25 nF.

**DANGER**



**Death or severe injury caused by high voltage or current**

- ▶ Never use **Quick** in combination with a DC output on test objects with highly capacitive characteristics.
- ▶ Mind the danger of test object's charged capacitance. Before connecting or disconnecting any leads, use a grounding/discharging rod
  - ▶ to discharge all terminals of the test object.
  - ▶ to connect all terminals of the test object to ground and short-circuit all capacitances.

**DANGER**



**Death or severe injury caused by high voltage or current**

- ▶ Never use **Quick** to measure the resistance of windings with highly inductive characteristics. Turning off the DC source results in life-threatening voltage levels.
- ▶ For this kind of measurement only use the special winding resistance test cards **RWinding**, **TRTapCheck** or **OLTC-Scan**.



Pressing the **Settings** menu key opens the **Settings** page. The **Settings** page allows setting the test cards individually. As a rule, do not use the **Settings** page but the **Device Setup** tab in the **Options** view (see "Device Setup" on page 56) to set the test cards. For more information, see "Settings page" on page 50.

## 4.2 Measurement settings

V1 AC	▼
I AC	▼

### Measured quantities

Combo boxes to select the first and second quantity to measure. Possible choices at each combo box:

- V1 AC
- V1 AC sel<sup>1</sup>
- V2 AC
- V2 AC sel
- V Out
- V Out sel
- VT<sup>2</sup>
- VT sel
- I AC
- I AC sel
- I Out/ $\sqrt{2}$ \*
- V Out, I Out, V Out/ $\sqrt{2}$  and I Out/ $\sqrt{2}$ , as well as f Out represent the measured values of the actual output range.
- I Out
- I Out sel
- I Clamp<sup>3</sup>
- I Clamp sel
- CT<sup>4</sup>
- CT sel
- V DC
- I DC
- f V1 AC<sup>5</sup>
- f Out
- V Out/ $\sqrt{2}$ \*

V1 AC	▼	I AC	▼
V	*	A	*
25.00 $\mu$	0.00	60.00 $\mu$	-176.80
25.00 $\mu$	0.00	60.00 $\mu$	-134.80

Each combo box has two corresponding cells in the measurement table below that display the measured values, where possible; otherwise "n/a" is displayed.

1. sel = frequency-selective. To learn more about frequency-selective measurements, refer to "The frequency-selective measurement" on page 81 of this chapter.

\*) Only available with a respective license for more accurate trigger times.

**Note:** Not all measured quantities are available in all output ranges.

2. VT (VT sel): Measures the voltage considering the set VT ratio setting.
3. I Clamp (I Clamp sel): Measures the current considering the set I Clamp ratio setting.
4. CT (CT sel): Measures the current considering the set CT ratio setting.
5. f V1 AC: Measures the frequency of the V1 AC input.



After having pressed **Keep Results**, the combo boxes of the measured quantities are disabled, that is, the quantities cannot be changed.

Z	▼	Ω	*
416.7m	176.80	416.7m	134.80

### Calculated value

Both the items to select from in this combo box and the corresponding display at the measurement table below depend on the selected measured quantities.

In this combo box you determine what the measurement table displays (see Table "After having pressed Keep Results, the combo boxes of the measured quantities are disabled, that is, the quantities cannot be changed." on page 79 of this chapter).

Figure 4-2: Display of calculated value in measurement table

Measured quantities		Display of calculated value in measurement table
(m1)	(m2)	
V	V	Ratio:1, Ratio:5, Diff: Ratio m1/m2 and phase angle $\phi_{m1} - \phi_{m2}$ (if phase angles are available; else "n/a"), and differences $\Delta U$ and $\Delta \phi_U$ .
I	I	Ratio:1, Ratio:5, Diff: Ratio m1/m2 and phase angle $\phi_{m1} - \phi_{m2}$ (if phase angles are available; else "n/a"), and differences $\Delta I$ and $\Delta \phi_I$ .
V	I	For AC: Z or R, X Impedance Z (magnitude in $\Omega$ and phase angle $\phi$ in $^\circ$ ) or R and X in $\Omega$ . For DC: R Resistance R (in $\Omega$ ) else "n/a"
V	I	For AC: P, Q, S Real power P (in W) and $\cos\phi$ , apparent power S (in VA) and $\cos\phi$ , reactive power Q (in var) and $\cos\phi$ . For DC: P Real power P (in W) else "n/a"
V	I	Rs, Ls or Rp, Cp: Resistance R and either inductance Ls in H (series equivalent circuit) or capacity Cp in F (parallel equivalent circuit) are just another representation of the impedance Z measurement; Z is displayed in its components. Using Rs, Ls, the impedance is given by: $\underline{Z} = R_s + j \omega L_s$ , where $\omega = 2 \pi f$ and the set frequency is used for the calculation. Using Rp, Cp, the admittance is given by: $1/\underline{Z} = 1/R_p + j \omega C_p$ , where $\omega = 2 \pi f$ and the set frequency is used for the calculation.



After having pressed **Keep Results**, the combo box for the calculated quantity is disabled, that is, the calculated quantities cannot be changed.

## 4.2.1 The frequency-selective measurement

55.00 Hz

The frequency-selective measurement is used to filter out interferences as they usually occur in substations. To do so, the frequency of the *CPC 100* output quantity is set to a value different from the substation's frequency, for example, the substation operates with a frequency of 50 Hz, the *CPC 100* output frequency is set to 55 Hz.

The quantity measured back at the *CPC 100* input is measured selectively, that is, only a quantity with the specified frequency is fully taken into consideration for the measurement. Quantities with different frequencies are filtered out according to the characteristics shown in Figure 4-3 below.

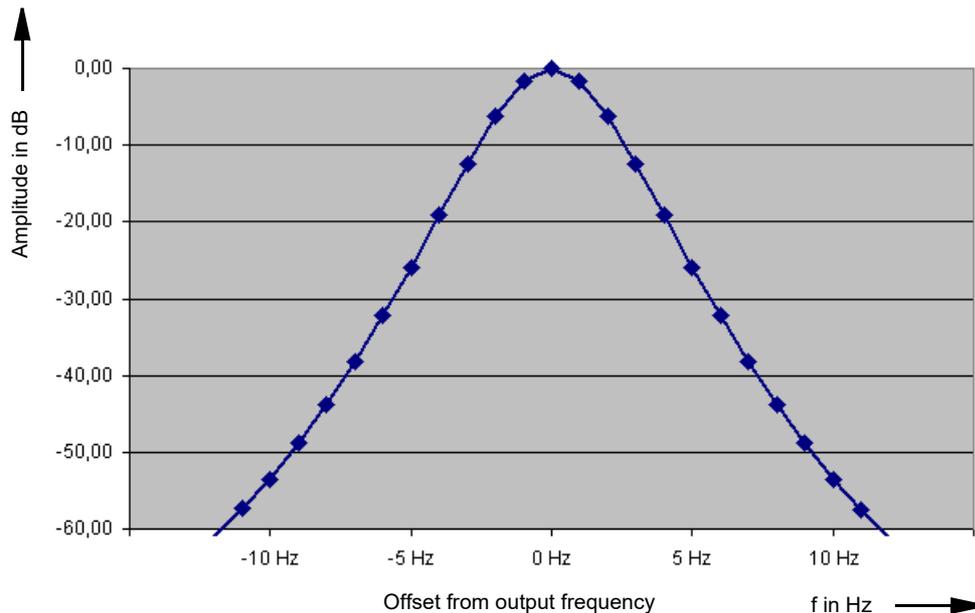


Figure 4-3: Characteristics of the frequency-selective measurement

Apart from **Quick**, the frequency-selective measurement is also available for other test cards:

CT	VT	Transformer	Others
<ul style="list-style-type: none"> <li>• CTRatio</li> <li>• CTBurden</li> <li>• CTRatioV</li> <li>• CTLowPower</li> <li>• SV-Ratio</li> </ul>	<ul style="list-style-type: none"> <li>• VTRatio</li> <li>• VTBurden</li> <li>• VTElectronics</li> <li>• SV-Ratio</li> </ul>	<ul style="list-style-type: none"> <li>• TRRatio</li> </ul>	<ul style="list-style-type: none"> <li>• Sequencer</li> <li>• Ramping</li> <li>• SV-Ratio</li> </ul>

In **Quick**, **Sequencer** and **Ramping** the frequency-selective measurement is selectable, whereas at the other test cards, it is preset and cannot be cleared.

### 4.3 Power output settings

The main settings are the range definition and the value for the power output (the data entry field in Figure 4-4 that has the focus).

The power output value can be changed instantaneously with the handwheel, even in the "on" state and while connected to a test object.

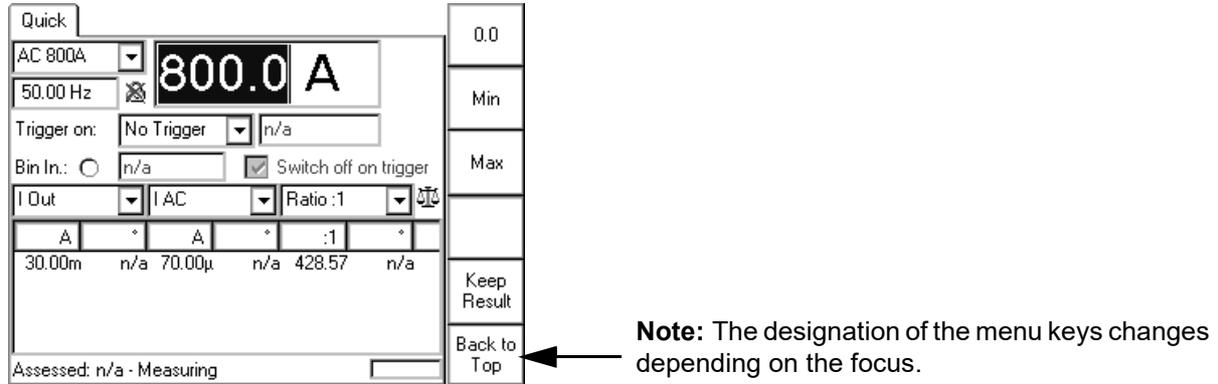
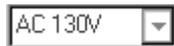


Figure 4-4: Quick test card



#### Range

Output ranges are available if the respective external booster was selected at the **Options** tab **Device Setup** (see 2.4.10 "Options" on page 56) or on the **Settings** page of the **Quick** test card.

Each range has an associated minimum and maximum value, a fixed precision value as well as a preset number of decimal characters (refer also to "Setting up a test card" on page 47).

If **Quick** operates in the "on" state, the output range setting is locked and cannot be changed.

While in the "measuring" state with de-activated outputs, when a range is changed, the output changes accordingly to a new value within the allowed range between minimum and maximum.

After having pressed **Keep Results**, the output range setting and the measurements settings are locked and cannot be changed.



#### Power output value

Current (I) or voltage (V) value, depending on the specified range (see above).

Any value between minimum and maximum as well as the explicit value 0.0 is possible, even while in the "on" state.

The respective minimum and maximum values depend on the range and, for voltage ranges, also on the frequency. For frequencies smaller than 50 Hz, and down to the minimum frequency of 15 Hz, the possible maximum voltage value decreases linear proportional to the frequency value.

Current ranges do not have such a dependency.

50.00 Hz

**Frequency / Phase angle**

Frequency value in Hz or - if "Sync w/ V1 AC" is selected (see below) - phase angle in degrees. For DC ranges this data entry field is disabled.

The frequency can be set within a range of 15.00 ... 400.00 Hz, even while in the "on" state.

The phase angle is displayed in a range of -180.0 ... +180.0°, and can also be changed at any time. If this range is exceeded, the phase angle will adapt itself automatically, that is, change from -180.0 to +180.0°.

Sync w/  
V1 AC

50.0 Hz

60.0 Hz

**Sync w/ V1 AC**

Set **Sync w/ V1 AC** by pressing the menu key that appears when the focus is on the frequency/phase angle data entry field.

This synchronizes the *CPC 100* output frequency with the V1 AC input frequency. In this case the phase angle of the output is displayed rather than the frequency. Set the phase angle value relative to the phase angle of the V1 AC input signal (we recommend a minimum input voltage of 10 V on V1 AC, possible range 48 - 62 Hz).

The icon next to the frequency/phase angle data entry field reflects the actual setting.



If "Sync w/ V1 AC" is disabled, the frequency returns to the previously set frequency value and the icon changes.



If **Quick** operates in the "on" state, the status of "Sync w/ V1 AC" cannot be changed.

**Note:** Due to the PLL (phase-locked loop) technology, the synchronization with V1 AC needs about 100 ms.

If for the particular test object the synchronism within the first 100 ms is relevant, start with a reduced magnitude of the output signal. Then enter the full magnitude of your choice, and press **Enter**.

This procedure assures that the high-level output signal is synchronized with V1 AC right from the beginning.

## 4.4 Trigger settings

A trigger is the occurrence of a selected event, for example, a binary trigger is the first change of the state at the binary input.

①

### Trigger on:

Selection of trigger event

- no trigger (default)
- binary trigger = CPC 100 input BIN IN is monitored for a trigger event
- trigger = first measurement value (m1) > set threshold value
- trigger = first measurement value (m1) < set threshold value
- trigger = second measurement value (m2) > set threshold value
- trigger = second measurement value (m2) < set threshold value
- overload = the trigger event is an overload condition that occurs at the selected output.

### What is an "Overload" trigger?

At the **800A AC** output, an overload trigger is a condition in which the set current cannot be reached any longer, for example, because of an opening contact or circuit breaker.

**Note:** Current values < 50 A do not initiate an "Overload" when the current circuit opens. Therefore, if you use the trigger condition "Overload", choose a nominal current value of  $\geq 50$  A.

**Quick** differentiates two "Overload" trigger conditions:

- 1.the occurrence of an overload (as described above)
- 2.the clearing of an overload condition (clearing is delayed by 100 ms to debounce).

**Note:** Trigger conditions with "<" are meaningful in combination with external signals only, that is, with signals that are not coming from the CPC 100.

Reason: if the trigger signal comes from the CPC 100, the trigger condition will always be "true" at the moment the I/O (test start/stop) push-button is pressed.

After having pressed **Keep Results**, the trigger event is locked and cannot be changed.

- ② Data entry field for the threshold value.  
 Setting a threshold value is not possible ("n/a", as shown above), if either
- a binary trigger condition
  - no trigger
  - overload
- was selected.

After having pressed **Keep Results**, data entry for the threshold value is disabled, that is, the value cannot be changed.

- ③ **Bin.In:**  
 Indicates the signal condition at the binary input **Bin In**. 4 different characteristics are possible:

Bin In:  **Closed:** potential-free contact between Bin In+ and Bin In– closed.

Bin In:  **Open:** potential-free contact between Bin In+ and Bin In– open.

Bin In:  **Come:**  
 trigger signal with rising edge  occurred at Bin In.

Bin In:  **Go:**  
 trigger signal with falling edge  occurred at Bin In

- ④ Delay time display  
 The delay time is the time between the last change of the *CPC 100* output value and the occurrence of the trigger event.

- ⑤ **Switch off on trigger**  
 This option is available if the trigger condition is either binary or overload. Else, "switch off on trigger" is preset and cannot be disabled.

"Switch off on trigger" is also locked and cannot be changed after having pressed **Keep Results**.

1. Enabled

When the trigger event occurs, the *CPC 100* outputs are switched off immediately (that is, in real-time).

The measurements are updated to show the values at the time the trigger event occurred, and are then "frozen", that is, not updated anymore from that moment on. **Quick** turns to the "off" state.

At the field for the power output value setting, the data entry mode is automatically disabled to prevent this value from being changed. The focus, however, remains on that field, enabling instant navigation with the handwheel.



Pressing the menu key **Keep Results** saves the measured values in the measurement table. **Quick** returns to the "measuring" state, the measurement continues in a new line of the measurement table.

2. Disabled

The *CPC 100* outputs remain active, that is, in "on" state, after the trigger event occurred. If the trigger is binary, the "BinIn" indicator reflects the occurrence of the trigger event accordingly.

The focus remains in data entry mode on the field for the power output value setting, allowing an immediate change of the output value.

The measurements continue after the trigger event.

As soon as the output value is changed, the display of the most recent delay time is removed.

## 4.5 Rapid Fault Sense (RFS)

The Rapid Fault Sense is an output supervisor that can detect output changes and initiate an immediate switch-off of the *CPC 100*.

**WARNING**



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

RFS is an addition, not a replacement for current safety measures. Its operability cannot be guaranteed in all situations. Users must not take an increased risk or rely on the unconditional functioning of RFS.

RFS is available in the following applications for both the *CPC 100* embedded software and *Primary Test Manager* (PTM) operation:

- Quick
- Any *CP TD* application
- Sequencer
- VTRatio
- Voltage Withstand

**Note:** RFS output supervision is not immediately active. Typical activation times are in the range of a few seconds.

A critical change in the signal form detected by RFS will initiate an immediate switch-off of the utilized *CPC 100* output. If active, RFS can detect a fault in less than 1 ms.

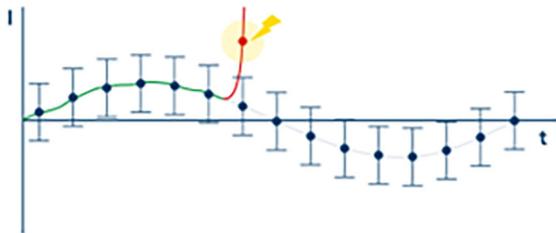


Figure 4-5: Visualization of RFS detecting a fault when the current exceeds the expected threshold

If the Rapid Fault Sense has been activated, the following message is displayed.

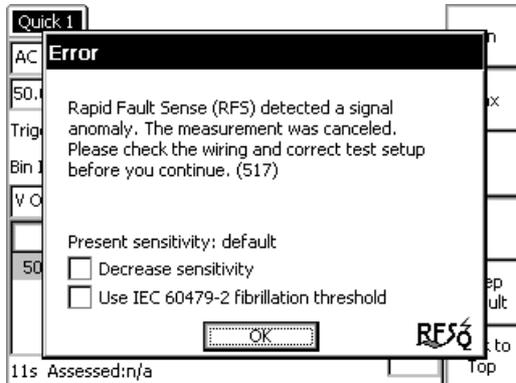


Figure 4-6: Rapid Fault Sense activation message generated by the *CPC 100* embedded software

To proceed, select one of the following options:

- Click **OK**.  
The *CPC 100* will continue to operate with the current RFS settings.
- Select **Decrease sensitivity**, and then click **OK**.  
The threshold for the RFS activation will be increased based on the highest measured deviation from the last RFS activation. This leads to a less sensitive behavior of RFS.

**Note:** The increased RFS threshold is only active as long as necessary. The *CPC 100* automatically sets the threshold back to the default values when the output signal form deviations are in a constantly low range.

- Select **Use IEC 60479-2 fibrillation threshold**, and then click **OK**.  
The IEC 60489-2 standard gives a general idea of how fast a device must be switched off to lower the risk for human heart fibrillation effectively. The *CPC 100* will only switch off if the threshold for the RFS activation is exceeded or the cumulative charge measured by the *CPC 100* exceeds the charge cumulation threshold.

**Note:** The option Use IEC 60479-2 fibrillation threshold is active until it is deactivated in the RFS message box or on the **Supervision** tab.

When the amplitude or frequency of the test signal has changed, the RFS algorithm requires an initial data acquisition time for calibrating to the new expected deviation range. When the required confidence level is reached, the *CPC 100* will automatically activate the RFS supervision.

#### 4.5.1 RFS Q – Use IEC 60479-2 fibrillation threshold

RFS Q is an extension of the general RFS algorithm. If **Use IEC 60479-2 fibrillation threshold** is selected, a lower limit for switch-off decisions is set. Consequently, the *CPC 100* will prevent the RFS switch-off if the determined charge value measured by the *CPC 100* is below 500  $\mu\text{C}$ , being approximately half of the "no fibrillation" threshold stated in the IEC 60479-2 standard.

It is important to note that the actual charge threshold measured by the *CPC 100* will deviate from the charge threshold stated by the IEC 60479-2 standard. According to the IEC 60479-2, the charge threshold is based on the current exposure through the human body. On the contrary, the *CPC 100* always measures the overall current of the measurement setup including the asset under test and the fault current.

**Note:** Activating the option Use IEC 60479-2 fibrillation threshold may induce lower sensitivity to the fault states. Especially, when low testing voltages are used, the measured charge value may not surpass the charge threshold, thus preventing the RFS switch-off.

**Note:** Activating the option Use IEC 60479-2 fibrillation threshold can be helpful when the *CPC 100* is operated with low output signals in very noisy environments.

## 4.5.2 Rapid Fault Sense indication

The *CPC 100* test cards that support Rapid Fault Sense (RFS) display different symbols in the status bar to indicate the current RFS status. The symbols are displayed at the bottom, next to the measurement time indicator. The following table describes the RFS status indicators.

Table 4-1: RFS status indicators

Symbol	Status
^ circumflex	RFS is active. When Rapid Fault Sense is active, it will switch off the <i>CPC 100</i> instantaneously if statistically significant deviations occur in the stable measurement signal.
ˇ caron	RFS is inactive. When Rapid Fault Sense is currently inactive, it will not switch off the <i>CPC 100</i> . The measurement signal might not be stable yet or the output value is too low.
~ small tilde	Low-signal warning Indicates that the signal is not sufficiently distinguishable. This may occur if the test object is not correctly wired. RFS is still active and will detect attempts to fix the wiring while the output is active.
Δ delta	RFS Q mode is enabled. In the charge-enabled mode (Q stands for charge), RFS will switch off the <i>CPC 100</i> when statistically significant deviations occur in the signal and the ventricular fibrillation charge threshold is about to be exceeded. The delta symbol warns that the contact with a high-voltage lead may still be hurtful. <b>Note:</b> This status can only appear in the RFS Q mode, i.e. when the ventricular fibrillation charge threshold according to IEC 60479-2 is enabled. Circumflex, caron or small tilde will appear to the right of the delta symbol.
‡ double dagger	RFS Q warning A statistically significant deviation in the signal was detected in the RFS Q mode, but the fault charge is below the ventricular fibrillation threshold. The <i>CPC 100</i> is not switched off and the test continues to run. <b>Note:</b> This status can only appear in the RFS Q mode, i.e. when the ventricular fibrillation charge threshold according to IEC 60479-2 is enabled. Circumflex, caron or small tilde will appear to the right of the double dagger symbol.

## 5 Current transformer

**Note:** With regard to software handling, this section confines to test-relevant issues, and does not go into detailed procedural descriptions. It is assumed that you have read and understood the section 2.4 "How to use the CPC 100 software" on page 40.

**Note:** In this manual, the *CPOL2* and *CPOL3* polarity checkers are collectively referred to as *CPOL*. The polarity checkers are named explicitly only if necessary due to their different features.

### 5.1 Scope of current transformer tests



Go to the Test Card View and press **Insert Card**.

Use the context-dependent **Up/Down** menu keys to the right, or the handwheel, to browse through the structure. On CT, press **Enter**.



Alternatively, press the accelerator key to open **Insert a new test card**.

CT comprises the following test cards:

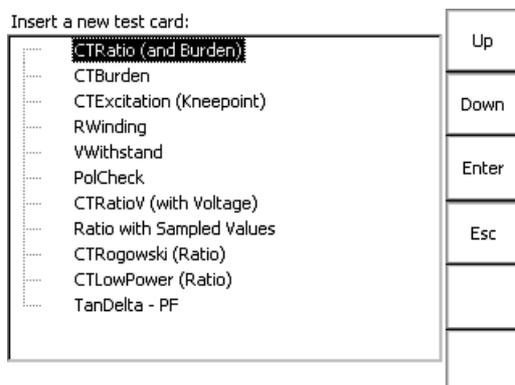


Figure 5-1: Inserting CT test cards

Highlight the test card of your choice either by navigating with the handwheel or by using the context-dependent **Up/Down** menu keys, and press **Enter**.

**Note:** The test cards

- **CTRatio** (and Burden)
- **CTBurden**
- **CTRatioV** (with Voltage)
- **CTLowPower** (Ratio)

employ the method of frequency-selective measurement, which is used to filter out interferences as they usually occur in substations.

To learn more about frequency-selective measurement, please refer to 4.2.1 "The frequency-selective measurement" on page 81.

## 5.2 CTRatio (and burden)

### 5.2.1 Testing ratio, polarity (and burden) with injection into current input

Use the **CTRatio** test card to measure a current transformer's ratio and burden with injection on the CT's primary side with up to 800 A from the **800A AC** output or up to 2000 A using the **CP CB2** current booster connected to the **"EXT. BOOSTER"** output.

It measures amplitude and phase angle of the current (at **I AC**) and voltage (at **V1 AC**) on the transformer's secondary side, and calculates the actual ratio and the deviation from the nominal ratio.

**DANGER**



**Death or severe injury caused by high voltage or current**

▶ Make sure that no secondary CT windings are open.

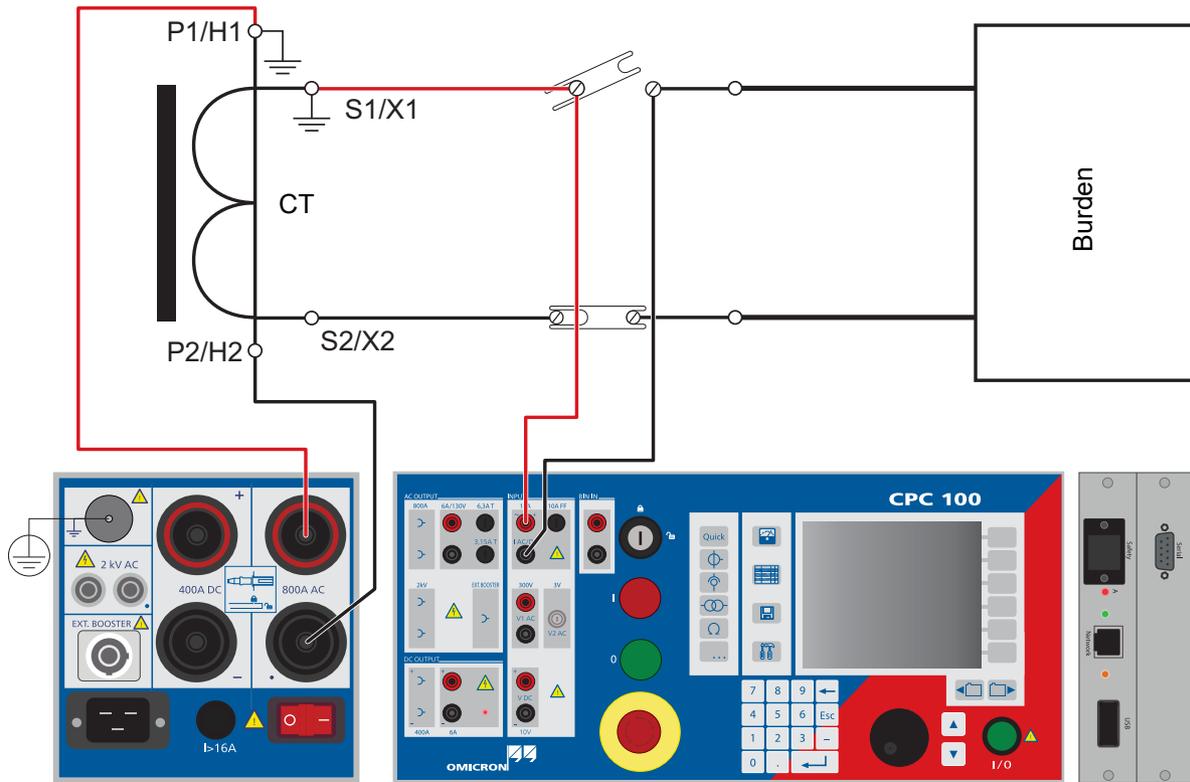


Figure 5-2: Setup of testing ratio, polarity (and burden) with injection to current input

## Test settings

The screenshot shows a software interface for a 'CTRatio 1' test card. At the top, there are tabs for 'CTRatio 1', 'CTRatio 2', 'CTBurden 1', and 'CTExcite'. Below the tabs, there are several input fields and checkboxes:
 

- Range:** A dropdown menu set to 'AC 800A' and a checked 'Auto' checkbox.
- I prim.:** A text box containing '200.0 A'.
- I sec.:** A text box containing '5.000 A'.
- I test:** A text box containing '200.0 A'.
- f:** A text box containing '50.00 Hz'.
- I prim.:** A text box containing '199.99 A' and an unchecked 'Current clamp I sec.' checkbox.
- I sec.:** A text box containing '5.0130 A', a text box containing '0.10 °', and an unchecked 'Manual input' checkbox.
- Ratio:** A text box containing '200.0:5.0133' and a text box containing '0.265 %'.
- Polarity:** A text box containing 'OK' and an unchecked 'Measure burden' checkbox.

 On the right side, there is a vertical menu with buttons: 'Insert Card', 'Delete Card', 'Rename Card', 'Clear Results', 'Save As Default', and 'Settings'. At the bottom left, there is a label 'Assessed:n/a' and a small icon.

Figure 5-3: **CTRatio** test card with test results

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

Range:	output range
Iprim:	nominal primary current
Isec:	nominal secondary current
Itest:	primary injection current.
f:	output frequency
Auto	select check box for automatic test (default), clear for manual test (refer to page 94).

**Note:** If the test involves either an external booster to gain a higher output current or a current clamp to measure I sec, set these devices at the **Options** tab **Device Setup** before starting the test.

- Measure burden **Measure Burden** The option **Measure Burden** lets you measure the burden, the secondary voltage and the  $\cos\phi$  (cosinus of angle between secondary current and secondary voltage).

**Settings** Pressing the **Settings** menu key opens the **Settings** page. The **Settings** page allows setting the test cards individually. As a rule, do not use the **Settings** page but the **Device Setup** tab in the **Options** view (see "Device Setup" on page 56) to set the test cards. For more information, see "Settings page" on page 50.

### Three methods to determine I sec

The secondary current Isec can be determined either

1. by leading it directly via the 10A current input **I AC** (refer to Figure 5-2 on page 90), and let the *CPC 100* measure it.
2. by means of a current clamp that is connected, for example, to the **V2 AC** low-level AC voltage measuring input (refer to "Testing ratio, polarity (and burden) with a current clamp" on page 96 of this chapter).
3. by selecting the check box **Manual input**. This option lets you enter the value for I sec manually, for example, when I sec was measured with an external current clamp that is not connected to the *CPC 100*.

**Note:** Select **Manual input** prior to starting the test. If the test card still contains results, clear them by pressing **Clear Results**.

When **Manual input** is selected, there is no phase available. Consequently, the polarity and  $\cos\phi$  cannot be calculated.

### Measurements

Iprim:	actual current output at the <b>800A AC</b> output that is injected into the CT's primary side
Isec:	measured secondary current and phase angle $\phi$ relative to Iprim
Ratio:	ratio Iprim /Isec., here 200:5.0133 <sup>1</sup> and deviation of current ratio in %. $((Kn \times Isec - Iprim) / Iprim) \times 100\%^2$ $((200A / 5A * 5.013A - 199.99A) / 199.99A) \times 100\% = +0.265\%$
Polarity:	displays the status of the polarity OK = phaseIsec - phaseIprim = $-45^\circ < 0^\circ < +45^\circ$ NOT OK = all other cases

1. The value 5.0133 is calculated as follows:  
Isec act x (Iprim nom / Iprim act); here: 5.013 A x (200A / 199.99A) = 5.0133
2. Kn = rated transformation value, here: 200A / 5A

### The "Measure burden" option

Select the check box **Measure Burden** to measure the burden in VA.

**Note:** This option is only useful as long as the injected current  $I_{test}$  is about of the magnitude of the nominal current  $I_{prim}$ .

**DANGER**



**Death or severe injury caused by high voltage or current**

- ▶ Do not touch other taps or windings of the CT during the test. They carry life-threatening voltage.
- ▶ Do not exceed the current specification of the CT.
- ▶ When testing multi-core CTs, make sure that no other windings of the CT are open. Leave the secondary windings of the other (non-measured) cores connected, or shortcircuit them if the windings are open.

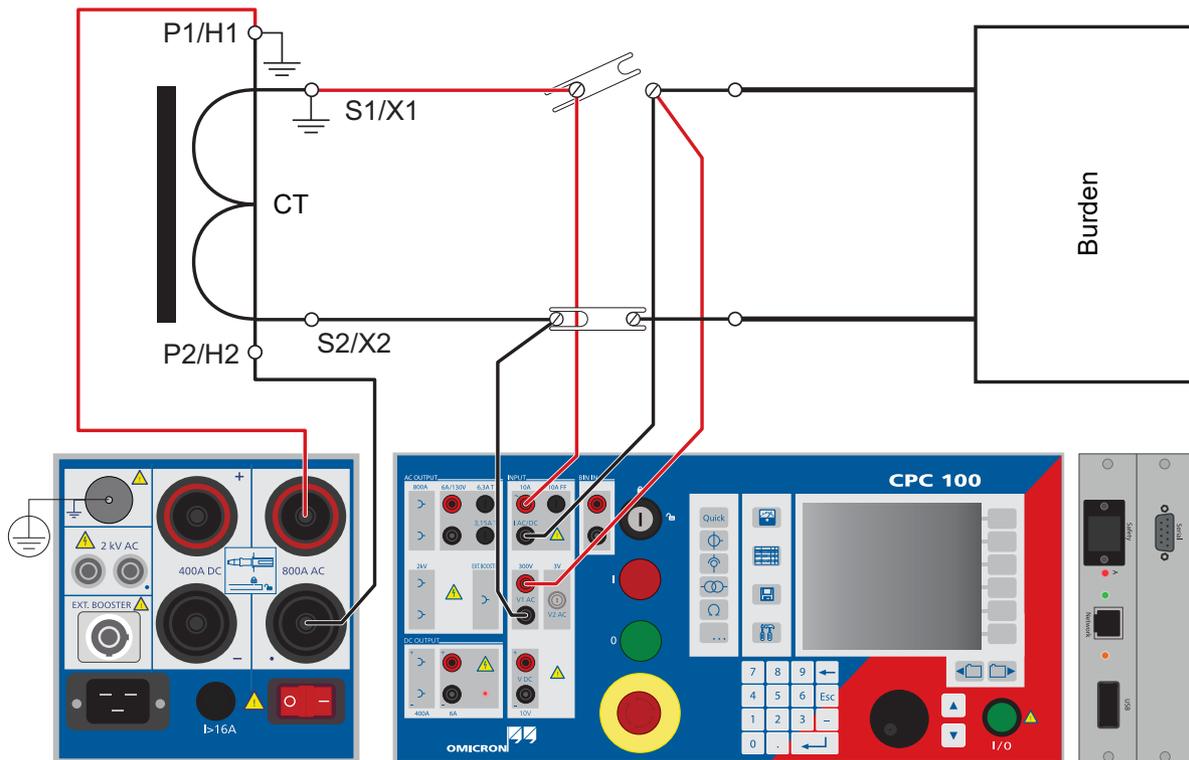


Figure 5-4: Setup for testing ratio, polarity and burden with injection to current input

**Note:** Disconnect the burden from the CT to avoid measurement errors.

**Note:** For CTs that have a hole rather than a primary busbar just loop the high-current cable through the hole and connect the high-current clamps together.

CTRatio 1	<b>CTRatio 2</b>	CTBurden 1	CTExcite	Insert Card
Range:	AC 800A	<input checked="" type="checkbox"/> Auto		Delete Card
I prim.:	200.0 A	I sec.:	5.000 A	Rename Card
I test:	200.0 A	f:	50.00 Hz	Clear Results
I prim.:	199.98 A	<input type="checkbox"/> Current clamp I sec.		Save As Default
I sec.:	5.0120 A	0.15 °	<input type="checkbox"/> Manual input	Settings
Ratio:	200.0:5.0125	0.250 %		
Polarity:	OK	<input checked="" type="checkbox"/> Measure burden		
V sec.:	1.7340 V	34.15 °	<input type="checkbox"/> Manual input	
Burden:	8.6492 VA	cos φ:	0.829	
Assessed:n/a				

Figure 5-5: CTRatio test card with selected "Measure burden" option and test results

### Additional measurements when "Measure burden" is selected

Vsec:	measured secondary voltage and phase angle relative to Iprim
Burden:	burden in VA: Isec nom × (Vsec act × Isec nom/Isec act)
cos φ	cosine of angle between Isec and Vsec

## Automatic test vs. manual test

### 1. Option "Manual input" clear<sup>1</sup>

#### Automatic test

- ▶ Press the I/O (test start/stop) push-button to start the test.
- ▶ The test current increases from 0A to Itest in a ramp characteristic within 1 second. Then Itest is kept for a period of 2.4 seconds, and the measurements are taken. Next, the ramp decreases again within 0.3 seconds.
- ▶ The automatic test stops by itself, it can now be assessed.
- ▶ To repeat the test, first press **Back to Top**, if applicable, and then **Clear Results**.

#### Manual test

Clearing **Auto** lets you set the test current Itest manually with the handwheel.

- ▶ Press the I/O (test start/stop) push-button to start the test. The focus is set onto the "I test:" entry field.
- ▶ Set the value of your choice either by turning the handwheel and/or by entering it with the numerical keys.

**Note:** A value set with the numerical keys needs to be fully entered and acknowledged by pressing either **Enter** or the handwheel before it is applied to the output. If needed, it can then be adjusted using the handwheel.

Values set by turning the handwheel are applied instantaneously.

1. Refer to "Three methods to determine I sec" on page 92 of this chapter.

- ▶ Now the measurements are taken and displayed.
- ▶ To save the measurement press **Keep Results** (pressing the I/O push-button has the same effect). The last measured values are "frozen", the test can now be assessed.
- ▶ Stop the manual test by pressing the I/O (test start/stop) push-button.
- ▶ To repeat the test, first press **Back to Top**, if applicable, and then **Clear Results**.

## 2. Option "Manual input" selected

**Note:** Select **Manual input** prior to starting the test. If the test card still contains results, clear them by pressing **Clear Results**.

When **Manual input** is selected, there is no phase available. Consequently, neither the polarity nor the phase angle nor  $\cos \varphi$  can be calculated.

Since an automatic test only lasts a very short period of time, and a manual measurement is rather difficult, an automatic test with a manual measurement is not useful. Therefore, this Reference Manual will not cover this subject.

### Manual test

Clearing **Auto** lets you set the test current  $I_{test}$  manually with the handwheel.

- ▶ Press the I/O (test start/stop) push-button to start the test. The focus is set onto the "I test:" entry field.
- ▶ Set the value of your choice either by turning the handwheel and/or by entering it with the numerical keys.
- ▶ A value set with the numerical keys needs to be fully entered and acknowledged by pressing either **Enter** or the handwheel before it is applied to the output. If needed, it can then be adjusted using the handwheel.  
Values set by turning the handwheel are applied instantaneously.
- ▶  $I_{prim}$  is measured and displayed.
- ▶ To save the measurement press **Keep Results**.
- ▶ Navigate to the  $I_{sec}$  entry field.
- ▶ Enter the measured  $I_{sec}$  value either by turning the handwheel or by entering this value with the numerical keys, and press **Enter** or the handwheel to acknowledge your setting.
- ▶ The ratio is calculated and displayed.
- ▶ To stop the manual test, press the I/O (test start/stop) push-button. The test can now be assessed.
- ▶ Alternatively, it is possible to enter the manually measured value into the test card after the test was stopped (for example, if the measurement was carried out at a remote location).
- ▶ To repeat the test, first press **Back to Top**, if applicable, and then **Clear Results**.
- ▶ To learn more about test assessment, refer to 10.1 "Test assessment" on page 271.

## 5.2.2 Testing ratio, polarity (and burden) with a current clamp

**DANGER**



**Death or severe injury caused by high voltage or current**

- ▶ Do not touch other taps or windings of the CT during the test. They carry life-threatening voltage.
- ▶ Do not exceed the current specification of the CT.
- ▶ When testing multi-core CTs, make sure that no other windings of the CT are open. Leave the secondary windings of the other (non-measured) cores connected, or shortcircuit them if the windings are open.

To measure  $I_{sec}$ , a current clamp can be connected to, for example, the **I AC/DC** current measuring input (as shown in Figure 5-6 below).

**Note:** If a current clamp is used to measure  $I_{sec}$ , select the corresponding check box on the test card, and specify the current clamp at the **Options** tab **Device Setup** (recommended) or on the **Settings** page.

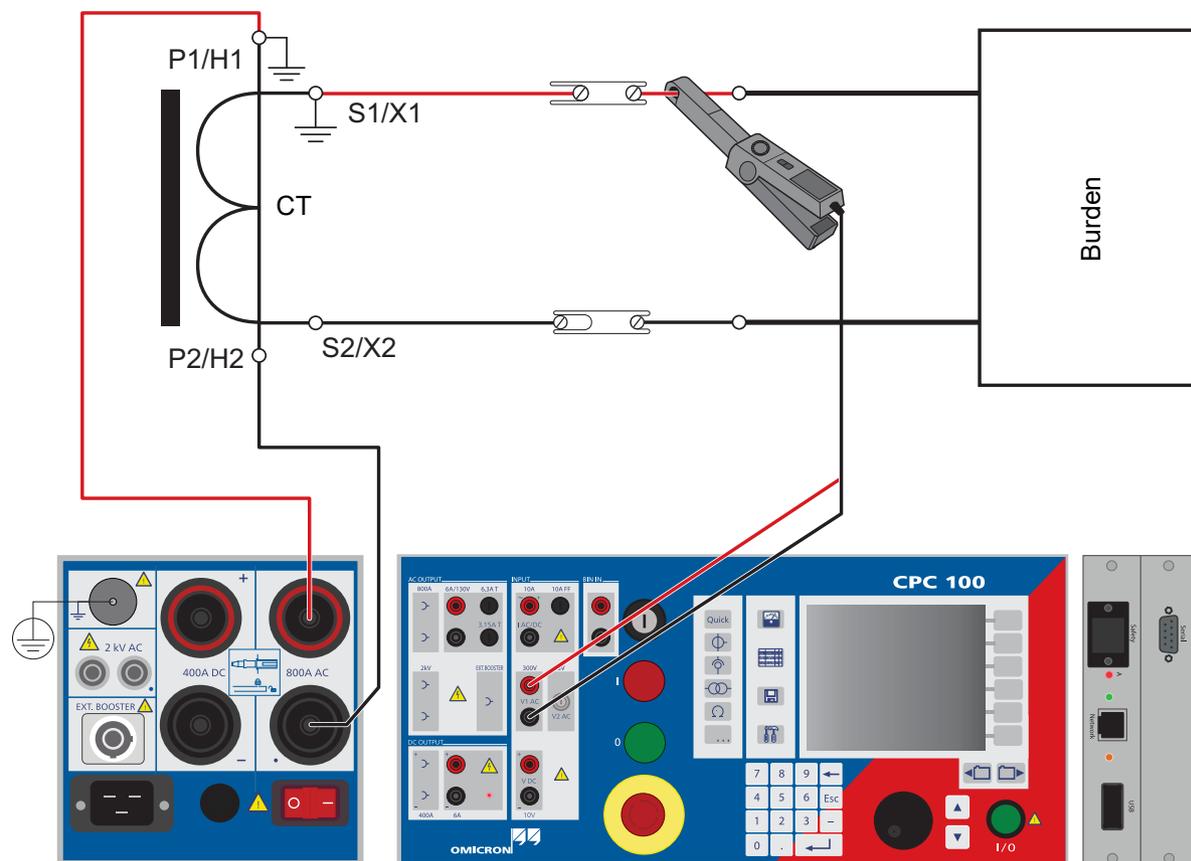


Figure 5-6: Setup for testing ratio, polarity (and burden) with a current clamp

The test itself is carried out in the same way as the test described at "Testing ratio, polarity (and burden) with injection into current input" on page 90 of this chapter. Please refer to this section.

**Note:** We recommend using a current clamp with voltage output to be connected to the **V2 AC** input.

**Note:** Due to cross-talk between the measuring inputs **V1 AC** and **V2 AC** on earlier *CPC 100* devices, we suggest not to connect a current clamp to the input **V2 AC**. This issue was solved for devices with serial number starting from KFxxxx (serial numbers are alphabetical in ascending order!). However, a hardware upgrade is available for older devices before this series. For further information, please contact your local sales partner.

### 5.3 CTBurden

Use the **CTBurden** test card to measure a current transformer's secondary burden with AC current injection into the load (up to 6A).

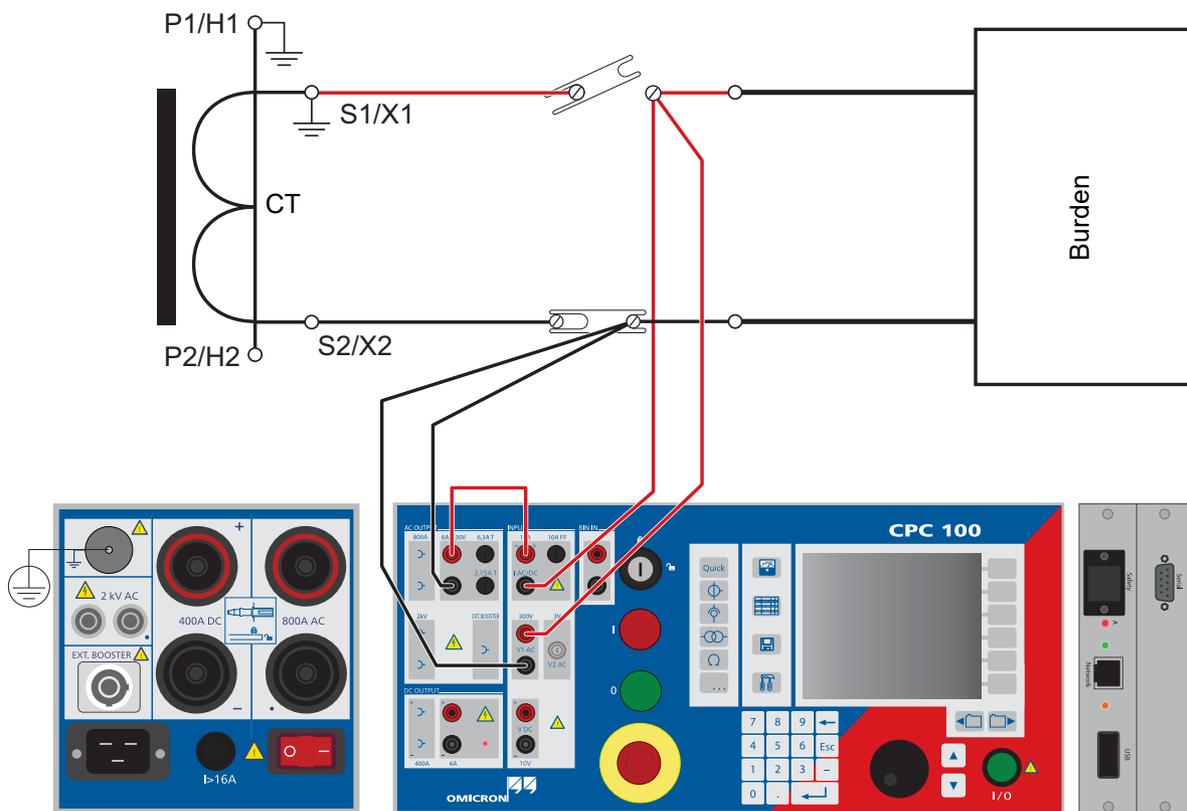
To do so, open the circuit as shown in Figure 5-7, and inject the AC current from the *CPC 100* **6A AC** output into the burden.

The **I AC** input measures the current that flows into the burden, and the **V1 AC** input measures the voltage at the burden.

From these measurements, the burden (in VA) and the power factor  $\cos\phi$  are calculated.

This is the preferred method in cases when the current of max. 800A that the *CPC 100* can feed into the CT's primary side is not sufficient.

**Note:** Disconnect burden from the CT to avoid measurement errors



### 5.3.1 Test settings

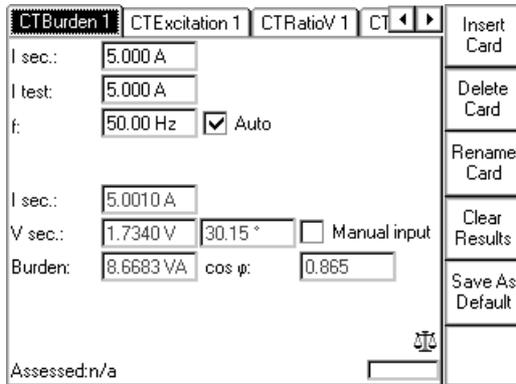


Figure 5-8: CTBurden test card with test results

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

Isec:	nominal secondary current
I test:	secondary injection current from <b>6A AC</b> output
f:	output frequency
Auto	select check box for automatic test (default), clear for manual test (refer to page 99).
<input checked="" type="checkbox"/> Manual input	Selecting the check box <b>Manual input</b> lets you enter the value for Vsec manually, for example, when Vsec was measured with an external volt meter rather than at input <b>V1 AC</b> .

### 5.3.2 Measurements

Isec:	actual secondary current, measured via input <b>I AC</b>
Vsec:	secondary voltage at the burden, measured at input <b>V1 AC</b> , and phase angle $\phi$ relative to Isec
Burden:	burden in VA: $Isec\ nom \times (Vsec\ act \times Isec\ nom / Isec\ act)$
cos $\phi$	cosine of phase angle $\phi$

### 5.3.3 Automatic test vs. manual test

#### 1. Option "Manual input" clear

##### Automatic test

- ▶ Press the I/O (test start/stop) push-button to start the test.
- ▶ The test current increases in a ramp characteristic from 0A to I<sub>test</sub> within 1 second. Then I<sub>test</sub> is kept and injected for a period of 2.4 seconds, the measurements are taken. Next, the ramp decreases again within 0.3 seconds.
- ▶ The automatic test stops by itself, it can now be assessed.
- ▶ To repeat the test, first press **Back to Top**, if applicable, and then **Clear Results**.

##### Manual test

Clearing **Auto** lets you set the test current I<sub>test</sub> manually with the handwheel.

- ▶ Press the I/O (test start/stop) push-button to start the test. The focus is set onto the "I test:" entry field.
- ▶ Set the value of your choice either by turning the handwheel and/or by entering it with the numerical keys.
- ▶ A value set with the numerical keys needs to be fully entered and acknowledged by pressing either **Enter** or the handwheel before it is applied to the output. If needed, it can then be adjusted using the handwheel.  
Values set by turning the handwheel are applied instantaneously.
- ▶ Now the measurements are taken and displayed.
- ▶ To save the measurement press **Keep Results** (pressing the I/O push-button has the same effect). The last measured values are "frozen", and can now be assessed.
- ▶ Stop the manual test by pressing the I/O (test start/stop) push-button. The test can now be assessed.
- ▶ To repeat the test, first press **Back to Top**, if applicable, and then **Clear Results**.

## 2. Option "Manual input" selected

**Note:** Select **Manual input** prior to starting the test. If the test card still contains results, clear them by pressing **Clear Results**. When **Manual input** is selected, there is no phase available. Consequently, neither the phase angle  $\varphi$  nor  $\cos\varphi$  can be calculated. Since an automatic test only lasts a very short period of time, and a manual measurement is rather difficult, an automatic test with a manual measurement is not useful. Therefore, this Reference Manual will not cover this subject.

### Manual test

Clearing **Auto** lets you set the test current  $I_{test}$  manually with the handwheel.

- ▶ Press the I/O (test start/stop) push-button to start the test. The focus is set onto the "I test:" entry field.
- ▶ Set the value of your choice either by turning the handwheel and/or by entering it with the numerical keys.
- ▶ A value set with the numerical keys needs to be fully entered and acknowledged by pressing either Enter or the handwheel before it is applied to the output. If needed, it can then be adjusted using the handwheel.  
Values set by turning the handwheel are applied instantaneously.
- ▶  $I_{sec}$  is measured and displayed.
- ▶ To save the measurement press **Keep Results**.
- ▶ Navigate to the "Vsec:" entry field
- ▶ Enter the measured  $V_{sec}$  value either by turning the handwheel or by entering this value with the numerical keys, and press **Enter** or the handwheel to acknowledge your setting.
- ▶ Now the burden is calculated and displayed.
- ▶ To stop the manual test, press the I/O (test start/stop) push-button. The test can now be assessed.
- ▶ Alternatively, it is possible to enter the manually measured value into the test card after the test was stopped (for example, if the measurement was carried out at a remote location).
- ▶ To repeat the test, first press **Back to Top**, if applicable, and then **Clear Results**.
- ▶ To learn more about test assessment, refer to 10.1 "Test assessment" on page 271.

## 5.4 CTExcitation (knee point)

Use the **CTExcitation** test card to record the excitation curve of a current transformer. This test performs an automatic injection of a test voltage of up to 2kV to the current transformer's secondary side.

**DANGER**



**Death or severe injury caused by high voltage or current**

Feeding test voltage to a tap of a CT can cause life-threatening voltages on other taps and windings.

- ▶ Make sure that no secondary CT windings are open.

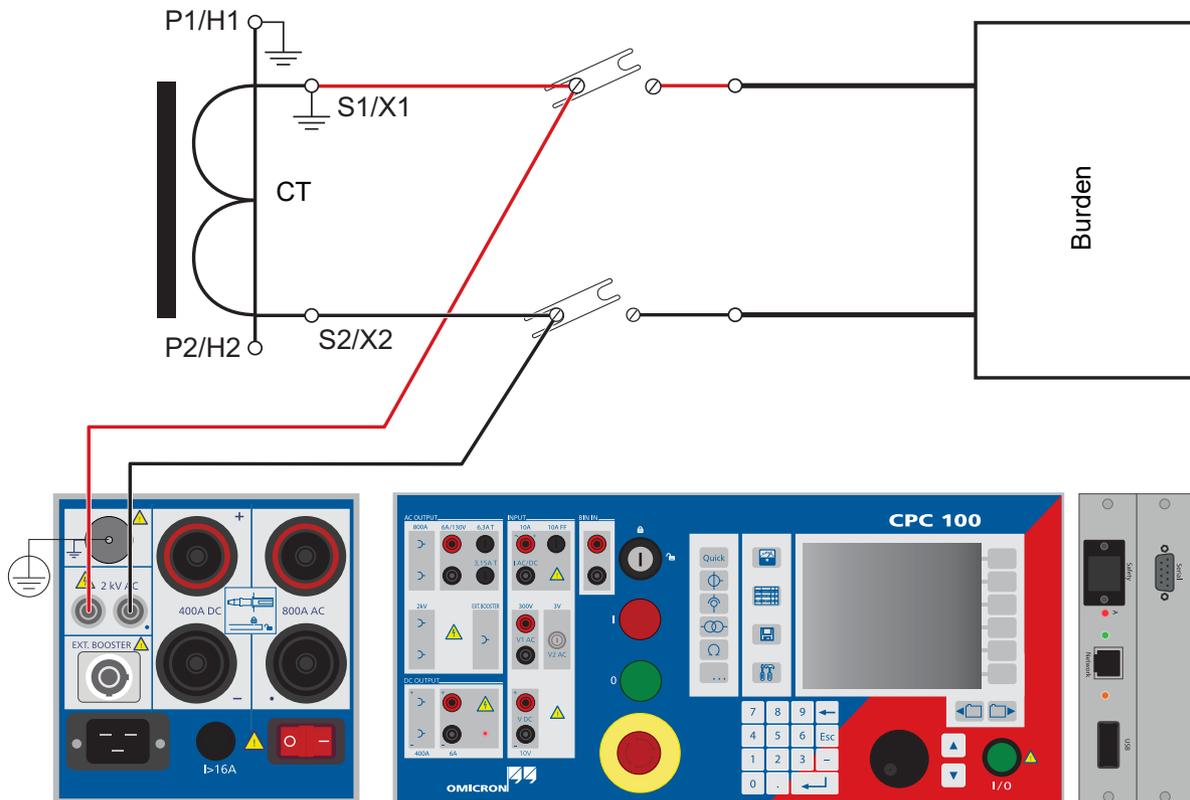


Figure 5-9: Setup for recording a CT excitation curve

### 5.4.1 Test settings

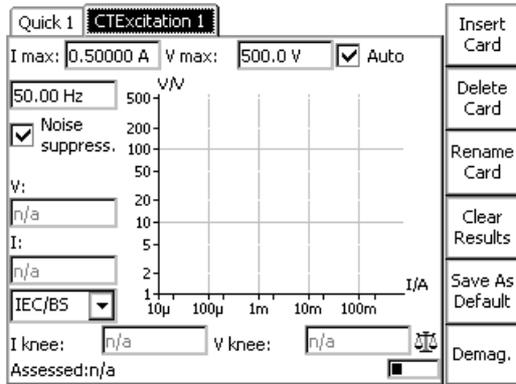


Figure 5-10: Blank **CTExcitation** test card

- ▶ Navigate to the parameter fields for "I max:", "V max:" and "f:", and enter the values according to your test requirements.
- ▶ Select check box "Auto" for automatic test (default), clear it for manual test (refer to page 103).
- ▶ Set the focus onto the combo box underneath "I:".
- ▶ The options of this combo box let you determine the method for the knee point calculation:

IEC/BS	According to IEC 60044-1, the knee point is defined as the point on the curve where a voltage increment of 10% increases the current by 50%.
ANSI 45°	According to IEEE C57.13, the knee point is the point where, with a double logarithmic representation, the tangent line to the curve forms a 45° angle.  Applies to current transformer cores without an air gap.
ANSI 30°	Like ANSI 45° but forming a 30° angle.  Applies to current transformer cores with an air gap.

Once the test is finished and the knee point calculated according to the selected method, it is possible to switch between IEC/BS, ANSI 45° and ANSI 30°. The knee point is recalculated accordingly.

Noise suppression: Select if you see unsteadiness and jumps in the CT excitation curve. The unsteadiness or jumps can occur due to noise or disturbance during the measurement.

If noise suppression is selected, the measurement is done with a different frequency.

$$\text{If } f_{nom} \geq 60 \text{ Hz} \rightarrow f_{test} = f_{nom} - 10 \text{ Hz.}$$

$$\text{If } f_{nom} < 60 \text{ Hz} \rightarrow f_{test} = f_{nom} + 10 \text{ Hz.}$$

The voltage will then be calculated back to  $f_{nom}$  ( $V = V_{meas} * f_{nom}/f_{test}$ ). With  $f_{nom} < 60$  Hz, the maximum test voltage is reduced up to 20% and with  $f_{nom} \geq 60$  Hz, the maximum test voltage is increased up to 16%. The exciting current will not be corrected as the influence is very small.

**Note:** According to the standards, the **CTExcitation** test card measures the rectified mean value (rmv) of the voltage, however, during the measurement the rms voltages are set. The rmv and rms values can differ considerably when the CT is in saturation.

## 5.4.2 Automatic test vs. manual test

### Automatic test

Selecting **Auto** increases and decreases the test voltage in a ramp characteristic, and places test points in an adaptive way to determine the knee point.

- ▶ Press the I/O (test start/stop) push-button to start the test.
- ▶ The range from  $V_{min}$  to  $V_{max}$  is swept through, which is indicated by the crosshair cursor in the graphics.
- ▶ The software places test points between  $V_{max}$  and  $V_{min}$  in a heuristic manner to calculate the knee point with an adequate accuracy.
- ▶ The graph<sup>1</sup> displays these test points as markers. A test point is a voltage-current value pair.
- ▶ The automatic test stops by itself, it can now be assessed.

### Manual test

Clearing **Auto** lets you set the test voltage  $V_{test}$  manually with the handwheel.

- ▶ Press the I/O (test start/stop) push-button to start the test. The focus is set onto the "V:" entry field.
- ▶ Set the first value of your choice (rms value) either by turning the handwheel or by entering this value with the numerical keys.
 

**Note:** When using the handwheel, make sure not to increase the amplitude too fast since this may shortly exceed the set value  $I_{max}$ . Turn the handwheel slowly.
- ▶ "I:" shows the corresponding current value and indicates it with the crosshair cursor in the graphics.
- ▶ Press **Add Point** to add the test point to the graph.
- ▶ Repeat this procedure for all additional test points.
- ▶ The points you set are automatically connected (interpolated) with linear line segments.
- ▶ Press **Remove Last P.** to undo the adding of the last test point. Press the key repeatedly to remove more than one point.
- ▶ Press **Remove All** to clear all points at once. This does not terminate the test but lets you set new test points.
- ▶ Once all test points are set, press the I/O (test start/stop) push-button to stop the manual test. The knee point is calculated, and its values are displayed at "Iknee:" and "Vknee:".
- ▶ The test can now be assessed.

---

1.  $V$  over  $I$  graph, X and Y axes with a double logarithmic scale

Both cases, an automatic stop after the test and stopping the test manually during the sweep, reduce the test voltage to the minimum (Vmin) within approx. 1 s of time, and demagnetize the transformer core.

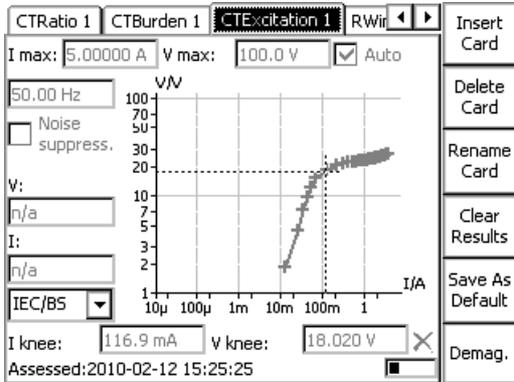


Figure 5-11: **CTExcitation** test card - test points set in automatic test mode

The graph displays the test results in form of an interpolated curve with test point markers.

Turn the handwheel to set the focus onto the graph, and press it. This will bring up a crosshair cursor that lets you navigate through the list of test points by using the keys **Previous Point** and **Next Point**. Turning the handwheel has the same effect. The fields "V:" and "I:" display the value pair of each test point.

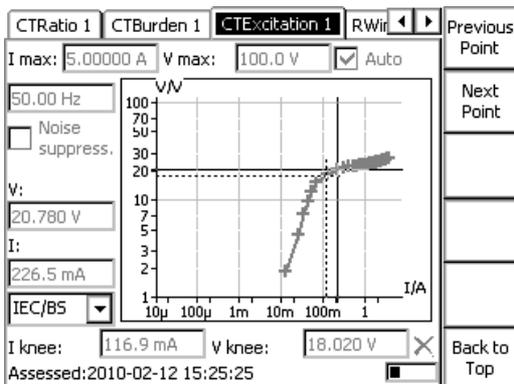


Figure 5-12: **CTExcitation** test card - using the crosshair cursor

The final step of the test is the test assessment.

To learn more about test assessment, refer to 10.1 "Test assessment" on page 271.

### 5.4.3 Demagnetization

Both direct currents (DC) or unsymmetrical AC currents (for example, asymmetries when the CT is switched off) can cause a residual induction in CT cores. Residual induction can result in an high increase of the ratio error.

To reduce the residual induction to zero, the CT cores should be demagnetized after all CT tests with DC, for example, after a measurement of the CT winding resistance, or the measurement of the contact resistances of the primary circuit.

Also demagnetize the core before carrying out ratio measurements.

If the limit values for current and voltage ( $I_{max}$  and  $V_{max}$ ) at the **CTExcitation** test card are high enough to bring the core into saturation during the recording of an excitation curve, slowly decreasing the testing voltage demagnetizes the CT automatically.

Demagnetization can also be done without recording an excitation curve by pressing the **Demag.** button.

## 5.5 Winding Resistance

**Note:** Some test cards are available in more than one test mode. For example, the test card **RWinding** can be selected in CT, Resistance and Transformer.

This is solely related to usability. With regard to functionality, the test card **RWinding** is identical in all test modes.

#### DANGER



#### Death or severe injury caused by high voltage or current

Injecting direct current into test objects with inductive characteristics will charge the winding of the test object.

- ▶ Follow instructions below.
- ▶ Refer to chapter 1.10 "DC output to test objects with a high inductance" on page 22.

#### DANGER



#### Death or severe injury caused by high voltage or current

- ▶ Do not exceed the current specification of the CT
- ▶ Never open the measuring circuit while current flows.
- ▶ Make sure that no other secondary windings are open.
- ▶ After a measurement, wait until the *CPC 100* has discharged completely.
- ▶ Before disconnecting from the *CPC 100*, connect the device under test on both ends to protective earth.
- ▶ Short-circuit the winding under test before disconnecting the test leads.

Use the test card **RWinding** to measure the resistance of a current transformer's secondary winding. To do so, open the circuit as shown in Figure 5-14, and inject DC current from the *CPC 100* **6A DC** output into the transformer's secondary winding. Currents higher than 6 A are not needed for measuring CTs.

**WARNING**



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

We recommend performing all winding resistance measurements with the *CP SA1* connected to the *CPC 100* **V DC** input sockets to protect yourself and the *CPC 100* from high-voltage hazards.

- ▶ The *CP SA1* must be used for measurements using the **400A DC** output.
- ▶ Before disconnecting the test leads, short-circuit the transformer's terminals first and then remove the wirings to the *CPC 100*.

Before using the *CP SA1*, you can check its functionality by following the test procedure in 16.4 "CP SA1" on page 328. If the *CP SA1* is defective, contact OMICRON.

**V DC** input measures the voltage generated at the transformer's secondary winding. From that value the winding resistance is calculated.

Due to the significant time span needed for the transformer's inductance to reach its saturation, this test evaluates the deviation of measured values within a time interval of 10 seconds. The winding resistance is continually measured and stored in the *CPC 100* internal memory. The calculated difference between the maximum and minimum measured values in % within the last 10 seconds is displayed.

Furthermore this test comprises the option to take a temperature compensation for copper (Cu) and aluminum (Al) into consideration (refer to page 109).

## 5.5.1 Test settings

The screenshot shows the RWinding test card interface. At the top, there are tabs for 'RWinding 1', 'TRTapCheck 1', 'RGround 1', and 'Cd'. Below the tabs, the interface is divided into several sections:

- Range:** DC 6A (selected), with an  for 'Auto'.
- I test:** 5.000 A
- I DC:** 4.9990 A
- V DC:** 2.5430 V
- R meas.:** 508.7 mΩ
- Time:** 31.000 s
- Temperature compensation for Cu
- T meas.:** 25.0 °C
- T ref.:** 70.0 °C
- R min.:** 40.00 μΩ
- R max.:** 2.0000 Ω
- Dev.:** 0.01 %
- R ref.:** 596.7 mΩ

At the bottom left, it says 'Assessed:n/a'. On the right side, there is a vertical menu with buttons: 'Insert Card', 'Delete Card', 'Rename Card', 'Clear Results', 'Save As Default', and 'Keep Result'.

Figure 5-13: **RWinding** test card with test results

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

Range:	output range (Use the <b>6A DC</b> output for measuring CTs.)
Auto:	select check box for automatic test (default), clear for manual test
I test:	nominal test current
R min:	calculated minimum winding resistance value (display only). Depends on the value of the nominal test current and the measuring range: <ul style="list-style-type: none"> <li>– 400A DC: <math>R_{min} = 0.2\text{mV} / I_{test}</math></li> <li>– 6A DC: <math>R_{min} = 0.2\text{mV} / I_{test}</math></li> <li>– V DC (2-wire): <math>R_{min} = 0.2\Omega</math></li> </ul>
R max:	calculated maximum winding resistance value (display only). Depends on the value of the nominal test current and the measuring range: <ul style="list-style-type: none"> <li>– 400A DC: <math>R_{max} = 5\text{V} / I_{test}</math>.</li> <li>– 6A DC: <math>R_{max} = 10\text{V} / I_{test}</math>.</li> <li>– V DC (2-wire): <math>R_{max} = 20\text{k}\Omega</math></li> </ul>

**Note:** The transformer's core is magnetized after the measurement. Demagnetization can be done using the **CTExcitation** test card (see "CTExcitation (knee point)" on page 101 of this chapter).



### 5.5.3 Temperature compensation

**Option selected:**  Temperature compensation

Provides two more parameters to enter:

$T_{\text{meas}}$ : ambient temperature

$T_{\text{ref}}$ : operating temperature of test object, that is, the current transformer's secondary winding

Depending on these two parameters, the reference resistance ( $R_{\text{ref}}$ , temperature-compensated winding resistance) is calculated:

Material	in Centigrade	in Fahrenheit
<b>Copper</b>	$R_{\text{ref}} = \frac{V_{\text{DC}}}{I_{\text{DC}}} \times \frac{235 + T_{\text{ref}}}{235 + T_{\text{meas}}}$ $T_{\text{meas}}, T_{\text{ref}}: [^{\circ}\text{C}]$	$R_{\text{ref}} = \frac{V_{\text{DC}}}{I_{\text{DC}}} \times \frac{391 + T_{\text{ref}}}{391 + T_{\text{meas}}}$ $T_{\text{meas}}, T_{\text{ref}}: [^{\circ}\text{F}]$
<b>Aluminum</b>	$R_{\text{ref}} = \frac{V_{\text{DC}}}{I_{\text{DC}}} \times \frac{225 + T_{\text{ref}}}{225 + T_{\text{meas}}}$ $T_{\text{meas}}, T_{\text{ref}}: [^{\circ}\text{C}]$	$R_{\text{ref}} = \frac{V_{\text{DC}}}{I_{\text{DC}}} \times \frac{373 + T_{\text{ref}}}{373 + T_{\text{meas}}}$ $T_{\text{meas}}, T_{\text{ref}}: [^{\circ}\text{F}]$

**Note:** Formulas according to IEC 60076-1.

**Option cleared:**  Temperature compensation

For the winding resistance measurement there is no temperature compensation taken into consideration.

- ▶ Once all settings are defined, press the I/O (test start/stop) push-button to start the test.
- ▶ When the measurements are taken, finish the test by assessing it.
- ▶ To learn more about test assessment, refer to 10.1 "Test assessment" on page 271.

## 5.6 Voltage Withstand test

**Note:** Some test cards are available in more than one test mode. For example, the test card **VWithstand** can be selected in CT, VT, Resistance and Transformer.

This is solely related to usability. With regard to functionality, the test card **VWithstand** is identical in all test modes.

Use the test card **VWithstand** to measure the voltage withstand capability of the secondary winding and secondary wiring.

To do so, disconnect the burden. As shown in Figure 5-15, connect one cable of the 2kV output to the transformer's secondary (1S1) winding connection and the other cable to earth and the transformer's primary connection (P1). Open the secondary ground connection and ground the burden for safety reasons.

### DANGER



#### Death or severe injury caused by high voltage or current

- ▶ Do not touch any terminals of the CT during the test. They carry life-threatening voltage.
- ▶ Disconnect all burdens from the CT.

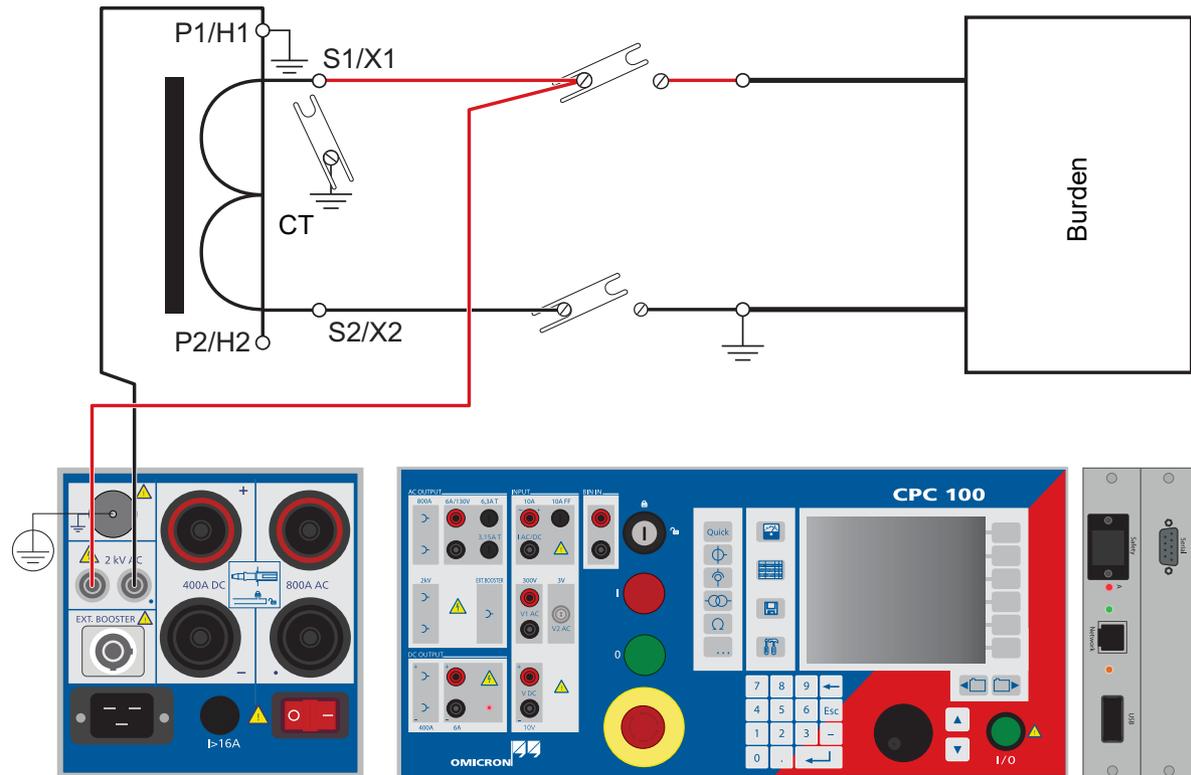


Figure 5-15: Setup for a voltage withstand test

## 5.6.1 Test settings

The screenshot shows a software interface for a VWithstand test card. At the top, there are tabs for 'VTElectronics', 'TRRatio', 'VWithstand', and 'Resist'. The 'VWithstand' tab is active. The interface includes several input fields and checkboxes:

- V test:** 2000.0 V
- f:** 50.00 Hz
- Switch off on I AC >:** 0.00100 A
- Auto:** Time: 30.000 s
- V AC:** 2.000 kV
- I AC:** 370.0  $\mu$ A
- I max:** 570.0  $\mu$ A

On the right side, there is a vertical menu with buttons: 'Insert Card', 'Delete Card', 'Rename Card', 'Clear Results', and 'Save As Default'. At the bottom left, it says 'Assessed: n/a'.

Figure 5-16: **VWithstand** test card with test results

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

Vtest:	nominal test voltage (2kV max.)
f:	output frequency
Time:	time span Vtest is applied to the output

### Option "Switch off on I AC>"

Select this combo box and specify a current threshold to turn off the voltage withstand test automatically if this value is exceeded.

If the combo box is clear (default), I AC is measured, however, there is no current threshold to turn off the voltage withstand test automatically if this value is exceeded. The data entry field cannot be accessed.

### Option "Auto"

Select this combo box and specify a duration time for the voltage withstand test to run (default = 60 seconds). After this time, the test is turned off automatically.

Clear this combo box if you prefer to either turn off the test manually, or have it turned off by the option "Switch off on I AC>" without a duration time involved.

**Note:** If both options "Switch off on I AC>" *and* "Auto" are selected, they act as an OR operation, that is, whatever occurs first will turn off the voltage withstand test.

## 5.6.2 Measurements

VAC:	injected voltage from <b>2kV AC</b> output at the time the test turned off
IAC:	measured current between the transformer's primary and secondary windings at the time the test turned off
I <sub>max</sub> :	maximum measured current between primary and secondary winding during the entire test cycle

Once all settings are defined, press the I/O (test start/stop) push-button to start the test.

The test voltage increases in a ramp characteristic from 0V to V<sub>test</sub>. V<sub>test</sub> is then applied to the output for the specified time span. The measurements are continuously taken. Afterwards V<sub>test</sub> decreases in a ramp characteristic.

When the measurements are taken, finish the test by assessing it.

To learn more about test assessment, refer to 10.1 "Test assessment" on page 271.

## 5.7 Polarity Check

**Note:** Some test cards are available in more than one test mode. For example, the **PolCheck** test card can be selected in CT and VT. This is solely related to usability. With regard to functionality, the Polarity Check test card is identical in all test modes.

**DANGER**



**Death or severe injury caused by high voltage or current**

- ▶ Do not exceed the current specification of the CT.
- ▶ Make sure that no secondary CT windings are open.

Use the **PolCheck** test card to check a series of test points for correct polarity.

To do so, the *CPC 100* injects a special polarity test signal at a certain location. This signal can either be a voltage or a current signal from the *CPC 100*, and has a signal characteristic similar to a saw-tooth signal with a different steepness for the rising and the falling slope.

The polarity check itself is then done with the accessory *CPOL*, a portable easy-to-use polarity checker.

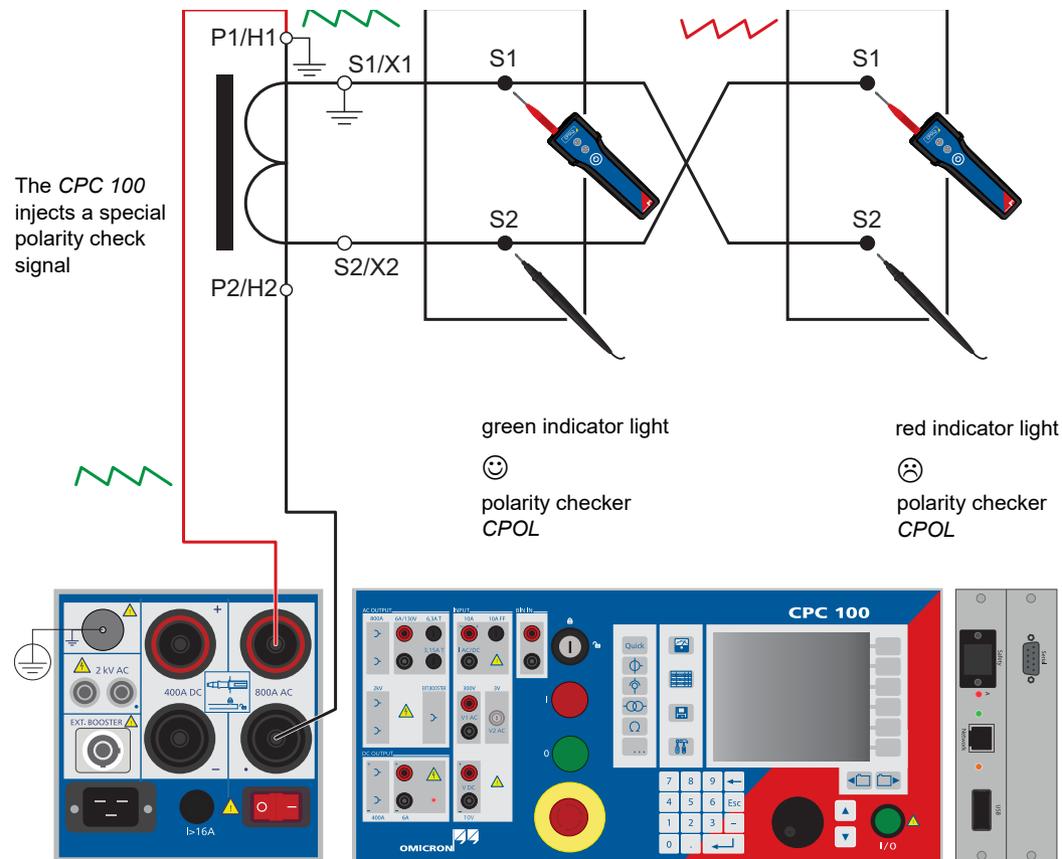


Figure 5-17: Illustrated setup for a polarity check

- ☺ If *CPOL* detects the same signal characteristic at a test point, it considers the polarity as OK, and lights up the green indicator light.
  - ☹ If the signal characteristic is inverted or distorted, *CPOL* considers the polarity not OK, and lights up the red indicator light.
  - ☺ + ☹ If *CPOL* detects a signal that is too low, both indicator lights light up at the same time.  
Remedy: increase the signal magnitude.
- ▶ If you are not quite certain whether your measurement is correct, you can confirm it by reversing the probes of the *CPOL*. In that case, the other indicator light should light up.
-

**CPOL battery**

If the capacity of the *CPOL*'s battery decreases to a certain level, the indicator lights start flashing. As long as the indicator lights are flashing, the *CPOL*'s battery provides sufficient power to continue working. However, the battery should be changed as soon as possible.

**DANGER****Death or severe injury caused by high voltage or current**

- ▶ Handle with extreme caution: The measurement circuit may carry life-threatening voltages. Only touch the measurement setup with the *CPOL* measurement tips and comply with the instructions stated in the relevant user manual.
- ▶ If you detect a wrong polarity in the current path, turn off the *CPC 100* first, and only then disconnect the terminals.
- ▶ Never operate the *CPOL* with an open battery compartment. A dangerous voltage level may occur in the battery compartment if the *CPOL*'s probe touches a test point with high-voltage potential.
- ▶ Do not use the *CPOL* during rain.
- ▶ Do not use the *CPOL* if it is damaged. Before use, inspect the case. Look for cracks or missing plastic. Pay particular attention to the insulation surrounding the connectors.
- ▶ Check the test leads and measurement tips for damaged insulation, exposed metal or bare wires before connecting them to the *CPOL*. Check the test leads for continuity. Replace damaged test leads immediately.
- ▶ If the test leads need to be replaced, only use test leads that meet the EN 61010-031 standard, rated at least for CAT II 1000 V, CAT III 600 V, CAT IV 300 V, or better.
- ▶ When using test probes, keep your fingers behind the finger guards of the test probes. When using the measurement tip, keep your fingers behind the finger guard of the *CPOL*.
- ▶ To power the *CPOL*, only use 2 AA cell batteries, properly installed in the battery compartment.
- ▶ When using the *CPOL3*, do not apply more than the rated voltage for the applicable measurement category between a terminal and earth ground (CAT II 1000 V, CAT III 600 V, or CAT IV 300 V). This also applies if test leads with a higher measurement category or voltage rating are used.
- ▶ Never leave the *CPOL3* under direct sunlight as it might heat up quickly. Check the permissible temperature range of the batteries in use. Operate and store the *CPOL3* only within the temperature range of the batteries in use.

**NOTICE****Equipment damage possible**

- ▶ Do not mix old and new batteries.
- ▶ Make sure that both batteries are of the same type.

### 5.7.1 Test settings

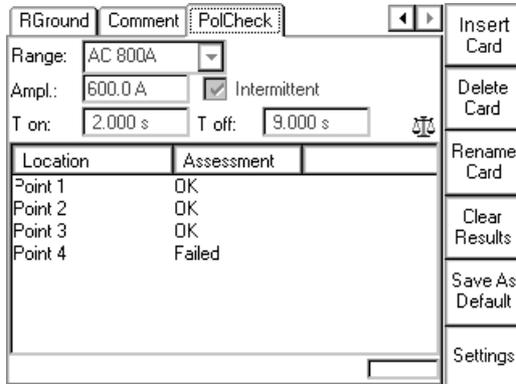


Figure 5-18: **PolCheck** test card with test points

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

Range: output range

Ampl.: amplitude of polarity check output signal. Any value between the minimum and maximum of the selected range is possible.

Intermittent Select the option "Intermittent" to define a pulse duty cycle for the output signal:

T on: time span the signal is applied to the output

T off: time span the signal output is paused

A Ton/Toff ratio of 2.000s/9.000 s means the signal is applied for 2 seconds, then paused for 9 seconds. After that the cycle repeats.

Intermittent Clear the option **Intermittent** to apply the polarity check output signal continuously.

**Note:** Please observe the allowed duty cycles that may apply to the selected AC output range. The allowed pulse duty cycle, that is, the typical time  $t_{max}$ , depends on the selected range, the ambient temperature, the operating conditions of the *CPC 100* etc.

For more information please refer to 15.3 "CPC 100 outputs" on page 297.

Settings Pressing the **Settings** menu key opens the **Settings** page. The **Settings** page allows setting the test cards individually. As a rule, do not use the **Settings** page but the **Device Setup** tab in the **Options** view (see "Device Setup" on page 56) to set the test cards. For more information, see "Settings page" on page 50.

## 5.7.2 Carrying out the polarity check

1. Define the first set of parameters, and press the I/O (test start/stop) push-button to start the test
2. The *CPC 100* now applies the polarity check signal with the specified parameters to the output.
3. Now carry out the polarity check at the test point of your choice using the *CPOL*.
4. Add the first test point to the test point table by pressing "New Result".

The column "Location" displays a default name "Point 1", and a "n/a" in the column "Assessment" shows that no assessment was done yet.

5. If you need multiple test points, repeat items 3 - 4 as often as needed.
6. For the assessment there are two alternatives:
  - a) assess each test point right away as it is entered
  - b) or add all test points needed, stop the test, and then do the assessment test point for test point.

To learn more about test assessment, refer to 10.1 "Test assessment" on page 271.

7. Press the I/O (test start/stop) push-button to stop the test.

**Note:** Alternatively it is possible to enter test points after the test was stopped (for example, if the measurement was carried out at a remote location).

## 5.7.3 Customizing test point names

Location	Assessment
Point 1	OK
Point 2	OK
Point 3	OK
Point 4	Failed

Figure 5-19: Highlighting a test point changes the context-dependent menu keys

- ▶ Highlight the test point of your choice by turning the handwheel.
- ▶ Press **Edit Location** to open the *String Editor*
- ▶ Use the *String Editor* functionality (refer to "The String Editor" in chapter 10) to specify a name of your choice for the selected test point.

## 5.8 CTRatioV (with voltage)

Use the **CTRatioV** test card to measure a current transformer's ratio. To do so, from the **2kV AC** output feed a voltage of up to 500V to the transformer's secondary side.

The preferred method for CT ratio measurement is current injection using the **CTRatio** test card. However, on CTs such as some GIS CTs or bushing CTs on power transformers where the primary current path is not accessible, the method described in this section is the only solution.

Both the amplitude of the injected test voltage as well as amplitude and phase angle of the voltage on the transformer's primary side are measured. The measurements taken are the basis for the calculation of the actual ratio and the deviation from the nominal ratio.

To measure the CT ratio using the **CTRatioV** test card, connect the **2kV AC** output to the CT's secondary winding and the **V2 AC** input to the main conductors, for example, on a power transformer to the transformer's bushings of different phases.

### DANGER



#### Death or severe injury caused by high voltage or current

Feeding test voltage to a tap of a CT can cause life-threatening voltages on other taps and windings.

- ▶ Do not touch tapped windings.
- ▶ Make sure that no secondary windings are open.

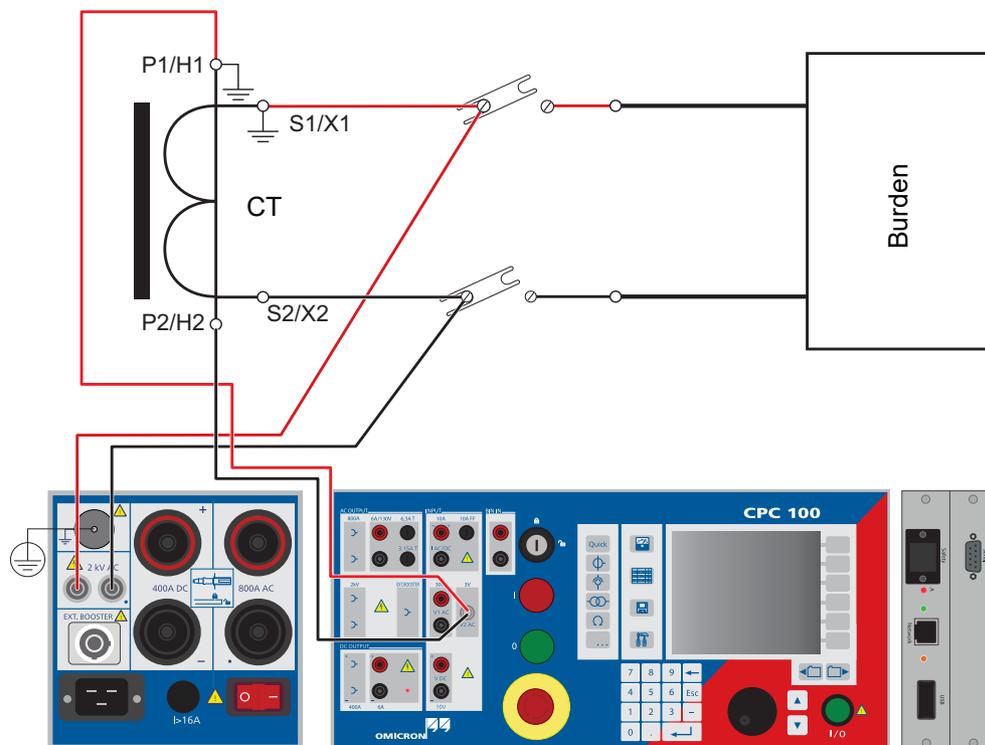


Figure 5-20: Setup for testing the ratio and polarity by measuring the voltage ratio

## 5.8.1 Test settings

Quick 1	CTRatioV 1		Insert Card
I prim.:	200.0 A	I sec.:	5.000 A
V test:	50.0 V		Delete Card
f:	75.00 Hz	<input checked="" type="checkbox"/> Auto	Rename Card
V sec.:	40.280 V	I out:	839.9 mA
V prim.:	503.0 mV	0.91 °	<input type="checkbox"/> Manual input
Ratio:	200.0:2.498		-50.05 %
Polarity:	OK		
Assessed:n/a			
			Clear Results
			Save As Default

Figure 5-21: **CTRatioV** test card with test results

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

Iprim:	nominal primary current
Isec:	nominal secondary current
Vtest:	secondary inception voltage
f:	output frequency
Auto:	select check box for automatic test (default), clear for manual test (refer to page 120).

**Note:** If the transformer's knee point voltage is approximated or exceeded due to the transformer's saturation, the measurement results are not correct anymore. If the knee point is extensively exceeded, the transformer can even be damaged.

Therefore, the knee point voltage should be known or measured beforehand.

Generally, to set the test voltage to 75% of the knee-point voltage is a good choice.

The frequency should be set 15 to 20 Hz off the mains frequency to avoid interferences by life systems in the neighborhood.

## 5.8.2 Measurements

Vsec:	actual output at the <b>2kV AC</b> output that is injected to the CT's secondary side
Vprim:	measured voltage on CT's primary side and phase angle $\phi$ relative to Vsec
Iout	measured current from Vsec output
Ratio:	ratio Iprim / Isec, here 200:5.0134 <sup>1</sup>
	and deviation of current ratio in %. Formula: $((K_n \times V_{prim} - V_{sec}) / V_{sec}) \times 100\%2$ $((200A / 5A * 1.2536V - 50.010V) / 50.010V) \times 100\% = +0.268\%$
Polarity:	displays the status of the polarity OK= phaseVprim - phaseVsec = -45° < 0° < 45° NOT OK = all other cases

1. The ratio value 5.0134A is calculated as follows:  
 $V_{prim\ act} \times (I_{prim\ nom} / V_{sec\ act})$ ; here:  $1.2536V \times (200A / 50.010V) = 5.0134A$
2.  $K_n$  = rated transformation value, here:  $200A / 5A$

Manual input Selecting the check box **Manual input** lets you enter the value for Vprim manually, for example, when Vprim was measured with an external volt meter.

## 5.8.3 Automatic test vs. manual test

### 1. Option "Manual input" clear

#### Automatic test

- ▶ Press the I/O (test start/stop) push-button to start the test.
- ▶ Within 1 second the test voltage increases in a ramp characteristic from 0V to Vtest. Then Vtest is kept for a period of 2.4 seconds, and the measurements are taken. Next, the ramp decreases again within 0.3 seconds.
- ▶ The automatic test stops by itself, it can now be assessed.
- ▶ To repeat the test, first press **Back to Top**, if applicable, and then **Clear Results**.

#### Manual test

Clearing **Auto** lets you set the test voltage Vtest manually with the handwheel.

- ▶ Press the I/O (test start/stop) push-button to start the test. The focus is set onto the "V test:" entry field.
- ▶ Set the value of your choice either by turning the handwheel and/or by entering it with the numerical keys.
- ▶ A value set with the numerical keys needs to be fully entered and acknowledged by pressing either **Enter** or the handwheel before it is applied to the output. If needed, it can then be adjusted using the handwheel.  
 Values set by turning the handwheel are applied instantaneously.
- ▶ Now the measurements are taken and displayed.
- ▶ To save the measurement press **Keep Results** (pressing the I/O push-button has the same effect).  
 The last measured values are "frozen", and can now be assessed.

- ▶ Stop the manual test by pressing the I/O (test start/stop) push-button. The test can now be assessed.
- ▶ To repeat the test, first press **Back to Top**, if applicable, and then **Clear Results**.

## 2. Option "Manual input" selected

**Note:** Select **Manual input** prior to starting the test. If the test card still contains results, clear them by pressing **Clear Results**.

When **Manual input** is selected, there is no phase available. Consequently, neither the polarity nor the phase angle nor  $\cos\phi$  can be calculated.

Since an automatic test only lasts a very short period of time, and a manual measurement is rather difficult, an automatic test with a manual measurement is not useful. Therefore, this Reference Manual will not cover this subject.

### Manual test

Clearing **Auto** lets you set the test voltage  $V_{test}$  manually with the handwheel.

- ▶ Press the I/O (test start/stop) push-button to start the test. The focus is set onto the "V test:" entry field.
- ▶ Set the value of your choice either by turning the handwheel and/or by entering it with the numerical keys.
- ▶ A value set with the numerical keys needs to be fully entered and acknowledged by pressing either **Enter** or the handwheel before it is applied to the output. If needed, it can then be adjusted using the handwheel.  
Values set by turning the handwheel are applied instantaneously.
- ▶ Vsec is measured and displayed.
- ▶ To save the measurement press **Keep Results**.
- ▶ Navigate to the "Vprim:" entry field
- ▶ Enter the measured Vprim value either by turning the handwheel or by entering this value with the numerical keys, and press **Enter** or the handwheel to acknowledge your setting.
- ▶ The ratio is calculated and displayed.
- ▶ To stop the manual test, press the I/O (test start/stop) push-button. The test can now be assessed.
- ▶ Alternatively it is possible to enter the manually measured value into the test card after the test was stopped (for example, if the measurement was carried out at a remote location).
- ▶ To repeat the test, first press **Back to Top**, if applicable, and then **Clear Results**.

To learn more about test assessment, refer to 10.1 "Test assessment" on page 271.

## 5.9 CT Rogowski (ratio)

**DANGER**



**Death or severe injury caused by high voltage or current**

- ▶ Make sure that no secondary CT windings are open

Use the **CTRogowski** test card to measure a Rogowski coil's ratio by injecting current up to 800 A from the **CPC 100 800A AC** output or up to 2000 A using the **CP CB2** current booster connected to the "**EXT. BOOSTER**" output into the current-carrying conductor, and by measuring the induced voltage at the end of the Rogowski coil windings.

A Rogowski coil's induced voltage is proportional to the conductor current differentiated with respect to time. Therefore, in order to acquire a direct equivalent of the conductor's current, the induced voltage needs to be integrated. In general, a Rogowski coil's output signal is either lead via an integrating amplifier or fed into an electronic protection relay with integrator. The **CTRogowski** test card integrates the Rogowski coil's output signal at the **CPC 100** input **V2 AC**.

Disconnect the Rogowski coil's output signal from the electronic protection relay, and plug it into the **CPC 100 V2 AC** input.

The **CTRogowski** test card measures the amplitude of the injected current  $I_{prim}$  and the Rogowski coil's output voltage  $V_{sec}$ , integrates this signal, and calculates the secondary current  $I_{sec}$ , its phase angle as well as the actual ratio and the deviation.

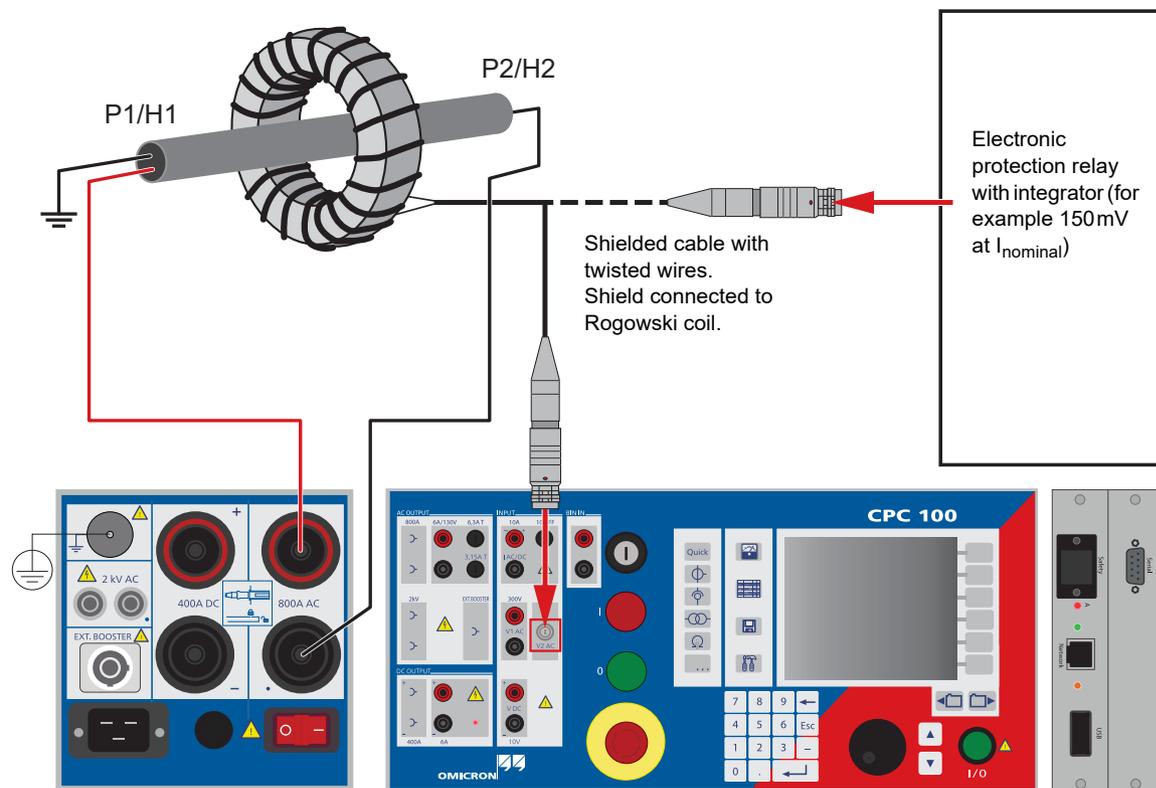


Figure 5-22: Setup for a CT ratio test of a Rogowski coil

### 5.9.1 Test settings

The screenshot shows the 'CTRogowski 1' test card interface. It includes the following fields and values:

- Range: AC 800A (dropdown),  Auto
- I prim.: 10.0 A, V sec.: 300.0 mV
- f nom.: 50.0 Hz
- I test: 10.0 A, f: 50.00 Hz
- I prim.: 10.000 A
- V sec.: 295.86 mV,  Manual input
- I sec.: 9.8600 A, -89.44 °
- Ratio: 110.0:9.98, f-0.17 % 0.56 °
- Polarity: Failed
- Assessed: 12/22/2021 3:41:10 PM

On the right side, there is a vertical menu with the following options: Insert Card, Delete Card, Rename Card, Clear Results, Save As Default, and Settings.

Figure 5-23: CTRogowski test card with test results

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

Range:	output range
Iprim:	nominal primary current of Rogowski coil (upper field)
Vsec:	nominal secondary voltage of Rogowski coil
f nom:	nominal frequency of the Rogowski coil's secondary voltage
I test:	primary injection current
f:	frequency of injected current I test
Auto:	select check box for automatic test (default), clear for manual test (refer to page 125).

**Note:** When using the CTRogowski test card, the 3V V2 AC input uses an additional software-based integration method.

In the range of 50 Hz < f < 60 Hz, this results in a phase shift of 90° as well as an additional phase error of ±0.1° and an additional amplitude error of ±0.01%. For frequencies in the range of 15 Hz < f < 400 Hz, the phase error is not specified, and the amplitude error can be up to ±0.50% higher.

Therefore, for phase measurements, use a frequency range of 50 Hz < f < 60 Hz only.

**Settings** Pressing the **Settings** menu key opens the **Settings** page. The **Settings** page allows setting the test cards individually. As a rule, do not use the **Settings** page but the **Device Setup** tab in the **Options** view (see "Device Setup" on page 56) to set the test cards. For more information, see "Settings page" on page 50.

Within the **Settings** menu, you can set correction factors in accordance with IEC 61869-10. The measured transformation ratio of the instrument transformer under test can be adjusted with the provided ratio- and phase-correction values. The correction factors are often available on the asset nameplate.

Amplitude correction:	Amplitude correction for corrected transformation ratio calculation
Phase correction:	Phase error offset for corrected phase error calculation

## 5.9.2 Measurements

Iprim: (lower field)	actual output current at the output that is injected into the Rogowski coil's current-carrying conductor
Vsec:	secondary voltage measured at <b>V2 AC</b>
I'sec:	calculated secondary current. $I'_{sec} = k \int V_{sec} dt$ with $k = I_{prim\ nom} / (V_{sec\ nom} \times 1\ s)$ . <b>Note:</b> The current I'sec does not really exist in the system. It is a calculated current only.
°	phase angle of calculated secondary current with reference to the primary current
Ratio:	$I_{prim} / I'_{sec} \times CF_1^1$ , here: 10.0:9.98 <sup>2</sup>
Ratio error:	$\epsilon = \frac{I'_{sec} \times CF_1 - I_{prim}}{I_{prim}} \times 100\%$ <b>Note:</b> Results are marked with an exclamation point (!) if a correction factor was used.
Phase error:	$\varphi = \varphi_{I_{sec}} - \varphi_{I_{prim}} - \varphi_{Phase\ correction}^3$
Polarity:	Displays the status of the polarity OK = phase I'sec – phase Iprim = $-45^\circ < 0^\circ < 45^\circ$ NOT OK = all other cases

1. CF<sub>1</sub> stands for the amplitude correction. By default, it is set to 1.00 and subsequently no additional ratio error is considered.
2. The value 9.98 is calculated as follows:  
(I'sec / Iprim) × Iprim<sub>nom</sub> × CF<sub>1</sub>, here: (9.86 A / 10 A) × 10 A × 1.012 = 9.98 A
3. By default, the phase correction is set to 0.0000° and subsequently no additional phase error is considered. Here: 0.00°, including 90° integration phase shift.

Selecting the check box **Manual input** lets you enter the value for Vsec manually, for example, when Vsec was measured with an external volt meter rather than at input **V2 AC**.

### 5.9.3 Automatic test vs. manual test

#### 1. Option "Manual input" clear

##### Automatic test

- ▶ Press the I/O (test start/stop) push-button to start the test.
- ▶ The test current increases from 0A to I<sub>test</sub> in a ramp characteristic within 1 second. Then I<sub>test</sub> is kept for a period of 2.4 seconds, and the measurements are taken. Next, the ramp decreases again within 0.3 seconds.
- ▶ The automatic test stops by itself, it can now be assessed.
- ▶ To repeat the test, first press **Back to Top**, if applicable, and then **Clear Results**.

##### Manual test

Clearing **Auto** lets you set the test current I<sub>test</sub> manually with the handwheel.

- ▶ Press the I/O (test start/stop) push-button to start the test. The focus is set onto the "I test:" entry field.
- ▶ Set the value of your choice either by turning the handwheel and/or by entering it with the numerical keys.
- ▶ A value set with the numerical keys needs to be fully entered and acknowledged by pressing either **Enter** or the handwheel before it is applied to the output. If needed, it can then be adjusted using the handwheel.  
Values set by turning the handwheel are applied instantaneously.
- ▶ Now the measurements are taken and displayed.
- ▶ To save the measurement press **Keep Results** (pressing the I/O push-button has the same effect). The last measured values are "frozen", the test can now be assessed.
- ▶ Stop the manual test by pressing the I/O (test start/stop) push-button.
- ▶ To repeat the test, first press **Back to Top**, if applicable, and then **Clear Results**.

## 2. Option "Manual input" selected

**Note:** Select "Manual input" prior to starting the test. If the test card still contains results, clear them by pressing **Clear Results**. When "Manual input" is selected, there is no phase available. Consequently, neither the polarity nor the phase angle can be calculated.

Since an automatic test only lasts a very short period of time, and a manual measurement is rather difficult, an automatic test with a manual measurement is not useful. Therefore, this Reference Manual will not cover this subject.

### Manual test

Clearing **Auto** lets you set the test current I test manually with the handwheel.

- ▶ Press the I/O (test start/stop) push-button to start the test. The focus is set onto the "I test:" entry field.
- ▶ Set the value of your choice either by turning the handwheel and/or by entering it with the numerical keys.
- ▶ A value set with the numerical keys needs to be fully entered and acknowledged by pressing either **Enter** or the handwheel before it is applied to the output. If needed, it can then be adjusted using the handwheel.  
Values set by turning the handwheel are applied instantaneously.
- ▶ I<sub>prim</sub> is measured and displayed.
- ▶ To save the measurement press **Keep Results**.
- ▶ Navigate to the V<sub>sec</sub> entry field.
- ▶ Enter the measured V<sub>sec</sub> value either by turning the handwheel or by entering this value with the numerical keys, and press **Enter** or the handwheel to acknowledge your setting.
- ▶ The ratio is calculated and displayed.
- ▶ To stop the manual test, press the I/O (test start/stop) push-button. The test can now be assessed.
- ▶ Alternatively it is possible to enter the manually measured value into the test card after the test was stopped (for example, if the measurement was carried out at a remote location).
- ▶ To repeat the test, first press **Back to Top**, if applicable, and then **Clear Results**.

To learn more about test assessment, refer to 10.1 "Test assessment" on page 271.

## 5.10 CTLow Power (ratio)

**DANGER**



**Death or severe injury caused by high voltage or current**

- ▶ Make sure that no secondary CT windings are open

Use the **CTLowPower** test card to measure the ratio of a low-power current transformer.

A low-power current transformer contains a built-in burden, and provides an output voltage that is directly proportional to the primary current. For both protection and measurement only one transformer is required. A low-power current transformer provides a wide nominal current range, and operates linear and without saturation through the entire range up to the short-circuit current.

To carry out this test, disconnect the ODU plug of the current transformer's secondary side from the protection relay, plug it into the **CPC 100 V2 AC** input, and inject current up to 800 A from the **CPC 100 800A AC** output or up to 2000 A using the **CP CB2** current booster connected to the **"EXT. BOOSTER"** output to the current transformer's primary side.

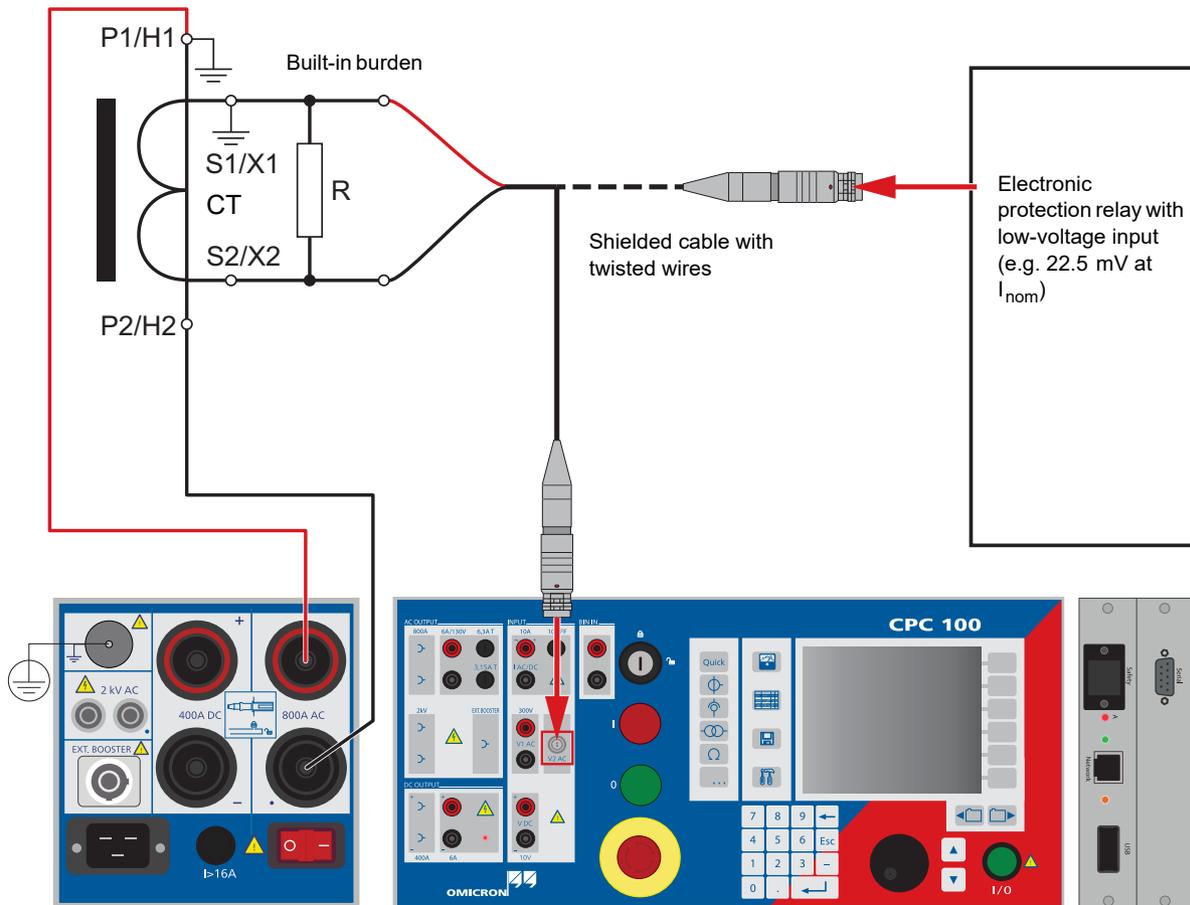


Figure 5-24: Setup for a CT ratio low-power test

### 5.10.1 Test settings

The screenshot shows a software interface for a test card named 'CTLowPower 1'. On the left, there are several input fields: 'Range' is set to 'AC 800A' with a dropdown arrow and a checked 'Auto' checkbox; 'I prim.' is '10.0 A'; 'I test' is '10.0 A'; 'V sec.' is '295.16 mV' with a phase angle of '0.51 °' and an unchecked 'Manual input' checkbox; 'Ratio' is '110:0.2990 A/V' with a phase correction of '1-0.33 % 0.63 °'; and 'Polarity' is 'OK'. On the right, a vertical menu contains buttons: 'Insert Card', 'Delete Card', 'Rename Card', 'Clear Results', 'Save As Default', and 'Settings'. The 'Settings' button is highlighted with a grey background. At the bottom left, it says 'Assessed:n/a'.

Figure 5-25: CTLowPower test card with test results

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

Range:	output range
Iprim:	nominal primary current
Vsec:	nominal secondary voltage
I test:	primary injection current
f:	output frequency
Auto:	select check box for automatic test (default), clear for manual test (refer to page 130).

**Note:** If the test involves an external booster to gain a higher output current, set this booster at the **Options** tab **Device Setup** before starting the test.

**Settings** Pressing the **Settings** menu key opens the **Settings** page. The **Settings** page allows setting the test cards individually. As a rule, do not use the **Settings** page but the **Device Setup** tab in the **Options** view (see "Device Setup" on page 56) to set the test cards. For more information, see "Settings page" on page 50.

Within the **Settings** menu, you can set correction factors in accordance with IEC 61869-10. The measured transformation ratio of the instrument transformer under test can be adjusted with the provided ratio- and phase-correction values. The correction factors are often available on the asset nameplate.

Amplitude correction:	Amplitude correction for corrected transformation ratio calculation
Phase correction:	Phase error offset for corrected phase error calculation

## 5.10.2 Measurements

I<sub>prim</sub>: actual output current at the output that is injected into the low power current transformer's primary side

V<sub>sec</sub>: secondary voltage measured at **V2 AC**, and its phase angle relative to I<sub>prim</sub>

Ratio: I<sub>prim</sub> / V<sub>sec</sub> × CF<sub>1</sub><sup>1</sup>, here: 10.0:0.2990 A/V<sup>2</sup>

**Note:** Results are marked with an exclamation point (!) if a correction factor was used.

Ratio error: 
$$\varepsilon = \frac{K_n \times V_{sec} \times CF_1 - I_{prim}}{I_{prim}} \times 100\%$$

where K<sub>n</sub> is rated transformation value, here: 10 A / 300 mV

**Note:** Results are marked with an exclamation point (!) if a correction factor was used.

Phase error: 
$$\varphi = \varphi_{I_{sec}} - \varphi_{I_{prim}} - \varphi_{Phase\ correction}^3$$

Polarity: displays the status of the polarity

OK = phase V<sub>sec</sub> - phase I<sub>prim</sub> = -45° < 0° < 45°

NOT OK = all other cases

1. CF<sub>1</sub> stands for the amplitude correction. By default, it is set to 1.00 and subsequently no additional ratio error is considered.

2. The value 0.2990 is calculated as follows:

$$V_{sec\ act} \times (I_{prim\ nom} / I_{prim\ act}) \times CF_1, \text{ here: } 295.16\ \text{mV} \times (10\ \text{A} / 10\ \text{A}) \times 1.012 = 0.2990\ \text{V}$$

3. By default, the phase correction is set to 0.0000° and subsequently no additional phase error is considered. Here: -0.12°.

Selecting the check box **Manual input** lets you enter the value for V<sub>sec</sub> manually, for example, when V<sub>sec</sub> was measured with an external volt meter rather than at input **V2 AC**.

## 5.10.3 Automatic test vs. manual test

### 1. Option "Manual input" clear

#### Automatic test

- ▶ Press the I/O (test start/stop) push-button to start the test.
- ▶ The test current increases from 0A to I<sub>test</sub> in a ramp characteristic within 1 second. Then I<sub>test</sub> is kept for a period of 2.4 seconds, and the measurements are taken. Next, the ramp decreases again within 0.3 seconds.
- ▶ The automatic test stops by itself, it can now be assessed.
- ▶ To repeat the test, first press **Back to Top**, if applicable, and then **Clear Results**.

#### Manual test

Clearing **Auto** lets you set the test current I<sub>test</sub> manually with the handwheel.

- ▶ Press the I/O (test start/stop) push-button to start the test. The focus is set onto the "I test:" entry field.
- ▶ Set the value of your choice either by turning the handwheel and/or by entering it with the numerical keys.
- ▶ A value set with the numerical keys needs to be fully entered and acknowledged by pressing either **Enter** or the handwheel before it is applied to the output. If needed, it can then be adjusted using the handwheel.  
Values set by turning the handwheel are applied instantaneously.
- ▶ Now the measurements are taken and displayed.
- ▶ To save the measurement press **Keep Results** (pressing the I/O push-button has the same effect). The last measured values are "frozen", the test can now be assessed.
- ▶ Stop the manual test by pressing the I/O (test start/stop) push-button.
- ▶ To repeat the test, first press **Back to Top**, if applicable, and then **Clear Results**.

## 2. Option "Manual input" selected

**Note:** Select **Manual input** prior to starting the test. If the test card still contains results, clear them by pressing **Clear Results**. When "Manual input" is selected, there is no phase available. Consequently, neither the polarity nor the phase angle can be calculated.

Since an automatic test only lasts a very short period of time, and a manual measurement is rather difficult, an automatic test with a manual measurement is not useful. Therefore, this Reference Manual will not cover this subject.

### Manual test

Clearing **Auto** lets you set the test current  $I_{test}$  manually with the handwheel.

- ▶ Press the I/O push-button (test start/stop) to start the test. The focus is set to the "I test:" entry field.
- ▶ Set the value of your choice either by turning the handwheel and/or by entering it with the numerical keys.
- ▶ A value set with the numerical keys needs to be fully entered and acknowledged by pressing either **Enter** or the handwheel before it is applied to the output. If needed, it can then be adjusted using the handwheel.  
Values set by turning the handwheel are applied instantaneously.
- ▶  $I_{prim}$  is measured and displayed.
- ▶ To save the measurement press **Keep Results**.
- ▶ Navigate to the  $V_{sec}$  entry field.
- ▶ Enter the measured  $V_{sec}$  value either by turning the handwheel or by entering this value with the numerical keys, and press **Enter** or the handwheel to acknowledge your setting.
- ▶ The ratio is calculated and displayed.
- ▶ To stop the manual test, press the I/O push-button (test start/stop). The test can now be assessed.
- ▶ Alternatively it is possible to enter the manually measured value into the test card after the test was stopped (for example, if the measurement was carried out at a remote location).
- ▶ To repeat the test, first press **Back to Top**, if applicable, and then **Clear Results**.

To learn more about test assessment, refer to 10.1 "Test assessment" on page 271.

## 5.11 TanDelta - PF

The test card **TanDelta - PF** was especially developed for the *CP TD*.

The *CP TD* (*CP TD1*, *CP TD12* or *CP TD15*) is an optionally available high-precision test system for on-site insulation tests of high-voltage systems like power and measuring transformers, circuit breakers, capacitors and isolators. The *CP TD* works as an add-on device to the *CPC 100* and is described in the *CP TD1* and *CP TD12/15* User Manuals on the *Primary Test Manager* DVD and the *CPC 100 Start Page*.

The **TanDelta - PF** test card can be accessed from CT, VT, Transformer and Others.

## 5.12 Ratio with sampled values

The **SV-Ratio** test card is mainly used to check the ratio between the output current or voltage and the input current or voltage of the selected merging unit channel according to the IEC 61850 standard. In addition, the **SV-Ratio** card is also used to determine the polarity of the signal, whereas the *CPC 100* serves as the signal source. The merging units generate the input voltages or currents.

IEC 61850 is a standard for the design of electrical substation automation. It is part of the International Electrotechnical Commission's (IEC) Technical Committee 57 (TC57) reference architecture for electric power systems. The protocols can run over TCP/IP networks and/or substation LANs using high-speed switched Ethernet to obtain the necessary response times of < 3.3 ms for protective relaying.

Background information about IEC 61850 would go beyond the scope of this documentation. Please refer to the numerous IEC 61850 publications on the Internet for detailed descriptions.

The SV (Sampled Values) are generated according to the "Implementation Guideline for Digital Interface to Instrument Transformers using IEC 61850-9-2" published by the UCA International Users Group. As this implementation guideline defines a subset of IEC 61850-9-2, it is commonly referred to as "9-2 Light Edition" or short "9-2 LE".

The *CPC 100* test system performs closed-loop testing whereby a test signal is injected on the primary side of the current/voltage sensors. The Merging Unit (MU) converts the sensor output into an SV stream which is published to the substation network. The *CPC 100* then reads the data back from the network in order to perform a variety of different tests.

The *CPC 100* transforms the sampled points to the spectral function of the signal. This Fourier-transformed sampled values signal is filtered with a special Hann window to only retrieve the "signal" at the selected frequency. This allows frequency-selective measurements to be performed on SV streams and thereby the noise is suppressed.

With this calculated noise-reduced signal, a re-transformation to the discrete signal is performed. At last, the RMS value of this signal is calculated.

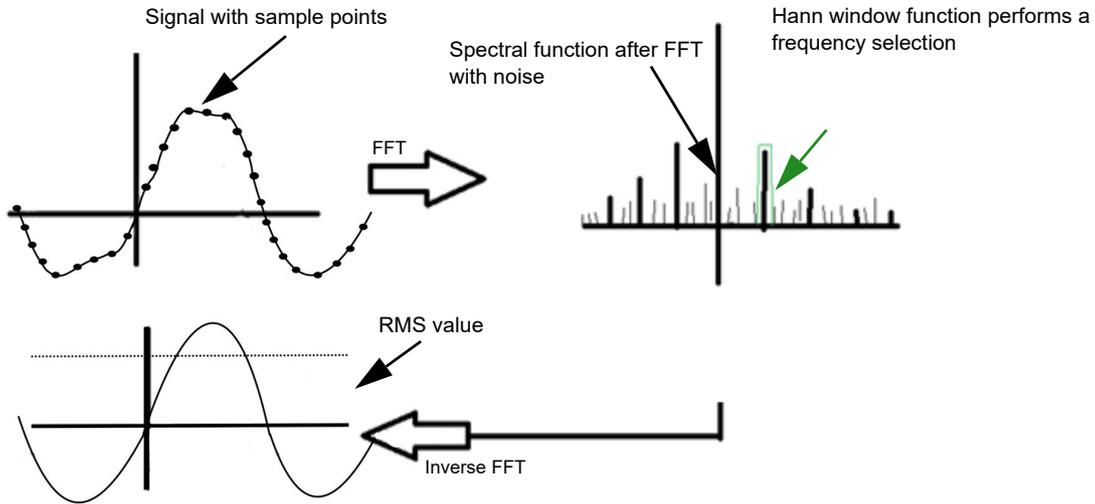


Figure 5-26: Characteristics of the frequency-selective measurement

Automatic MU and channel detection is achieved by injecting a unique test signal. An optimized and time-effective algorithm searches for the unique test pattern within all available MUs on the network to identify the correct channel for testing.

55.00 Hz The frequency-selective measurement is used to filter out interferences as they usually occur in substations. To do so, the frequency of the *CPC 100* output quantity is set to a value different from the substation's frequency, for example, the substation operates with a frequency of 50 Hz, the *CPC 100* output frequency is set to 55 Hz.

The quantity measured back at the *CPC 100* input is measured selectively, that is, only a quantity with the specified frequency is fully taken into consideration for the measurement. Quantities with different frequencies are filtered out according to the characteristics shown in Figure 5-27.

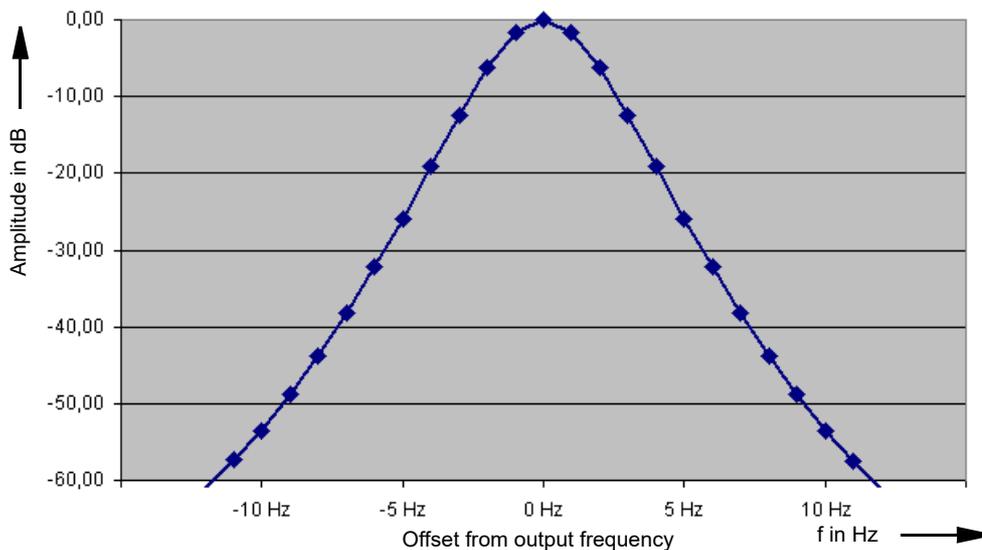


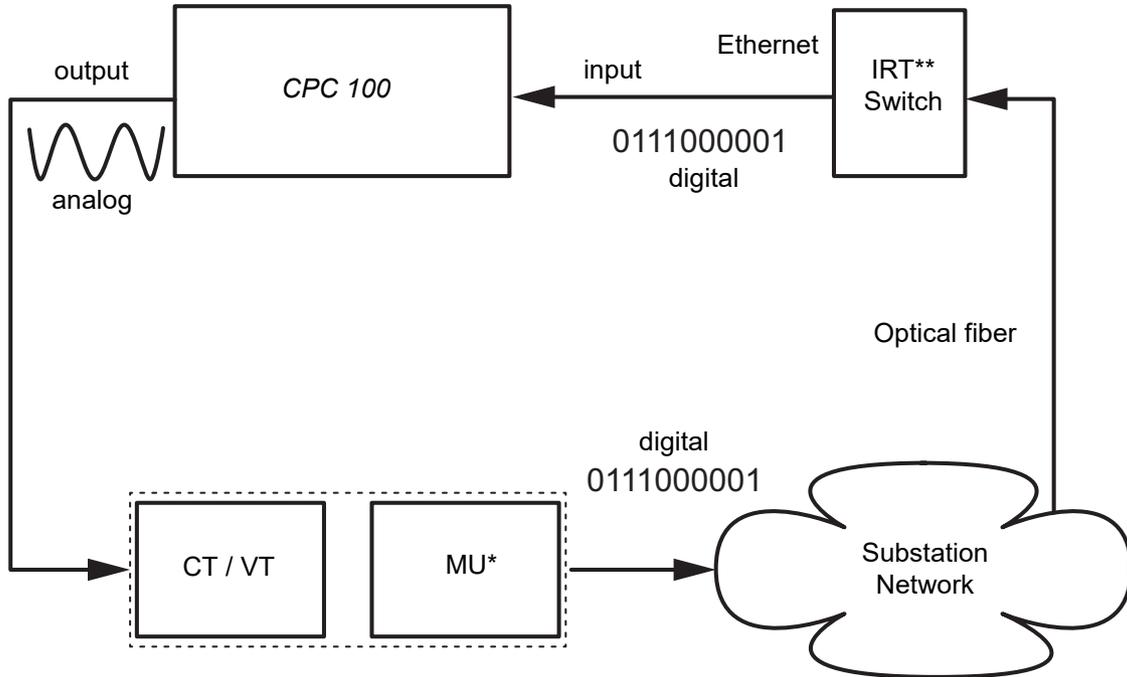
Figure 5-27: Typical characteristics of the frequency-selective Hann window

## 5.12.1 Glossary

<b>Merging Unit (MU)</b>	A merging unit collects the analog inputs of four voltage and four current transformers and sends them as a digital sampled values (SV) stream in Ethernet packets to a destination MAC address together with the name (SVID) (a clear text string) and the APPID (a number) of the merging unit. The eight values (four voltages and four currents) are called <b>channels</b> , named Va, Vb, Vc, Vn and Ia, Ib, Ic, In. The merging unit delivers primary values.
<b>Sampled Value ID (SVID)</b>	The sampled value ID is for identifying the SV stream. It is unique within a system and is correlated to a merging unit (MU).
<b>MAC Address</b>	<p>A Media Access Control address (MAC address) is a unique identifier assigned to network interfaces for communications on the physical network segment. MAC addresses are used for numerous network technologies and most IEEE 802 network technologies including Ethernet.</p> <p>An Ethernet host is addressed by its Ethernet MAC address.</p>
<b>Destination MAC Address</b>	<p>This is the multicast MAC address according to IEEE 802.3 of the receiving host.</p> <p>The range is 01-0C-CD-04-00-00 (default) to 01-0C-CD-04-01-FF.</p> <p>The MAC address is displayed in a hyphen notation (as shown above). It is also allowed to enter the MAC address using colons as delimiters: 01:0C:CD:04:00:00.</p>
<b>Source MAC Address</b>	MAC address of the sending host.
<b>Application ID (APPID)</b>	<p>This is the application identifier according to IEC 61850-9-2. The range is 0x4000 (default) to 0x7FFF.</p> <p>The value is displayed in decimal notation. The ToolTip shows the value in hexadecimal notation. However, entering in hexadecimal notation is also allowed.</p> <p>The implementation guideline specifies the single value 0x4000, while IEC 61850-9-2 allows the range as stated above and recommends having unique, source orientated APPIDs within a system.</p>
<b>Nominal frequency (f nom) of MU</b>	Either 50 Hz or 60 Hz as parameterized by the MU.

### 5.12.2 General setup

Primary side



\* If the MU has an Ethernet output, no IRT switch is required

\*\* IRT Switch: Industrial Real-Time Switch

Figure 5-28: Closed-loop setup

**DANGER**



Death or severe injury caused by high voltage or current  
▶ Make sure that no secondary CT windings are open.

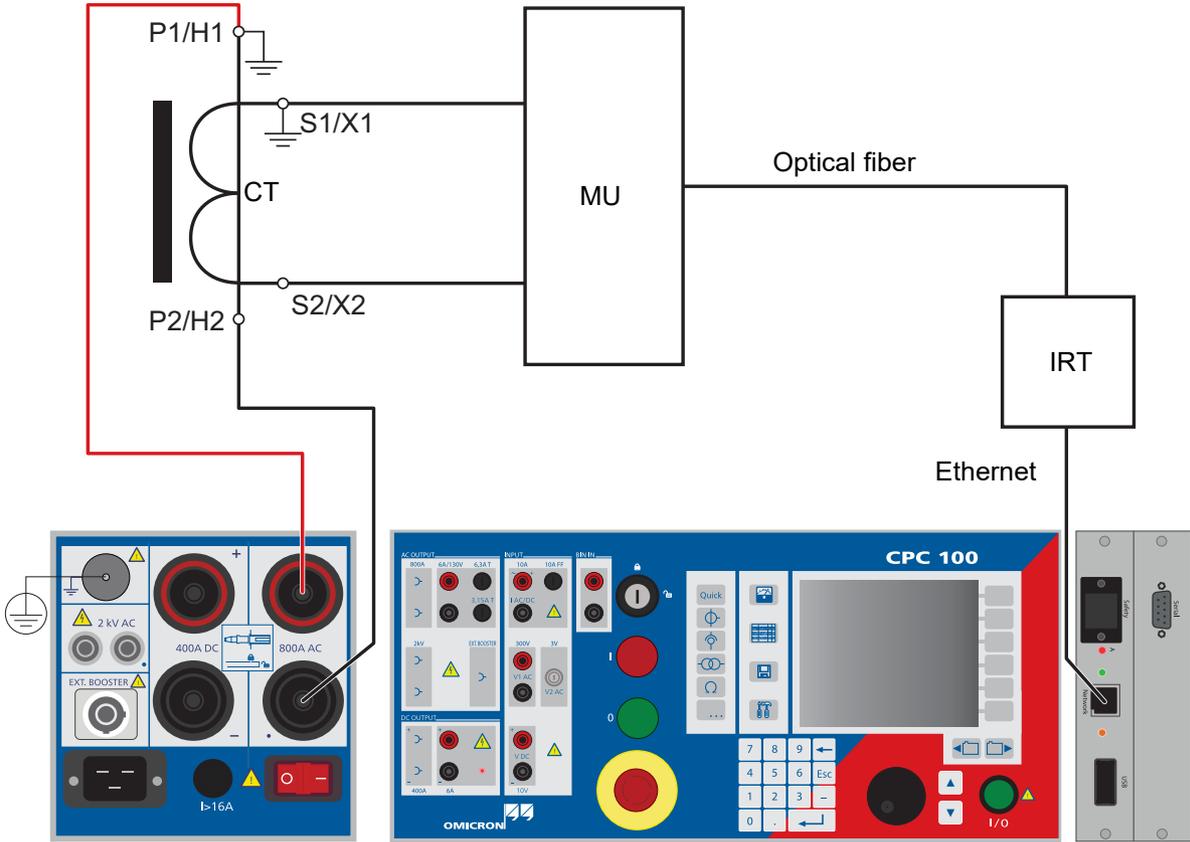


Figure 5-29: Measurement setup for **SV-Ratio** using CTs

**DANGER**



**Death or severe injury caused by high voltage or current**

- ▶ Do not connect the *CPC 100* output to the secondary side of the VT. This will cause hazardous voltages on the primary side.

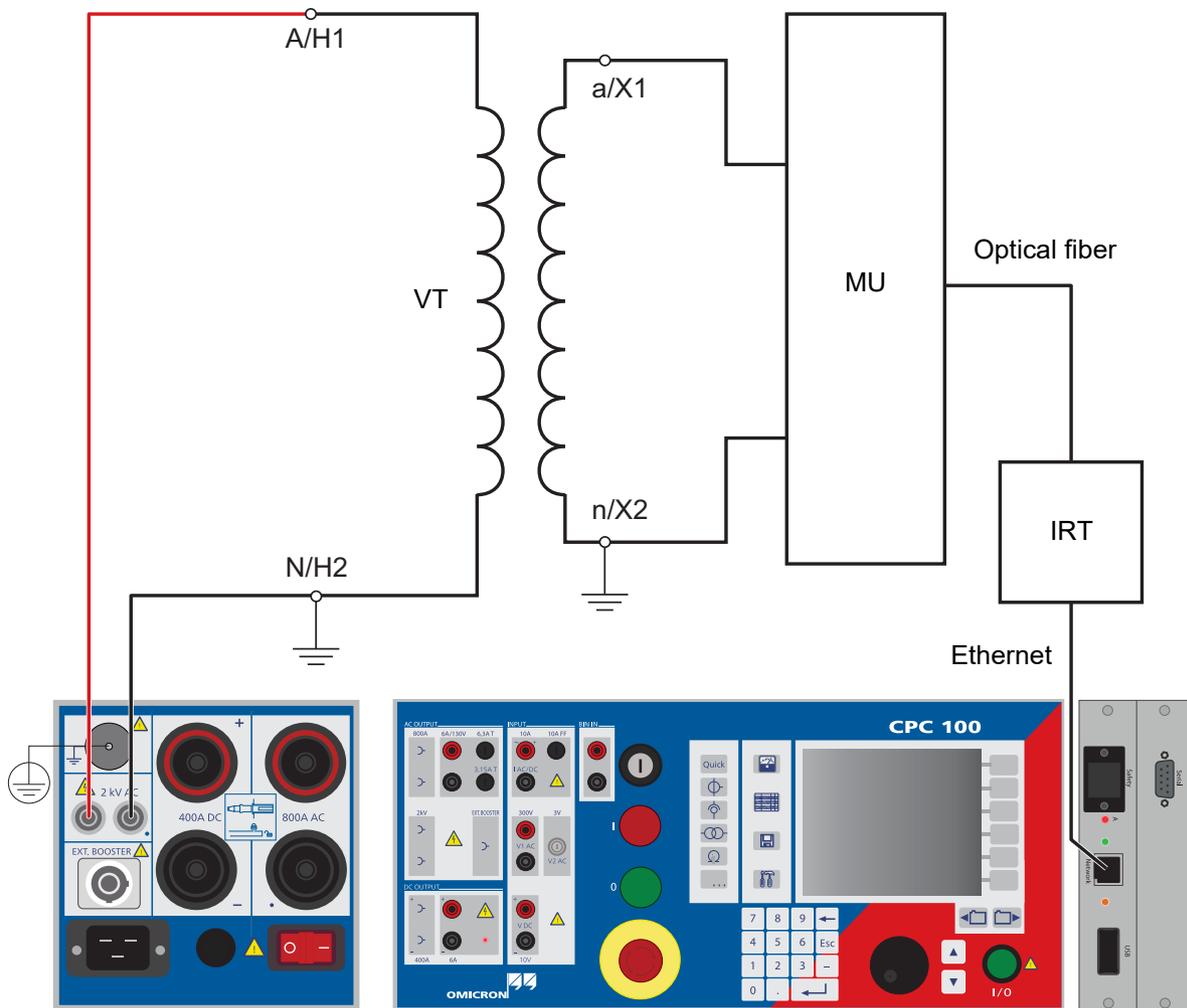


Figure 5-30: Measurement setup for **SV-Ratio** using VTs

### 5.12.3 Test settings

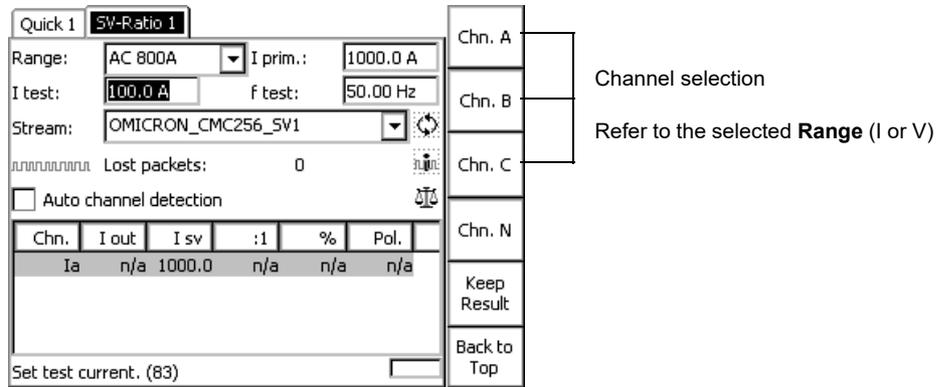


Figure 5-31: **SV-Ratio** test card

Range:	output range <b>Note:</b> Settings <b>AC 6A</b> and <b>AC 130V</b> require different wiring (input via <b>I AC</b> and <b>V1 AC</b> input of <i>CPC 100</i> ).
I test or V test:	primary injection current or voltage
I prim or V prim:	nominal primary current or voltage
f test:	output frequency
Stream:	This is the SVID and refers to the selected stream, which consists of packages. Stream interruptions are indicated in the result line with "?" after the channel name.
Lost packets:	Identifies the quality of the connection. If more than 0.1% of packets are lost, the value is shown in ppm, for example, "xx ppm". The number of lost packets should be ideally 0.  An indicator "!" is shown in the result line after the channel name (for example, "Ia") where the packet loss occurred.
Auto channel detection:	Select to choose the channels automatically. <b>Auto channel detection</b> runs without considering channel N. If the <i>CPC 100</i> is not performing an active test, the channel with the highest value is selected.  If the <i>CPC 100</i> is activated, the channel where the polarity signal is detected has priority over the channel with the closest frequency-selective RMS value to the test voltage or current.

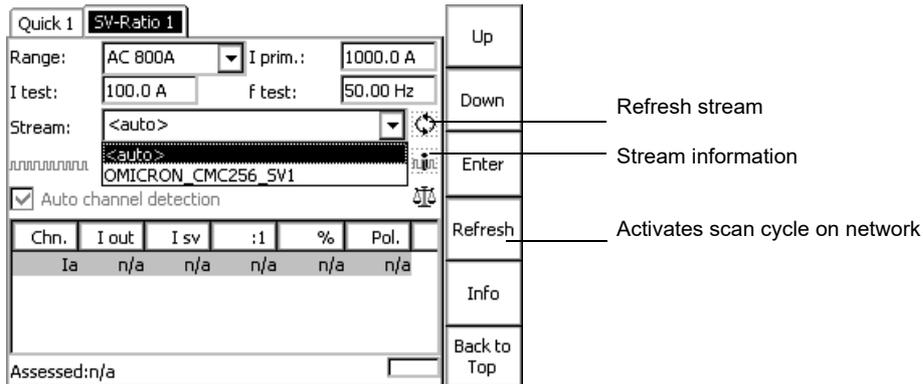


Figure 5-32: Stream search feature

If the MU stream is unknown, the stream search feature (<auto>) conducts an automatic scan of all found streams until the signal injected by the *CPC 100* is found. The search starts upon activating the *CPC 100*. The currently searched stream is updated in the user interface until a match is found. If none matches, the last MU in the list is selected and the polarity in the result table shows "n/a".

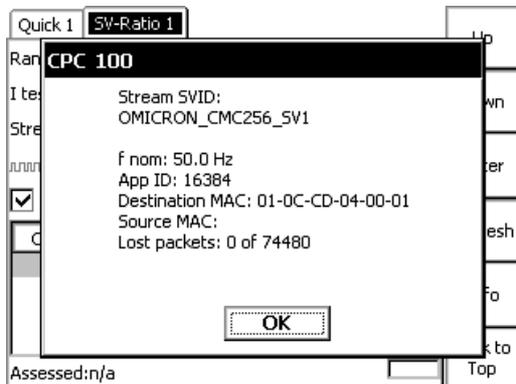


Figure 5-33: Stream information dialog

## 5.12.4 Measurements

The **SV-Ratio** test card displays the measurement results in a table:

<b>Chn.</b>	channel name; refers to the selected <b>Range</b> (either I or V)
<b>I out or V out</b>	output current or voltage
<b>I sv or V sv</b>	primary values regarding frequency-selective measurements (with a bandwidth of $\pm 10$ Hz; also when the <i>CPC 100</i> is not performing an active test)
<b>:1</b>	calculated ratio value from the measured values $V_{\text{prim}}/V_{\text{sec}}$ or $I_{\text{prim}}/I_{\text{sec}}$
<b>%</b>	The % shows the deviation of the actual ratio from the nominal ratio in %.
<b>Pol.</b>	displays the status of the polarity  Upon activation, a polarity check signal is issued for a short time to detect polarity faults in the measurement loop. The detection is stable against injected correlated and uncorrelated noise signals and has a good transmission characteristic on known CTs and VTs.  <b>Note:</b> The polarity of channels $V_n$ and $I_n$ is not calculated. OK = If the input signal correlates with the output signal. NOT OK = Inverse polarity  n/a = If the input signal does not correlate with the output signal.

It is possible to start a test several times, and to save results any time, except when the test card is loaded from a file and has results. For the first **SV-Ratio** test card, the first MU (alphabetical order) is selected. For further **SV-Ratio** test cards, the selection of the preceding **SV-Ratio** test card is taken over as default.

The selected MU can only be changed when the *CPC 100* is deactivated, and no results are available. After refreshing the streams, the previously selected MU is retained. If a new **SV-Ratio** test card is inserted, the MU of the preceding test card is retained as default.

## 5.12.5 Tests

### 1. Ratio and Polarity:

- a) The MU is set to a fixed ratio (for example, 1000:1). If the CT also features a ratio of 1000:1 (usual case), the *CPC 100* shows about 1:1 for the ratio. If not, several mistakes or defects are possible:
  - wrong wiring (wrong channel of the MU assigned)
  - wrong settings in the MU or wrong MU for this CT
  - defect in the CT which influences the ratio
- b) A unique signal is used to check if the CT is correctly connected to the MU or the *CPC 100* output is connected correctly to the primary side of the CT. For a short time, the *CPC 100* sends the signal and does a cross-correlation with the signal measured back from the SV stream. Afterwards, the *CPC 100* gets a correlation value and with internal limits the software decides if the polarity is OK, not OK, or if the signal correlation failed.

2. **Automatic MU detection:** For commissioning purposes, the MU and channel detection can be performed as a test to check that the MU and CT cores are correctly wired and named. The *CPC 100* searches automatically on which channel the polarity check signal is present and does the polarity check afterwards.

a) The **Automatic stream search** feature does a search on all channels of all streams. If on any of these channels the polarity check signal could be detected, the MU and its channel is selected and a polarity check is performed.

3. **Frequency-selective current/voltage measurement:**

a) Apart from the ratio test, the *CPC 100* can also read the primary side values without injecting any signal. Thus, the *CPC 100* acts as a selective voltage/current meter. This is especially suitable to see the primary side voltage and currents of the bay before de-energizing or after energizing. The voltage and currents of neighboring systems can also be viewed, for example, for some additional information during special investigations. For this case, another stream needs to be selected. To see all the channels, press **Chn. A**, **Chn. B**, **Chn. C** or **Chn. N**. Example:

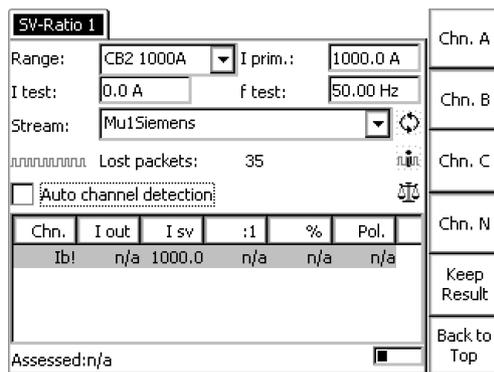


Figure 5-34: Measuring the current on Channel B without injecting

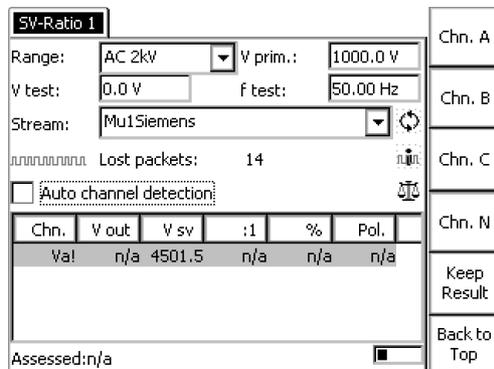


Figure 5-35: Measuring the voltage on Channel A without injecting

b) You have also the possibility to check if the system you want to measure at is really free of voltage and no current is actually flowing, and if other neighboring live systems are coupling any dangerous values.

4. **Noise level measurement:** This test is used to measure all the frequencies of the *CPC 100* to see if there is "noise" or other signals on a channel without injecting. Thus, you can check on all channels of the MU at which frequencies the noise is high to determine the best test frequency for your system.
  - Quick check: Scan through the channel and look for the maximum value. Save this maximum value and rename the test card.
  - Detailed measurement with Excel for special investigations.
  - Cross-coupling noise of the system: Inject a signal with the *CPC 100* into one channel and read back the amplitude of your signal on any other channel. For this test, **Auto channel detection** needs to be cleared. With a previously done noise level measurement you can measure at the frequencies with the lowest noise influence from outside to see how good your test cycle (*CPC 100* -> CT/VT -> MU -> *CPC 100*) is shielded against cross-talks from other channels. In addition, you can directly inject into the MU to see how much cross-talk the MU itself causes.
5. **Magnitude response of the signal processing chain (15 to 400 Hz):**
  - Primary injection (of the whole system): By taking the amplitude response of the signal processing chain (*CPC 100* -> CT/VT -> MU -> *CPC 100*) you can check the frequency behavior of the whole cycle. Instead, you can also directly inject into the MU channels to check the amplitude response.

### Automatic channel detection vs. manual channel selection

#### Automatic channel detection or <auto> stream search

- ▶ Set the **Range, I test/V test**, as well as **I prim/V prim** and **f test**.
- ▶ Select **Auto channel detection** or **<auto>** from the **Stream** combo box.
- ▶ Press the I/O (test start/stop) push-button to start the test.
- ▶ A polarity check signal is issued while all MU streams/channels are scanned. The matching stream/channel is selected.
- ▶ To save the measurement press **Keep Result**.

#### Manual channel selection

Clearing **Auto channel detection** lets you select the channels manually.

- ▶ Set the **Range, I test/V test**, as well as **I prim/V prim** and **f test**.
- ▶ Press the I/O (test start/stop) push-button to start the test.
- ▶ Select the channels manually by using the context-dependent menu keys on the right side of the test card.
- ▶ To save the measurement press **Keep Result**.

## 6 Voltage transformer

**Note:** With regard to software handling, this section confines to test-relevant issues, and does not go into detailed procedural descriptions. It is assumed that you have read and understood the section 2.4 "How to use the CPC 100 software" on page 40.

**Note:** In this manual, the *CPOL2* and *CPOL3* polarity checkers are collectively referred to as *CPOL*. The polarity checkers are named explicitly only if necessary due to their different features.

### 6.1 Scope of voltage transformer tests



Go to the Test Card View and press **Insert Card**.

Use the context-dependent **Up/Down** menu keys to the right, or the handwheel, to browse through the structure. On VT, press **Enter**.



Alternatively, press the accelerator key to open **Insert a new test card**.

VT comprises the following test cards:

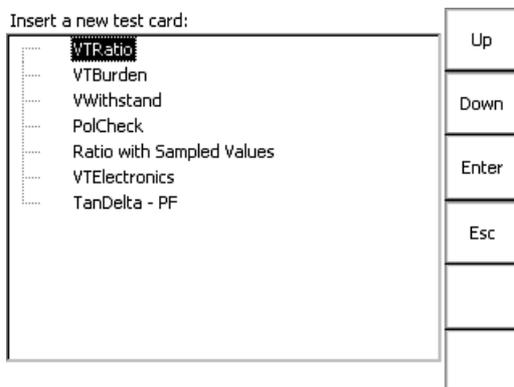


Figure 6-1: Inserting VT test cards

Highlight the test card of your choice either by navigating with the handwheel or by using the context-dependent **Up/Down** menu keys, and press **Enter**.

**Note:** The test cards

- **VTRatio**
- **VTBurden**
- **VTElectronics**
- **SV-Ratio**

employ the method of frequency-selective measurement, which is used to filter out interferences as they usually occur in substations.

To learn more about frequency-selective measurement, please refer to 4.2.1 "The frequency-selective measurement" on page 81.

## 6.2 VTRatio

Use the **VTRatio** test card to measure a voltage transformer's ratio with injection on the VT's primary side with up to 2 kV from **AC OUTPUT**.

It measures amplitude and phase angle of the voltage (at **V1AC**) and the current on the transformer's secondary side, and calculates the actual ratio and the deviation from the nominal ratio.

**DANGER**



**Death or severe injury caused by high voltage or current**

- ▶ Do not connect the *CPC 100* output to the secondary side of the VT. This will cause hazardous voltages on the primary side.

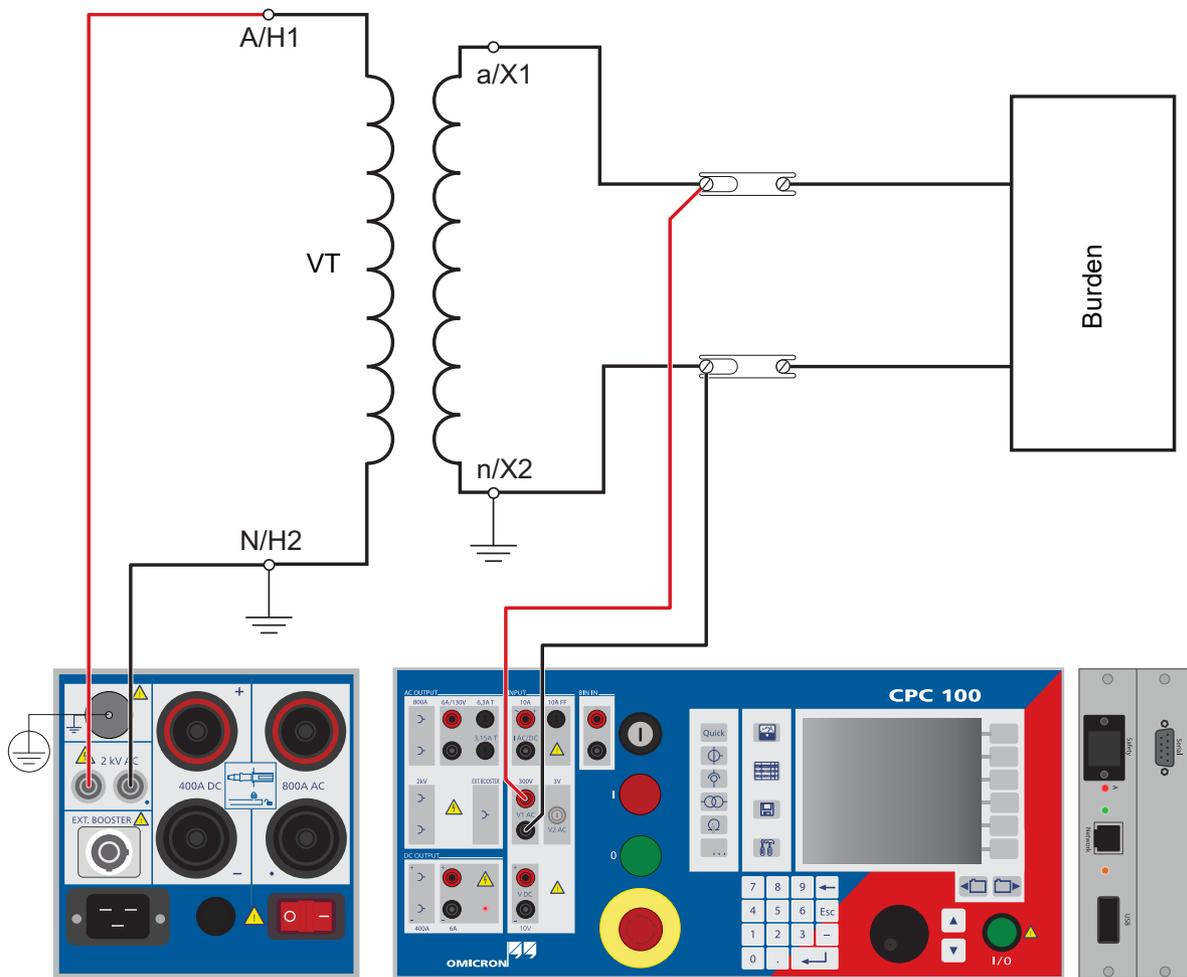


Figure 6-2: Setup for testing ratio

## 6.2.1 Test settings

VTRatio 1		VTBurden 1	VTElectronics 1	TF	OK
V prim.:	10000.0 V	V sec.:	100.0 V		Failed
	<input checked="" type="checkbox"/> 1/√3		<input checked="" type="checkbox"/> 1/√3 <input type="checkbox"/> 1/3		Clear Assess.
V test:	2000.0 V				
f:	50.00 Hz		<input checked="" type="checkbox"/> Auto		
V prim.:	2.000 kV				
V sec.:	20.087 V	0.25 °	<input type="checkbox"/> Manual input		
Ratio:	10000.0/√3:100.43/√3	0.433 %			
Polarity:	OK				
Assessed:n/a					Exit Card

Figure 6-3: **VTRatio** test card with test results

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

**Vprim:** nominal primary voltage with the option "value x  $1/\sqrt{3}$ "

**Vsec:** nominal secondary voltage with the options  
value x  $1/\sqrt{3}$   
value x 1/3

**Vtest:** primary injection voltage.  
By default,  $V_{test} = V_{prim}$  (with option x  $1/\sqrt{3}$ ) if  $V_{prim} \leq 2\text{kV}$ .  
If  $V_{prim} > 2\text{kV}$ ,  $V_{test} = 2\text{kV}$ .

**f:** output frequency

**Auto:** select check box for automatic test (default), clear for manual test (refer to 6.2.3 "Automatic test vs. manual test" on page 147).

## 6.2.2 Measurements

<b>Vprim:</b>	actual output voltage at <b>2kV AC</b> output that is injected into the voltage transformer's primary side
<b>Vsec:</b>	secondary voltage measured at <b>V1 AC</b> , and its phase angle relative to Vprim nominal
<b>Ratio:</b>	ratio Vprim / Vsec., here $10000.0/\sqrt{3}:100.43/\sqrt{3}$ <sup>1</sup> and deviation of voltage ratio in %. Formula: $((K_n \times V_{sec} - V_{prim}) / V_{prim}) \times 100\%$ <sup>2</sup> $((10000V / 100V * 20.087V - 2000V) / 2000V) \times 100\% = 0.431\%$
<b>Polarity:</b>	displays the status of the polarity OK = phaseVsec - phaseVprim = $-45^\circ < 0^\circ < 45^\circ$ NOT OK = all other cases

- The value  $100.43/\sqrt{3}$  is calculated as follows:  
 $V_{sec\ act} * (V_{prim\ nom} / V_{prim\ act}) * (1/\sqrt{3} / 1/\sqrt{3}) = 20.087V * (10000V / 2kV) = 100.43/\sqrt{3}$
- $K_n$  = rated transformation value, here:  $10000V / 100V$

Selecting the check box **Manual input** lets you enter the value for Vsec manually, for example when Vsec was measured with an external volt meter rather than at input **V1 AC**.

## 6.2.3 Automatic test vs. manual test

### 1. Option "Manual input" clear

#### Automatic test

- ▶ Press the I/O (test start/stop) push-button to start the test.
- ▶ The test voltage increases from 0V to  $V_{test}$  in a ramp characteristic within 1 second. Then  $V_{test}$  is kept for a period of 2.4 seconds, and the measurements are taken. Next, the ramp decreases again within 0.3 seconds.
- ▶ The automatic test stops by itself, it can now be assessed.
- ▶ To repeat the test, first press **Back to Top**, if applicable, and then **Clear Results**.

#### Manual test

Clearing **Auto** lets you set the test voltage  $V_{test}$  manually with the handwheel.

- ▶ Press the I/O (test start/stop) push-button to start the test. The focus is set onto the "V test:" entry field.
- ▶ Set the value of your choice either by turning the handwheel and/or by entering it with the numerical keys.

**Note:** A value set with the numerical keys needs to be fully entered and acknowledged by pressing either **Enter** or the handwheel before it is applied to the output. If needed, it can then be adjusted using the handwheel.

Values set by turning the handwheel are applied instantaneously.

- ▶ Now the measurements are taken and displayed.
- ▶ To save the measurement press **Keep Results** (pressing the I/O push-button has the same effect). The last measured values are "frozen", the test can now be assessed.
- ▶ Stop the manual test by pressing the I/O (test start/stop).
- ▶ To repeat the test, first press **Back to Top**, if applicable, and then **Clear Results**.

## 2. Option "Manual input" selected

**Note:** Select **Manual input** prior to starting the test. If the test card still contains results, clear them by pressing **Clear Results**.

When **Manual input** is selected, there is no phase available. Consequently, neither the polarity nor the phase angle can be calculated.

Since an automatic test only lasts a very short period of time, and a manual measurement is rather difficult, an automatic test with a manual measurement is not useful. Therefore, this Reference Manual will not cover this subject.

### Manual test

Clearing **Auto** lets you set the test voltage  $V_{test}$  manually with the handwheel.

- ▶ Press the I/O (test start/stop) push-button to start the test. The focus is set onto the "V test:" entry field.
- ▶ Set the value of your choice either by turning the handwheel and/or by entering it with the numerical keys.
- ▶ A value set with the numerical keys needs to be fully entered and acknowledged by pressing either **Enter** or the handwheel before it is applied to the output. If needed, it can then be adjusted using the handwheel.  
Values set by turning the handwheel are applied instantaneously.
- ▶  $V_{prim}$  is measured and displayed.
- ▶ To save the measurement press **Keep Results**.
- ▶ Navigate to the "V sec" entry field.
- ▶ Enter the measured  $V_{sec}$  value either by turning the handwheel or by entering this value with the numerical keys, and press **Enter** or the handwheel to acknowledge your setting.
- ▶ The ratio is calculated and displayed.
- ▶ To stop the manual test, press the I/O (test start/stop). The test can now be assessed.
- ▶ Alternatively, it is possible to enter the manually measured value into the test card after the test was stopped (for example, if the measurement was carried out at a remote location).
- ▶ To repeat the test, first press **Back to Top**, if applicable, and then **Clear Results**.

To learn more about test assessment, refer to 10.1 "Test assessment" on page 271.

## 6.3 VT Burden

Use the **VT Burden** test card to measure a voltage transformer's secondary burden with voltage injection on the VT's secondary side with up to 130V from **AC OUTPUT**.

- ▶ To do so, open the circuit as shown in Figure 6-4 and inject the AC voltage from the *CPC 100*'s **130V AC** output into the burden.

### DANGER



#### Death or severe injury caused by high voltage or current

- ▶ Make sure that all primary VT terminals are connected to ground.
- ▶ Disconnect all burdens from the VT.

Input **I AC** measures the current that flows into the burden, and input **V1 AC** the voltage at the burden. From these measurements, the burden (in VA) and the power factor  $\cos\phi$  are calculated.

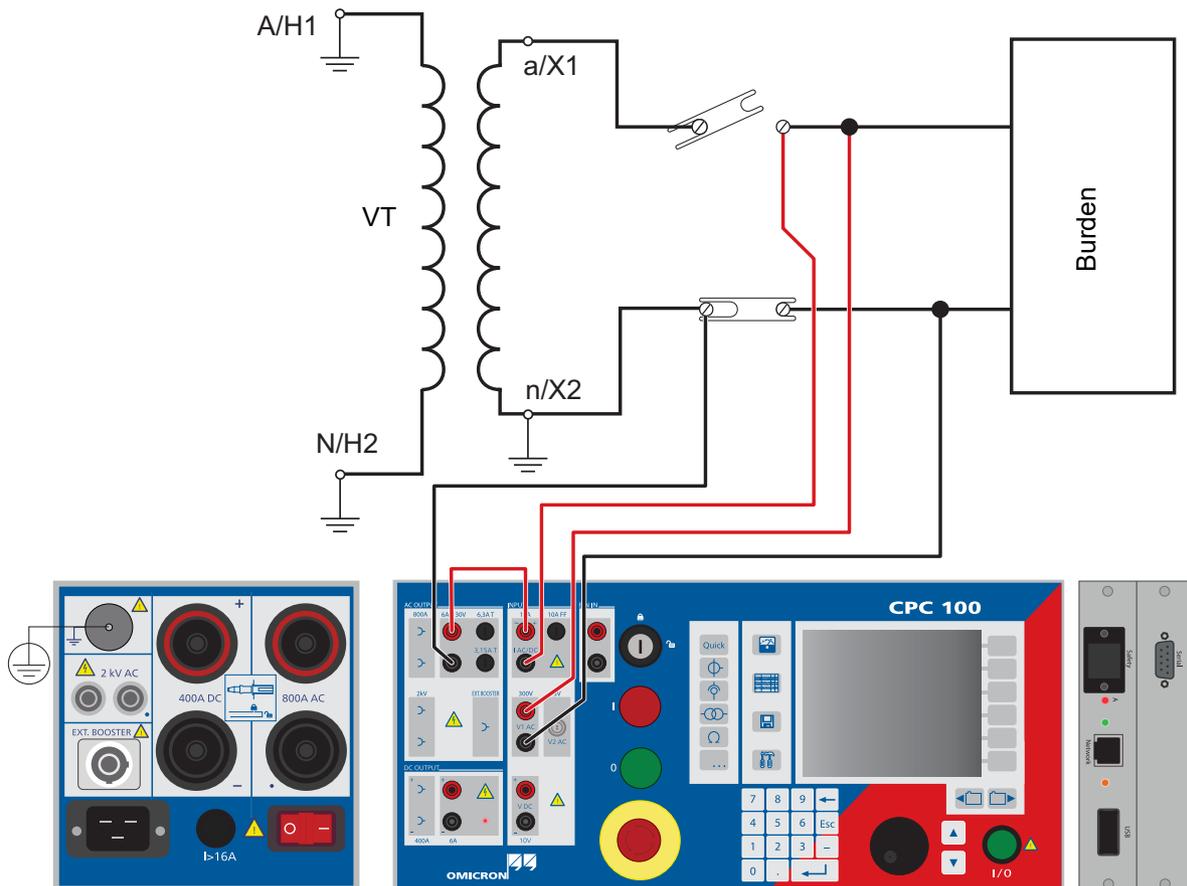


Figure 6-4: Setup for a VT burden measurement

### 6.3.1 Test settings

Figure 6-5: **VTBurden** test card with test results

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

<b>Vsec:</b>	nominal secondary voltage with the option "value x $1/\sqrt{3}$ "
<b>f:</b>	output frequency
<b>Auto:</b>	select check box for automatic test (default), clear for manual test (refer to 6.3.3 "Automatic test vs. manual test" on page 151).
<b>Vtest:</b>	secondary injection voltage from <b>130V AC</b> output

**Note:** If a current clamp is used to measure Isec, select the corresponding check box on the test card, and specify the current clamp device at the **Options** tab **Device Setup**.

**Note:** Due to cross-talk between the measuring inputs **V1 AC** and **V2 AC**, we suggest not to connect a current clamp to the input **V2 AC**.

Therefore, use a current clamp with current output.

Pressing the **Settings** menu key opens the **Settings** page. The **Settings** page allows setting the test cards individually. As a rule, do not use the **Settings** page but the **Device Setup** tab in the **Options** view (see "Device Setup" on page 56) to set the test cards. For more information, see "Settings page" on page 50.

### 6.3.2 Measurements

<b>Vsec:</b>	actual voltage at the burden, measured at input <b>V1 AC</b>
<b>Isec:</b>	actual current through burden, measured via input <b>I AC</b>
<b>Burden:</b>	burden in VA: $Vsec\ nom \times (Isec\ act \times Vsec\ nom / Vsec\ act)$
<b>cos φ</b>	cosinus of phase angle φ

**Manual input** Selecting the check box **Manual input** lets you enter the value for Isec manually, for example, when Isec was measured with a current clamp rather than at input **I AC**.

### 6.3.3 Automatic test vs. manual test

#### 1. Option "Manual input" clear

##### Automatic test

- ▶ Press the I/O (test start/stop) push-button to start the test.
- ▶ The test voltage increases in a ramp characteristic from 0V to  $V_{test}$  within 1 second. Then  $V_{test}$  is kept and injected for a period of 2.4 seconds, the measurements are taken. Next, the ramp decreases again within 0.3 seconds.
- ▶ The automatic test stops by itself, it can now be assessed.
- ▶ To repeat the test, first press **Back to Top**, if applicable, and then **Clear Results**.

##### Manual test

Clearing **Auto** lets you set the test voltage  $V_{test}$  manually with the handwheel.

- ▶ Press the I/O (test start/stop) push-button to start the test. The focus is set onto the "V test:" entry field.
- ▶ Set the value of your choice either by turning the handwheel and/or by entering it with the numerical keys.
- ▶ A value set with the numerical keys needs to be fully entered and acknowledged by pressing either **Enter** or the handwheel before it is applied to the output. If needed, it can then be adjusted using the handwheel.  
Values set by turning the handwheel are applied instantaneously.
- ▶ Now the measurements are taken and displayed.
- ▶ To save the measurement press **Keep Results** (pressing the I/O push-button has the same effect). The last measured values are "frozen", and can now be assessed.
- ▶ Stop the manual test by pressing the I/O (test start/stop). The test can now be assessed.
- ▶ To repeat the test, first press **Back to Top**, if applicable, and then **Clear Results**.

#### 2. Option "Manual input" selected

**Note:** Select **Manual input** prior to starting the test. If the test card still contains results, clear them by pressing **Clear Results**.

When "Manual input" is selected, there is no phase available. Consequently, neither the phase angle  $\varphi$  nor  $\cos\varphi$  can be calculated.

Since an automatic test only lasts a very short period of time, and a manual measurement is rather difficult, an automatic test with a manual measurement is not useful. Therefore, this Reference Manual will not cover this subject.

### Manual test

Clearing **Auto** lets you set the test voltage  $V_{test}$  manually with the handwheel.

- ▶ Press the I/O (test start/stop) push-button to start the test. The focus is set onto the "V test:" entry field.
- ▶ Set the value of your choice either by turning the handwheel and/or by entering it with the numerical keys.
- ▶ A value set with the numerical keys needs to be fully entered and acknowledged by pressing either **Enter** or the handwheel before it is applied to the output. If needed, it can then be adjusted using the handwheel.  
Values set by turning the handwheel are applied instantaneously.
- ▶  $V_{sec}$  is measured and displayed.
- ▶ To save the measurement press **Keep Results**.
- ▶ Navigate to the "I sec:" entry field
- ▶ Enter the measured  $I_{sec}$  value either by turning the handwheel or by entering this value with the numerical keys, and press **Enter** or the handwheel to acknowledge your setting.
- ▶ Now the burden is calculated and displayed.
- ▶ To stop the manual test, press the I/O (test start/stop). The test can now be assessed.
- ▶ Alternatively, it is possible to enter the manually measured value into the test card after the test was stopped (for example, if the measurement was carried out at a remote location).
- ▶ To repeat the test, first press **Back to Top**, if applicable, and then **Clear Results**.

To learn more about test assessment, refer to 10.1 "Test assessment" on page 271.

## 6.4 Voltage Withstand test

**Note:** Some test cards are available in more than one test mode. For example, the test card **VWithstand** can be selected in CT, VT, Resistance and Transformer.

This is solely related to usability. With regard to functionality, the test card **VWithstand** is identical in all test modes.

Use the test card **VWithstand** to measure the voltage withstand capability of the secondary winding and secondary wiring.

To do so, disconnect the burden. As shown in Figure 6-6, connect the 2kV output socket without point to the transformer's secondary (a) winding connection, and the output socket marked with a point to earth and the transformer's primary connection (N).

### DANGER



#### Death or severe injury caused by high voltage or current

- ▶ Do not touch any taps or windings of the CT during the test. They carry life-threatening voltage.
- ▶ Disconnect all burdens from the VT.

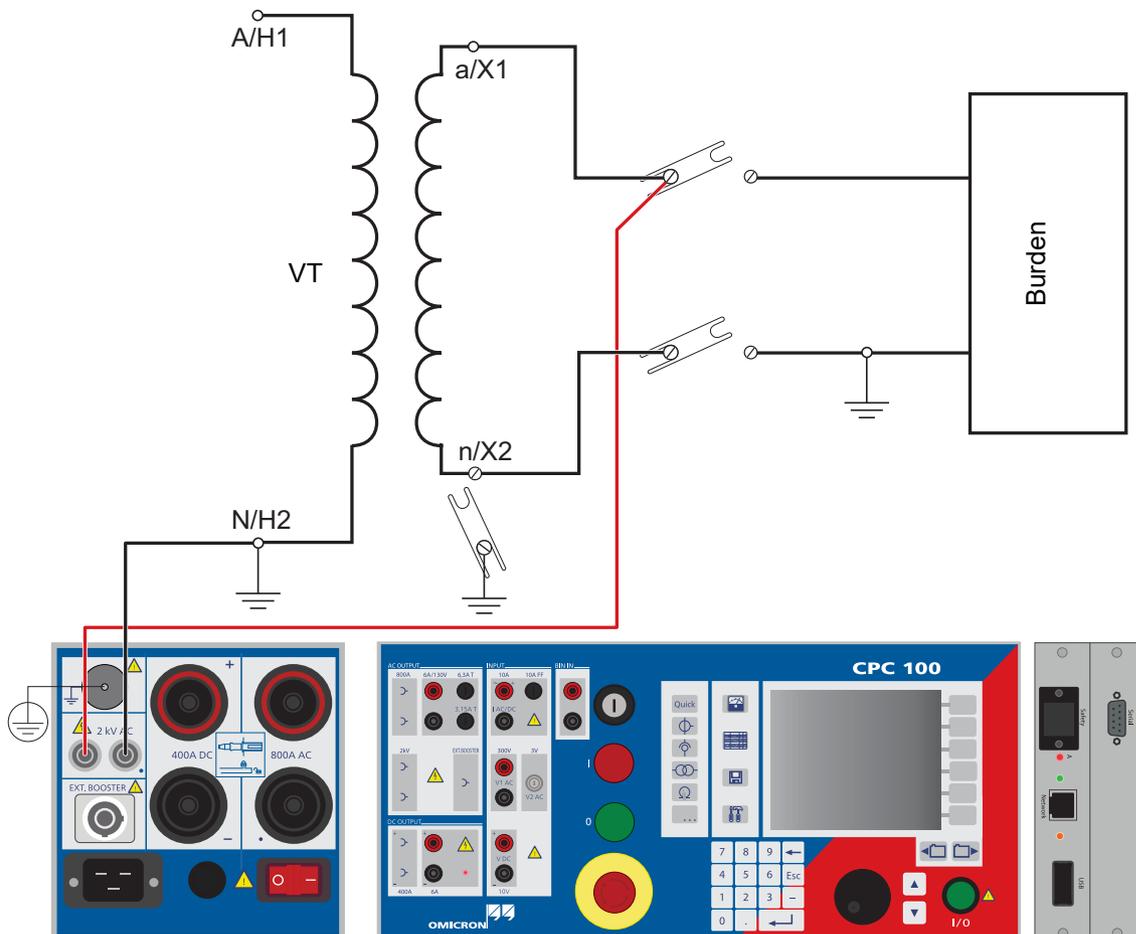


Figure 6-6: Setup for a voltage withstand test

**Note:** For test settings and measurement see also chapter Current Transformer 5.6.1 "Test settings" on page 111 and 5.6.2 "Measurements" on page 112.

To learn more about test assessment, refer to 10.1 "Test assessment" on page 271.

## 6.5 Polarity check



### DANGER

#### Death or severe injury caused by high voltage or current

- ▶ Do not connect the *CPC 100* output to the secondary side of the VT. This will cause hazardous voltages on the primary side.
- ▶ Do not short-circuit the secondary VT windings.
- ▶ Make sure that no secondary VT windings are open.

**Note:** Some test cards are available in more than one test mode. For example, the test card **PoICheck** can be selected in CT and VT. This is solely related to usability. With regard to functionality, the test card **PoICheck** is identical in all test modes.

Use the **PoICheck** test card to check a series of test points for correct polarity.

To do so, the *CPC 100* injects a special polarity test signal at a certain location. This signal can either be a voltage or a current signal from the *CPC 100*, and has a signal characteristic similar to a saw-tooth signal with a different steepness for the rising and the falling slope.

The polarity check itself is then done with the *CPOL* accessory, a portable easy-to-use polarity checker.

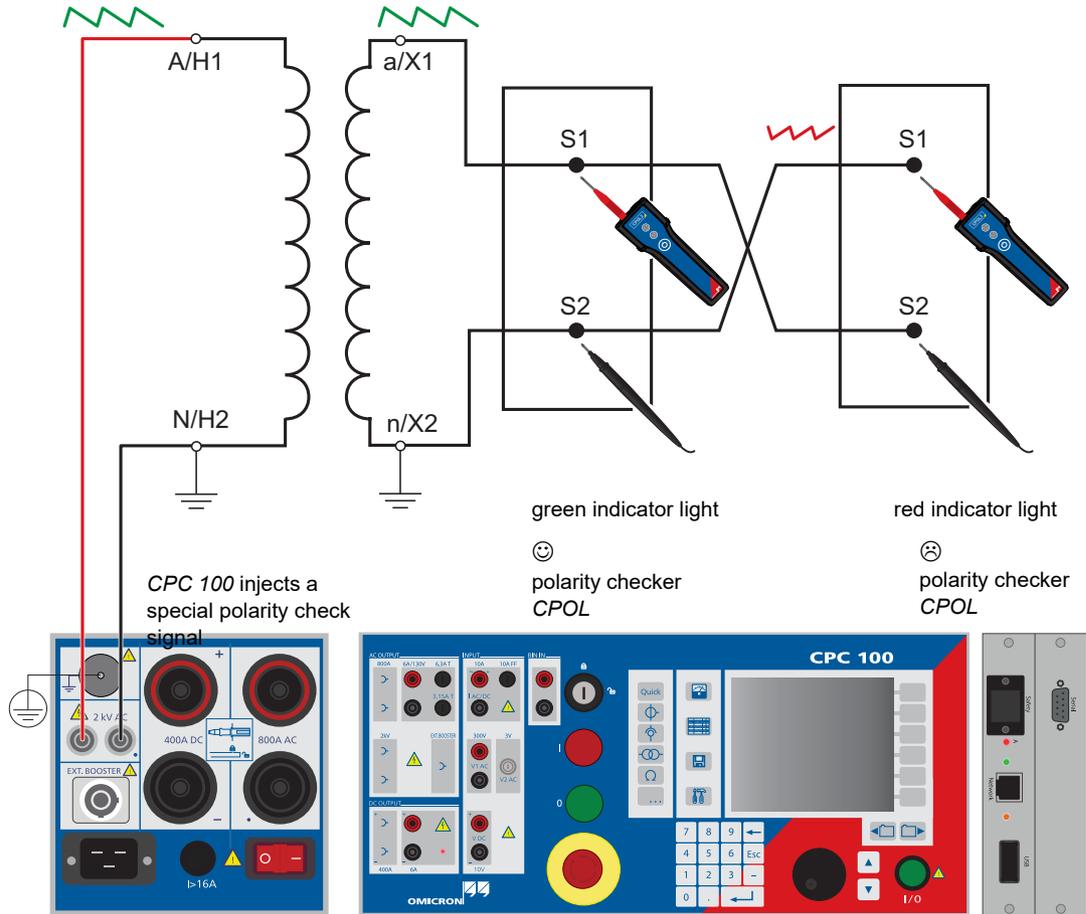


Figure 6-7: Illustrated setup for a polarity check

- ☺ If *CPOL* detects the same signal characteristic at a test point, it considers the polarity as OK, and lights up the green indicator light.
  - ☹ If the signal characteristic is inverted or distorted, *CPOL* considers the polarity not OK, and lights up the red indicator light.
  - ☺ + ☹ If *CPOL* detects a signal that is too low, both indicator lights light up at the same time. Remedy: increase the signal magnitude.
- If you are not quite certain whether your measurement is correct, you can confirm it by reversing the probes of the *CPOL*. In that case, the other indicator light should light up.

**CPOL battery**

on/off

If the capacity of the *CPOL*'s battery level decreases to a certain level, both indicator lights start flashing simultaneously. As long as the indicator lights are flashing, the *CPOL*'s battery provides sufficient power to continue working. However, the battery should be changed as soon as possible.

**DANGER****Death or severe injury caused by high voltage or current**

- ▶ Handle with extreme caution: The measurement circuit may carry life-threatening voltages. Only touch the measurement setup with the *CPOL* measurement tips and comply with the instructions stated in the relevant user manual.
- ▶ If you detect a wrong polarity in the current path, turn off the *CPC 100* first, and only then disconnect the terminals.
- ▶ Never operate the *CPOL* with an open battery compartment. A dangerous voltage level may occur in the battery compartment if the *CPOL*'s probe touches a test point with high-voltage potential.
- ▶ Do not use the *CPOL* during rain.
- ▶ Do not use the *CPOL* if it is damaged. Before use, inspect the case. Look for cracks or missing plastic. Pay particular attention to the insulation surrounding the connectors.
- ▶ Check the test leads and measurement tips for damaged insulation, exposed metal or bare wires before connecting them to the *CPOL*. Check the test leads for continuity. Replace damaged test leads immediately.
- ▶ If the test leads need to be replaced, only use test leads that meet the EN 61010-031 standard, rated at least for CAT II 1000 V, CAT III 600 V, CAT IV 300 V, or better.
- ▶ When using test probes, keep your fingers behind the finger guards of the test probes. When using the measurement tip, keep your fingers behind the finger guard of the *CPOL*.
- ▶ To power the *CPOL*, only use 2 AA cell batteries, properly installed in the battery compartment.
- ▶ When using the *CPOL3*, do not apply more than the rated voltage for the applicable measurement category between a terminal and earth ground (CAT II 1000 V, CAT III 600 V, or CAT IV 300 V). This also applies if test leads with a higher measurement category or voltage rating are used.
- ▶ Never leave the *CPOL3* under direct sunlight as it might heat up quickly. Check the permissible temperature range of the batteries in use. Operate and store the *CPOL3* only within the temperature range of the batteries in use.

**NOTICE****Equipment damage possible**

- ▶ Do not mix old and new batteries.
- ▶ Make sure that both batteries are of the same type.

## 6.5.1 Test settings

RGround		Comment		PolCheck			
Range:	AC 2kV						
Ampl.:	500.0V	<input checked="" type="checkbox"/>	Intermittent				
T on:	2.000 s	T off:	9.000 s				
Location	Assessment						
Point 1	OK						
Point 2	OK						
Point 3	OK						
Point 4	Failed						

Insert Card
Delete Card
Rename Card
Clear Results
Save As Default
Settings

Figure 6-8: **PolCheck** test card with test points

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

Range:            output range

Ampl.:            maximum amplitude of polarity check output signal. Any value between the minimum and maximum of the selected range is possible.

---

Intermittent    Clear the option **Intermittent** when working with voltage outputs.

## 6.5.2 Carrying out the polarity check

1. Define the first set of parameters, and press the I/O (test start/stop) push-button to start the test
2. The CPC 100 now applies the polarity check signal with the specified parameters to the output.
3. Now carry out the polarity check at the test point of your choice using the CPOL.
4. Add the first test point to the test point table by pressing **New Result**.

The column "Location" displays a default name "Point 0", and a "n/a" in the column "Assessment" shows that no assessment was done yet.

5. If you need multiple test points, repeat items 3 - 4 as often as needed.
6. For the assessment there are two alternatives:
  - assess each test point right away as it is entered
  - or add all test points needed, stop the test, and then do the assessment test point for test point.

To learn more about test assessment, refer to 10.1 "Test assessment" on page 271.

7. Press the I/O (test start/stop) push-button to stop the test.

**Note:** Alternatively, it is possible to enter test points after the test was stopped (for example, if the measurement was carried out at a remote location).

## 6.5.3 Customizing test point names

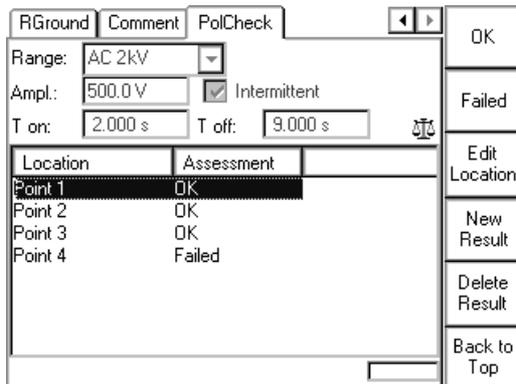


Figure 6-9: Highlighting a test point changes the context-dependent menu keys

- ▶ Highlight the test point of your choice by turning the handwheel.
- ▶ Press **Edit Location** to open the *String Editor*
- ▶ Use the *String Editor* functionality (refer to "The String Editor" in chapter 10) to specify a name of your choice for the selected test point.

## 6.6 VTElectronics

Use the **VTElectronics** test card to test the ratio of non-conventional electronic voltage transformers with a very low-level secondary voltage.

To carry out this test, disconnect the plug of the electronic transformer's secondary side from the protection relay, plug it into the **CPC 100 V2 AC** input, and inject voltage from the **2kV AC** output to the electronic transformer's primary side.

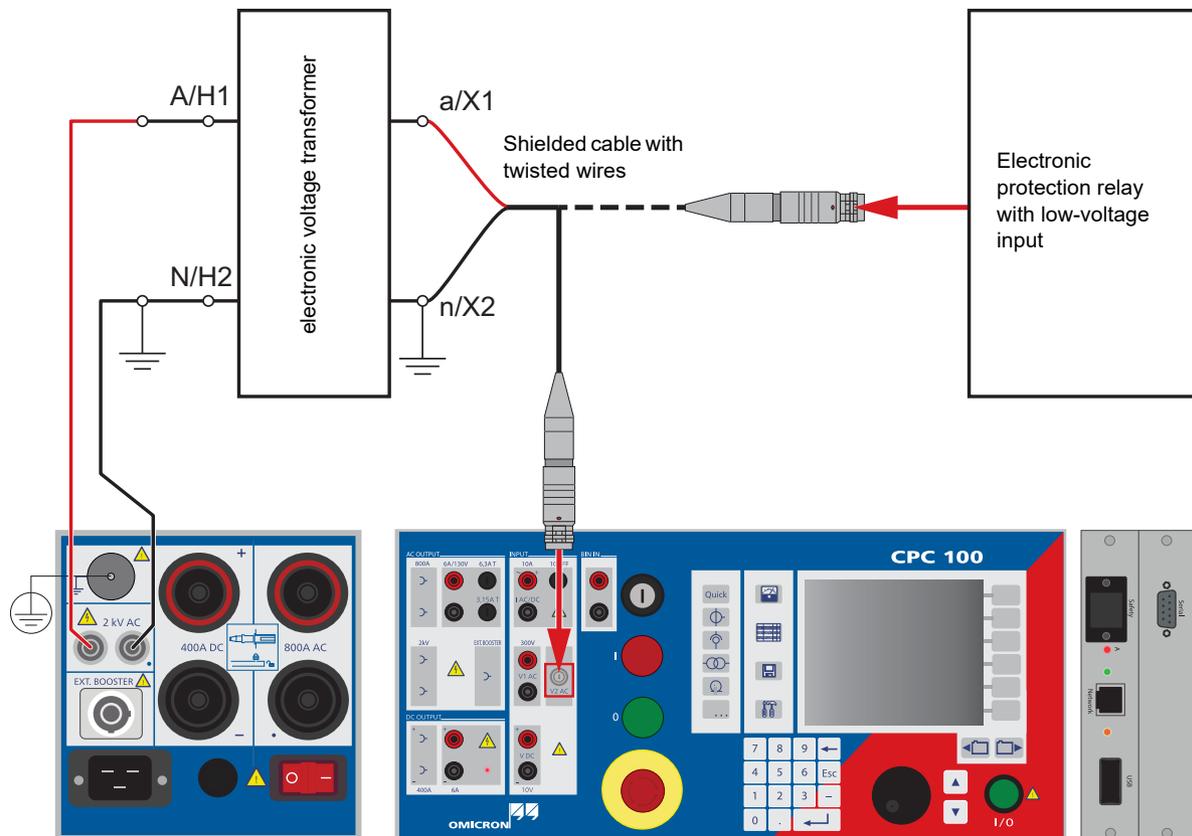


Figure 6-10: Setup for an electronic voltage transformer ratio test

### 6.6.1 Test settings

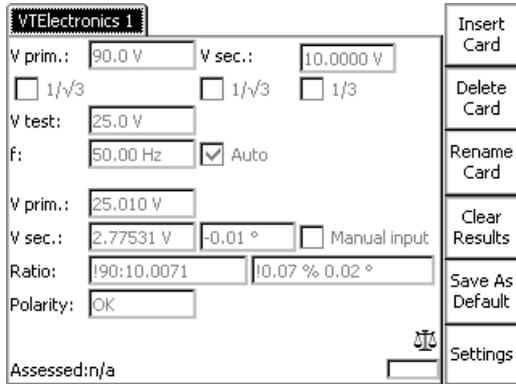


Figure 6-11: VTElectronics test card with test results

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

- Vprim:** nominal primary voltage with the option "value x  $1/\sqrt{3}$ "
- Vsec:** nominal secondary voltage with the options  
value x  $1/\sqrt{3}$   
value x  $1/3$
- Vtest:** primary injection voltage.  
By default,  $V_{test} = V_{prim}$  (with option x  $1/\sqrt{3}$ ) if  $V_{prim} \leq 2kV$ .  
If  $V_{prim} > 2kV$ ,  $V_{test} = 2kV$ .
- f:** output frequency
- Auto:** select check box for automatic test (default), clear for manual test (refer to 6.6.3 "Automatic test vs. manual test" on page 162).

**Settings** Pressing the **Settings** menu key opens the **Settings** page. The **Settings** page allows setting the test cards individually. As a rule, do not use the **Settings** page but the **Device Setup** tab in the **Options** view (see "Device Setup" on page 56) to set the test cards. For more information, see "Settings page" on page 50.

Within the **Settings** menu, you can set correction factors in accordance with IEC 61869-10. The measured transformation ratio of the instrument transformer under test can be adjusted with the provided ratio- and phase-correction values. The correction factors are often available on the asset nameplate.

- Amplitude correction: Amplitude correction for corrected transformation ratio calculation
- Phase correction: Phase error offset for corrected phase error calculation

## 6.6.2 Measurements

**Vprim:** actual output voltage at **2kV AC** output that is injected into the electronic voltage transformer's primary side

**Vsec:** secondary voltage measured at **V2AC**, and its phase angle relative to Vprim nominal

**Ratio:**  $V_{prim} / V_{sec} \times CF_U^1$ , here:  $90.0/\sqrt{3}:10.0071/\sqrt{3}^2$

**Note:** Results are marked with an exclamation point (!) if a correction factor was used.

**Ratio error:** 
$$\varepsilon = \frac{K_n \times V_{sec} \times CF_U - V_{prim}}{V_{prim}} \times 100\%$$

where  $K_n$  is rated transformation value, here:  $90.0 \text{ V} / 10.0 \text{ V}$

**Note:** Results are marked with an exclamation point (!) if a correction factor was used.

**Phase error:**  $\varphi = \varphi_{V_{sec}} - \varphi_{V_{prim}} - \varphi_{Phase\ correction}^3$

**Polarity:** displays the status of the polarity

OK= phaseVsec - phaseVprim =  $-45^\circ < 0^\circ < 45^\circ$

NOT OK = all other cases

1.  $CF_U$  stands for the amplitude correction. By default, it is set to 1.00 and subsequently no additional ratio error is considered.

2. The value  $10.0071/\sqrt{3}$  is calculated as follows:

$$V_{sec\ act} \times CF_U \times (V_{prim\ nom} / V_{prim\ act}), \text{ here: } 2.77531 \text{ V} \times 1.001 \times (90 \text{ V}/\sqrt{3}/25.010 \text{ V}) = 10.0071 \text{ V}/\sqrt{3}$$

3. By default, the phase correction is set to  $0.0000^\circ$  and subsequently no additional phase error is considered. Here:  $-0.03^\circ$ .

Manual input Selecting the check box **Manual input** lets you enter the value for Vsec manually, for example, when Vsec was measured with an external volt meter rather than at input **V1 AC**.

## 6.6.3 Automatic test vs. manual test

### 1. Option "Manual input" clear

#### Automatic test

- ▶ Press the I/O (test start/stop) push-button to start the test.
- ▶ The test voltage increases from 0V to  $V_{test}$  in a ramp characteristic within 1 second. Then  $V_{test}$  is kept for a period of 2.4 seconds, and the measurements are taken. Next, the ramp decreases again within 0.3 seconds.
- ▶ The automatic test stops by itself, it can now be assessed.
- ▶ To repeat the test, first press **Back to Top**, if applicable, and then **Clear Results**.

#### Manual test

Clearing **Auto** lets you set the test voltage  $V_{test}$  manually with the handwheel.

- ▶ Press the I/O (test start/stop) push-button to start the test. The focus is set onto the "V test:" entry field.
- ▶ Set the value of your choice either by turning the handwheel and/or by entering it with the numerical keys.
- ▶ A value set with the numerical keys needs to be fully entered and acknowledged by pressing either **Enter** or the handwheel before it is applied to the output. If needed, it can then be adjusted using the handwheel.  
Values set by turning the handwheel are applied instantaneously.
- ▶ Now the measurements are taken and displayed.
- ▶ To save the measurement press **Keep Results** (pressing the I/O push-button has the same effect). The last measured values are "frozen", the test can now be assessed.
- ▶ Stop the manual test by pressing the I/O (test start/stop).
- ▶ To repeat the test, first press **Back to Top**, if applicable, and then **Clear Results**.

## 2. Option "Manual input" selected

**Note:** Select **Manual input** prior to starting the test. If the test card still contains results, clear them by pressing **Clear Results**.

When **Manual input** is selected, there is no phase available. Consequently, neither the polarity nor the phase angle can be calculated.

Since an automatic test only lasts a very short period of time, and a manual measurement is rather difficult, an automatic test with a manual measurement is not useful. Therefore, this Reference Manual will not cover this subject.

### Manual test

Clearing **Auto** lets you set the test voltage  $V_{sec}$  manually with the handwheel.

- ▶ Press the I/O (test start/stop) push-button to start the test. The focus is set onto the "V test:" entry field.
- ▶ Set the value of your choice either by turning the handwheel and/or by entering it with the numerical keys.
- ▶ A value set with the numerical keys needs to be fully entered and acknowledged by pressing either **Enter** or the handwheel before it is applied to the output. If needed, it can then be adjusted using the handwheel.  
Values set by turning the handwheel are applied instantaneously
- ▶  $V_{prim}$  is measured and displayed.
- ▶ To save the measurement press **Keep Results**.
- ▶ Navigate to the "V sec" entry field.
- ▶ Enter the measured  $V_{sec}$  value either by turning the handwheel or by entering this value with the numerical keys, and press **Enter** or the handwheel to acknowledge your setting.
- ▶ The ratio is calculated and displayed.
- ▶ To stop the manual test, press the I/O (test start/stop). The test can now be assessed.
- ▶ Alternatively, it is possible to enter the manually measured value into the test card after the test was stopped (for example, if the measurement was carried out at a remote location).
- ▶ To repeat the test, first press **Back to Top**, if applicable, and then **Clear Results**.

To learn more about test assessment, refer to 10.1 "Test assessment" on page 271.

## 6.7 TanDelta - PF

The test card **TanDelta - PF** was especially developed for the *CP TD*.

The *CP TD* (*CP TD1*, *CP TD12* or *CP TD15*) is an optionally available high-precision test system for on-site insulation tests of high-voltage systems like power and measuring transformers, circuit breakers, capacitors and isolators. The *CP TD* works as an add-on device to the *CPC 100* and is described in the *CP TD1* and *CP TD12/15* User Manuals on the *Primary Test Manager* DVD and the *CPC 100 Start Page*.

The **TanDelta - PF** test card can be accessed from CT, VT, Transformer and Others.

## 6.8 Ratio with sampled values

Use the **SV-Ratio** test card to check the ratio of the output current or voltage and the input current or voltage of the selected merging unit channel according to the IEC 61850 standard. In addition, the **SV-Ratio** card is used to determine the polarity of the signal, whereas the *CPC 100* serves as the signal source. The merging units generate the input voltages or currents.

The **SV-Ratio** test card can be accessed from CT, VT and Others. For further information, refer to 5.12 "Ratio with sampled values" on page 132.

## 7 Transformer

**Note:** With regard to software handling, this section confines to test-relevant issues, and does not go into detailed procedural descriptions.

It is assumed that you have read and understood the section 2.4 "How to use the CPC 100 software" on page 40.

**Note:** We strongly advise you to carefully read the transformer-specific safety instructions at 1.6 "General" on page 19 before carrying out transformer tests.

### 7.1 Scope of transformer tests



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 **Insert a new test card** dialog box.

For power transformers, the following test cards are available:

- TRRatio (per Tap)
- RWinding
- TRTapCheck (for OLTC)
- VWithstand
- TanDelta
- Dynamic OLTC-Scan (DRM)
- Demagnetization
- Vector group check

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**.

## 7.2 Transformer Ratio (per tap)

Use the **TRRatio** test card to measure the ratio of power transformers by injecting AC voltage with up to 2kV from **AC OUTPUT** into the transformer's high-voltage side (refer to Figures 7-1 and 7-2).

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 exciting current and its phase angle, and the phase angle between the high-voltage and the low-voltage side are measured.

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

### DANGER



**Death or severe injury caused by high voltage or current**

- ▶ Do not connect the CPC 100 putput to the low-voltage side of the transformer. This will cause hazardous voltagles on the high-voltage side.

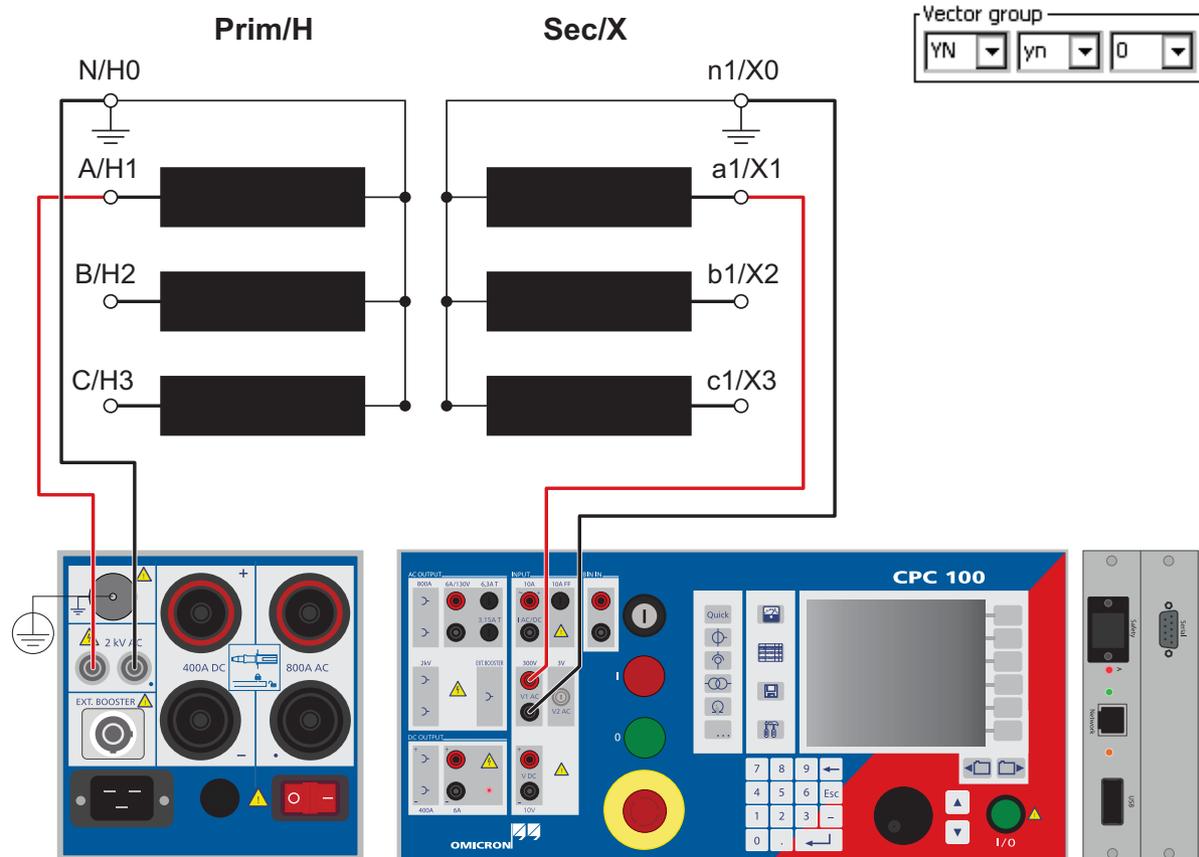


Figure 7-1: Setup for testing a power transformer ratio: YNyn0 transformer, high-voltage and low-voltage side star connection

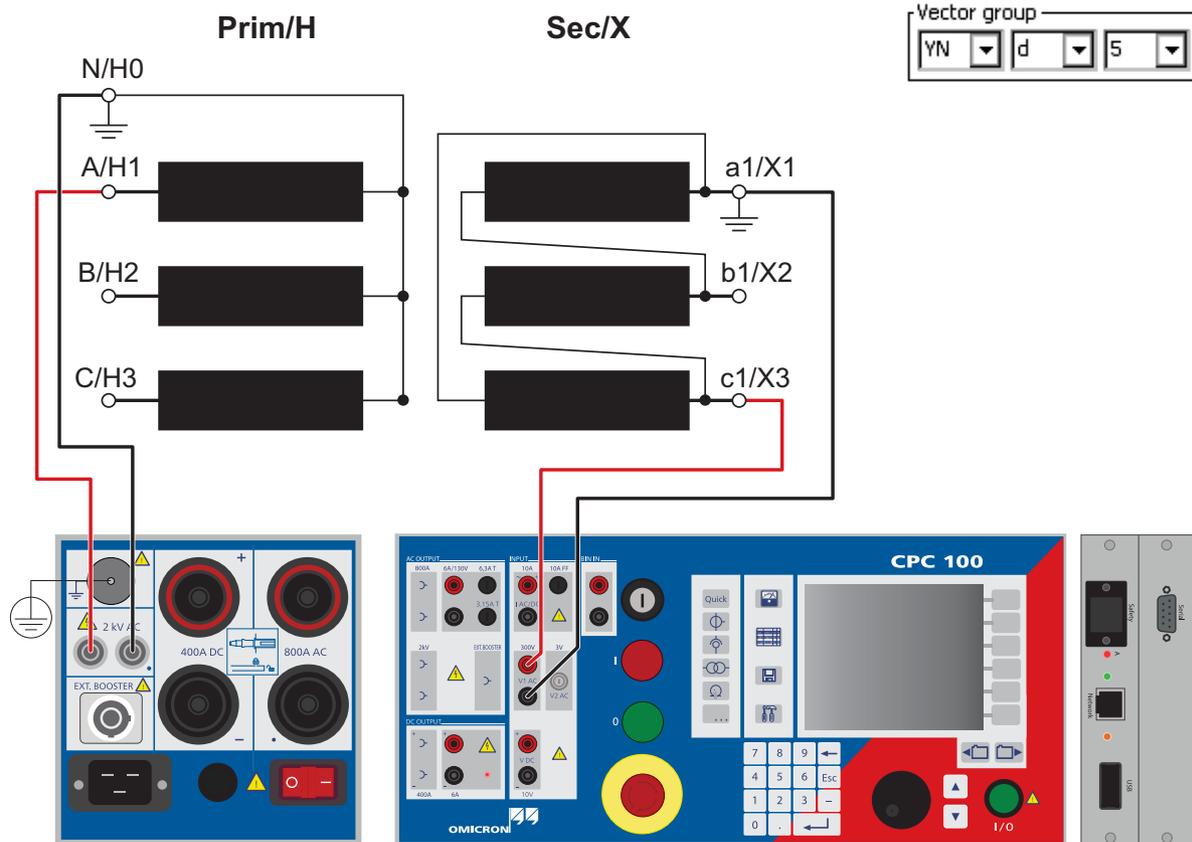


Figure 7-2: Setup for testing a power transformer ratio: YNd5 transformer, high-voltage side star connection, low-voltage side delta connection with a  $5 \times 30^\circ = 150^\circ$  phase shift.

Table shows the  $V_{prim}$  and  $V_{sec}$  settings on the **TRRatio** test card for different connections of the transformer under test.

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

To learn more about frequency-selective measurement, please refer to 4.2.1 "The frequency-selective measurement" on page 81.

Table 7-1: TRRatio test card settings for different transformer winding connections

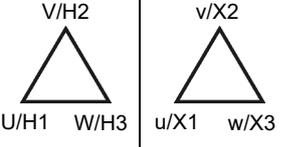
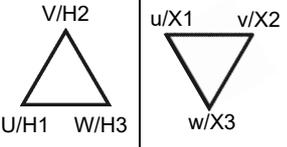
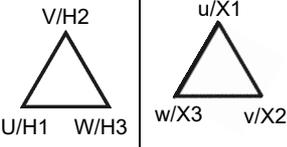
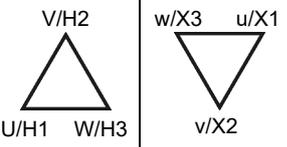
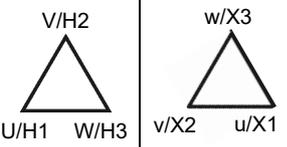
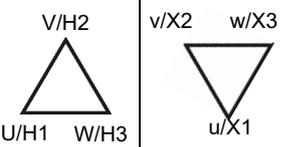
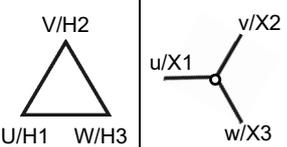
IEC 60076 vector group	Winding connection		Measurement	Trans-former high-voltage side	Trans-former low-voltage side	Measured turn ratio
	HV / H	LV / X				
Dd0			A	U-V / H1-H2	u-v / X1-X2	1
			B	V-W / H2-H3	v-w / X2-X3	
			C	W-U / H3-H1	w-u / X3-X1	
Dd2			A	U-V / H1-H2	w-v / X3-X2	1
			B	V-W / H2-H3	u-w / 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	
Dyn1			A	U-V / H1-H2	n-v / X0-X2	1*√3
			B	V-W / H2-H3	n-w / X0-X3	
			C	W-U / H3-H1	n-u / X0-X1	

Table 7-1: TRRatio test card settings for different transformer winding connections

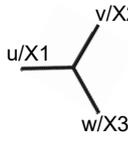
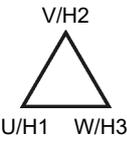
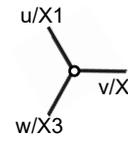
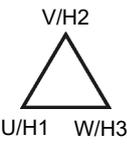
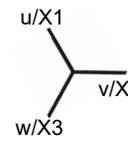
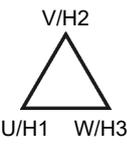
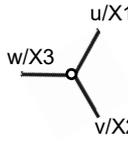
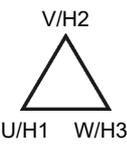
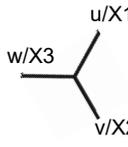
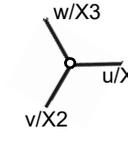
IEC 60076 vector group	Winding connection		Measurement	Trans-former high-voltage side	Trans-former low-voltage side	Measured turn ratio
	HV / H	LV / X				
Dy1			A	$U-(V+W) / H1-(H2+H3)$	$u-v / X1-X2$	$\sqrt{3}/2$
			B	$V-(U+W) / H2-(H1+H3)$	$v+w / X2-X3$	
			C	$W-(U+V) / H3-(H1+H2)$	$w-u / X3-X1$	
Dyn3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

Table 7-1: TRRatio test card settings for different transformer winding connections

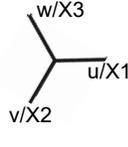
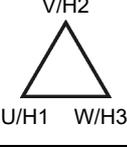
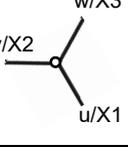
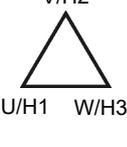
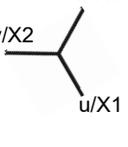
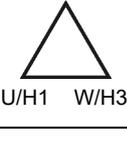
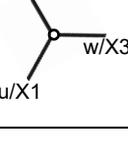
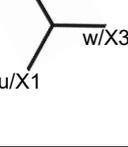
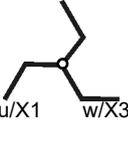
IEC 60076 vector group	Winding connection		Measurement	Trans-former high-voltage side	Trans-former low-voltage side	Measured turn ratio
	HV / H	LV / X				
Dy7			A	$U-(V+W) / H1-(H2+H3)$	$v-u / X2-X1$	$1*\sqrt{3}/2$
			B	$V-(U+W) / H2-(H1+H3)$	$w-v / X3-X2$	
			C	$W-(U+V) / H3-(H1+H2)$	$u-w / X1-X3$	
Dyn9			A	$U-V / H1-H2$	$n-w / X0-X3$	$\sqrt{3}$
			B	$V-W / H2-H3$	$n-u / X0-X1$	
			C	$W-U / H3-H1$	$n-v / X0-X2$	
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 7-1: TRRatio test card settings for different transformer winding connections

IEC 60076 vector group	Winding connection		Measurement	Trans-former high-voltage side	Trans-former 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	
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	

Table 7-1: TRRatio test card settings for different transformer winding connections

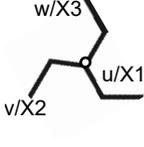
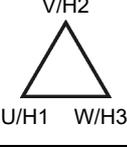
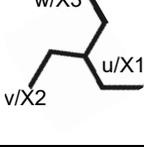
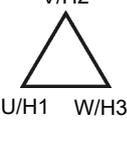
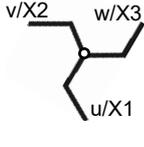
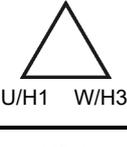
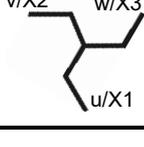
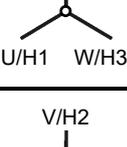
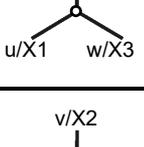
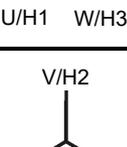
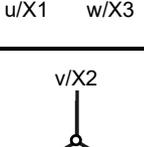
IEC 60076 vector group	Winding connection		Measurement	Trans-former high-voltage side	Trans-former low-voltage side	Measured turn ratio
	HV / H	LV / X				
Dzn8			A	$U-(V+W) / H1-(H2+H3)$	$v-n / X2-X0$	1.5
			B	$V-(U+W) / H2-(H1+H3)$	$w-n / X3-X0$	
			C	$W-(U+V) / H3-(H1+H2)$	$u-n / X1-X0$	
Dz8			A	$U-V / H1-H2$	$v-w / X2-X3$	1
			B	$V-W / H2-H3$	$w-u / X3-X1$	
			C	$W-U / H3-H1$	$u-v / X1-X2$	
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 7-1: TRRatio test card settings for different transformer winding connections

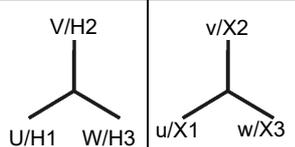
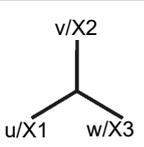
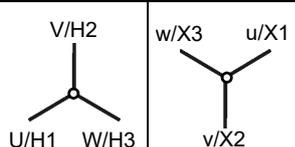
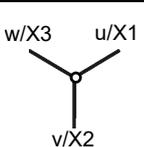
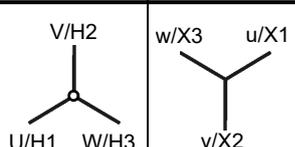
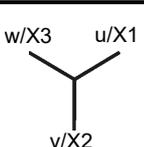
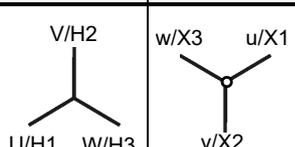
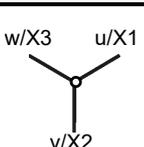
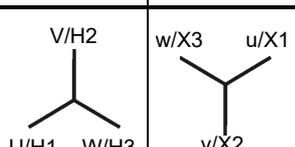
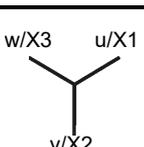
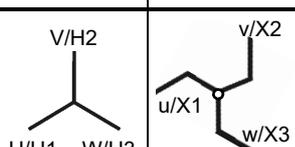
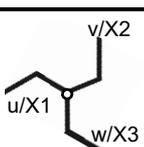
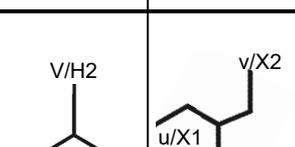
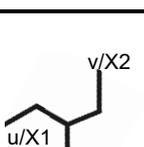
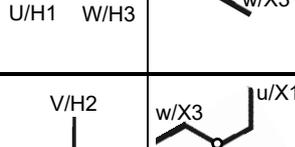
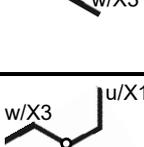
IEC 60076 vector group	Winding connection		Measurement	Trans-former high-voltage side	Trans-former low-voltage side	Measured turn ratio
	HV / H	LV / X				
Yy0			A	U-V / H1-H2	u-v / X1-X2	1
			B	V-W / H2-H3	v-w / X2-X3	
			C	W-U / H3-H1	w-u / X3-X1	
YNyn6			A	U-N / H1-H0	n-u / X0-X1	1
			B	V-N / H2-H0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

Table 7-1: TRRatio test card settings for different transformer winding connections

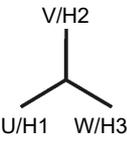
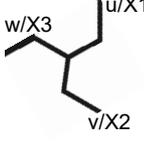
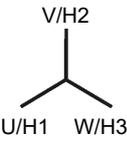
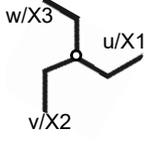
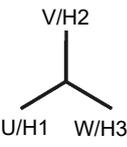
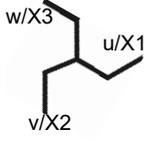
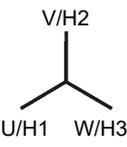
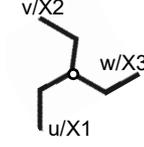
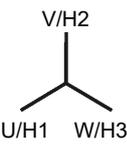
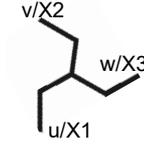
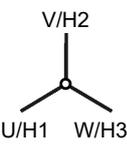
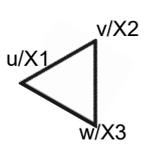
IEC 60076 vector group	Winding connection		Measurement	Trans-former high-voltage side	Trans-former low-voltage side	Measured turn ratio
	HV / H	LV / X				
Yz5			A	$U-(V+W) / H1-(H2+H3)$	$w-u / X3-X1$	$\sqrt{3}/2$
			B	$V-(U+W) / H2-(H1+H3)$	$u-v / X1-X2$	
			C	$W-(U+V) / H3-(H1+H2)$	$v-w / X2-X3$	
Yzn7			A	$U-V / H1-H2$	$v-n / X2-X0$	$\sqrt{3}$
			B	$V-W / H2-H3$	$w-n / X3-X0$	
			C	$W-U / H3-H1$	$u-n / X1-X0$	
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 7-1: TRRatio test card settings for different transformer winding connections

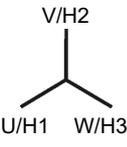
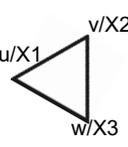
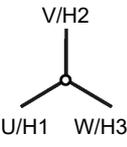
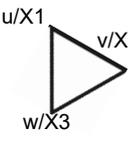
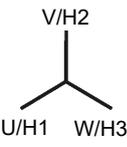
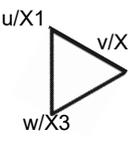
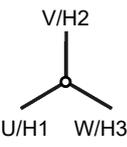
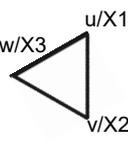
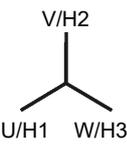
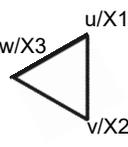
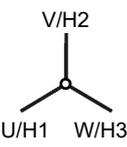
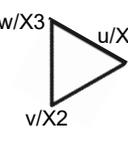
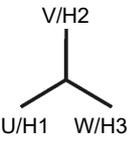
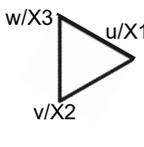
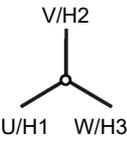
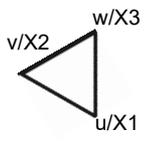
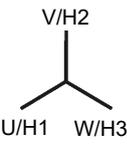
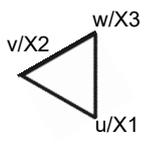
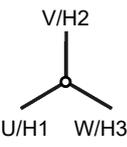
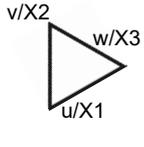
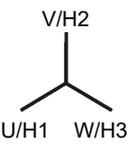
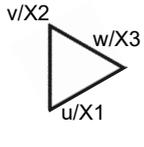
IEC 60076 vector group	Winding connection		Measurement	Trans-former high-voltage side	Trans-former low-voltage side	Measured turn ratio
	HV / H	LV / X				
Yd1			A	$U-(V+W) / H1-(H2+H3)$	$u-v / X1-X2$	$\sqrt{3}/2$
			B	$V-(U+W) / H2-(H1+H3)$	$v-w / X2-X3$	
			C	$W-(U+V) / H3-(H1+H2)$	$w-u / X3-X1$	
YNd3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

Table 7-1: TRRatio test card settings for different transformer winding connections

IEC 60076 vector group	Winding connection		Measurement	Trans-former high-voltage side	Trans-former low-voltage side	Measured turn ratio
	HV / H	LV / X				
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	$W-N / H3-H0$	$u-v / X1-X2$	
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 need to be short circuited.

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

## 7.2.1 Test settings

Tap	V prim	V sec	°	:1	%
007	1999.5	4.4500	0.04	449.34	-1.15
008	1999.5	4.4499	0.04	449.35	-0.15
009	1999.5	4.4499	0.04	449.34	0.85
010	1999.6	4.4499	0.04	449.35	9.84

Figure 7-3: **TRRatio** test card with test results

**Note:** The **Auto-tap** mode is for use with the *CP SB1* switch box. For detailed description on how to use the test card in connection with the *CP SB1*, refer to the *CP SB1* User Manual. If you use the *CP SB1*, automatic testing of the measurements (A, B, C) over all tap changer positions is possible.

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

<b>Ratio table:</b>	Nominal ratios of all taps, calculated from $V_{prim\ nom} / V_{sec\ nom}$
<b>Vtest:</b>	Nominal primary injection voltage
<b>f:</b>	Output frequency
<b>Operation mode:</b>	Manual wiring. The Auto-tap mode is reserved for the <i>CP SB1</i> only. The <b>Wiring</b> settings are only relevant if the <i>CP SB1</i> is connected. Otherwise, they are for information purposes. The wiring information can be displayed via the <b>Wiring Info</b> key.
<b>Vector group:</b>	Selection depending on the settings

**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.

Tap	V prim	V sec
001	110000.0	10000.0
002	110250.0	10000.0
003	110500.0	10000.0
004	110750.0	10000.0
005	111000.0	10000.0
006	111250.0	10000.0

Figure 7-4: **Settings** page of the **TRRatio** test card

**Note:** Auto-tap is only available with the *CP SB1* connected.

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. After then, pressing the **Add Tap** menu key repeatedly adds more taps with a step calculated from the values of the preceeding 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.

Use the **Automatic Tap Fill** function (see 7.2.2 "Automatic Tap Fill" on page 179) to automatically fill in the nominal ratio table of the **TRRatio** test card for symmetric tap changers.

**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.

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

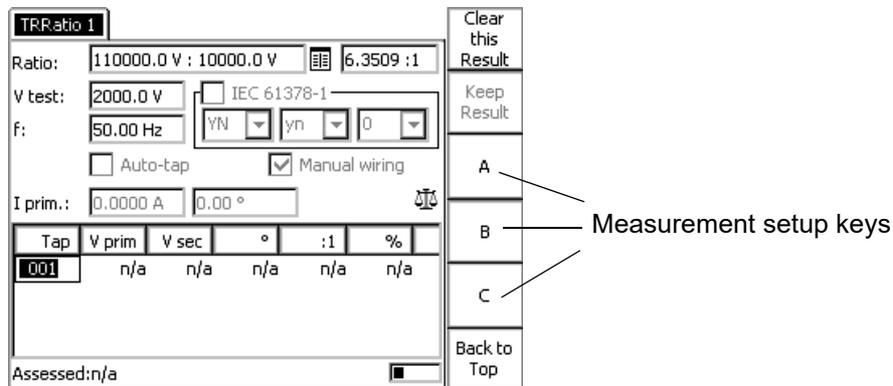


Figure 7-5: Setting up the different measurements

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

## 7.2.2 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.

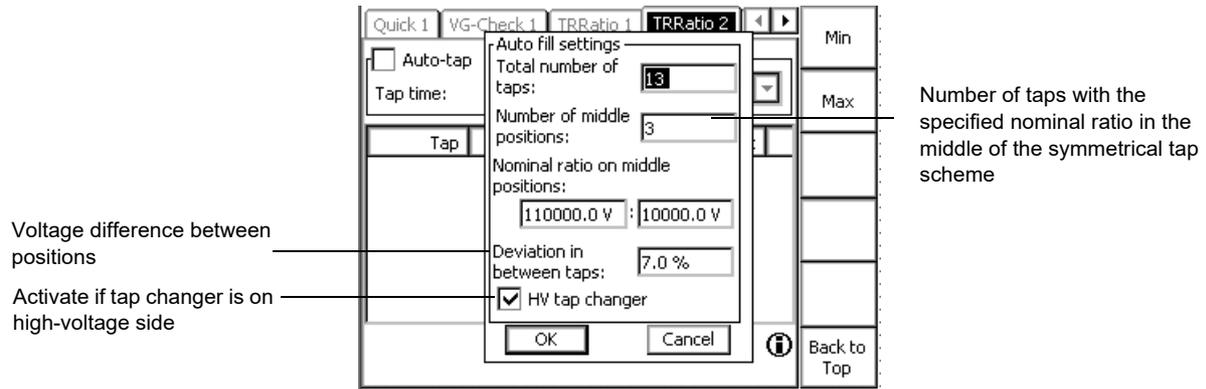


Figure 7-6: **Auto fill settings** window

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.

## Measurements

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

<b>Iprim:</b>	Primary current from the <b>2kV AC</b> output, measured by the <i>CPC 100</i> internally. If the focus is on the table, scrolling through the lines will change this display accordingly, depending on the selected line. The ° shows the phase angle of the primary current relative to Vprim nominal.
<b>Tap (in table):</b>	Displays the transformer tap identifier and tap number for the measurements in the respective line of the table.
<b>Vprim:</b>	Actual voltage injected from the <b>AC OUTPUT</b> into the transformer's high-voltage side
<b>Vsec:</b>	Actual voltage measured at the <b>V1 AC</b> from the transformer's low-voltage side. The ° shows the phase angle of the secondary voltage relative to Vprim nominal.
<b>Note:</b>	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.
<b>Ratio: 1</b>	Calculated ratio value from the measured values Vprim / Vsec
<b>%:</b>	The % shows the deviation of the actual ratio from the nominal ratio in %.

### Carrying out a TRRatio test (per tap)

1. Define the ratio table first on the **Settings** page, then the parameters 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<sub>test</sub> 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. Place the tap changer onto the next position.
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<sub>test</sub> 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.

### Entering the tap number during or after a test

During the test, only the current tap number can be changed. Even after the test, the tap number can still be entered. To do so, select the line of your choice in the measurement table and enter the desired tap number.

The test can now be assessed.

To learn more about test assessment, refer to 10.1 "Test assessment" on page 271.

## 7.2.3 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.

**Note:** The **IEC 61378-1** check box is only available if the *CP SB1* switchbox is connected. If the **IEC 61378-1** check box is activated, the manual wiring mode is deactivated and not available.

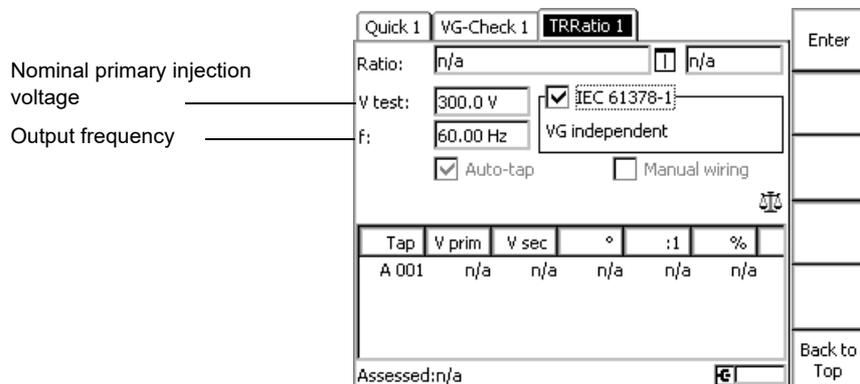


Figure 7-7: TRRatio test card with IEC 61378-1 check box

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.

Refer to the following diagram for correct wiring:

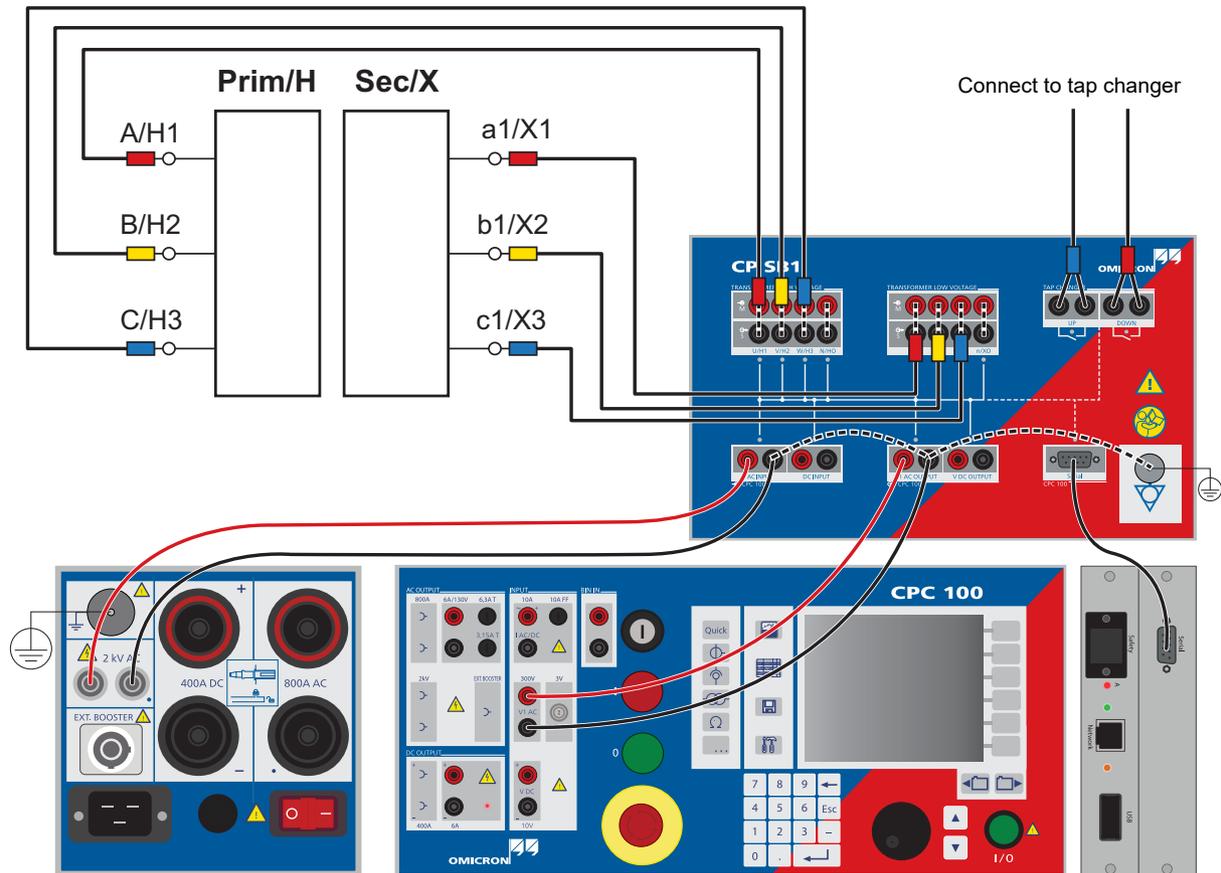


Figure 7-8: Detailed measurement setup and wiring for **TRRatio** test according to IEC 61378-1

The IEC 61378-1 standard<sup>1</sup> states that the turn ratio measurements shall be performed in the single phase configuration, feeding, by a cyclic permutation, the HV phase (U, V, W) with the other two in short circuit, against the respective LV phase (u, v, w). The following table applies:

$K_b$	$K_c$	$K_b$	$K_b$	$K_b$	$K_c$
U - VW	U - VW	V - WU	V - WU	W - UV	W - UV
u - v	u - w	v - w	v - u	w - u	w - v

1. IEC 61378-1 ed.2.0 Copyright © 2011 IEC Geneva, Switzerland. www.iec.ch

The values  $K_b$  and  $K_c$  (the average of the three measurements) are used in the following formulas:

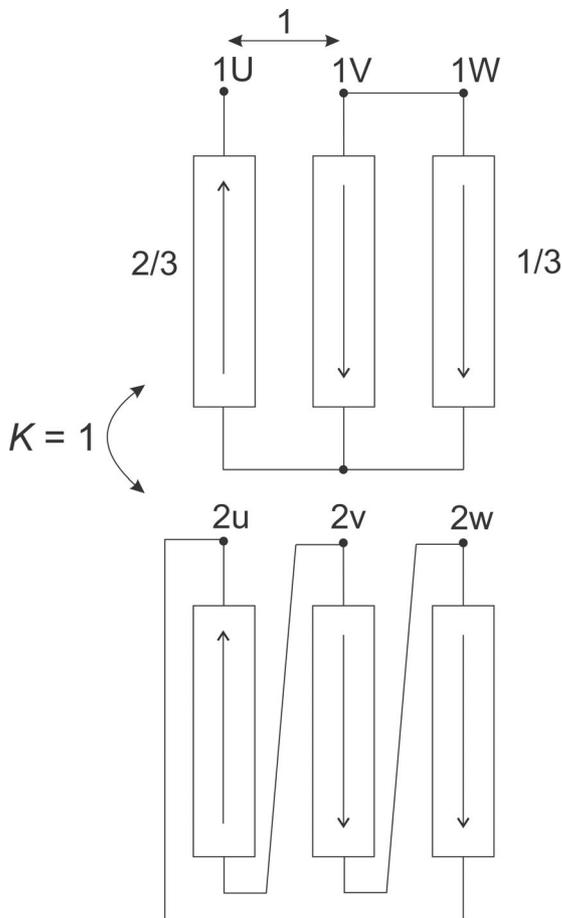
- For the voltage ratio:

$$\rho = \frac{K_b}{\sqrt{1 + \left(\frac{K_b}{K_c}\right)^2 - \frac{K_b}{K_c}}}$$

- For the phase displacement:

$$\tan \alpha = \frac{\sqrt{3} \times \left(1 - \frac{K_b}{K_c}\right)}{\left(1 + \frac{K_b}{K_c}\right)}$$

**Note:** The formulas above are independent of the transformer connections. Refer to the following examples for details.



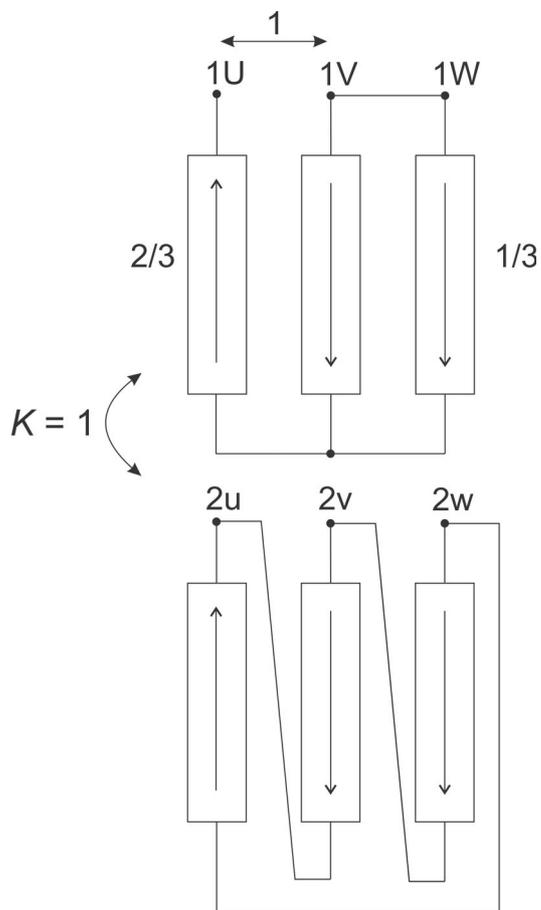
$$K_b = \frac{1U - 1V}{2u - 2v} = \frac{1}{2} = \frac{3}{2}$$

$$K_c = \frac{1U - 1V}{2u - 2w} = \frac{1}{1} = 3$$

$$\tan \alpha = \frac{1.73 \left(1 - \frac{1}{2}\right)}{1 + \frac{1}{2}} = 0.577$$

$$\alpha = 30^\circ$$

Figure 7-9: Example of star-delta connection – vector group 1 (30° lag phase displacement)



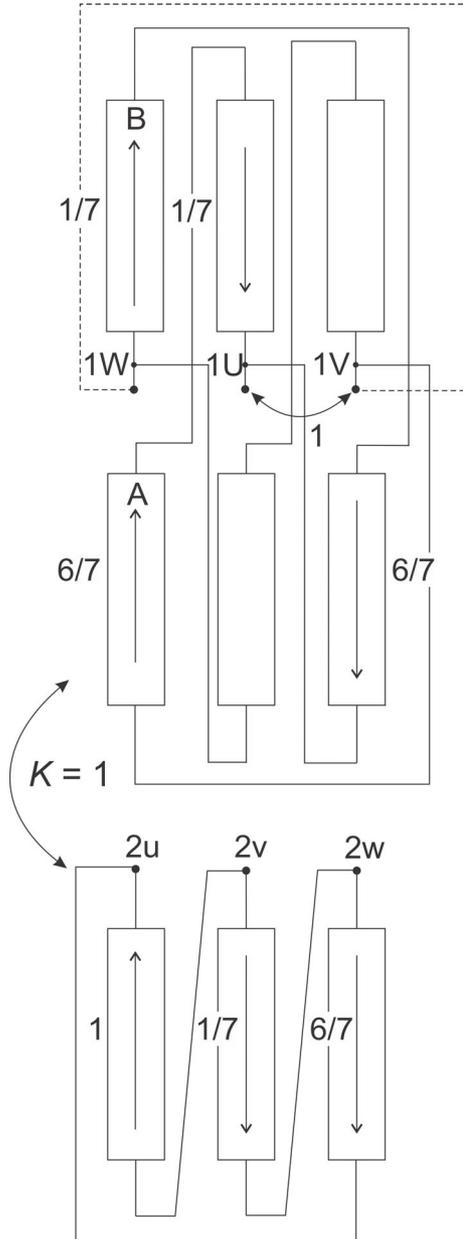
$$K_b = \frac{1U - 1V}{2u - 2v} = \frac{1}{\frac{1}{3}} = 3$$

$$K_c = \frac{1U - 1W}{2u - 2w} = \frac{1}{\frac{2}{3}} = \frac{3}{2}$$

$$\tan \alpha = \frac{1.73(1 - 2)}{1 + 2} = -0.577$$

$$\alpha = -30^\circ$$

Figure 7-10: Example of star-delta connection – vector group 11 (30° lead phase displacement)



$$K_b = \frac{1U - 1V}{2u - 2v} = \frac{1}{1} = 1$$

$$K_c = \frac{1U - 1V}{2u - 2w} = \frac{1}{\frac{6}{7}} = \frac{7}{6}$$

$$\tan \alpha = \frac{1.73(1 - 2)}{1 + \frac{6}{7}} = 0.133$$

$$\alpha = 7.5^\circ$$

Table 7-2: Example of polygon-delta connection – vector group Pd0+7.5 (7.5° lag phase displacement)

In order to obtain the phase displacement of  $7.5^\circ$ , the relation between the modules of the voltage vector A and B is:

$$A = \frac{\sin(60 - 7.5)}{\sin 120} = 0.916$$

$$B = \frac{\sin 7.5}{\sin 120} = 0.151$$

This leads to the following turn ratio between the windings A and B:

$$\frac{A}{B} = \frac{0.916}{0.151} = 6.5$$

In Table we consider the turn ratio to be  $\frac{A}{B} = 6$  and, as a consequence,  $B = \frac{1}{6}$  if  $A = 1$ .

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## 7.3 Vector Group Check

Use the **Vector Group Check** test card 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** (see "Demagnetization" on page 206 of this chapter) to ensure reliable results.
- ▶ To start the **Vector Group Check** enter the test voltage and frequency in the **VG-Check** test card.

**Note:** The **Vector Group Check** test requires a *CP SB1* transformer switch box.

**DANGER**



**Death or severe injury caused by high voltage or current**

During the **Vector Group Check**, the *CPC 100* continuously puts out the set test voltage.

- ▶ Do not touch the *CPC 100*'s outputs and do not touch or unplug any cables.

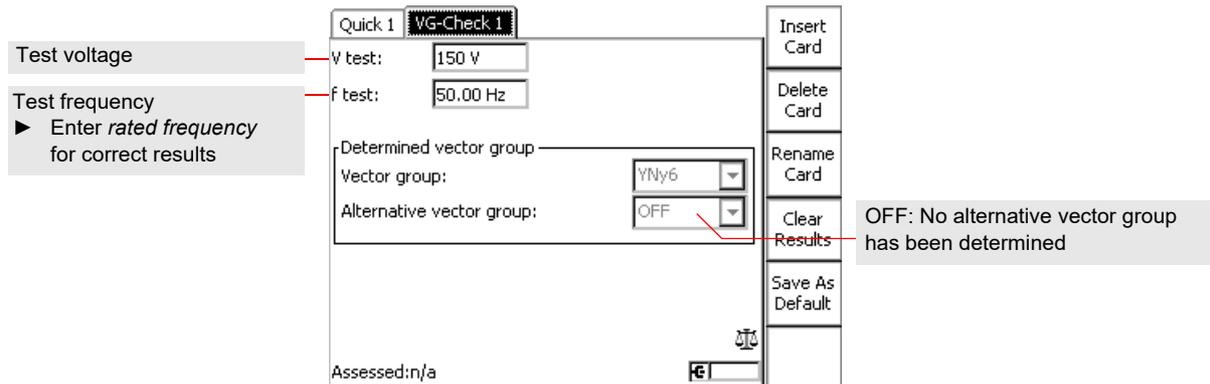


Figure 7-11: **Vector Group Check** test card

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.

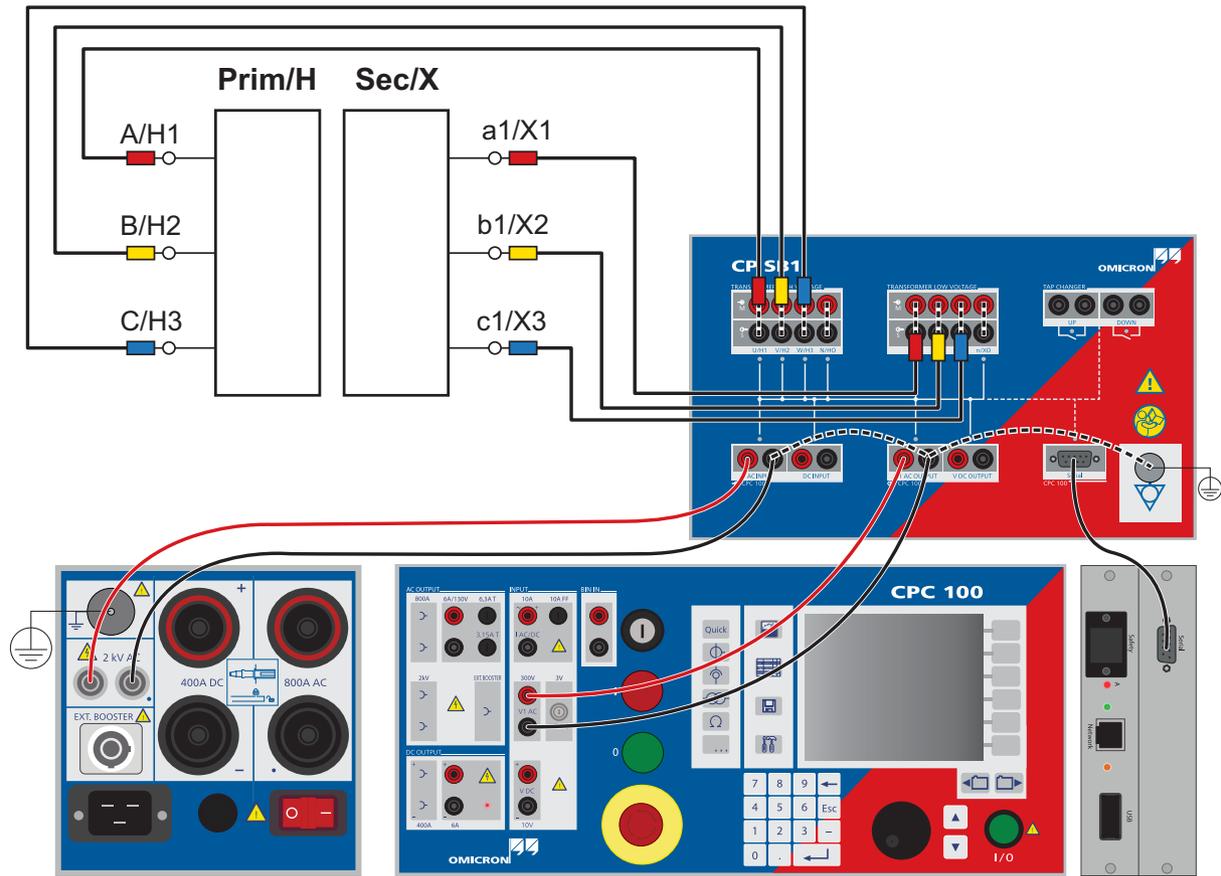


Figure 7-12: Detailed measurement setup and wiring for **Vector Group Check**

## 7.4 Winding Resistance

**Note:** Some test cards are available in more than one test mode. For example, the test card **RWinding** can be selected in CT, Resistance and Transformer.

This is solely related to usability. With regard to functionality, the test card **RWinding** is identical in all test modes.



### DANGER

#### Death or severe injury caused by high voltage or current

Injecting direct current into test objects with inductive characteristics will charge the winding of the test object.

- ▶ Follow instructions below.
- ▶ Refer to chapter 1.10 "DC output to test objects with a high inductance" on page 22.



### DANGER

#### Death or severe injury caused by high voltage or current

- ▶ Never open the measuring circuit while current flows.
- ▶ After a measurement, wait until the test device has discharged completely.
- ▶ Ground all terminals of the test object before touching the test setup.
- ▶ Short-circuit the terminals before disconnecting the test leads.
- ▶ Disconnect cables not used for testing both from the test object and the test device.

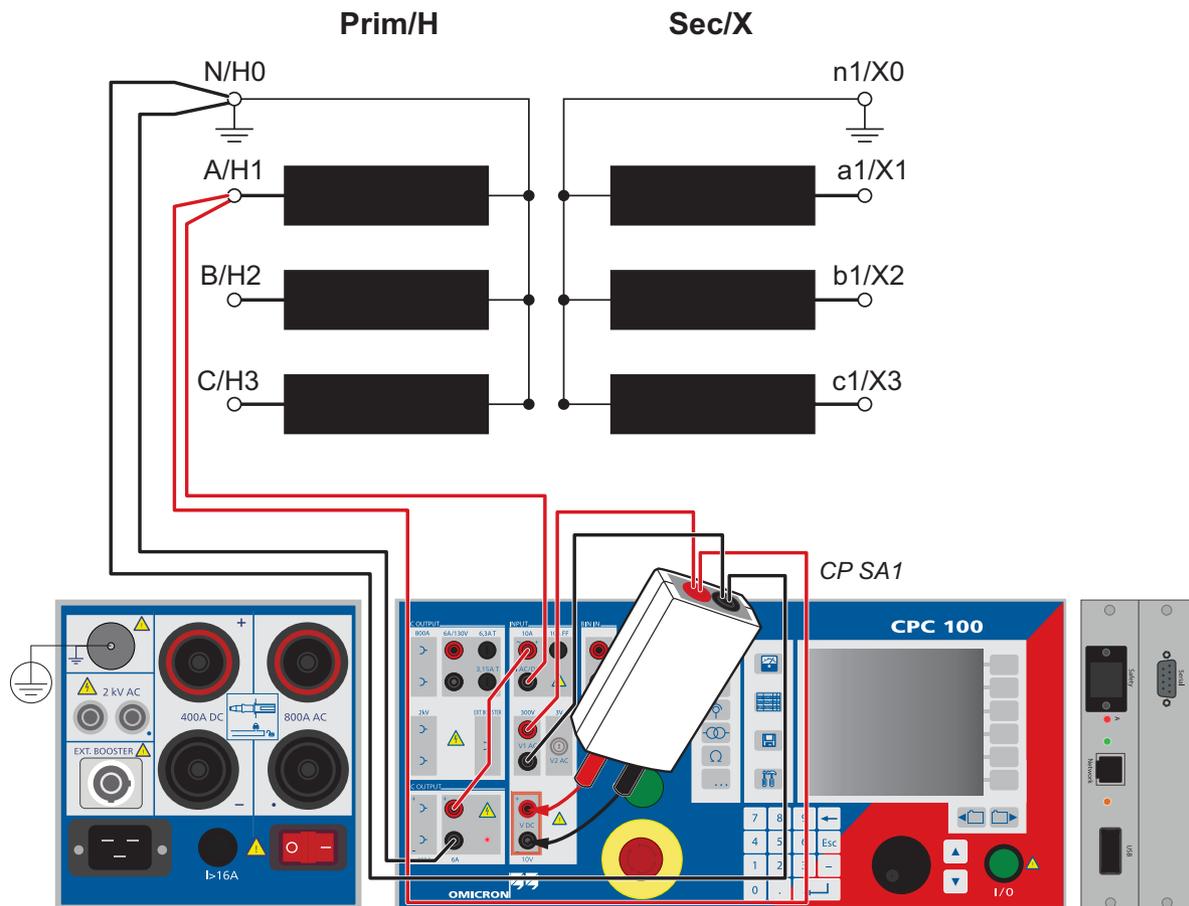


Figure 7-13: Setup of a winding resistance test

Use the **RWinding** test card to measure the resistance of a power transformer's winding. To do so, loop the I DC current signal from the **CPC 100 6A DC** output via **IAC/DC** as shown in Figure 7-14 and inject it into the transformer's winding.

**IAC/DC** measures the injected current, and **V DC** input measures the voltage generated at the transformer's winding. From these values the winding resistance is calculated.

Alternatively, inject the current directly from the **400A DC** output (see Figure 7-14).

#### WARNING



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

We recommend performing all winding resistance measurements with the **CP SA1** connected to the **CPC 100 V DC** input sockets to protect yourself and the **CPC 100** from high-voltage hazards.

► The **CP SA1** *must* be used for measurements using the **400A DC** output.

Before using the *CP SA1*, you can check its functionality by following the test procedure in 16.4 "CP SA1" on page 328. If the *CP SA1* is defective, contact OMICRON.

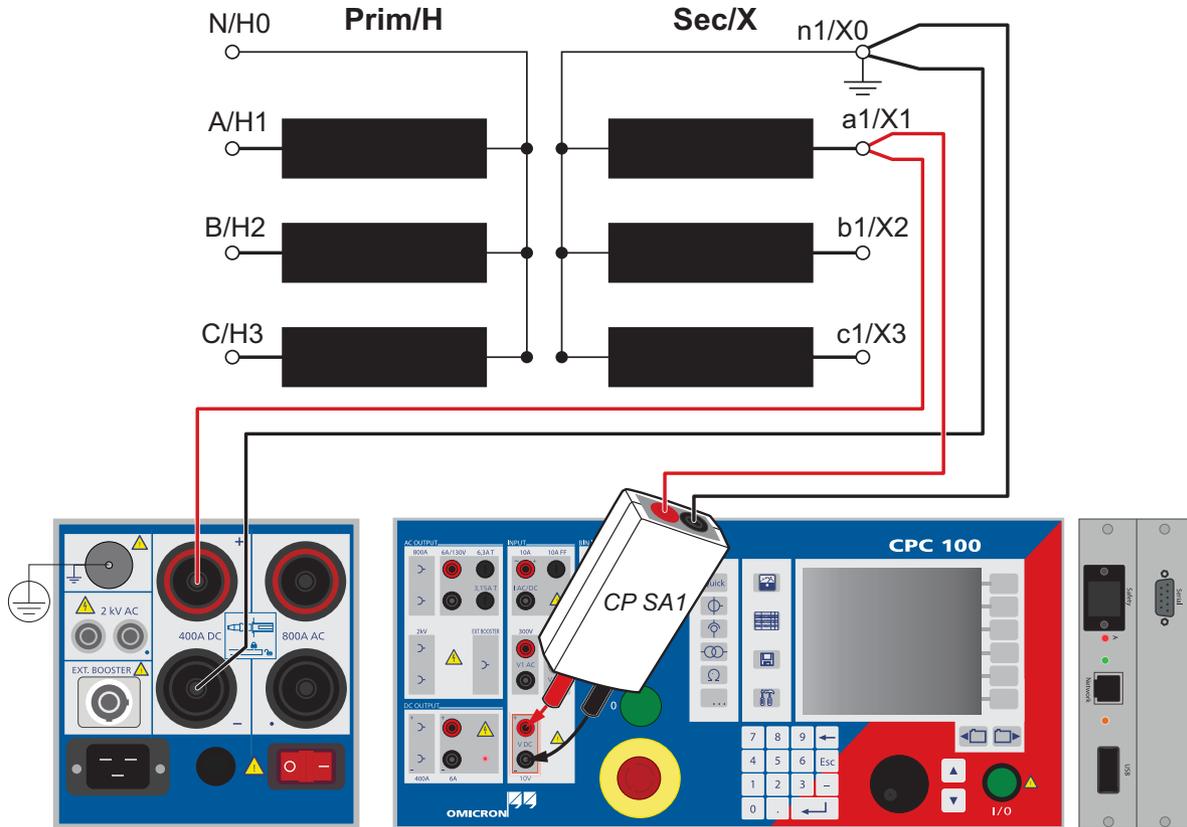


Figure 7-14: Winding resistance test using the **400A DC** output

Due to the significant time span needed for the transformer's inductance to finish its loading process, this test evaluates the deviation of measured values within a time interval of 10 seconds. The winding resistance is continually measured and stored in the *CPC 100* internal memory. The calculated difference between the maximum and minimum measured values in % within the last 10 seconds is displayed.

Furthermore, this test comprises the option to take a temperature compensation for copper (Cu) and Aluminum (Al) into consideration (refer to 5.5.3 "Temperature compensation" on page 109).

## 7.4.1 Test settings

RWinding 1		TRTapCheck 1		RGround 1		Cd		Insert Card	
Range: DC 6A		<input checked="" type="checkbox"/> Auto						Delete Card	
I test: 5.000 A		R min: 40.00 $\mu\Omega$						Rename Card	
I DC: 4.9990 A		R max: 2.0000 $\Omega$						Clear Results	
V DC: 2.5430 V		Dev.: 0.01 %						Save As Default	
R meas.: 508.7 m $\Omega$		Time: 31.000 s						Keep Result	
<input checked="" type="checkbox"/> Temperature compensation for Cu									
T meas.: 25.0 °C									
T ref.: 70.0 °C		R ref.: 596.7 m $\Omega$							
Assessed:n/a									

Figure 7-15: **RWinding** test card with test results

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

<b>Range:</b>	Output range
<b>Note:</b>	The <b>400A DC</b> output range provides maximum current 100 A.
<b>Itest:</b>	Nominal test current
<b>R min:</b>	Calculated minimum winding resistance value (display only). Depends on the value of the nominal test current and the measuring range: 400A DC: $R_{min} = 0.2mV / I_{test}$ 6A DC: $R_{min} = 0.2mV / I_{test}$ V DC (2 wire): $R_{min} = 0.2\Omega$
<b>R max:</b>	Calculated maximum winding resistance value (display only). Depends on the value of the nominal test current and the measuring range: 400A DC: $R_{max} = 5V / I_{test}$ . 6A DC: $R_{max} = 10V / I_{test}$ . V DC (2 wire): $R_{max} = 20k\Omega$

## 7.4.2 Measurements

<b>IDC:</b>	Actual test current from the <b>6A DC</b> output or <b>400A DC</b> output
<b>VDC:</b>	Voltage that IDC generates at the transformer's secondary winding, measured at the <b>V DC</b> input
<b>R meas:</b>	Transformer's winding resistance, calculated from $VDC / IDC$
<b>Time:</b>	Total elapsed test time
<b>Dev:</b>	<p>Deviation in % between the maximum and the minimum measured values evaluated within the last 10 seconds of the measurement. The results are considered stable if <math>Dev &lt; 0.1\%</math>.</p> <p>Press the context-dependent <b>Keep Result</b> menu key to save the actual result in the measurement table. This adds a new line to the measurement table and the next measurement can be started.</p>

- For information about **Temperature compensation**, refer to 5.5.3 "Temperature compensation" on page 109.

## 7.5 OLTC test (per tap)

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 **6A DC** output into the power transformer and the current is led via the **IAC/DC** input for measurement. Alternatively, the current injected from the **400A DC** output is measured internally ( $I_{test}$  is limited to 100 A). From this current value and the voltage measured by the **V DC** input (see Figure 7-17), 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.

The ripple and slope values are indicated at the **TRTapCheck** test card's measurement table (refer to Figure 7-18).

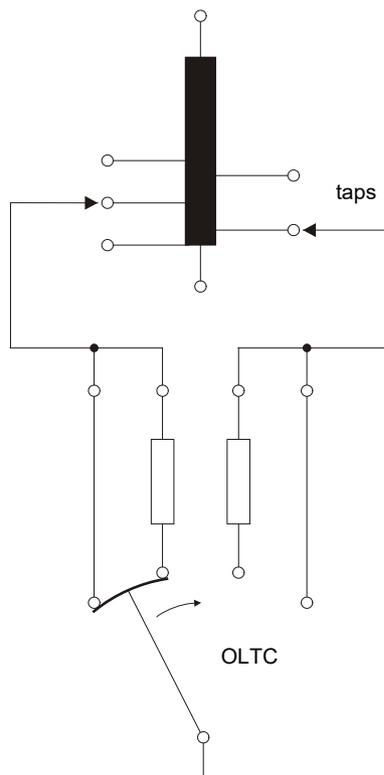


Figure 7-16: Simplified schematic of a tap changer

**WARNING**



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

We recommend performing all winding resistance measurements with the *CP SA1* connected to the *CPC 100 V DC* input sockets to protect yourself and the *CPC 100* from high-voltage hazards.

- ▶ The *CP SA1* must be used for measurements using the **400A DC** output.
- ▶ Before disconnecting the test leads, short-circuit the transformer's terminals first and then remove the wirings to the *CPC 100*.

Before using the *CP SA1*, you can check its functionality by following the test procedure in 16.4 "CP SA1" on page 328. If the *CP SA1* is defective, contact OMICRON sales office (for ordering information, see 16.4.1 "Assembly instructions for Odu MINI-SNAP plug" on page 329).

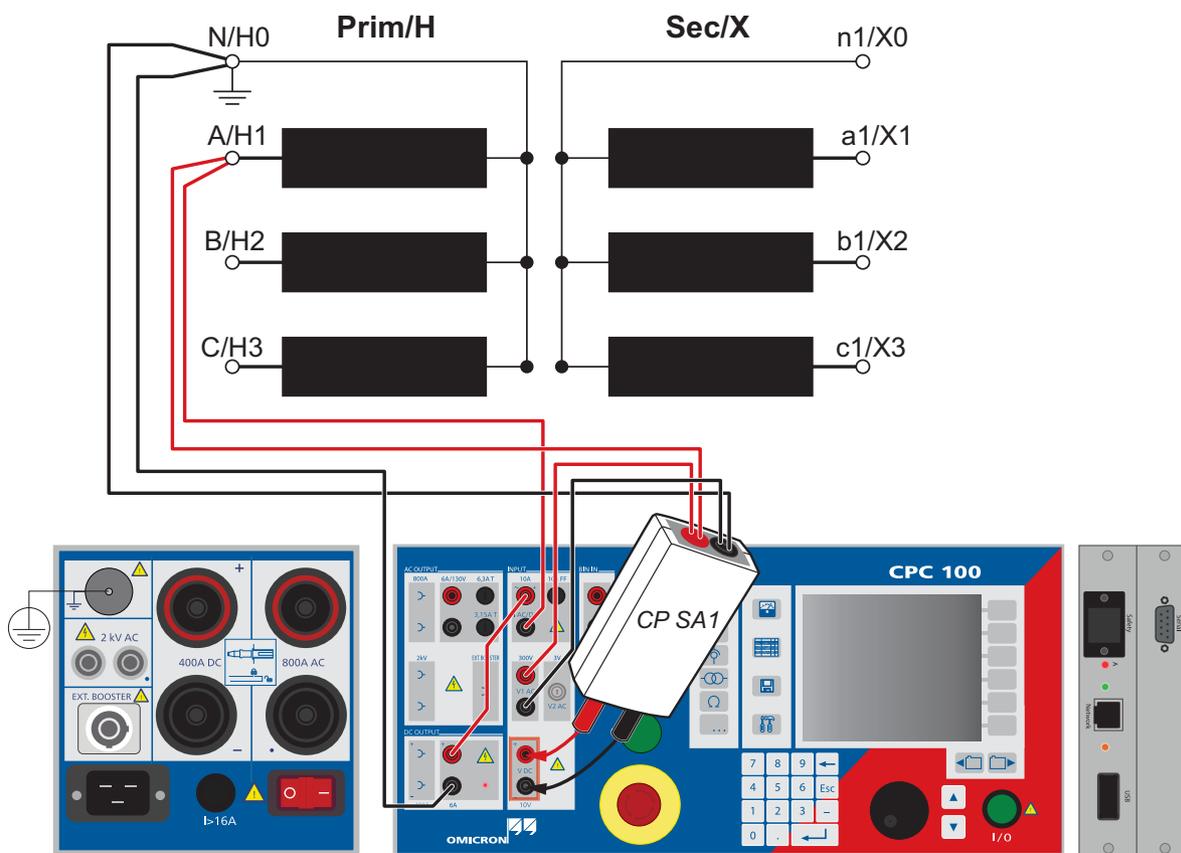


Figure 7-17: Setup for a tap changer test - winding resistance and interruption

**DANGER**



**Death or severe injury caused by high voltage or current**

- ▶ Before disconnecting the test leads, short-circuit and ground the transformer's terminals and then remove the wirings to the *CPC 100*.

## 7.5.1 Test settings

The screenshot shows the TRTapCheck test card interface. At the top, there are three tabs: TRTapCheck 1, TRTapCheck 2 (selected), and TRTapCheck 3. The main area contains several input fields and a table. On the right side, there is a vertical menu with buttons: Insert Card, Delete Card, Rename Card, Clear Results, Save As Default, and Settings.

Settings:

- Range: DC 6A
- Wiring: YN
- I test: 5.000 A
- I DC: 0.0000 A
- V DC: 0.0000 V
- Auto-tap:
- Auto Result:
  - Tolerance: 0.1 %
  - $\Delta t$ : 10.0 s

Tap	R meas.	Dev.	R ref.	Ripple	Slope
	$\Omega$	%	$\Omega$	%	A/s
001	71.67m	n/a	85.45m	n/a	n/a
002	74.05m	n/a	88.29m	96.280-691.5m	

Assessed: n/a

Figure 7-18: TRTapCheck test card with test results

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

**Range:** Output range

**Note:** The **400A DC** output range provides maximum current 100 A.

**Itest:** Nominal test current

- Wiring:**
- **D, Y, YN:** for measurements on the high-voltage side
  - **d, y, yn, z, zn:** for measurements on the low-voltage side

The measurement is performed where the tap changer is mounted.

- **manual:** manual wiring to the *CP SB1* for special measurements

The **Wiring** settings are only relevant if the *CP SB1* is connected. Otherwise, they are for information purposes. The wiring information can be displayed via the **Wiring Info** key.

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.

**Tolerance:** Tolerance of the deviation in percent. This setting refers to the **Auto Keep Result** function.

**$\Delta t$ :** Settling time. This setting refers to the **Auto Keep Result** function.

 Pressing the **Settings** menu key or activating the Auto-tap operation mode (with connected *CP SB1* unit) will open the second page of the **TRTapCheck** test card.

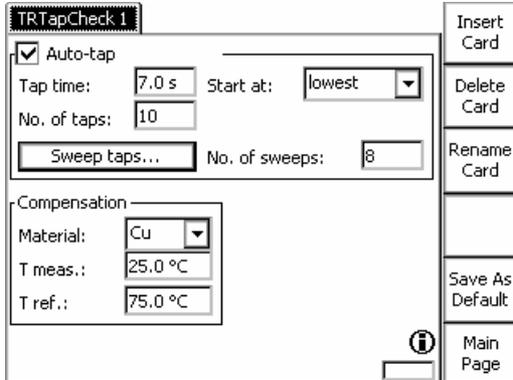


Figure 7-19: Settings page of the **TRTapCheck** test card

<b>Tmeas:</b>	Actual specimen temperature
<b>Tref:</b>	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.  The winding resistance value at this temperature always represents the nominal resistance value.
<b>Tap time, Start at, No. of taps:</b>	These settings are only available with the <i>CP SB1</i> connected. For further information refer to the <i>CP SB1</i> User Manual.

## 7.5.2 Measurements

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

<b>IDC:</b>	Actual test current from the <b>6A DC</b> output measured at the <b>IAC/DC</b> input or from the <b>400A DC</b> output measured internally
<b>VDC:</b>	Voltage measured at the 10V DC input
<b>Tap (in table):</b>	Displays the transformer tap identifier and tap number for the measurements in the respective line of the table.
<b>Rmeas:</b>	Actual resistance, calculated from VDC / IDC
<b>Dev. in %:</b>	Deviation in % between the maximum and the minimum measured values evaluated within the settling time ( $\Delta t$ ).
<b>Rref:</b>	Temperature-corrected resistance value, that is, the resistance value at an actual specimen temperature of Tref.
<b>Ripple:</b>	Samples and holds the biggest measured current ripple that occurred in the measuring cycle. It is indicated in % with reference to IDC.
<b>Slope:</b>	Samples and holds the biggest measured steepness of the falling edge of the actual test current that occurred in the measuring cycle.

### 7.5.3 Examples using the TRTapCheck test card

Press the context-dependent **Keep Result** or **Auto Keep Result** menu keys to save the actual result in the measurement table. 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 ( $\Delta t$ ) 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 context-dependent menu key **Set Current Deviation** resumes the value of the current deviation in the **Tolerance** field.

#### Measuring the winding resistance of the taps

We recommend injecting the same current value for each phase.

#### DANGER



#### Death or severe injury caused by high voltage or current

Injecting direct current into test objects with inductive characteristics will charge the winding of the test object.

- ▶ Follow instructions below.
- ▶ Refer to chapter 1.10 "DC output to test objects with a high inductance" on page 22.

#### DANGER



#### Death or severe injury caused by high voltage or current

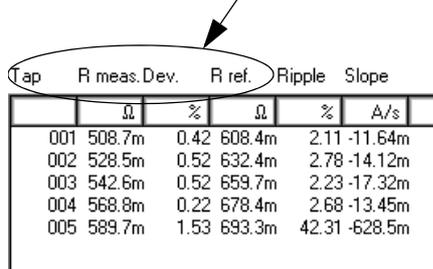
- ▶ Never open the measuring circuit while current flows.
- ▶ After a measurement, wait until the test device has discharged completely.
- ▶ Ground all terminals of the test object before touching the test setup.
- ▶ Short-circuit the terminals before disconnecting the test leads.
- ▶ Disconnect cables not used for testing both from the test object and the test device.

To perform a test:

1. Press the I/O (test start/stop) push button to start the test.
2. 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  $\Delta t$  are achieved. After then, a new result line is added showing the number of the next measured tap.
3. Move to the next position on the tap changer.
4. Repeat steps 2 and 3 for all taps you want to measure.

5. Press the I/O (test start/stop) push button to stop the test and wait until the transformer windings are discharged.

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	%		
001	508.7m	0.42	608.4m	2.11	-11.64m	
002	528.5m	0.52	632.4m	2.78	-14.12m	
003	542.6m	0.52	659.7m	2.23	-17.32m	
004	568.8m	0.22	678.4m	2.68	-13.45m	
005	589.7m	1.53	693.3m	42.31	-628.5m	

Figure 7-20: Measurement table - relevant columns for winding resistance measurement

### Editing the tap number during or after a test

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

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.

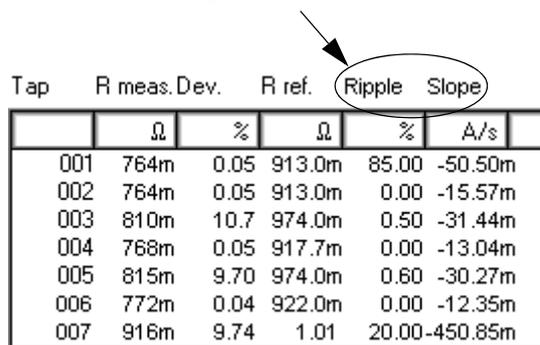


### Tap changer test and measuring the winding resistance

When testing a tap changer, we recommend:

- Injecting the same current value for each phase.
- Performing tests of each phase, start with the lowest tap through to the highest and continue backwards down to the lowest tap again. Taps 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	%		
001	764m	0.05	913.0m	85.00	-50.50m	
002	764m	0.05	913.0m	0.00	-15.57m	
003	810m	10.7	974.0m	0.50	-31.44m	
004	768m	0.05	917.7m	0.00	-13.04m	
005	815m	9.70	974.0m	0.60	-30.27m	
006	772m	0.04	922.0m	0.00	-12.35m	
007	916m	9.74	1.01	20.00	-450.85m	

Figure 7-21: Measurement table with results of tap changer and winding resistance test

### 7.5.4 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.

**Note:** The **Tap Changer Cleaner Sequence** can only be activated if the *CP SB1* transformer switchbox is connected and **Auto-tap** is selected.

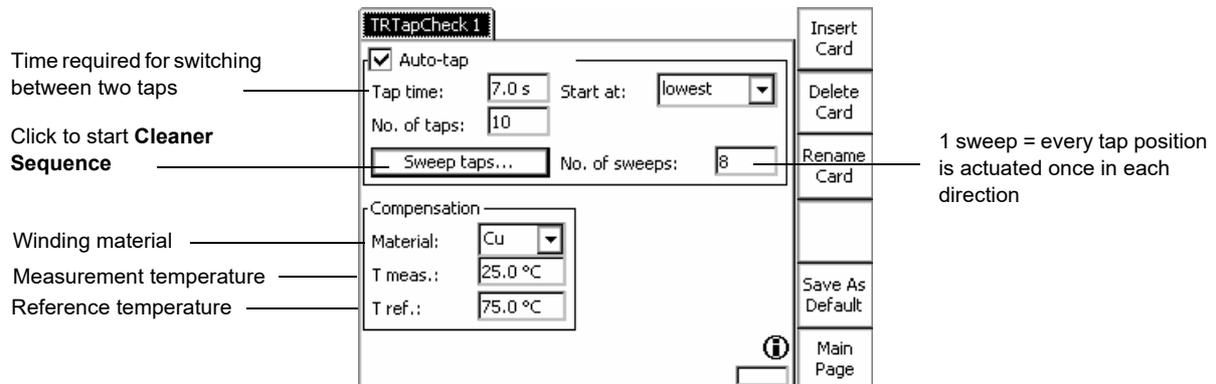


Figure 7-22: TRTapCheck test card with **Tap Changer Cleaner Sequence**

The currently swept tap and the remaining time are displayed during the sequence:

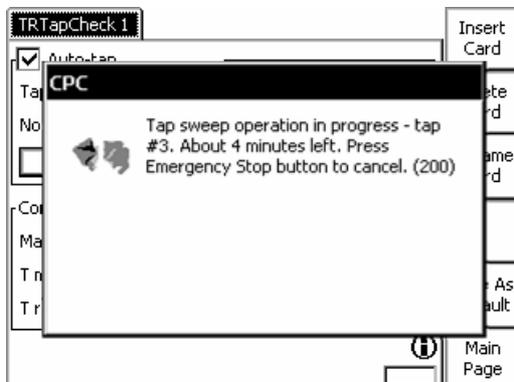


Figure 7-23: **Tap Changer Cleaner Sequence** progress dialog

**Note:** You can only interrupt the **Tap Changer Cleaner Sequence** by pressing the **Emergency Switching off** button.

## 7.6 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.

**Note:** The *CPC 100 Dynamic OLTC-Scan* requires a *CP SB1* transformer switch box.



### DANGER

#### Death or severe injury caused by high voltage or current

Injecting direct current into test objects with inductive characteristics will charge the winding of the test object.

- ▶ Follow instructions below.
- ▶ Refer to chapter 1.10 "DC output to test objects with a high inductance" on page 22.



### DANGER

#### Death or severe injury caused by high voltage or current

- ▶ Never open the measuring circuit while current flows.
- ▶ After a measurement, wait until the test device has discharged completely.
- ▶ Ground all terminals of the test object before touching the test setup.
- ▶ Short-circuit the terminals before disconnecting the test leads.
- ▶ Disconnect cables not used for testing both from the test object and the test device.

Refer to the following diagram for correct wiring:

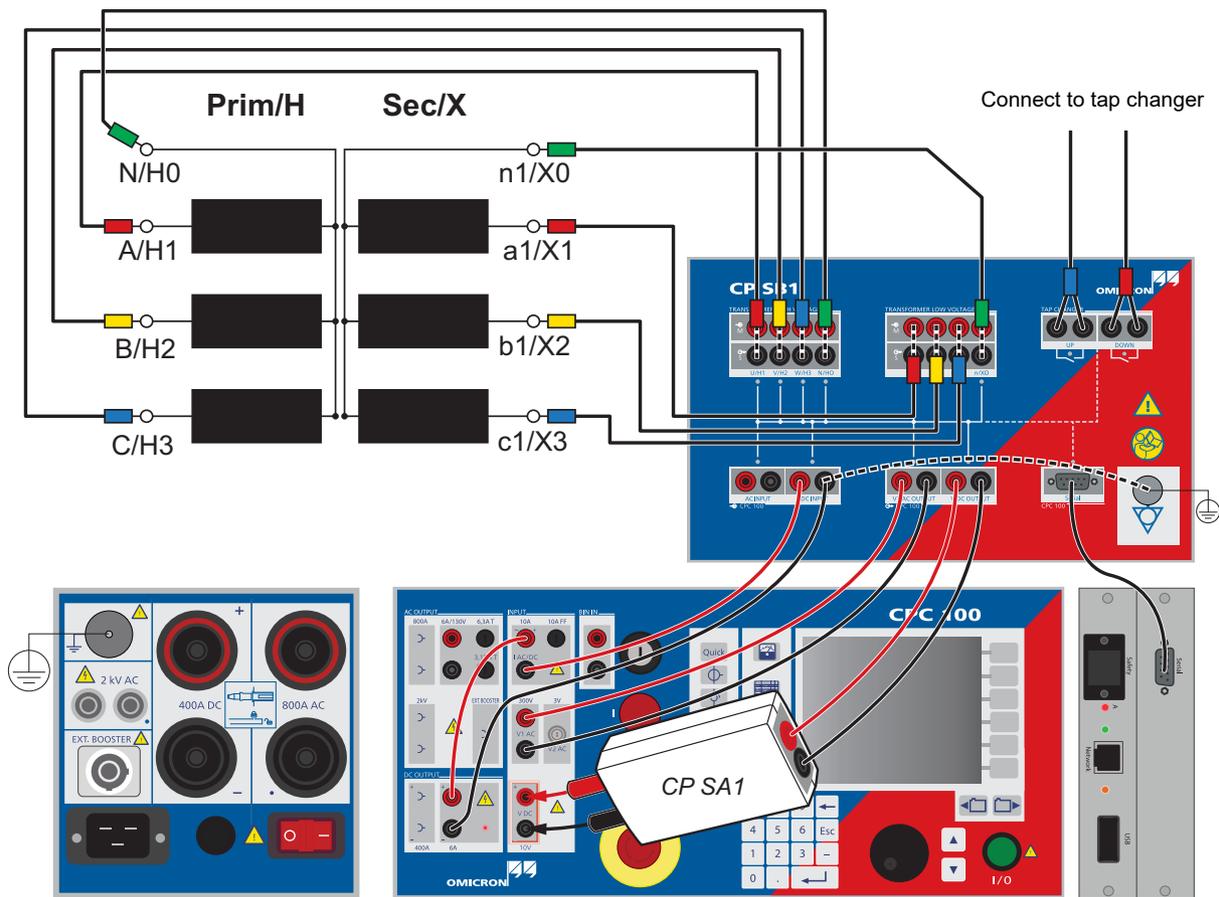
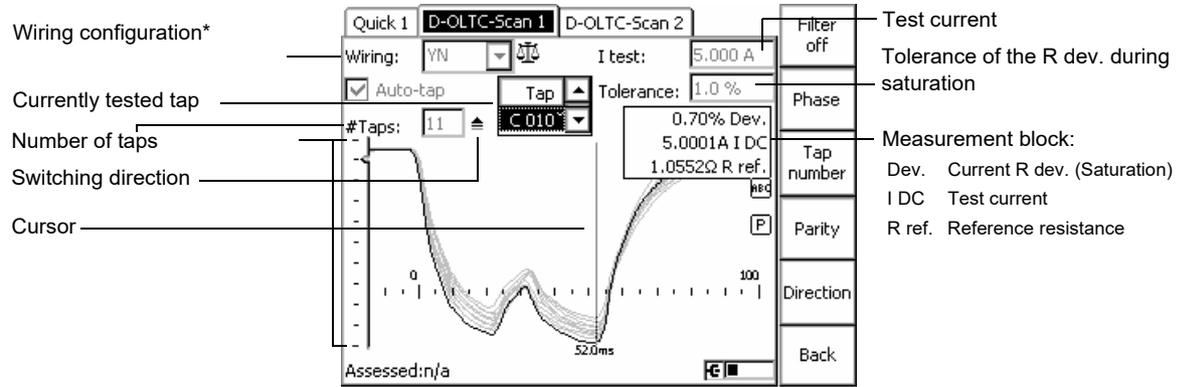


Figure 7-24: Detailed measurement setup and wiring for the Dynamic OLTC-Scan

- ▶ 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 7-25: Dynamic OLTC-Scan test card

### Status icons

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.

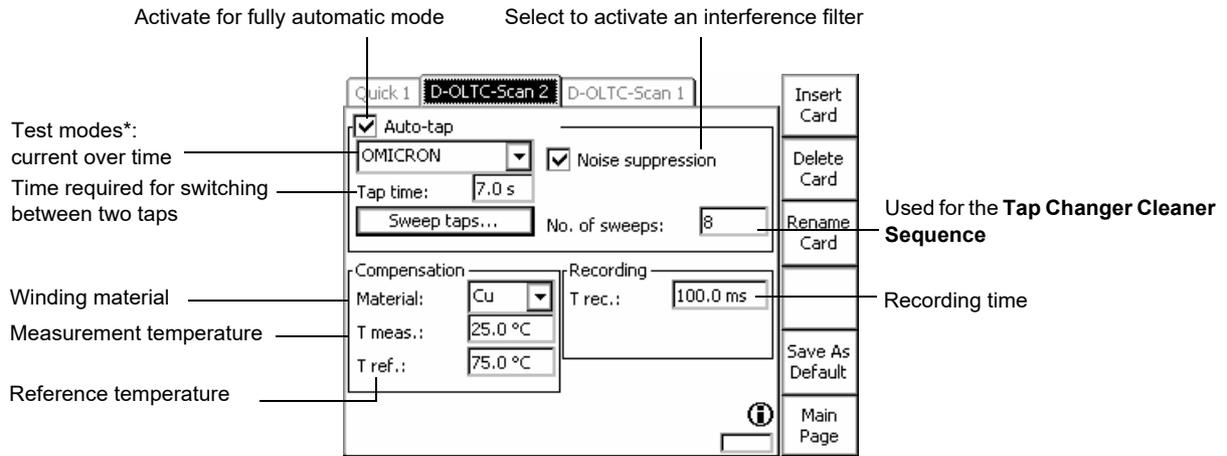
### Available menu keys

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:



\* **Basic:** standard test without dynamic LV shorting

**OMICRON: Basic** mode expanded by dynamic shorting of the transformer's LV side for increased sensitivity

Figure 7-26: Dynamic OLTC-Scan Settings page

### 7.6.1 General: On-load tap changer testing

Winding resistances are tested in the field to check for loose connections, broken strands and high contact resistance in tap changers. Additionally, the dynamic resistance measurement enables an analysis of the transient switching operation of the diverter switch.

For a better understanding of the resistance measurements, it is necessary to understand the method of operation of the tap changer.

In most cases, the tap changer consists of two units. The first unit is the tap selector, which is directly located inside the transformer tank and switches to the next higher or lower tap without carrying current. The second unit is the diverter switch, which switches without any interruption from one tap to the next while carrying load current. The commutation resistances R limit the short circuit current between the taps which could otherwise become very high due to the interruption-free switching of the contacts. The switching process between two taps takes approximately 40 - 80 ms.

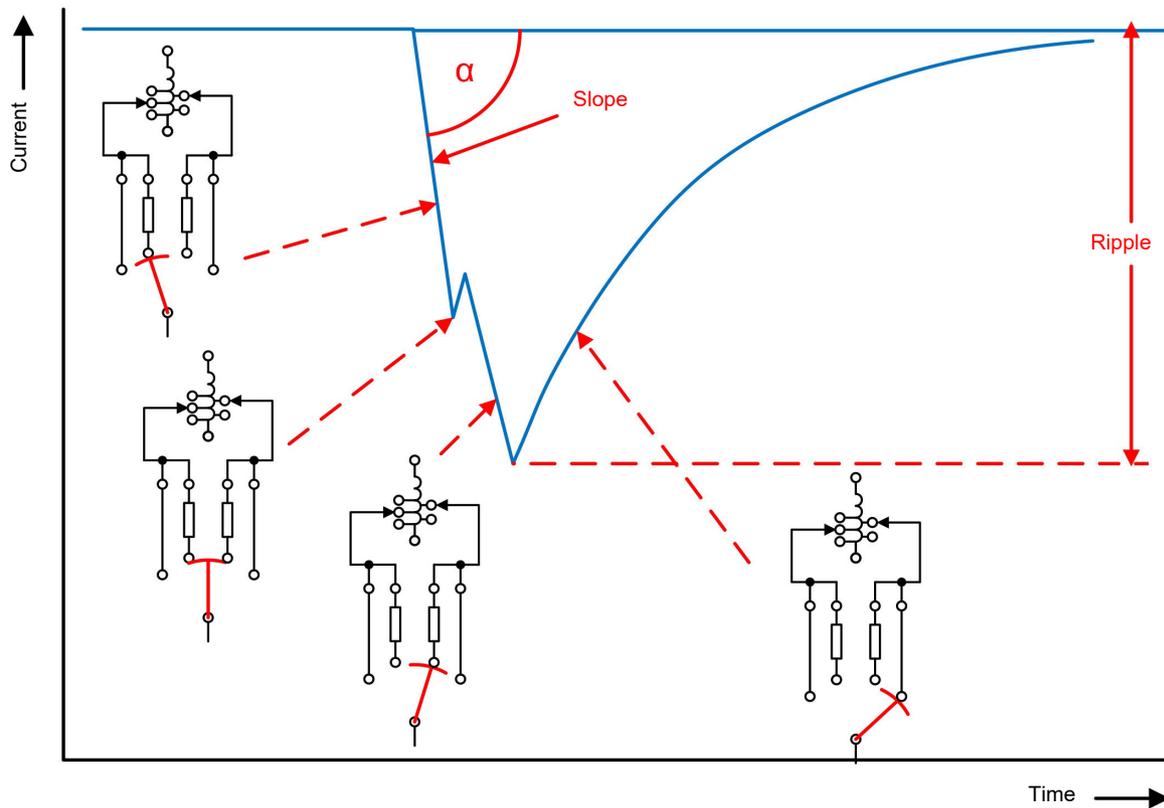


Figure 7-27: Tap changer switching cycle with curve illustrating the movement

## 7.7 Voltage Withstand test

**Note:** Some test cards are available in more than one test mode. For example, the test card **VWithstand** can be selected in CT, VT, Resistance and Transformer.

This is solely related to usability. With regard to functionality, the test card **VWithstand** is identical in all test modes.

Use the test card **VWithstand** to measure the voltage withstand capability of the secondary winding and secondary wiring.

As shown in Figure 7-28, connect the 2kV output socket without point to the transformer's secondary (a) winding connection, and the output socket marked with a point to earth and the transformer's primary connection (A).

### DANGER



**Death or severe injury caused by high voltage or current**

- ▶ Be aware that all terminals of the transformer may carry dangerous voltages on the high-voltage side.

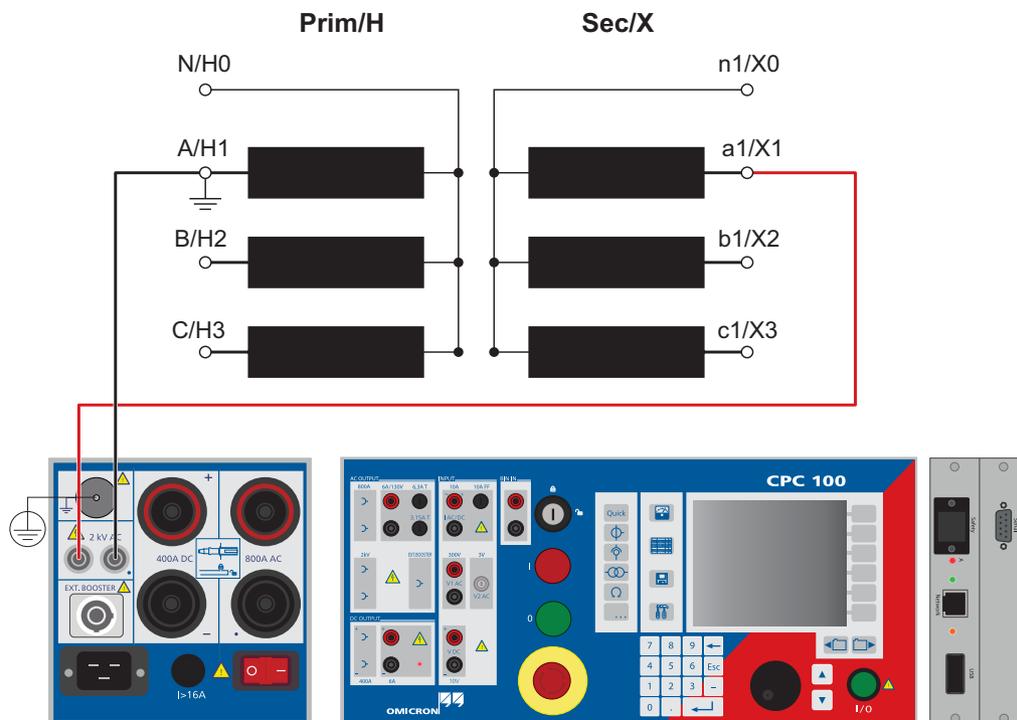


Figure 7-28: Setup for a power transformer voltage withstand test

### 7.7.1 Test settings

For Test settings and Measurements see also 5.6 "Voltage Withstand test" on page 110.

## 7.8 Demagnetization

Use the **Demag** test card to demagnetize the transformer core. Magnetized transformers may easily saturate and draw an excessive inrush current upon energization. Since the forces on the windings due to high inrush current may cause damage or even breakdown, it is desirable to avoid them.

The *CPC 100 Demag* process requires a *CP SB1* transformer switch box. The wiring is the same as for a standard resistance test plus a connection of the **V1** input to the switch box.

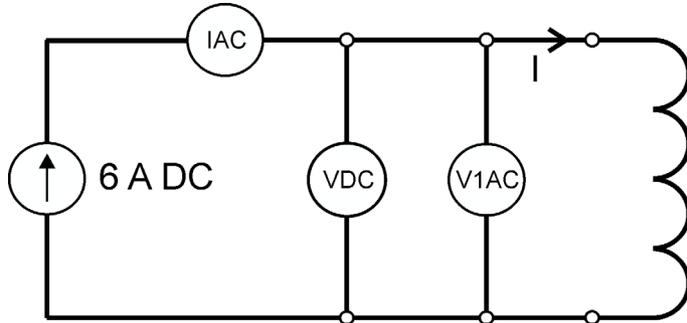


Figure 7-29: Simplified **Demag** setup: *CPC 100* and transformer

Via the switch box, the *CPC 100* injects a constant current from the **6A DC** output into the power transformer. The current is led through the **I AC / DC** input for measurement.

Before the actual **Demag** cycle, the *CPC 100* will perform a wiring check. Incorrect wiring will prompt an error message.

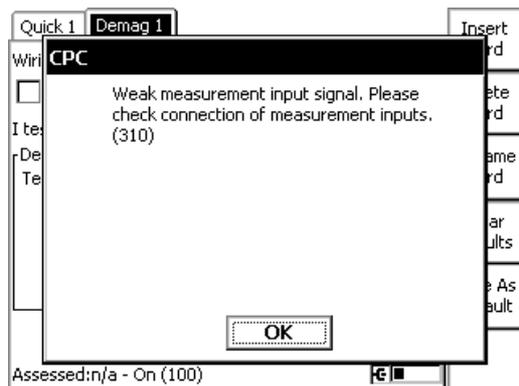


Figure 7-30: Example of a wiring error message



In the **Demag** test card you need to:

- ▶ enter the vector group of the transformer,
- ▶ specify whether the test object is a single-phase transformer, and
- ▶ enter the test current.

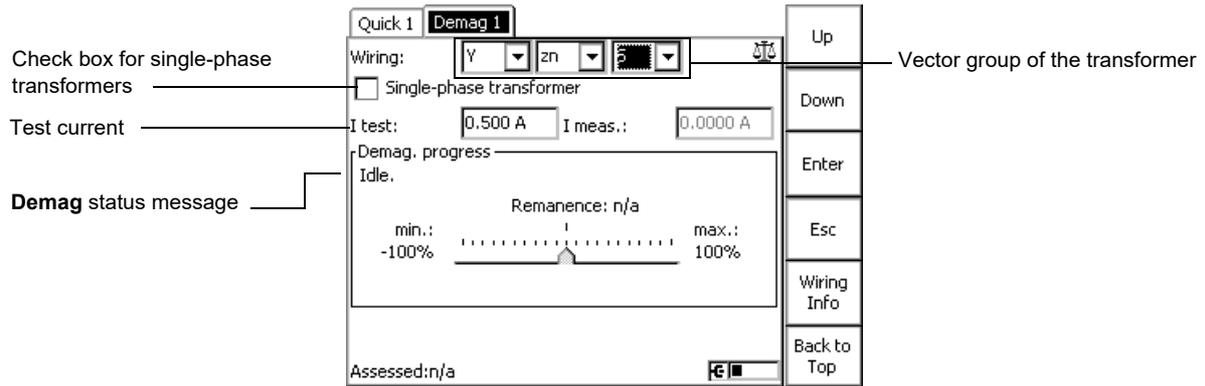


Figure 7-32: **Demag** test card before the test is started

The test current should not exceed a value of between 10 and 15 percent of the transformer’s nominal current.

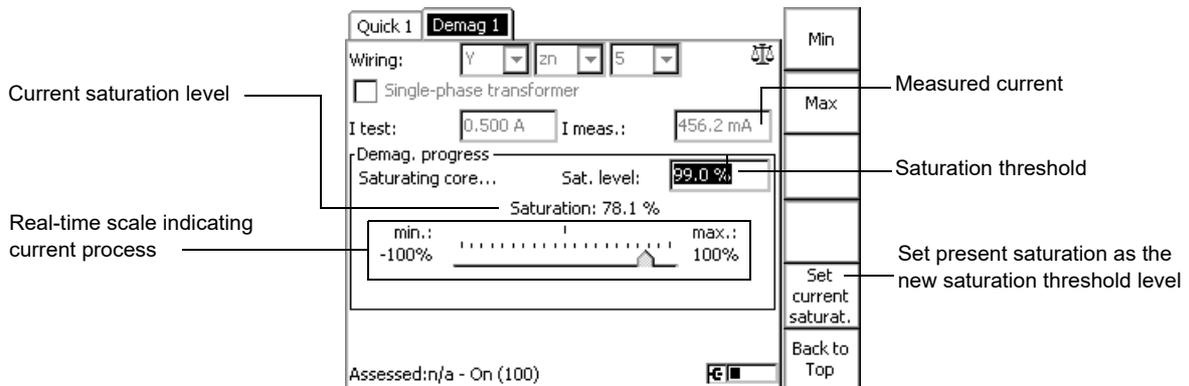


Figure 7-33: **Demag** test card during the test

In the first step during the demagnetization process, the transformer core is saturated. This is visualized in real time by the indicator in the center of the test card. The saturation process stops at predefined thresholds. If a threshold is not reached over a long period of time, the saturation level can be adapted manually. By pressing the **Set current saturat.** key, the present saturation level can be determined as the new threshold.

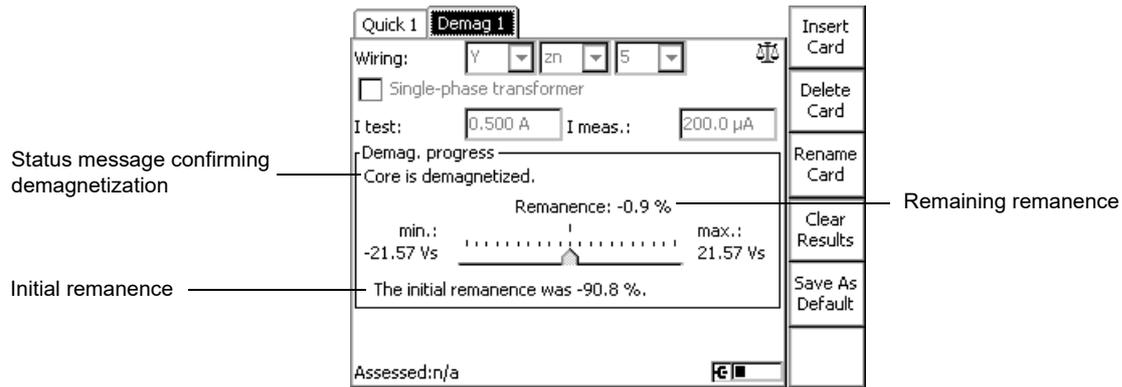


Figure 7-34: **Demag** test card after the test

During the **Demag** cycle, the initial remanence is detected and the currently remaining remanence is constantly displayed. After the test, the core is demagnetized.

The table below contains the various status messages:

Wiring check...	Checking for correct wiring
Idle.	Displayed before the process is started
Test was canceled.	Displayed after pressing the <b>Emergency Switching off</b> 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.	<b>Demag</b> cycle has been successful

The relationship between the applied magnetic field strength (H), which is a function of the injected current, and the induced magnetic flux density (B) is visualized by the hysteresis loop. It is generated by measuring the magnetic flux of a ferromagnetic material while the magnetic field strength is changed.

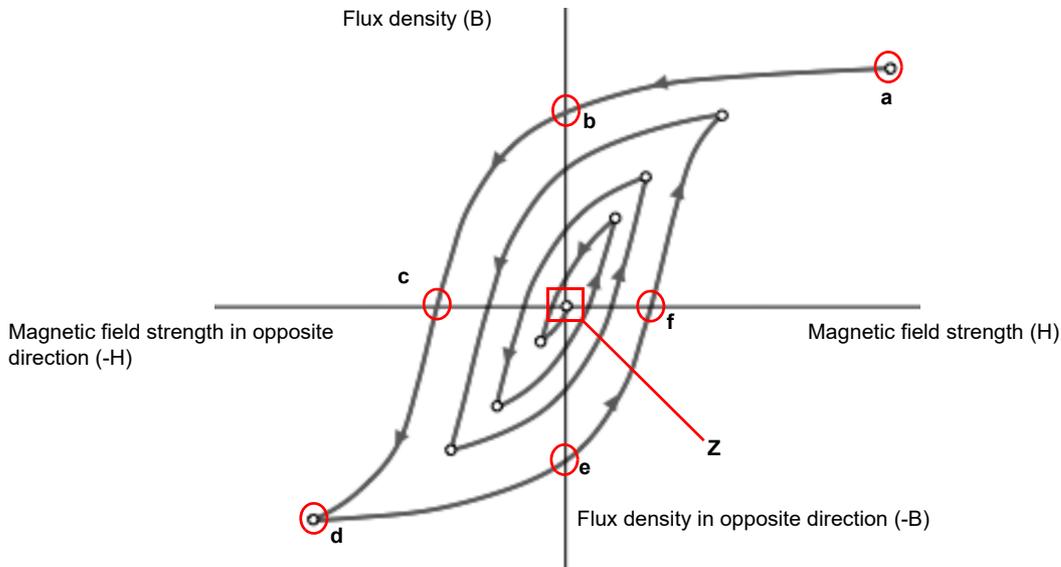


Figure 7-35: Example of a hysteresis loop visualizing the demagnetization process

**B** and **H** are applied to saturate the core in the positive and negative direction. During the demagnetization process, the remanence follows the line of the hysteresis loop. In the first two steps (towards points **a** and **b**), the transformer core is saturated to reach a threshold close to 100 % (see "The test current should not exceed a value of between 10 and 15 percent of the transformer's nominal current." on page 208). While **b** and **e** mark the remanent flux density, **c** and **f** designate the coercive field strength.

The effect of the *CPC 100 Demag* test card is to reduce the remanence and achieve a value close to zero (**Z**).

## 7.9 TanDelta - PF

The test card **TanDelta - PF** was especially developed for the *CP TD*.

The *CP TD* (*CP TD1*, *CP TD12* or *CP TD15*) is an optionally available high-precision test system for on-site insulation tests of high-voltage systems like power and measuring transformers, circuit breakers, capacitors and isolators. The *CP TD* works as an add-on device to the *CPC 100* and is described in the *CP TD1* and *CP TD12/15* User Manuals on the *Primary Test Manager* DVD and the *CPC 100 Start Page*.

The **TanDelta - PF** test card can be accessed from CT, VT, Transformer and Others.

## 8 Resistance

**Note:** With regard to software handling, this section confines to test-relevant issues, and does not go into detailed procedural descriptions.

It is assumed that you have read and understood the section 2.4 "How to use the CPC 100 software" on page 40

### 8.1 Scope of resistance tests



Go to the Test Card View and press **Insert Card**.

Use the context-dependent **Up/Down** menu keys to the right, or the handwheel, to browse through the structure. On Resistance, press **Enter**.



Alternatively, press the accelerator key to open **Insert a new test card**.

Resistance comprises the following test cards:

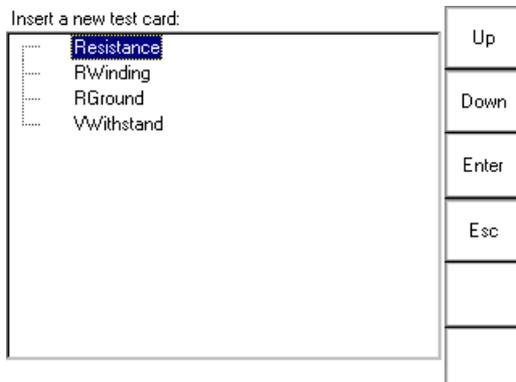


Figure 8-1: Inserting **Resistance** test cards

Highlight the test card of your choice either by navigating with the handwheel or by using the context-dependent **Up/Down** menu keys, and press **Enter**.

## 8.2 Resistance - $\mu\Omega$ measurement

Use the **Resistance** test card to measure test objects with very low resistance, such as contacts.

To do so, the *CPC 100* injects DC current into the test object, measures the current that flows through the test object, and calculates the test object's resistance.

### DANGER



#### Death or severe injury caused by high voltage or current

- ▶ Do not use the Resistance test card to measure the resistance of inductive test objects such as windings. Turning off the DC source results in life-threatening voltage levels. There is no discharge functionality when using the Resistance test card.
- ▶ For this kind of measurement only use the special winding resistance test cards **RWinding**, **TRTapCheck** or **OLTC-Scan**.

The **Resistance** test card provides a total of three output ranges:

400A DC	Range: <input type="text" value="400A DC"/>
	I test: <input type="text" value="300.0 A"/>
6A DC	Range: <input type="text" value="6A DC"/>
	I test: <input type="text" value="5.000 A"/>
V DC (2 wire)	Range: <input type="text" value="V DC (2 wire)"/>
	I test: <input type="text" value="n/a"/>

The test setup depends on the selected range:

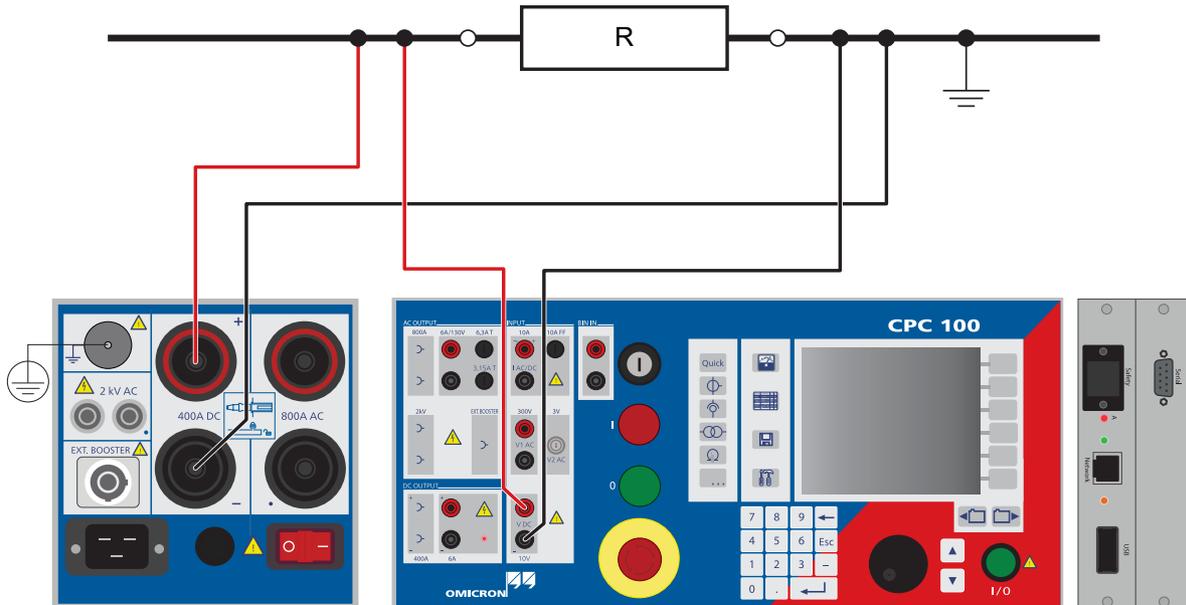


Figure 8-2: Setup for a  $\mu\Omega$  measurement in the 400A DC range

Inject current from the **400A DC** output to both sides of the test object. Input **V DC** measures the voltage drop at the test object, the current is measured internally by the *CPC 100*, and from these values the software calculates the test object's resistance.

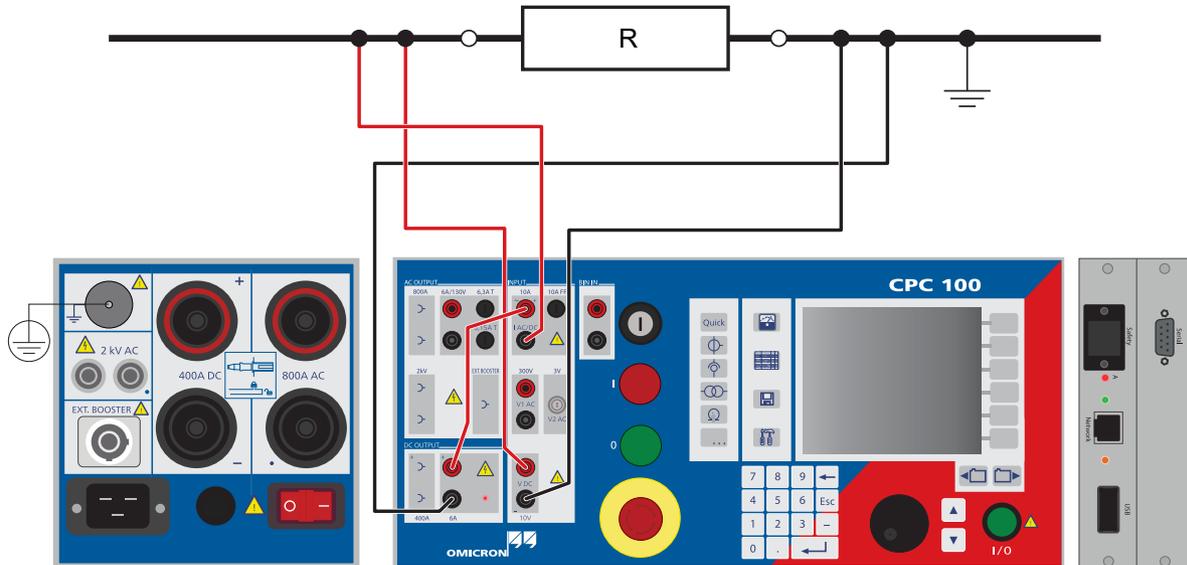


Figure 8-3: Setup for a  $m\Omega$  measurement in the 6A DC range

Inject current from the **6A DC** output to both sides of the test object. To measure this current, route it via the **IAC/DC** input as shown in Figure 8-3. Input **V DC** measures the voltage drop at the test object, and from these values the software calculates the test object's resistance.

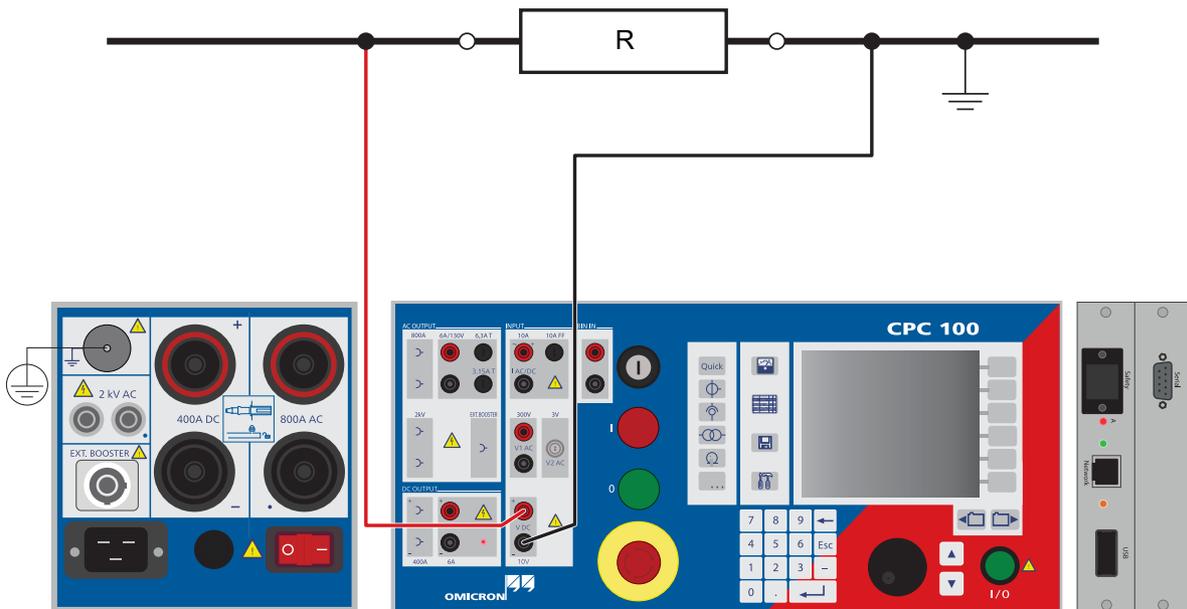


Figure 8-4: Setup for a  $\Omega$  ... $k\Omega$  measurement in the VDC (2 wire) range

At this range, the DC input **V DC** works as a combination of DC output and DC measuring input, that is, it injects current to both sides of the test object, measures this current internally, and also measures the voltage drop at the test object at the same time. The software calculates the test object's resistance.

### 8.2.1 Test settings

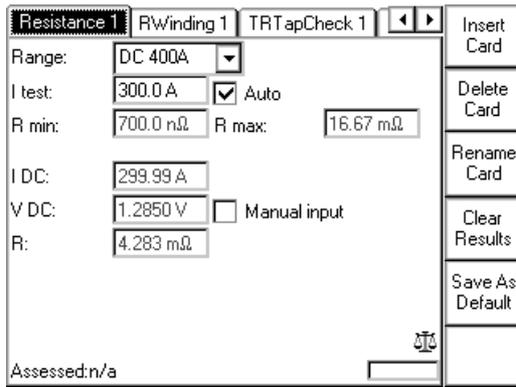


Figure 8-5: **Resistance** test card in 400A DC range with test results.

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

<b>Range:</b>	output range
<b>Itest:</b>	nominal test current ("n/a" if VDC 2-wire)
<b>Rmin:</b>	calculated minimum winding resistance value (display only). Depends on the value of the nominal test current and the measuring range: 400A DC: $R_{min} = 0.2mV / I_{test}$ 6A DC: $R_{min} = 0.2mV / I_{test}$ V DC (2 wire): $R_{min} = 0.2\Omega$
<b>Rmax:</b>	calculated maximum winding resistance value (display only). Depends on the value of the nominal test current and the measuring range: 400A DC: $R_{max} = 5V / I_{test}$ . 6A DC: $R_{max} = 10V / I_{test}$ . V DC (2 wire): $R_{max} = 20k\Omega$
<b>Auto:</b>	select check box for automatic test (default), clear for manual test (refer to section 8.2.3 on page 215).

## 8.2.2 Measurements

<b>IDC:</b>	actual test current that is injected into the test object
<b>VDC:</b>	measured voltage drop at the test object
<b>R:</b>	calculated resistance of test object, $R = VDC / IDC$

Selecting the check box **Manual input** lets you enter the value for VDC manually, for example, when VDC was measured with an external volt meter rather than at input **V DC**.

**Note:** "Manual Input" cannot be selected at the range VDC (2 wire).

## 8.2.3 Automatic test vs. manual test

### 1. Option "Manual input" clear

#### Automatic test

- ▶ Press the I/O (test start/stop) push-button to start the test.
- ▶ The test current increases from 0A to I<sub>test</sub> in a ramp characteristic within 1 second. Then I<sub>test</sub> is kept for a period of 1 second, and the measurements are taken. Next, the ramp decreases again within 1 second.
- ▶ The automatic test stops by itself, it can now be assessed.
- ▶ To repeat the test, first press **Back to Top**, if applicable, and then **Clear Results**.

#### Manual test

Clearing **Auto** lets you set the test current I<sub>test</sub> manually with the handwheel.

- ▶ Press the I/O (test start/stop) push-button to start the test. The focus is set onto the "I test:" entry field.
- ▶ Set the value of your choice either by turning the handwheel and/or by entering it with the numerical keys.
- ▶ A value set with the numerical keys needs to be fully entered and acknowledged by pressing either **Enter** or the handwheel before it is applied to the output. If needed, it can then be adjusted using the handwheel.  
Values set by turning the handwheel are applied instantaneously.
- ▶ Now the measurements are taken and displayed.
- ▶ To save the measurement press **Keep Results** (pressing the I/O push-button has the same effect). The last measured values are "frozen", the test can now be assessed.
- ▶ Stop the manual test by pressing the I/O (test start/stop).
- ▶ To repeat the test, first press **Back to Top**, if applicable, and then **Clear Results**.

## 2. Option "Manual input" selected

**Note:** Select **Manual input** prior to starting the test. If the test card still contains results, clear them by pressing **Clear Results**.

When **Manual input** is selected, there is no phase available. Consequently, neither the polarity nor the phase angle nor  $\cos\phi$  can be calculated.

Since an automatic test only lasts a very short period of time, and a manual measurement is rather difficult, an automatic test with a manual measurement is not useful. Therefore, this Reference Manual will not cover this subject.

### Manual test

Clearing **Auto** lets you set the test current  $I_{test}$  manually with the handwheel.

- ▶ Press the I/O (test start/stop) push-button to start the test. The focus is set onto the "I test:" entry field.
- ▶ Set the value of your choice either by turning the handwheel and/or by entering it with the numerical keys.
- ▶ A value set with the numerical keys needs to be fully entered and acknowledged by pressing either **Enter** or the handwheel before it is applied to the output. If needed, it can then be adjusted using the handwheel.  
Values set by turning the handwheel are applied instantaneously.
- ▶ IDC is measured and displayed.
- ▶ To save the measurement press **Keep Results**.
- ▶ Navigate to the "V DC" entry field.
- ▶ Enter the measured VDC value either by turning the handwheel or by entering this value with the numerical keys, and press **Enter** or the handwheel to acknowledge your setting.
- ▶ The ratio is calculated and displayed.
- ▶ To stop the manual test, press the I/O (test start/stop). The test can now be assessed.

**Note:** Alternatively, it is possible to enter the manually measured value into the test card after the test was stopped (for example, if the measurement was carried out at a remote location).

- ▶ To repeat the test, first press **Back to Top**, if applicable, and then **Clear Results**.

To learn more about test assessment, refer to 10.1 "Test assessment" on page 271.

## 8.3 Winding Resistance

**Note:** Some test cards are available in more than one test mode. For example, the test card **RWinding** can be selected in CT, Resistance and Transformer.

This is solely related to usability. With regard to functionality, the test card **RWinding** is identical in all test modes.



### DANGER

#### Death or severe injury caused by high voltage or current

Injecting direct current into test objects with inductive characteristics will charge the winding of the test object.

- ▶ Follow instructions below.
- ▶ Refer to chapter 1.10 "DC output to test objects with a high inductance" on page 22.



### DANGER

#### Death or severe injury caused by high voltage or current

- ▶ Never open the measuring circuit while current flows.
- ▶ After a measurement, wait until the test device has discharged completely.
- ▶ Ground all terminals of the test object before touching the test setup.
- ▶ Short-circuit the terminals before disconnecting the test leads.
- ▶ Disconnect cables not used for testing both from the test object and the test device.

Use the **RWinding** test card to measure the resistance of a test object's secondary winding.

To do so, open the circuit, loop the I DC current signal from the *CPC 100 6A DC* output via **IAC/DC** or directly from the **400A DC** output, and inject it into the winding of a test object.

### WARNING



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

We recommend performing all winding resistance measurements with the *CP SA1* connected to the *CPC 100 V DC* input sockets to protect yourself and the *CPC 100* from high-voltage hazards.

- ▶ The *CP SA1* must be used for measurements using the **400A DC** output.
- ▶ Before disconnecting the test leads, short-circuit the test object's terminals first and then remove the wirings to the *CPC 100*.

Before using the *CP SA1*, you can check its functionality by following the test procedure in 16.4 "CP SA1" on page 328. If the *CP SA1* is defective, contact OMICRON sales office (for ordering information, see 16.4.1 "Assembly instructions for Odu MINI-SNAP plug" on page 329).

**IAC/DC** measures the injected current if the **6A DC** output is used. The **400A DC** output is measured internally. The **V DC** input measures the voltage that IDC generates at the test object's secondary winding; from these values the winding resistance is calculated.

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Due to the significant time span needed for the transformer's inductance to finish its loading process, this test evaluates the deviation of measured values within a time interval of 10 seconds. The winding resistance is continually measured and stored in the *CPC 100* internal memory. The calculated difference between the maximum and minimum measured values in % within the last 10 seconds is displayed.

Furthermore this test comprises the option to take a temperature compensation for copper (Cu) and Aluminum (Al) into consideration (refer to chapter 5.5.3 on page 109).

### 8.3.1 Test settings

RWinding 1		TRTapCheck 1		RGround 1		Co		Insert Card	
Range:	DC 6A	<input checked="" type="checkbox"/>	Auto						
I test:	5.000 A	R min:	40.00 $\mu\Omega$						
I DC:	4.9990 A	R max:	2.0000 $\Omega$						
V DC:	2.5430 V	Dev.:	0.01 %						
R meas.:	508.7 m $\Omega$	Time:	31.000 s						
<input checked="" type="checkbox"/> Temperature compensation for Cu									
T meas.:	25.0 °C								
T ref.:	70.0 °C	R ref.:	596.7 m $\Omega$						
Assessed:n/a								Keep Result	

Figure 8-6: RWinding test card with test results

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

<b>Range:</b>	output range
<b>Auto:</b>	Select check box for automatic test (default), clear for manual test.
<b>Note:</b>	The <b>400A DC</b> output range provides maximum current 100 A.
<b>Itest:</b>	nominal test current
<b>R min:</b>	calculated minimum winding resistance value (display only). Depends on the value of the nominal test current and the measuring range: 400A DC: $R_{min} = 0.2\text{mV} / I_{test}$ 6A DC: $R_{min} = 0.2\text{mV} / I_{test}$ V DC (2 wire): $R_{min} = 0.2\Omega$
<b>R max:</b>	calculated maximum winding resistance value (display only). Depends on the value of the nominal test current and the measuring range: 400A DC: $R_{max} = 5\text{V} / I_{test}$ . 6A DC: $R_{max} = 10\text{V} / I_{test}$ . V DC (2 wire): $R_{max} = 20\text{k}\Omega$

### 8.3.2 Measurements

<b>IDC:</b>	actual test current from the <b>6A DC</b> output
<b>VDC:</b>	voltage that IDC generates at the transformer's secondary winding, measured at <b>V DC</b> input
<b>R meas:</b>	transformer's winding resistance, calculated from $VDC / IDC$
<b>Time:</b>	total elapsed test time
<b>Dev:</b>	<p>deviation in % between the maximum and the minimum measured values evaluated within the last 10 seconds of the measurement. The results are considered stable if <math>Dev &lt; 0.1\%</math>.</p> <p>Press the context-dependent <b>Keep Result</b> menu key to save the actual result in the measurement table. This adds a new line to the measurement table and the next measurement can be started.</p>

- For information about **Temperature compensation**, refer to 5.5.3 "Temperature compensation" on page 109.

## 8.4 RGround

A good substation grounding system is crucial to protect people from injury and damage of equipment. International standards such as DIN VDE 0101/CENELEC HD637S1, IEEE Std 80-2000 or IEEE Std 81-1983 give guidelines how to measure such impedances.

Smaller grounding systems with a diameter of 100 m (300 ft) or smaller can be tested with the **RGround** test card and the *CPC 100* alone, for large systems the *CP CU1* coupling unit and the **Sequencer** test card is a better choice. Note that no other grounding system must be close by.

The current-voltage method as called in CENELEC HD637S1 or fall of potential method as called in IEEE standards is a good solution to measure the ground impedance of a substation. The current is fed via a long cable into a remote ground. This ground can be any ground from a simple test probe to another large grounding system. The distance between this probe and the grounding system under test shall be at least 10 times the diameter of the grounding system, 15 to 20 times is better.

**Important:** To ensure correct measurement results, the arising voltage cone from the current injection must not overlap.

Then measure the voltages with a second test probe at various distances around the substation. If possible, choose the measurement points in a 90° angle (bird's-eye view) relative to the current path. In any case, avoid measuring close (< 60°) to the current path.

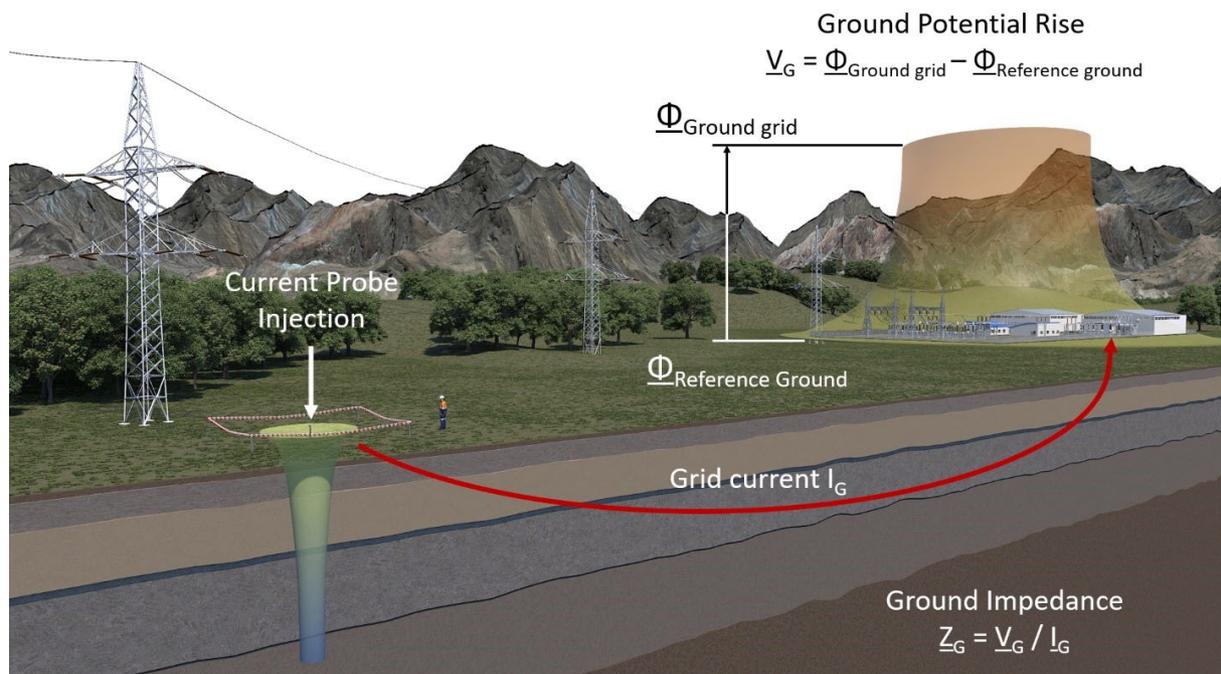


Figure 8-7: Schematic illustration of the current probe injection and the resulting ground potential rise

Measurement data at a large distance (typically three times the length of the substation) from the substation allow the calculation of the overall substation ground impedance  $Z_{\text{ground}}$  as defined in VDE 0101. Measurements at different distances are recommended. The measurement points should all show similar results. If the points are set too close to the substation or close to other grounding systems or over buried pipes, the results obtained are not stable.

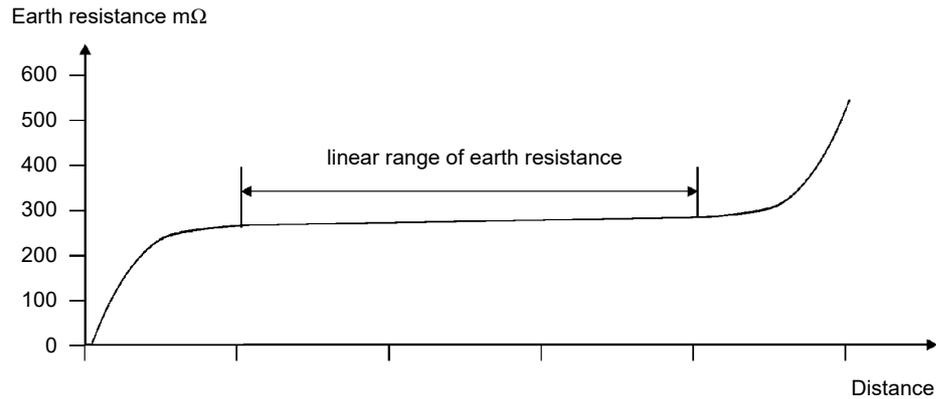


Figure 8-8: Theoretical resistance characteristic of an earth electrode

**DANGER**



**Death or severe injury caused by high voltage or current**

In case of a high-current ground fault within the substation during the test, considerably high voltages could arise in any wire connected to the substation and leading away from it.

- ▶ Do not touch the test probe without insulating gloves outside of the substation area.

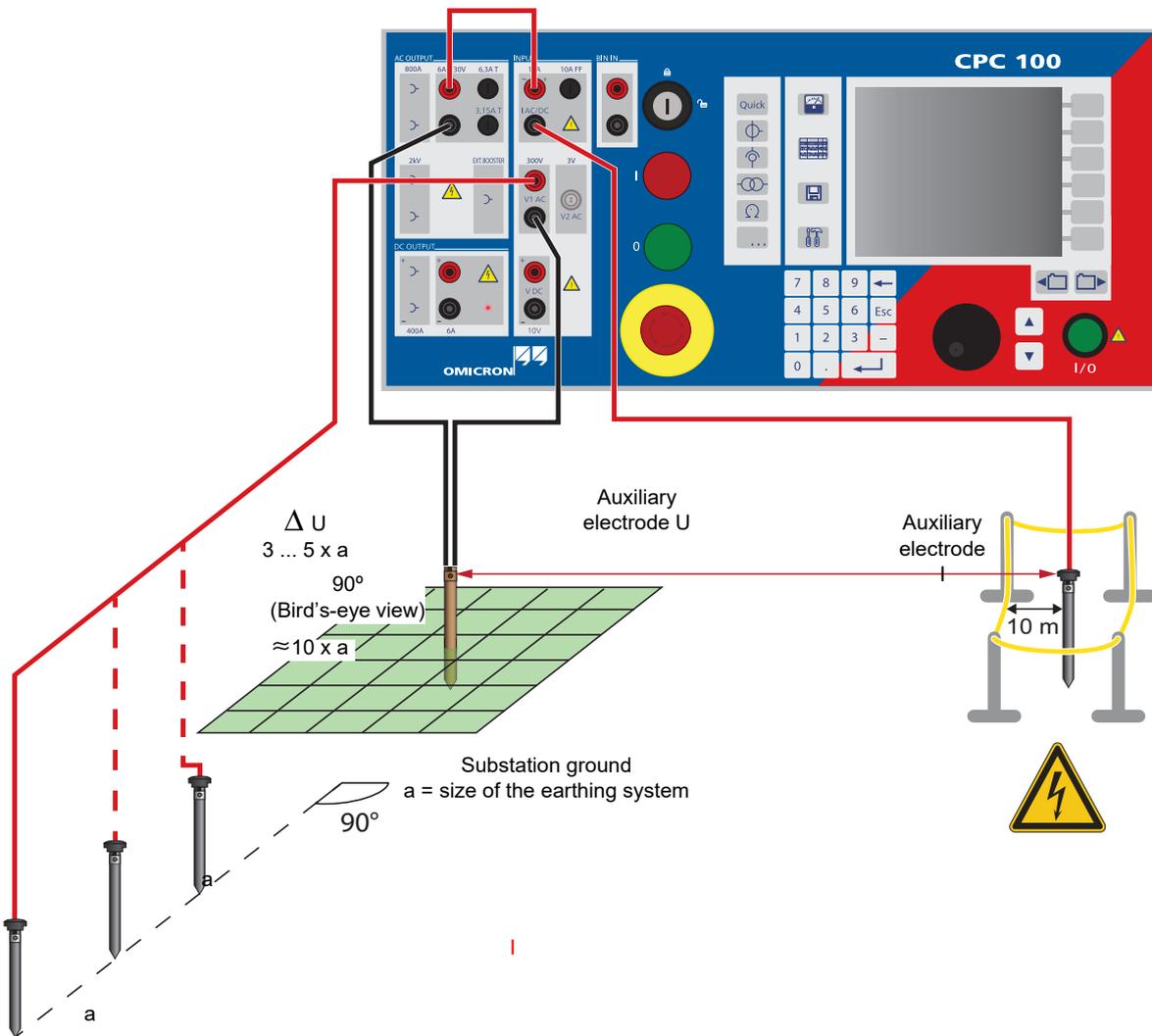


Figure 8-9: Measuring the ground resistance of small ground systems

### WARNING



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

The "Auxiliary electrode I" carries life threatening voltages during the test. Also the step voltage around the electrode can be quite high.

- ▶ Mark an area of 10 m (30 ft) around the electrode as dangerous zone and position a guard outside this area to keep people from entering the dangerous zone.
- ▶ If the desired current cannot be reached or an overload occurs, the contact resistance of the "Auxiliary electrode I" to the soil might be too high. Place several electrodes in a distance of a few meters and connect them all together to keep the resistance to the soil low. This also reduces the hazard due to high voltages around the electrode.

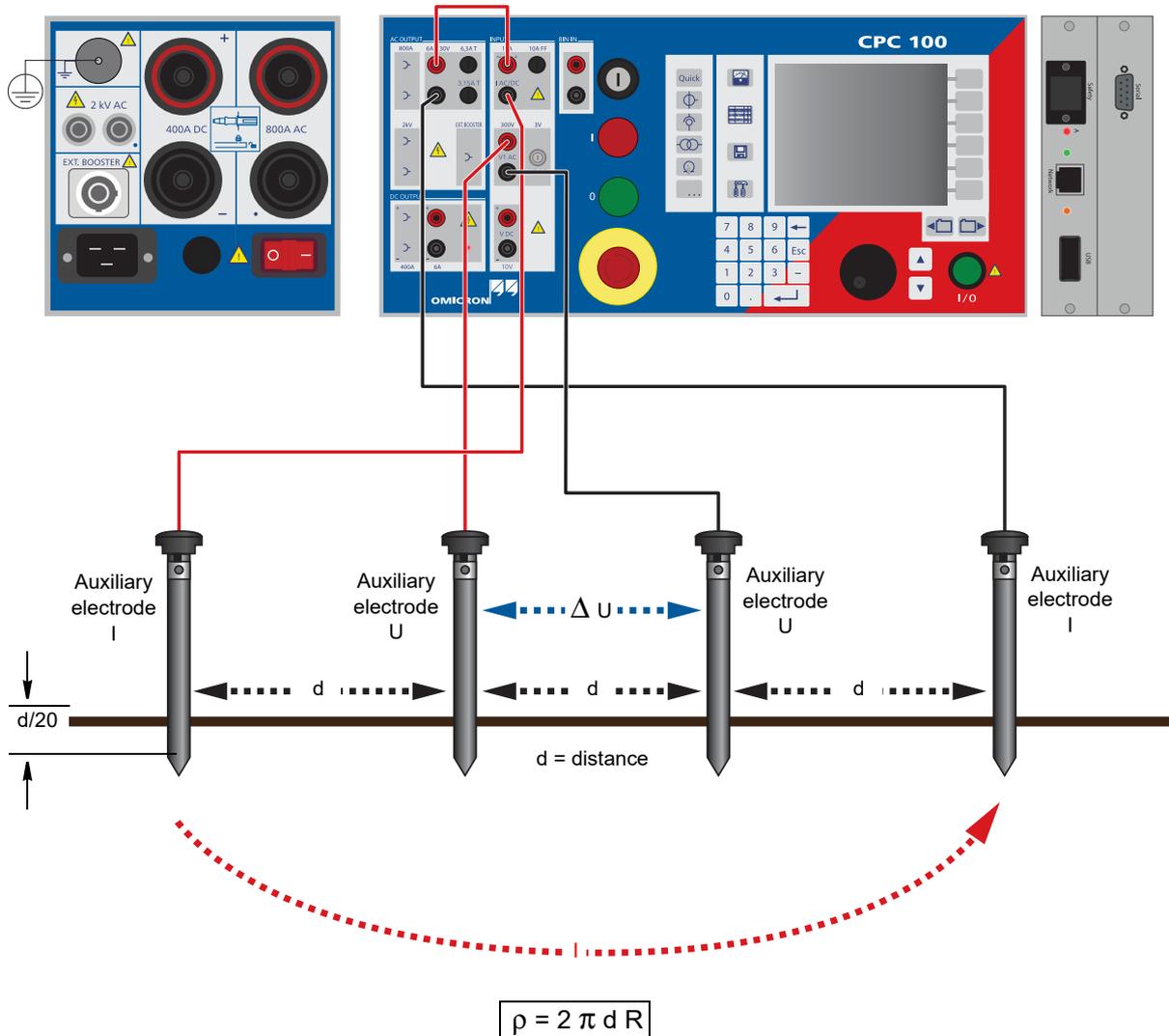


Figure 8-10: Measuring the soil resistivity

**Legend:**

$\rho$  = soil resistivity

$d$  = distance between auxiliary electrodes (identical between all electrodes)

$R$  = calculated resistance as indicated at the **RGround** test card ( $R(f)$ )

With the spacing of "d", the test measures the average soil resistivity between the U auxiliary electrodes down to a depth of "d". Therefore, varying "d" also varies the depth of the volume for which the soil resistivity is to be measured.

The following table lists typical resistivity of some common soil types.

Soil Type	Soil Resistivity
Moor, marsh, very moist soil	1...50 Ωm
Loess, clay	20...100 Ωm
Humus, acre	10...200 Ωm
Sandy clay	50...500 Ωm
Glass sand	200...3000 Ωm
Rock	300...5000 Ωm
Stony, grassy soil	100...300 Ωm
Granite, freestone	1500...10000 Ωm

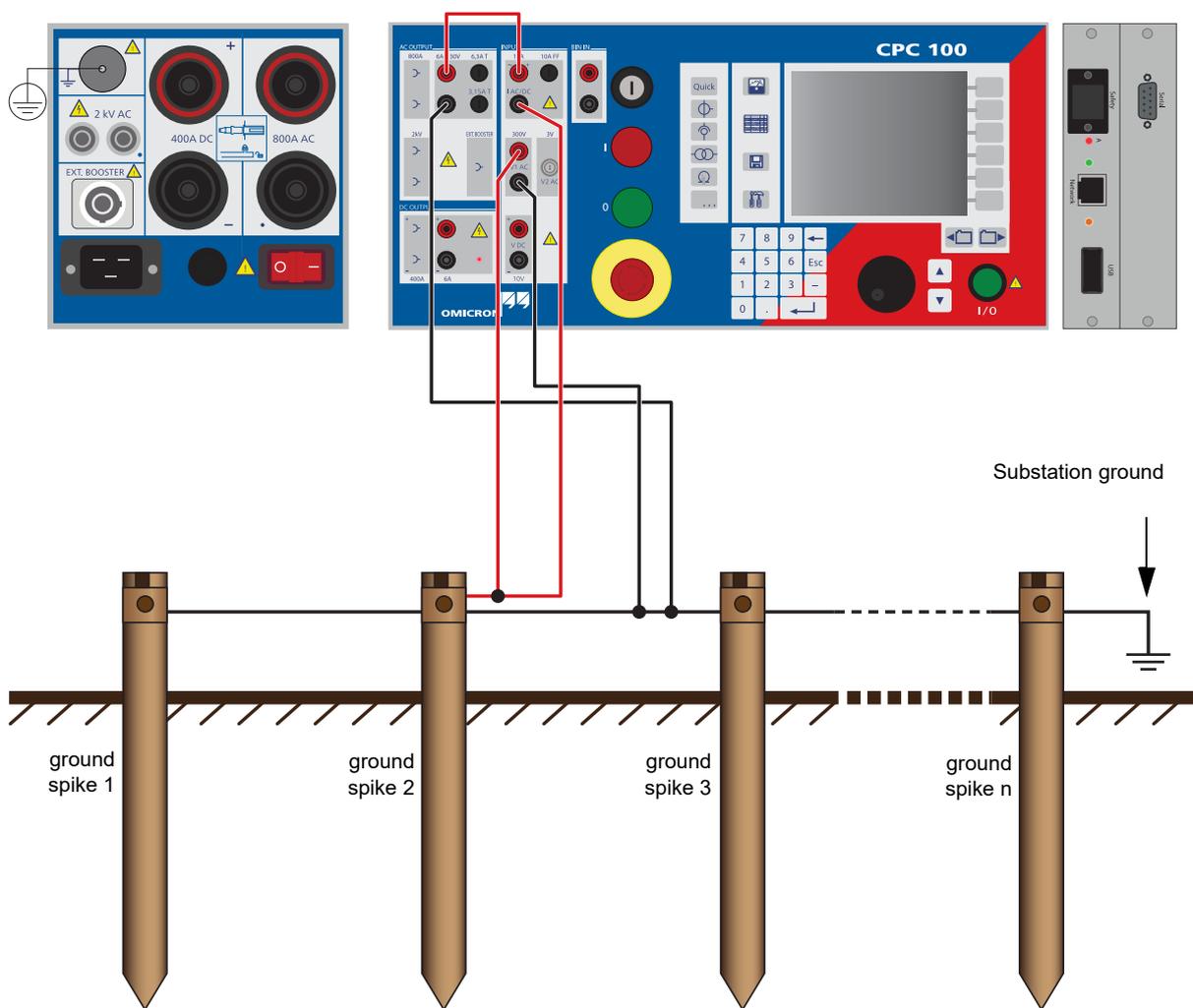


Figure 8-11: Measuring the resistance of a single ground spike

In an earthing system with several grounding rods it may be of interest to measure the resistance of a single rod. To do so, disconnect the rod to be measured from the earthing system, and feed current through the rod into the grounding system (as shown in Figure 8-11 above for rod 2). The voltage is measured directly at the current supply points.

**Note:** The resistance measured is only an approximation of the actual grounding resistance because the parallel resistance of all other ground spikes is measured, too. If one electrode is too close by the measured electrode, values by far too small could be measured.

### 8.4.1 Test settings

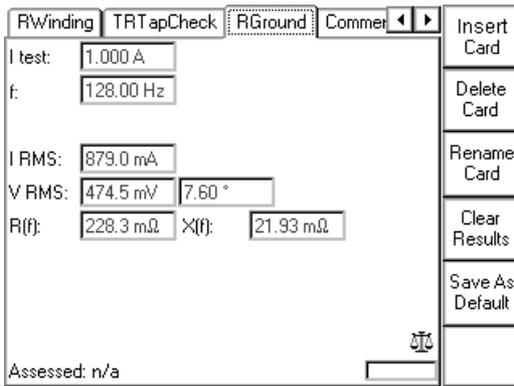


Figure 8-12: **RGround** test card with test results

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

<b>Itest:</b>	nominal test current
<b>f:</b>	frequency of test current.  Select a frequency other than the 50 or 60 Hz mains frequency to prevent interferences by stray earth currents (caused by the mains frequency and their harmonics). The value can be varied between 15 ... 400 Hz. Default is 128 Hz.

## 8.4.2 Measurements

**IRMS:** actual test current (rms value)

**VRMS:** measured voltage between substation ground and the auxiliary electrode U (rms value).

This measurement represents a broad band measurement, that is, it detects all frequencies, for example, the 50 or 60 Hz mains frequency. That way, possible dangerous voltage levels between the U auxiliary electrode and the substation ground are indicated.

Phase shift between VRMS and IRMS.

**R(f):** calculated ohmic part of earth impedance (narrow-band measurement)

**X(f):** calculated inductive part of earth impedance (narrow-band measurement)

---

## 8.5 Voltage Withstand test

For the voltage withstand test, also refer to chapters 5.6 on page 110, 6.4 on page 153, and 7.7 on page 205.

## 9 Others

**Note:** With regard to software handling, this section confines to test-relevant issues, and does not go into detailed procedural descriptions.

It is assumed that you have read and understood the section 2.4 "How to use the CPC 100 software" on page 40.

### 9.1 Scope of Others



Go to the Test Card View and press **Insert Card**.

Use the context-dependent **Up/Down** menu keys to the right, or the handwheel, to browse through the structure. On Others, press **Enter**.



Alternatively, press the accelerator key to open **Insert a new test card**.

**Others** comprises the following test cards:

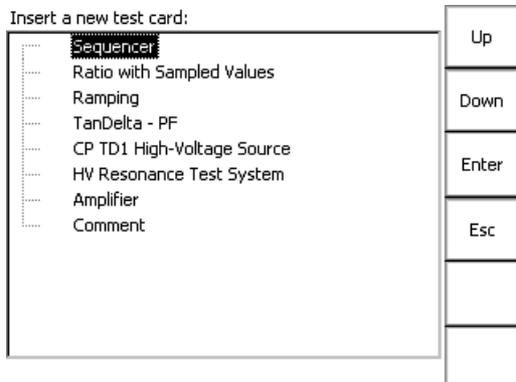


Figure 9-1: Inserting test cards from Others

Highlight the test card of your choice either by navigating with the handwheel or by using the context-dependent **Up/Down** menu keys, and press **Enter**.

**Note:** The test cards

- **Sequencer**
- **Ramping**
- **SV-Ratio**

employ the method of frequency-selective measurement, which is used to filter out interferences as they usually occur in substations.

To learn more about frequency-selective measurement, please refer to 4.2.1 "The frequency-selective measurement" on page 81

## 9.2 Sequencer

Use the **Sequencer** test card to define a sequence of states to be applied to a connected test object.



### DANGER

#### Death or severe injury caused by high voltage or current

Together with the test object's capacitance, the leakage inductance of the *CPC 100*'s internal output transformer forms a series resonant circuit. Especially at frequencies  $> 50 / 60$  Hz this may result in voltage superelevation.

- ▶ When testing capacitive test objects using voltages  $\geq 500$  V, make sure that the test object's capacitance does not exceed 25 nF.



### DANGER

#### Death or severe injury caused by high voltage or current

- ▶ Never use **Sequencer** in combination with a DC output on test objects with highly capacitive characteristics.
- ▶ Mind the danger of test object's charged capacitance. Before connecting or disconnecting any leads, use a grounding/discharging rod
  - ▶ to discharge all terminals of the test object.
  - ▶ to connect all terminals of the test object to ground and short-circuit all capacitances.



### DANGER

#### Death or severe injury caused by high voltage or current

- ▶ Never use **Sequencer** to measure the resistance of windings with highly inductive characteristics. Turning off the DC source results in life-threatening voltage levels.
- ▶ For this kind of measurement only use the special winding resistance test cards **RWinding**, **TRTapCheck** or **OLTC-Scan**.

A state represents an output quantity with defined settings, for example, a certain magnitude and frequency, for a preset period of time.

A sequence of up to 7 states can be defined. The states within that sequence execute sequentially. For each state, a trigger signal can be specified to prematurely terminate this state and execute the next one.

A sequence of states can either be executed once from state 1 to state  $x$ , or repeated continuously. Furthermore, the complete sequence can prematurely be terminated if during the execution of one of its states this state's specified trigger condition occurs.

The test object's characteristic is measured, and the values are displayed in the measurement table.

The Sequencer test card can be subdivided into three sections:

Sequence settings (apply to all states)

- Range selection
- Synchronize with V1 AC
- SOOT (switch off on trigger)
- Repeat sequence

States table (state-specific settings)

- output quantity settings
- trigger specification
- duration of state

Measurement table

- definition of displayed quantities
- display of the measured values

Quick		Sequencer		Sequencer	
AC 800A		<input checked="" type="checkbox"/>	<input type="checkbox"/> SOOT	<input type="checkbox"/> Repeat	
A	Hz	Trigger	Thresh	s	
9.5	50.00	Binary	n/a	5.000	
799.0	55.00	I Out >	799.00	15.000	
2.0	50.00	No Trigger	n/a	20.000	
I Out	I AC	Bin/Time			
A	*	A	*	Bin In	s
Assessed: n/a					

↑  
To learn more about test assessment, refer to 10.1 "Test assessment" on page 271

Insert Card

Delete Card

Rename Card

Clear Results

Save As Default

Settings

Figure 9-2: **Sequencer** test card

Settings Pressing the **Settings** menu key opens the **Settings** page. The **Settings** page allows setting the test cards individually. As a rule, do not use the **Settings** page but the **Device Setup** tab in the **Options** view (see "Device Setup" on page 56) to set the test cards. For more information, see "Settings page" on page 50.

## 9.2.1 Defining a sequence of states

First set the sequence parameters, that is, the parameters that apply to all states.

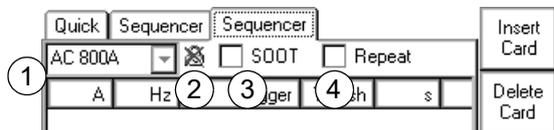


Figure 9-3: Step 1 - Set the sequence parameters

① From the range combo box select the *CPC 100* output range of your choice.

② Click the "Sync w/ V1AC" icon to enable or disable this feature.

 Enabling "Sync w/ V1AC" synchronizes the *CPC 100* output frequency with the V1 AC input frequency (we recommend a minimum input voltage of 10 V on V1 AC, possible range 48 - 62 Hz). In that case, the phase angle of the output is displayed in the states table rather than the frequency. Set the phase angle value relative to the phase angle of the V1 AC input signal (also refer to "Sync w/ V1AC" on page 83).

After the start of a sequence the output needs up to 200 ms to synchronize with V1 AC. Therefore, define a first state with an amplitude other than zero.

 If disabled, the states table displays the actual frequency value in Hz to be edited.

③ "SOOT" (switch off on trigger) check box selected:

- The complete sequence is prematurely terminated if during the execution of one of its states this state's specified trigger condition (to be set at "Trigger") occurs.

"SOOT" check box cleared:

The sequence is not terminated by an occurring state trigger. Such a trigger signal will only terminate this particular state, and continue executing the next state.

④ "Repeat" check box selected:

- A sequence of states is executed from state 1 to state *x*, and then restarts with executing state 1 again. If "SOOT" is additionally selected, the complete sequence is prematurely terminated if during the execution of one of its states this state's specified trigger condition occurs.

"Repeat" check box cleared:

A sequence of states is executed from state 1 to state *x*, and then stops. If "SOOT" is additionally selected, the complete sequence is prematurely terminated if during the execution of one of its states this state's specified trigger condition occurs.

► Next set the state(s) parameters, that is, the parameters that apply to this particular state only. Each line of the states table represents one state.  
continued

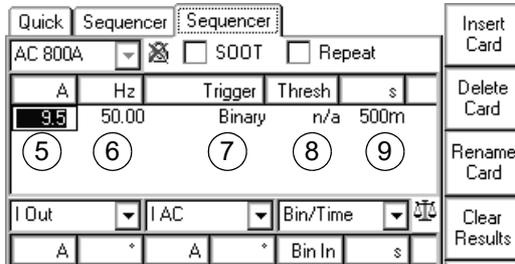


Figure 9-4: Step 2 - Set the state parameters

⑤ Turn the handwheel to set the focus onto the states table's first cell; in Figure 9-4 above it is the output current. Then press the handwheel. The cell turns into an entry field. Now set the output current value of your choice by turning the handwheel, or use the number keys of the CPC 100 soft-touch keyboard. Press **Enter** or the handwheel to acknowledge your setting and move to the next table cell by turning the handwheel.

Note that the units of the states table (the table's columns) depend on the selected output range.

On applications with overload we recommend not using currents above 600 A without a current booster.

⑥ Frequency of the output signal.



If "Sync w/ V1 AC" was selected (also refer to ②), the table column displays the phase angle of the output rather than the frequency. Set the phase angle value relative to the phase angle of the V1 AC input signal.

⑦ For each state, a trigger signal can be specified to prematurely terminate this state and execute the next one. If you move to the "Trigger" cell and press the handwheel, the cell turns into a combo box.



The following trigger conditions are available for each state:

- No Trigger: the state runs for the pre-defined period of time, no trigger signal will terminate this state.
- Binary: a trigger signal is fed into the Binary trigger input **Bin In**. The state is terminated as soon as this signal occurs.
- I Out >: as soon as the output current exceeds a certain threshold value (to define in column "Thresh"), the state is terminated.
- I Out <: as soon as the output current falls below a certain threshold value (to define in column "Thresh"), the state is terminated.
- V2 AC >: as soon as the signal connected to the low level voltage measuring input **V2 AC** (0...3V AC) exceeds a certain threshold value (to define in column "Thresh"), the state is terminated.
- V2 AC <: as soon as the signal connected to the low level voltage measuring input **V2 AC** (0...3V AC) falls below a certain threshold value (to define in column "Thresh"), the state is terminated.

- ⑦ • The availability of the trigger signals depends on the selected values set at ⑩ and ⑪ of the measurement table (refer to Figure 9-5).

**Note:** Since the determination of the r.m.s. value requires some hundred milliseconds ( $\tau \approx 150$  ms), do not use this trigger condition for measurements in millisecond ranges.

- Overload: the state terminates as soon as an Overload condition occurs at the selected output.

**What is an "Overload" trigger?**

- At the **800A AC** output, an overload trigger is a condition in which the set current cannot be reached any longer, for example, because of an opening contact or circuit breaker.

**Note:** Current values  $< 50$  A do not initiate an "Overload" when the current circuit opens. Therefore, if you use the trigger condition "Overload", chose a nominal current value of  $\geq 50$  A.

Manual  
Trigger

Sequencer differentiates two "Overload" trigger conditions:

- the occurrence of an overload (as described above)
- the clearing of an overload condition.

**Note:** Clearing of an overload condition means: the CB closes again. For debouncing purposes, at CB closing time measurements, the *CPC 100* adds a fixed time of 100 ms to the measured value. In order to determine the true CB closing time value, these 100 ms need to be deducted from the value displayed in the measurement table (refer to the following examples).

**Note:** The feature **Manual Trigger** provides a possibility to manually initiate a trigger signal (that is, a premature termination) of the current state at any time. This manual trigger has the same function as an automatic trigger signal.

- ⑧ Trigger threshold.

Only available if a trigger ">" or "<" was selected (refer to ⑦).

- ⑨ State duration. After this period of time the state terminates and the sequence continues with the next state (if any). If a trigger signal occurs *before* this time has elapsed, the currently running state terminates and the sequence continues with the next state. If "SOOT" is selected, the trigger signal terminates the complete sequence.

The default state duration time is 2 s.

A current state has a minimal time of 250 ms if the "Repeat" check box is cleared.

**Note:** Do not set the state duration shorter than 500 ms if the "Repeat" check box is selected.

A voltage state has a minimal time of 2 s.

Setting a time of 0.000 s makes the state infinite. Only a trigger signal will terminate it.

Press the **Add State** button, and repeat steps ⑤ to ⑨ to define additional states. Note that the maximum possible number of states is 7.

Add  
State

► Specify values m1 and m2 that the measurement table will show.

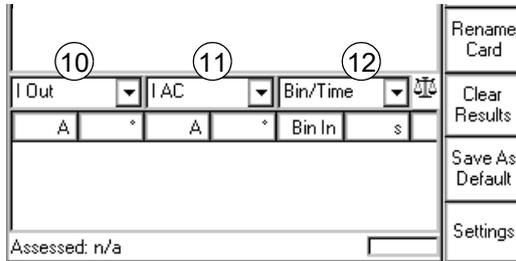


Figure 9-5: Step 3 - Specify the values that the measurement table will show

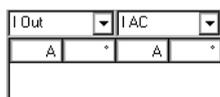
⑩ m1: Turn the handwheel to set the focus onto the measurement table's first combo box. Press the handwheel to display the available quantities to measure, and select the one of your choice.

⑪ m2: Repeat this step at the combo box for the second quantity to measure.

Possible choices of each combo box:

- V1 AC
- V1 AC sel<sup>1</sup>
- V2 AC
- V2 AC sel
- VT
- VT sel
- I AC
- I AC sel
- I Clamp
- I Clamp sel
- CT
- CT sel
- V DC
- I DC
- f V1 AC
- f Out

1. sel = frequency-selective. To learn more about frequency-selective measurements, refer to 4.2.1 "The frequency-selective measurement" on page 81.



Each combo box has two corresponding cells in the measurement table below that display the measured quantities, where possible; otherwise "n/a" is displayed.

⑫ **Calculated value**

In this combo box you determine whether the measurement table displays trigger signal characteristic / elapsed state time until trigger signal occurrence, ratio and phase angle difference, impedance Z or resistance R, real power P, apparent power S or the power factor  $\cos \varphi$ .

Depending on the selected measured quantities, both the items to select from in this combo box and the corresponding display at the measurement table below will differ accordingly.

Table 9-1: Display of calculated value in measurement table

Measured quantities		Display of calculated value in measurement table
(m1)	(m2)	
Bin/Time		<p>If selected, the column "BinIn" displays the characteristic of the trigger signal at the binary input BinIn, and the column "s" the elapsed state time until the occurrence of the trigger signal in seconds.</p> <p>4 different characteristics are possible at BinIn:</p> <ul style="list-style-type: none"> <li><input checked="" type="radio"/> <b>Closed:</b> potential-free contact between BinIn+ and BinIn– closed.</li> <li><input type="radio"/> <b>Open:</b> potential-free contact between BinIn+ and BinIn– open.</li> <li><input type="radio"/> <b>Come:</b> trigger signal with rising edge  occurred at Bin In.</li> <li><input type="radio"/> <b>Go:</b> trigger signal with falling edge  occurred at Bin In</li> </ul>
V	V	<p>Ratio: 1, Ratio:5, Diff:</p> <p>Ratio m1/m2 and phase angle <math>\varphi_{m1} - \varphi_{m2}</math> (if phase angles are available; otherwise "n/a"), and differences <math>\Delta U</math> and <math>\Delta\varphi_U</math>.</p>
I	I	<p>Ratio: 1, Ratio:5, Diff:</p> <p>Ratio m1/m2 and phase angle <math>\varphi_{m1} - \varphi_{m2}</math> (if phase angles are available; otherwise "n/a"), and differences <math>\Delta I</math> and <math>\Delta\varphi_I</math>.</p>
V	I	<p>For AC: Z or R, X</p> <p>Impedance Z (magnitude in <math>\Omega</math> and phase angle <math>\varphi</math> in <math>^\circ</math>) or R and X in <math>\Omega</math>.</p> <p>For DC: R</p> <p>Resistance R (in <math>\Omega</math>)</p> <p>else "n/a"</p>

Table 9-1: Display of calculated value in measurement table

Measured quantities		Display of calculated value in measurement table
(m1)	(m2)	
V	I	<p>For AC: P, Q, S</p> <p>Real power P (in W) and <math>\cos\phi</math>, apparent power S (in VA) and <math>\cos\phi</math>, reactive power Q (in var) and <math>\cos\phi</math>.</p> <hr/> <p>For DC: P</p> <p>Real power P (in W)</p> <p>else "n/a"</p>
V	I	<p>Rs, Ls or Rp, Cp:</p> <p>Resistance R and either inductance Ls in H (series equivalent circuit) or capacity Cp in F (parallel equivalent circuit).</p> <p>This is just another representation of the impedance <math>\underline{Z}</math> measurement; <math>\underline{Z}</math> is displayed in its components.</p> <p>Using Rs, Ls, the impedance is given by:  <math>\underline{Z} = R_s + j \omega L_s</math>, where <math>\omega = 2 \pi f</math> and the set frequency is used for the calculation.</p> <p>Using Rp, Cp, the admittance is given by:  <math>1/\underline{Z} = 1 / R_p + j \omega C_p</math>, where <math>\omega = 2 \pi f</math> and the set frequency is used for the calculation.</p>

- Press the I/O (test start/stop) push-button to start the output of the sequence of states (or the single state, if only one was defined).

In the states table, the first state is highlighted and its values are output. The measurement table displays the measured values, and updates them as well as the indication of the binary input's signal status with an interval of approx. 0.5 s.

At the end of each state - either after the state time has elapsed at the transition to the next state, or at the occurrence of the state's trigger signal - the values in the measurement table are once more updated.

## 9.2.2 Testing an overcurrent relay with ARC function

This sequence of four states tests a complete autoreclosure cycle with both a short dead time (rapid autoreclosure) and a long dead time (slow autoreclosure).

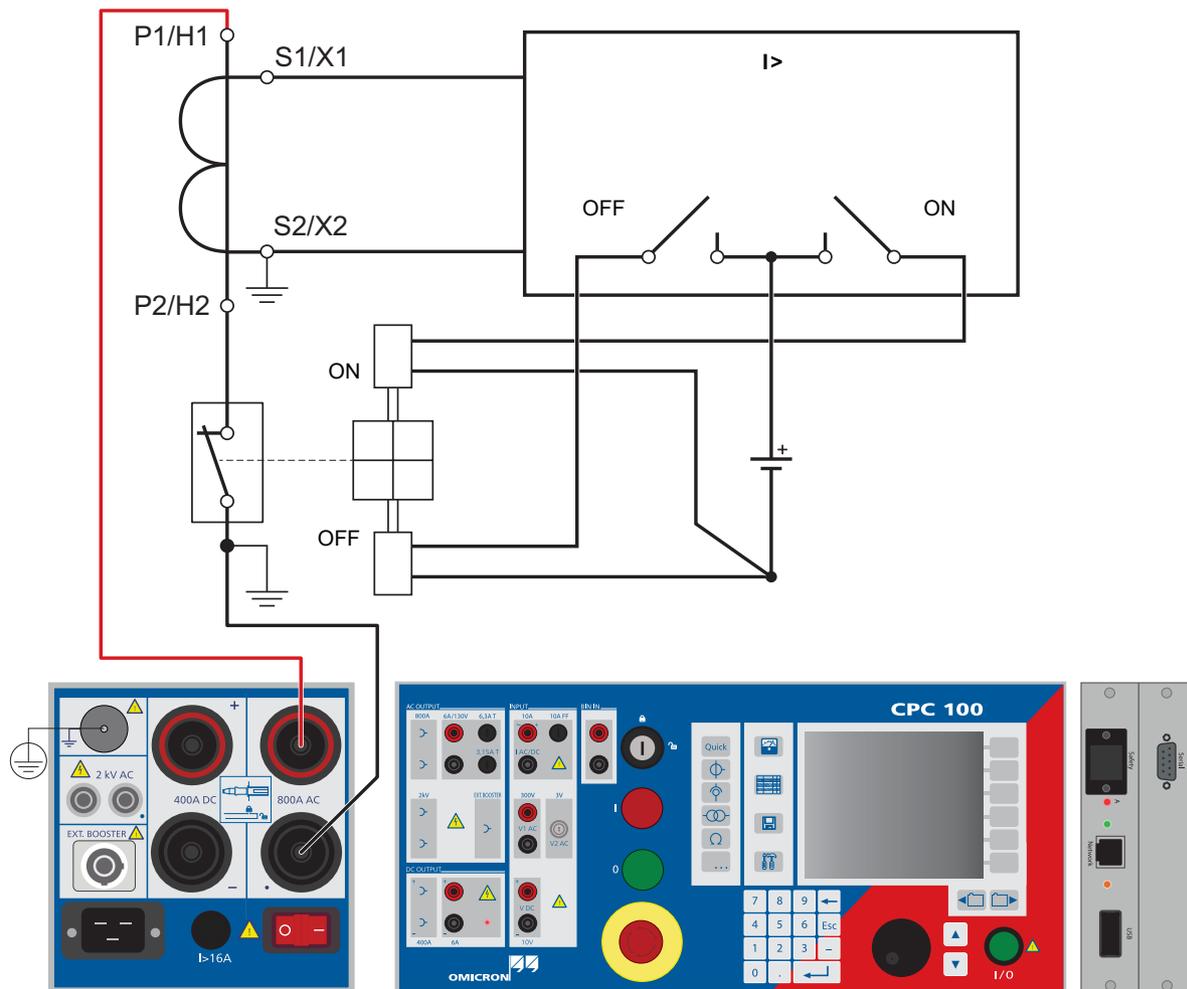


Figure 9-6: Setup for testing an overcurrent relay with autoreclosure function

**State 1: "wait for the CB to open"**

Set to output 400 A until the trigger condition "Overload" occurs. Here, trigger condition "Overload" means: The CPC 100 cannot provide the 400 A any longer because of the opening CB contact. Therefore, the opening CB contact terminates state 1. The measurement table shows for state 1 that the relay time + the CB opening time lasted 290 ms.

**State 2: "wait for the CB to close"**

Short dead time. Set to output 50 A until the "Overload" trigger condition that started state 2 clears. The measurement table shows for state 2 that the short dead time + the CB closing time lasted 477 ms. This time also includes the additional time to compensate for the debounce (see note below).  
The actual value for CB close equals  $477\text{ ms} - 100\text{ ms} = 377\text{ ms}$ .  
Note that the r.m.s. measurement of IOut reacts slow and therefore the measurement table does not show the full current.

**State 3: "wait for the CB to open"**

Like state 1.

Quick		Sequencer		Sequencer			
AC 800A		<input checked="" type="checkbox"/>	<input type="checkbox"/> SOOT	<input type="checkbox"/> Repeat			
A	Hz	Trigger	Thresh	s			
400.0	50.00	Overload	n/a	30.000			
50.0	50.00	Overload	n/a	30.000			
400.0	50.00	Overload	n/a	30.000			
50.0	50.00	Overload	n/a	30.000			
I Out	I AC	A	*	Bin In	s		
399.8	0.00	xxx	xxx	○	290m		
35.6	0.00	xxx	xxx	○	477m		
399.8	0.00	xxx	xxx	○	291m		
35.6	0.00	xxx	xxx	○	3.1910		
Assessed: n/a							

Not relevant for this test.

**State 4: "wait for the CB to close"**

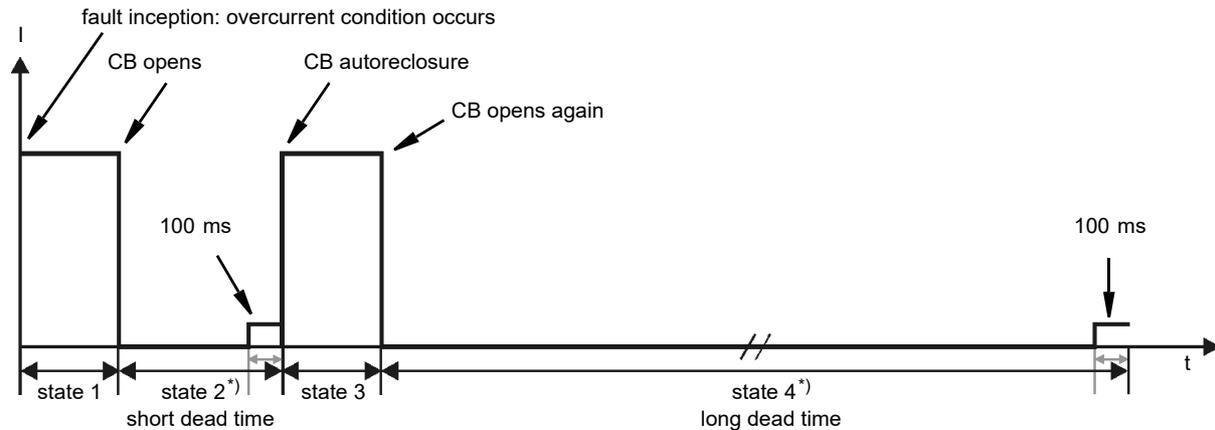
Long dead time. Set to output 50 A<sup>1</sup> until the "Overload" trigger condition that started state 4 clears. The measurement table shows for state 4 that the long dead time + the CB closing time lasted 3.1910 s. This time also includes the additional time to compensate for the debounce (see note below).  
The actual value for CB close equals  $3.1910\text{ s} - 100\text{ ms} = 3.0910\text{ s}$ .

Figure 9-7: Sequencer test card with parameters and measurements of the four states

1 Current values < 50A do not initiate an "Overload" when the current circuit opens. For this reason, a nominal current value of 50A was chosen here, even though the CB is open.

**Note:** For debouncing purposes, at CB closing time measurements, the CPC 100 adds a fixed time of 100 ms to the measured value. In order to determine the true CB closing time value, these 100 ms need to be deducted from the value displayed in the measurement table.

**Time sequence of the four states**



\*)State 2 and 4 incl. the additional 100 ms the CPC 100 adds to compensate for the debounce (see note above).

Figure 9-8: Time sequence of the four states to test the autoreclosure cycle

### 9.2.3 Measuring a CT ratio at different current magnitudes

Example of a sequence of five states to measure the ratio of a current transformer. To do so, different current amplitudes (5%, 20%, 50%, 100% and 120% of nominal value) are injected into the CT, and the CT's secondary current is measured at the *CPC 100* current input **I AC/DC**.

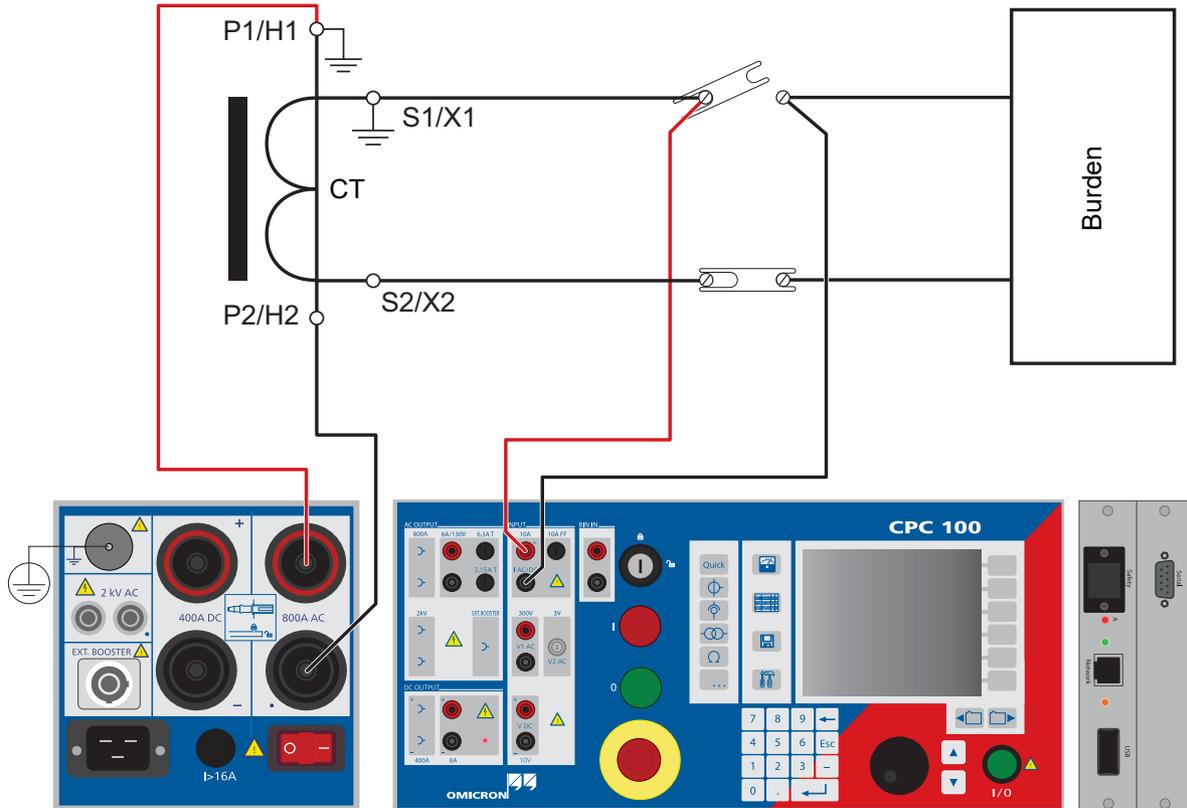


Figure 9-9: Setup to measure the ratio of a current transformer at different current magnitudes

#### Parameters of the states 1 ... 5

A	Hz	Trigger	Thresh	s
20 (= 5%)	50.00	No Trigger	n/a	2.000
80 (= 20%)	50.00	No Trigger	n/a	2.000
200 (= 50%)	50.00	No Trigger	n/a	2.000
400 (= 100%)	50.00	No Trigger	n/a	2.000
480 (= 120%)	50.00	No Trigger	n/a	2.000

Each of the five states injects a current with a different magnitude into the CT's primary winding. There is no trigger specified, so each state runs exactly 2 s.

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Since the "Repeat" check box is cleared, the sequence of five states executes exactly one time and then terminates.

Quick		Sequencer		Sequencer	
AC 800A		<input checked="" type="checkbox"/>	<input type="checkbox"/> S00T	<input type="checkbox"/> Repeat	
A	Hz	Trigger	Thresh	s	
80.0	50.00	No Trigger	n/a	2.000	
200.0	50.00	No Trigger	n/a	2.000	
400.0	50.00	No Trigger	n/a	2.000	
480.0	50.00	No Trigger	n/a	2.000	
I Out	IAC		Ratio:1		
A	°	A	°	:1	°
80.0	0.00	0.201	0.12	398.0	-0.12
200.0	0.00	0.502	0.11	398.4	-0.11
400.0	0.00	1.004	0.13	398.4	-0.13
480.0	0.00	1.205	0.15	398.3	-0.15
Assessed: n/a					

Figure 9-10: **Sequencer** test card with parameters and measurements of the five states (states 2...5 shown)

**Measured values of the states 1 ... 5**

I Out		IAC		Ratio:1	
A	°	A	°	:1	°
20	0	0.051	0.11	392.2	-0.11
80	0	0.201	0.12	398.0	-0.12
200	0	0.502	0.11	398.4	-0.11
400	0	1.004	0.13	398.4	-0.13
480	0	1.205	0.15	398.3	-0.15

### 9.2.4 Generating an intermittent high-current output

In a substation, certain control measurements and/or performance checks require the injection of high current at one location, and the respective measurement at another, sometimes remote location.

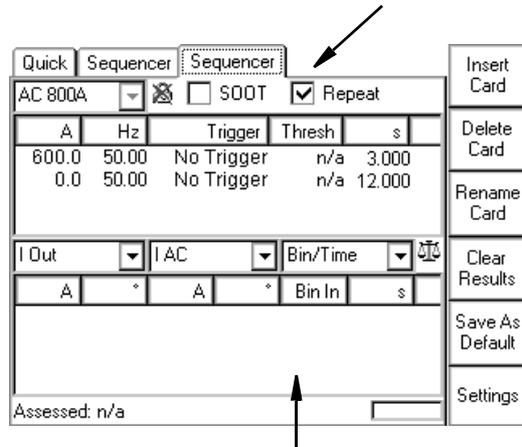
When the *CPC 100* outputs high current, duty cycles may apply to the selected AC output range. The allowed pulse duty cycle ("on/off" operation) depends on the selected range, the ambient temperature, the operating conditions of the *CPC 100* etc. For more information about duty cycles refer to 15.3 "CPC 100 outputs" on page 297.

If you want to output high current for a longer period of time, perform such a test by creating two states in **Sequencer**:

- one state that outputs high current
- and another state with a sufficient pause.

The duration of both states need to comply with the permitted duty cycle. This will prevent an automatic shutdown of the *CPC 100* due to an overload.

Set the states in such a way that they constantly repeat: select "Repeat".



Measurement table not relevant for this test.

Figure 9-11: **Sequencer** test card with two states for an intermittent high-current output

**Time sequence of the repeating two states:**

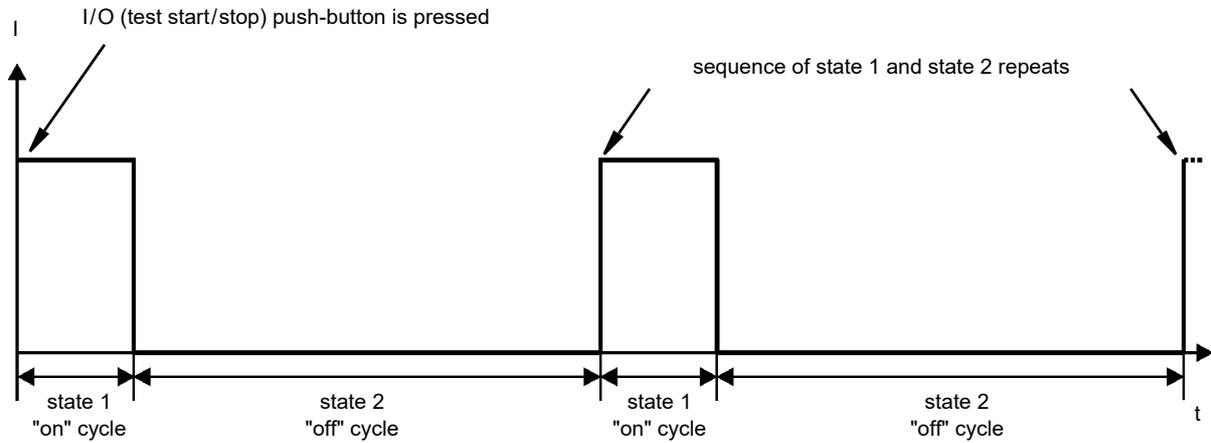


Figure 9-12: Time sequence of the repeating two states to output an intermittent high current

The lower the averaged value of the output current  $I_{rms}$  over the time the longer the *CPC 100* can be operated in that mode. This value is calculated with the following formula:

$$I_{rms} = I_{test} \times \sqrt{\frac{t_{on}}{(t_{on} + t_{off})}} = 600A \times \sqrt{\frac{3s}{(3s + 12s)}} = 268.3A$$

A	Hz	Trigger	Thresh	s
600.0	50.00	No Trigger	n/a	3.000
0.0	50.00	No Trigger	n/a	12.000

$I_{test}$  →

→  $t_{on}$

→  $t_{off}$

I Out	I AC	Bin/Time	UNIT
A	*	A	* Bin In s

## 9.3 Ramping

Use the **Ramping** test card to define a series of ramps to be applied to a connected test object.

A ramp represents a linear change of either amplitude or frequency of one specified output signal whereas the other quantity remains fixed.

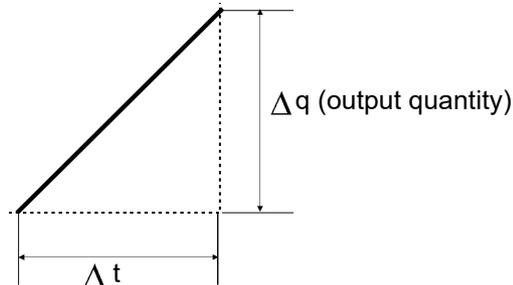


Figure 9-13: A typical ramp characteristic:  $\Delta q / \Delta t$ , a linear change of either amplitude or frequency of one specified output signal within a defined period of time.

### DANGER



#### Death or severe injury caused by high voltage or current

Together with the test object's capacitance, the leakage inductance of the *CPC 100*'s internal output transformer forms a series resonant circuit. Especially at frequencies  $> 50 / 60$  Hz this may result in voltage superelevation.

- ▶ When testing capacitive test objects using voltages  $\geq 500$  V, make sure that the test object's capacitance does not exceed 25 nF.

### DANGER



#### Death or severe injury caused by high voltage or current

- ▶ Never use **Ramping** in combination with a DC output on test objects with highly capacitive characteristics.
- ▶ Mind the danger of test object's charged capacitance. Before connecting or disconnecting any leads, use a grounding/discharging rod
  - ▶ to discharge all terminals of the test object.
  - ▶ to connect all terminals of the test object to ground and short-circuit all capacitances.

### DANGER



#### Death or severe injury caused by high voltage or current

- ▶ Never use **Ramping** to measure the resistance of windings with highly inductive characteristics. Turning off the DC source results in life-threatening voltage levels.
- ▶ For this kind of measurement only use the special winding resistance test cards **RWinding**, **TRTapCheck** or **OLTC-Scan**.

A series of up to 5 ramps can be defined. The ramps within that series execute sequentially, and run from a start to an end value within a set period of time.

It is possible to specify a trigger signal that prematurely terminates either

- the entire series of ramps
- or the actual ramp only, and then continues with the next one (if any).

The test object's characteristic is measured, and the values are displayed in the measurement table.

The **Ramping** test card can be subdivided into three sections:

Series settings (apply to all ramps)

- Range selection & display
- Ramp & fixed quantity
- SOOT (switch off on trigger)
- Start value (of first ramp)

Ramps table (ramp-specific settings)

- output quantity settings
- duration of ramp
- trigger specification

Measurement table

- definition of displayed quantities
- display of the measured values

Quick		Sequencer		Sequencer		Ramping	
AC 800A				<input type="checkbox"/> SOOT			
Amplitude		50.00 Hz		Start val:		1.0 A	
A	s	Trigger		Thresh			
200.0	5.000	No Trigger		n/a			
200.0	10.000	Binary		n/a			
0.0	5.000	No Trigger		n/a			
I Out		I AC		Bin/Time			
A	*	A	*	Bin In	s		
Assessed: n/a							

↑

To learn more about test assessment, refer to 10.1 "Test assessment" on page 271.

Insert Card  
Delete Card  
Rename Card  
Clear Results  
Save As Default  
Settings

Figure 9-14: **Ramping** test card

**Settings** Pressing the **Settings** menu key opens the **Settings** page. The **Settings** page allows setting the test cards individually. As a rule, do not use the **Settings** page but the **Device Setup** tab in the **Options** view (see "Device Setup" on page 56) to set the test cards. For more information, see "Settings page" on page 50.

### 9.3.1 Defining a ramp

First set the series parameters, that is, the parameters that apply to the entire series of ramps.

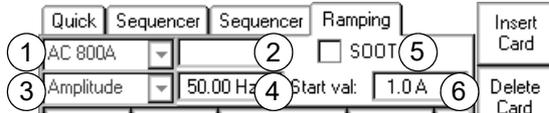


Figure 9-15: Step 1 - Set the series parameters

- ① From the range combo box select the *CPC 100* output range of your choice.
- ② During the output of a ramp, this field displays the currently output value of the signal's quantity selected at ③.
- ③ From the combo box, select the output signal's quantity to be ramped: "Amplitude" or "Frequency".
- ④ Enter the value of the output signal's fixed quantity.  
If at ③ "Amplitude" was selected as quantity to be ramped, enter the output signal's fixed frequency value here. Otherwise, if "Frequency" was selected, enter the output signal's fixed amplitude value.
- ⑤ "SOOT" (switch off on trigger) check box selected:
  - The entire series of ramps is prematurely terminated if during the execution of one of its ramps this ramp's specified trigger condition (to be set at "Trigger") occurs.
 "SOOT" check box cleared:
  - The series of ramps is not terminated by an occurring ramp trigger. Such a trigger signal will only terminate this particular ramp, and continue executing the next ramp.
- ⑥ Enter the ramp's start value here. If a series contains more than one ramp, this is the start value of the first ramp of that series. The second ramp starts with the end value of the first one, and so on (refer to "Example of a series of ramps" on page 248 of this chapter).

Next, set the ramp(s) parameters, that is, the parameters that apply to this particular ramp only. Each line of the ramps table represents one ramp.

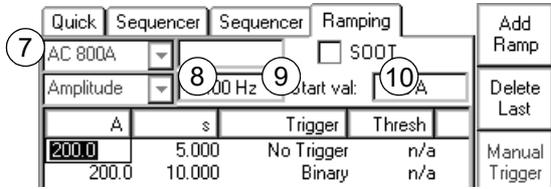


Figure 9-16: Step 2 - Set the ramp parameters

- ⑦ Turn the handwheel to set the focus onto the ramps table's first cell; in Figure 9-16 above it is the output current. Then press the handwheel. The cell turns into an entry field. Now set the output current value of your choice by turning the handwheel, or use the number keys of the *CPC 100* soft-touch keyboard. Press **Enter** or the handwheel to acknowledge your setting and move to the next table cell by turning the handwheel.

Note that the units of the ramps table (the table's columns) depend on the selected output range.

- ⑧ Duration of ramp, that is, the time this particular ramp sweeps the selected signal from the start to the end value.

After this period of time the ramp terminates and the series continues with the next ramp (if any).

If a trigger signal occurs *before* this time has elapsed, the currently running ramp terminates and the series continues with the next ramp. If "SOOT" is selected, the trigger signal terminates the complete series of ramps.

9

For each ramp, a trigger signal can be specified to prematurely terminate this ramp and execute the next one. If you move to the "Trigger" cell and press the handwheel, the cell turns into a combo box.



The following trigger conditions are available for each ramp:

- No Trigger: the ramp sweeps the selected signal from the start to the end value within the pre-defined period of time, no trigger signal will terminate this ramp.
- Binary: a trigger signal is fed into the Binary trigger input **Bin In**. The ramp is terminated as soon as this signal occurs.
- IOut>: as soon as the output current exceeds a certain threshold value (to define in column "Thresh"), the ramp is terminated.
- IOut<: as soon as the output current falls below a certain threshold value (to define in column "Thresh"), the ramp is terminated.
- V2 AC >: as soon as the signal connected to the low level voltage measuring input **V2 AC** (0...3V AC) exceeds a certain threshold value (to define in column "Thresh"), the ramp is terminated.
- V2 AC <: as soon as the signal connected to the low level voltage measuring input **V2 AC** (0...3V AC) falls below a certain threshold value (to define in column "Thresh"), the ramp is terminated.

The availability of the trigger signals depends on the selected values set at (11) and (12) of the measurement table (refer to Figure 9-18).

**Note:** Since the determination of the r.m.s. value requires some hundred milliseconds ( $\tau \approx 150$  ms), do not use this trigger condition for measurements in millisecond ranges.

- Overload: the ramp terminates as soon as an Overload condition occurs at the selected output.

**What is an "Overload" trigger?**

- At the **800A AC** output, an overload trigger is a condition in which the set current cannot be reached any longer, for example, because of an opening contact or circuit breaker.
- Current values < 50 A do not initiate an "Overload" when the current circuit opens. Therefore, if you use the trigger condition "Overload", chose a nominal current value of  $\geq 50$  A.



Ramping differentiates two "Overload" trigger conditions:

- the occurrence of an overload (as described above)
- the clearing of an overload condition.

**Note:** Clearing of an overload condition means: the CB closes again. For debouncing purposes, at CB closing time measurements, the *CPC 100* adds a fixed time of 100 ms to the measured value. In order to determine the true CB closing time value, these 100 ms need to be deducted from the value displayed in the measurement table (refer to the following example).

- The feature **Manual Trigger** provides a possibility to manually initiate a trigger signal (that is, a premature termination) of the current ramp at any time. This manual trigger has the same function as an automatic trigger signal.

⑩ Trigger threshold.

Only available if a trigger ">" or "<" was selected (refer to ⑨).

Add Ramp

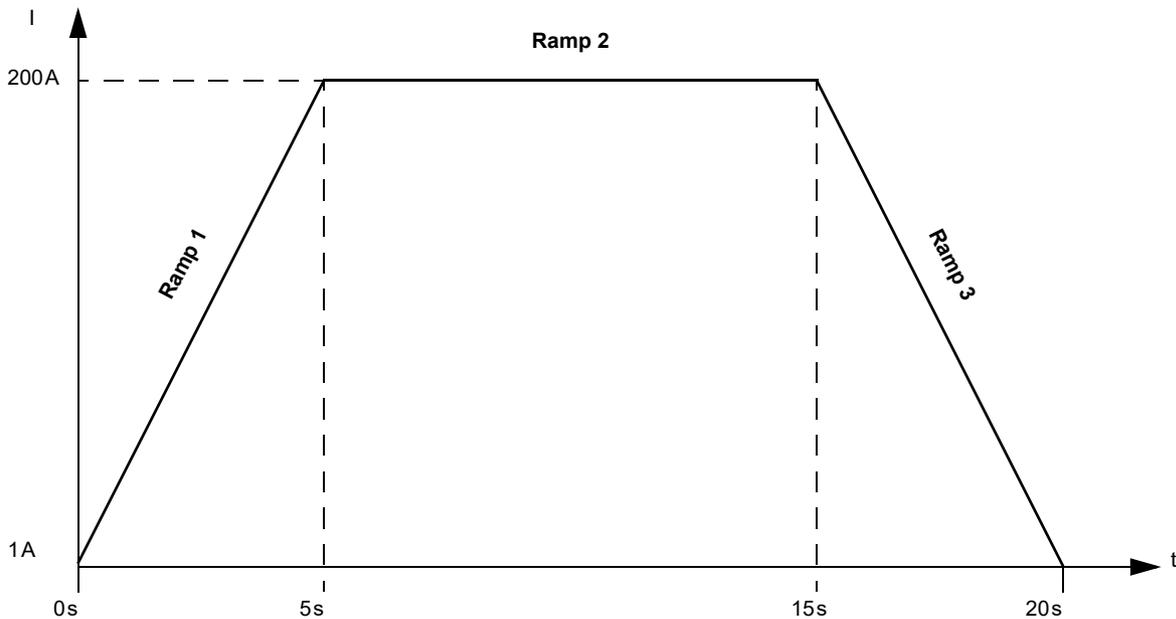
Press the **Add Ramp** button, and repeat steps ⑦ to ⑩ to define additional ramps. Note that the maximum possible number of ramps is 5.

### Example of a series of ramps

	Amplitude	50.00 Hz	Start val:	1.0 A	
	A	s	Trigger	Thresh	
Ramp 1	200.0	5.000	No Trigger	n/a	Delete Card
Ramp 2	200.0	10.000	Binary	n/a	Rename Card
Ramp 3	0.0	5.000	No Trigger	n/a	Class

Figure 9-17: A series of three ramps defined in the ramps table

The three ramps defined in the ramps table shown above result in an output signal like this:



#### Ramp 1

- from 1 A (set at "Start val:")
- to end value 200 A (set in line 1 at column "A")
- in 5 s (set in line 1 at column "s")

#### Ramp 2

- from 200 A (end value of ramp 1)
- to end value 200 A (set in line 2 at column "A")
- for 10 seconds (set in line 2 at column "s")

#### Ramp 3

- from 200 A (end value of ramp 2)
- to end value 0 A (set in line 3 at column "A")
- in 5 seconds (set in line 3 at column "s")

Specify values m1 and m2 that the measurement table will show.

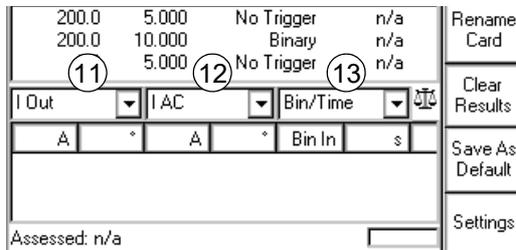


Figure 9-18: Step 3 - Specify the values that the measurement table will eventually show

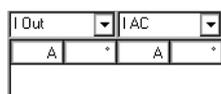
① m1: Turn the handwheel to set the focus onto the measurement table's first combo box. Press the handwheel to display the available quantities to measure, and select the one of your choice.

② m2: Repeat this step at the combo box for the second quantity to measure.

Possible choices of each combo box:

- V1 AC
- V1 AC sel<sup>1</sup>
- V2 AC
- V2 AC sel
- VT
- VT sel
- I AC
- I AC sel
- I Clamp
- I Clamp sel
- CT
- CT sel
- V DC
- I DC
- f V1 AC
- f Out

1. sel = frequency-selective. To learn more about frequency-selective measurements, refer to 4.2.1 "The frequency-selective measurement" on page 81.



Each combo box has two corresponding cells in the measurement table below that display the measured quantities, where possible; otherwise "n/a" is displayed.

③ **Calculated value**

In this combo box you determine whether the measurement table displays trigger signal characteristic / elapsed ramp time until trigger signal occurrence, ratio and phase angle difference, impedance Z or resistance R, real power P, apparent power S or the power factor  $\cos \varphi$ .

Depending on the selected measured quantities, both the items to select from in this combo box and the corresponding display at the measurement table below will differ accordingly.

Table 9-2: Display of calculated value in measurement table

Measured quantities		Display of calculated value in measurement table
(m1)	(m2)	
Bin/Time		<p>If selected, the column "BinIn" displays the characteristic of the trigger signal at the binary input BinIn, and the column "t(s)" the elapsed ramp time until the occurrence of the trigger signal in seconds.</p> <p>4 different characteristics are possible at BinIn:</p> <ul style="list-style-type: none"> <li><input checked="" type="radio"/> <b>Closed:</b> potential-free contact between BinIn+ and BinIn– closed.</li> <li><input type="radio"/> <b>Open:</b> potential-free contact between BinIn+ and BinIn– open.</li> <li><input type="radio"/> <b>Come:</b> trigger signal with rising edge  occurred at BinIn.</li> <li><input type="radio"/> <b>Go:</b> trigger signal with falling edge  occurred at BinIn</li> </ul>
V	V	<p>Ratio: 1, Ratio:5, Diff:</p> <p>Ratio m1/m2 and phase angle <math>\varphi_{m1} - \varphi_{m2}</math> (if phase angles are available; otherwise "n/a"), and differences <math>\Delta U</math> and <math>\Delta\varphi_U</math>.</p>
I	I	<p>Ratio: 1, Ratio:5, Diff:</p> <p>Ratio m1/m2 and phase angle <math>\varphi_{m1} - \varphi_{m2}</math> (if phase angles are available; otherwise "n/a"), and differences <math>\Delta I</math> and <math>\Delta\varphi_I</math>.</p>
V	I	<p>For AC: Z or R, X</p> <p>Impedance Z (magnitude in <math>\Omega</math> and phase angle <math>\varphi</math> in <math>^\circ</math>) or R and X in <math>\Omega</math>.</p> <p>For DC: R</p> <p>Resistance R (in <math>\Omega</math>)</p> <p>otherwise "n/a"</p>
V	I	<p>For AC: P, Q, S</p> <p>Real power P (in W) and <math>\cos\varphi</math>, apparent power S (in VA) and <math>\cos\varphi</math>, reactive power Q (in var) and <math>\cos\varphi</math>.</p> <p>For DC: P</p> <p>Real power P (in W)</p> <p>otherwise "n/a"</p>

Table 9-2: Display of calculated value in measurement table

Measured quantities		Display of calculated value in measurement table
(m1)	(m2)	
V	I	<p>Rs, Ls or Rp, Cp:</p> <p>Resistance R and either inductance Ls in H (series equivalent circuit) or capacity Cp in F (parallel equivalent circuit).</p> <p>This is just another representation of the impedance <math>\underline{Z}</math> measurement; <math>\underline{Z}</math> is displayed in its components.</p> <p>Using Rs, Ls, the impedance is given by:  <math>\underline{Z} = R_s + j \omega L_s</math>, where <math>\omega = 2 \pi f</math> and the set frequency is used for the calculation.</p> <p>Using Rp, Cp, the admittance is given by:  <math>1/\underline{Z} = 1 / R_p + j \omega C_p</math>, where <math>\omega = 2 \pi f</math> and the set frequency is used for the calculation.</p>

Press the I/O (test start/stop) push-button to start the output of the series of ramps (or the single ramp, if only one was defined).

In the ramps table, the first ramp is highlighted and its values are output. The measurement table displays the measured values, and updates them as well as the indication of the binary input's signal status with an interval of approx. 0.5s.

At the end of each ramp - either after the ramp time has elapsed at the transition to the next ramp state, or at the occurrence of the trigger signal - the values in the measurement table are once more updated.

### 9.3.2 Testing pick-up/drop-off value of an overcurrent relay

To determine the pick up and the drop off value of a relay, a series of three ramps is defined. The first ramp determines the pick up value, the second one represents a 1 s pause time, and the third ramp determines the drop off value.

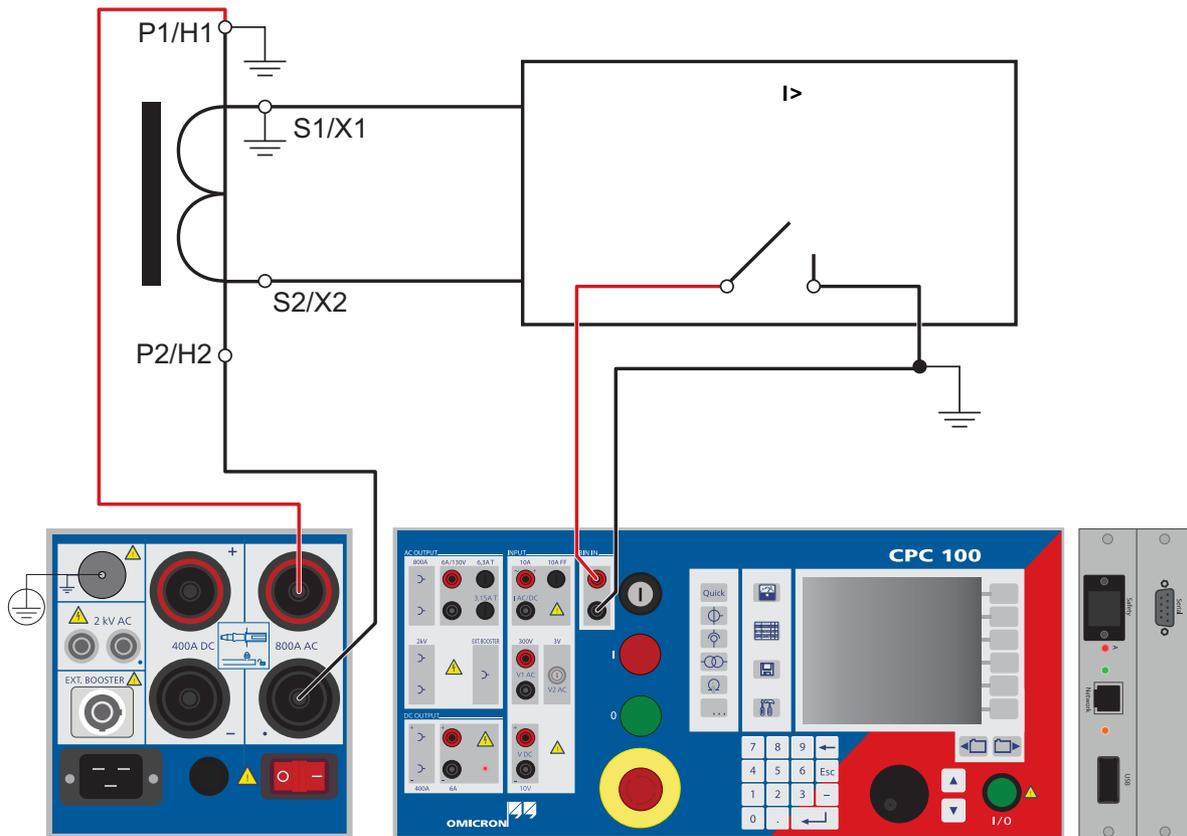


Figure 9-19: Setup for testing the pick up and drop off values of an Overcurrent relay

The **CPC 100 AC OUTPUT** feeds the ramped current signal into a CT, which is connected to an overcurrent relay. The overcurrent relay's trip contact is fed into the **CPC 100** binary input **Bin In**, and acts there as a trigger signal (as described on page 247 of this chapter).

**Ramp 1:**  
Set to output a ramped current signal from 100.0 A to either 200.0 A in 10 s, or until the trigger condition "Binary" occurs.  
Here, trigger condition "Binary" means: the relay contact picks up. In this moment, ramp 1 terminates and the series continues with ramp 2.  
The measurement table shows for ramp 1 that the relay contact picked up after 7.175 s at a current value of 170.29 A.

**Ramp 2:**  
Pause time. Test current is output for 1 s.

**Ramp 3:**  
Because ramp 1 did not reach the 200 A due to the trigger signal, ramp 3 starts with 170.29 A, and then ramps down to zero with the set steepness (200.0 A to 0.0 A in 10 s) until the trigger condition "Binary" occurs.  
Here, trigger condition "Binary" means: the relay contact drops off. Since there are no further ramps defined, in this moment the sequence terminates.  
The measurement table shows for ramp 3 that the relay contact dropped off 1.1 s after ramp 3 started at a current value of 152.35 A.

Quick		Sequencer		Sequencer		Ramping		Insert Card	
AC 800A						<input type="checkbox"/> SOOT			
Amplitude	50.00 Hz	Start val:	100.0 A						Delete Card
A	s	Trigger	Thresh						Rename Card
200.0	10.000	Binary	n/a						Clear Results
200.0	1.000	No Trigger	n/a						Save As Default
0.0	10.000	Binary	n/a						Settings
I Out	I AC	Bin/Time							
A	°	A	°	Bin In	s				
170.29	0.00	xxx	xxx	⬆	7.1750				
170.29	0.00	xxx	xxx	⊙	1.0000				
152.35	0.00	xxx	xxx	⬇	1.1000				
Assessed: n/a									

Figure 9-20: **Ramping** test card with parameters and measurement values of the three ramps

**Time sequence of the three ramps:**

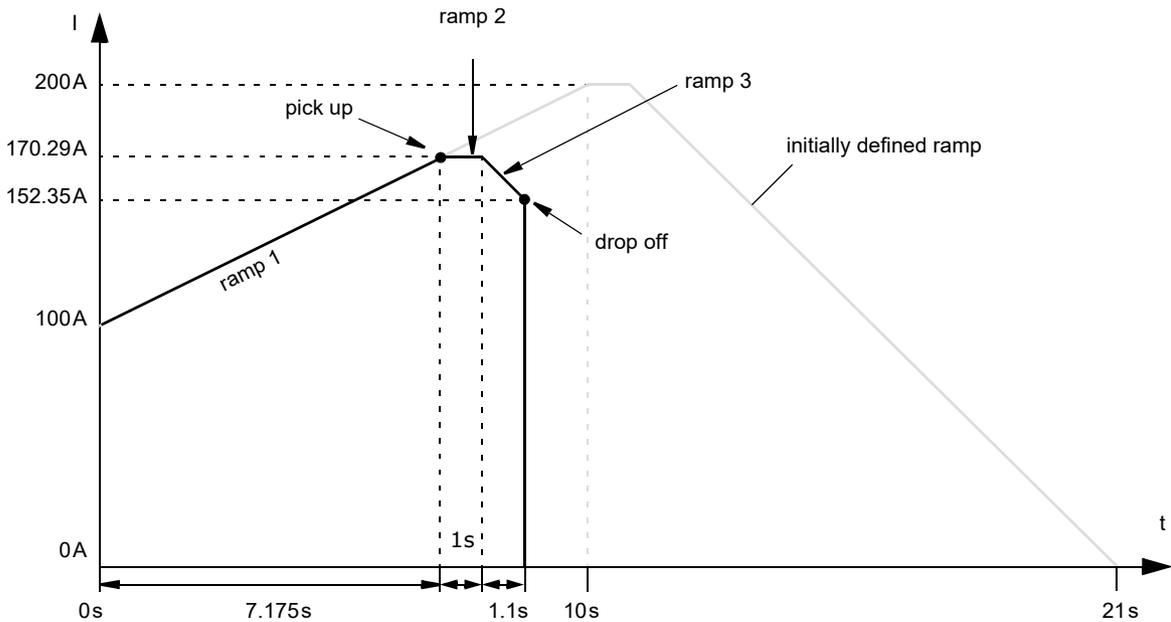


Figure 9-21: Time sequence of the three ramps to determine the pick up and drop off values of an Overcurrent relay

## 9.4 Amplifier

Use the **Amplifier** test card to set the *CPC 100* to an "amplifier-like" mode. In this mode, an input signal fed into a synchronization input drives the high-current output's magnitude, frequency and phase angle.

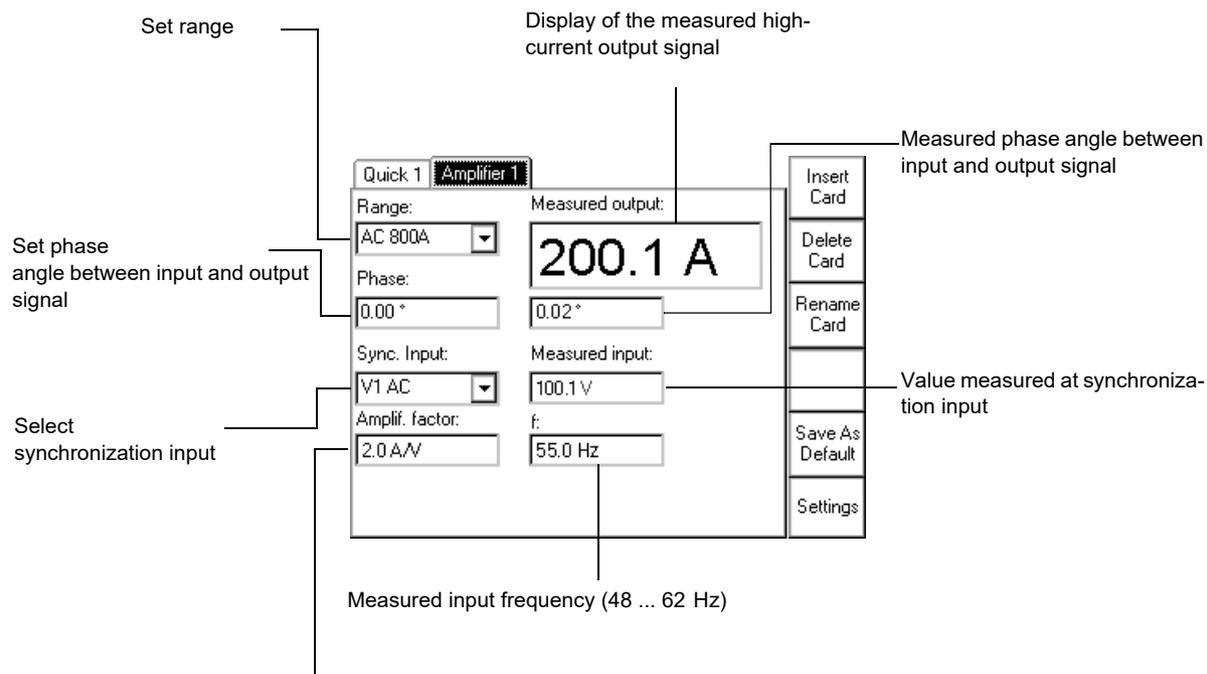
Select between **I AC**, **V1 AC** and **V2 AC** as synchronization inputs.

To prevent saturation, the output signal follows sudden magnitude changes at the synchronization input slowly. This smoothening effect delays the follow-up of the output current up to 250 ms.

Both the "amplification" factor and the phase angle between input and output are set by the user in the **Amplifier** test card.

**Note:** Changes in frequency and phase angle may result in unwanted effects. Both frequency and phase must be held stable.

**Note:** The input frequency is limited to a range of 48 ... 62 Hz.



Set the amplification factor to determine the ratio between the input and the output signal.

**Note:** The synchronization input is not automatically range-switching, it is fixed to its maximum value.

Figure 9-22: The **Amplifier** test card

 Pressing the **Settings** menu key opens the **Settings** page. The **Settings** page allows setting the test cards individually. As a rule, do not use the **Settings** page but the **Device Setup** tab in the **Options** view (see "Device Setup" on page 56) to set the test cards. For more information, see "Settings page" on page 50.

## Starting a high-current output

### WARNING



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

Depending on the measured input signal, setting the amplification factor can result in unintentionally high currents.

- ▶ Set the amplification factor to “0” before starting the test.

- ▶ Set an amplification factor of “0”.
- ▶ Press I/O (test start/stop) to output the signal.
- ▶ With the measured input value in mind, enter the amplification factor now or increase the factor slowly using the handwheel.
- ▶ Acknowledge this entry by pressing the handwheel or the **Enter** key to start the output.

### 9.4.1 Amplifier use case: GPS-synchronized 3-phase system for end-to-end testing

This example shows how the three current outputs of a *CMC 256plus* are led to the I AC/DC synchronization inputs of three *CPC 100* test sets to drive their high-current outputs. In this scenario, the *CPC 100*'s high-current outputs (800 A AC) represent the "amplified" *CMC 256plus* outputs and are connected to three CTs.

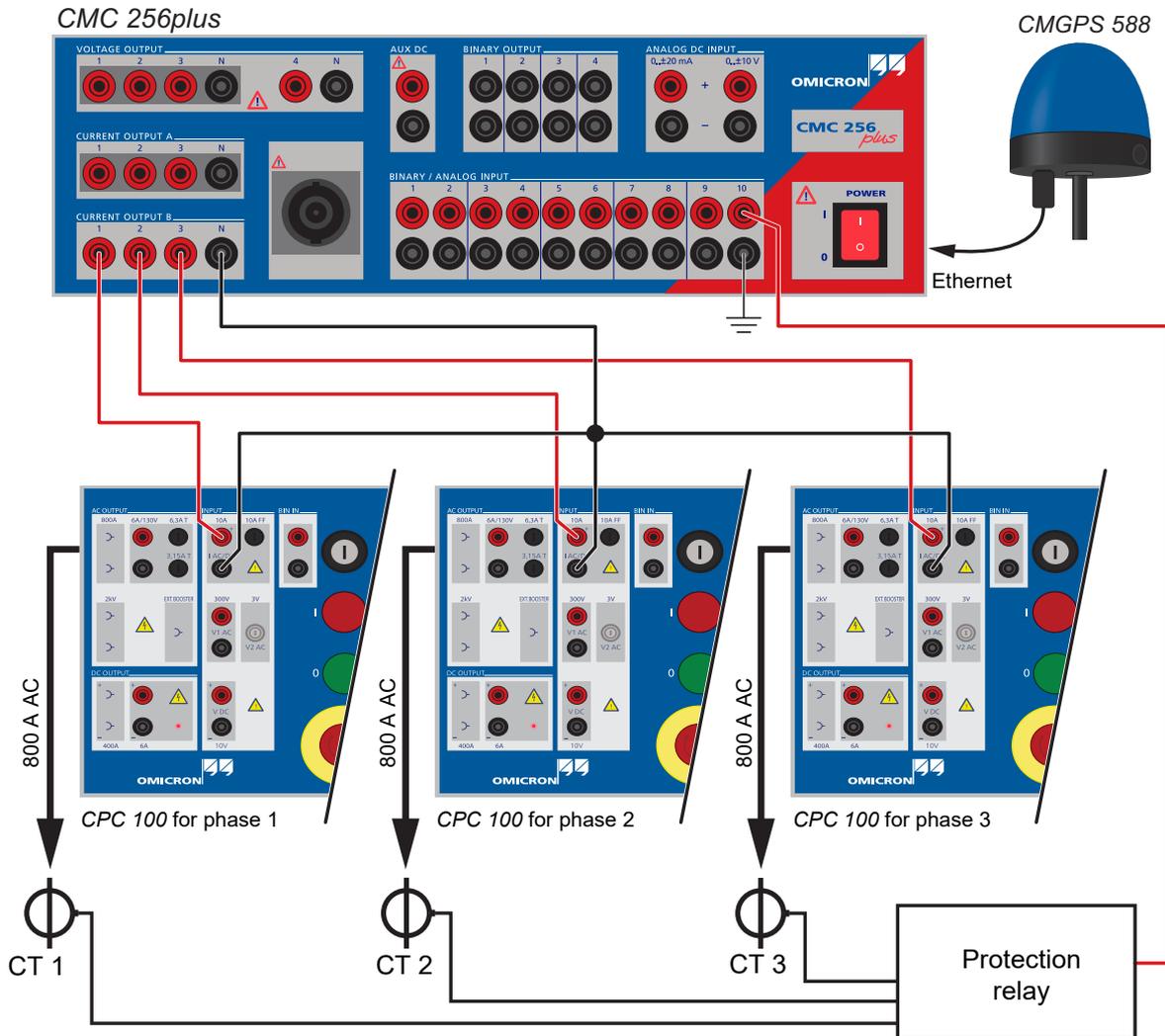


Figure 9-23: Setup of a GPS-synchronized 3-phase system for end-to-end testing using a *CMGPS 588* synchronization unit, a *CMC 256-3* and three *CPC 100*

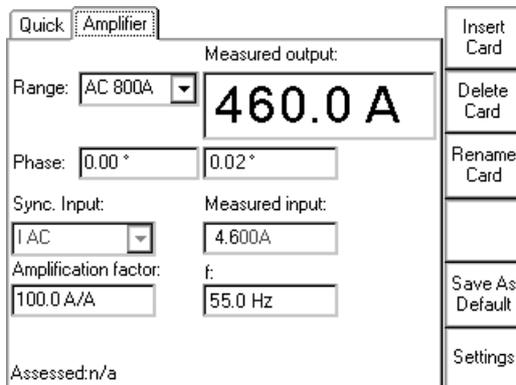


Figure 9-24: Settings of **Amplifier** test card for this example use case

## 9.5 Comment

The **Comment** card is inserted to a test procedure in the same manner like a test card. Its purpose is to hold a user-defined comment and/or note regarding the actual test procedure or other important information such as operational data of a transformer, for example.

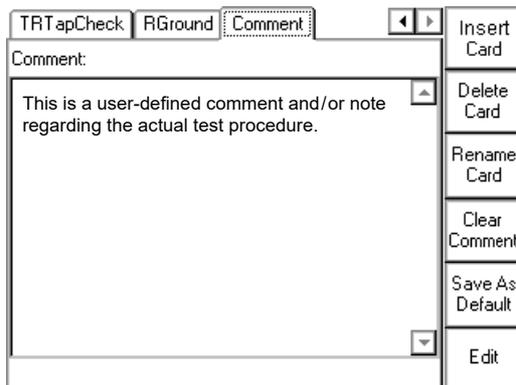


Figure 9-25: The **Comment** card

-  ► Insert a **Comment** card to the actual test procedure by pressing **Insert Card**. If required, you can insert more than one **Comment** cards.
-  ► Press the context-dependent menu key **Edit** to start the *String Editor*.

When used for the **Comment** card, the *String Editor* differentiates between the input modes "Form Editor" and "Text Editor".

After pressing **Edit**, "Text Editor" is active. With the exception of the context-sensitive key to switch between these two modes, the user interface is identical.

To create "flowing" text with no tabs in it, either input mode can be used. Compose a text of your choice by selecting the individual characters and symbols needed one by one and confirm them by pressing the handwheel. When finished, acknowledge with **OK**.

## 9.5.1 Form editor - text editor:

To o create such a "2 columns" layout, press **Edit Form**.

Sub.:	Buers
Trans.:	TR24
Manuf.:	Siemens
Type:	KFRM 1863A / 22E
Year:	1955
Se. No.:	T-54953
Power:	100 MVA
VecGr.:	YN/yn0
Uprim:	220.000V
Iprim:	262.5A
Usec:	110.000V
Isec:	525.0A
Uk:	10.2%

Enter the first word "Substation" and then a tab. Proceed with "Buers" and a carriage return. Proceed accordingly:

Sub.	→	Buers	↵
Trans.	→	TR24	↵
Manuf.	→	Siemens	↵
Type	→	a.s.o.	

The tab quasi denotes a column-break.

The difference between Form Editor and Text Editor is that text left of the tab (the "first column", so to speak) cannot be accessed anymore in Text Editor, that is, it is protected. To add, edit or delete first column entries use the Form Editor.

More about function and handling of the *String Editor* at 10.2 "The String Editor" on page 272.

### How to change a comment



- ▶ If you need to change an existing comment, press **Edit**. This starts the *String Editor*.
- ▶ Start the appropriate input mode, "Form Editor" or "Text Editor", change the entries of your choice and press **OK**.

### How to clear a comment



- ▶ Press **Clear Comment**.
- ▶ The context-dependent menu keys change and provide two more keys: **Clear All** and **Clear Text**.

**Clear All:** Deletes the entire comment at once, that is, all text in all columns.

**Clear Text:** Deletes all to the right of the tab, that is, everything but the left-hand side column.

## 9.6 TanDelta - PF

The test card **TanDelta - PF** was especially developed for the *CP TD*.

The *CP TD* (*CP TD1*, *CP TD12* or *CP TD15*) is an optionally available high-precision test system for on-site insulation tests of high-voltage systems like power and measuring transformers, circuit breakers, capacitors and isolators. The *CP TD* works as an add-on device to the *CPC 100* and is described in the *CP TD1* and *CP TD12/15* User Manuals on the *Primary Test Manager* DVD and the *CPC 100 Start Page*.

The **TanDelta - PF** test card can be accessed from CT, VT, Transformer and Others.

## 9.7 Ratio with sampled values

Use the **SV-Ratio** test card to check the ratio of the output current or voltage and the input current or voltage of the selected merging unit channel according to the IEC 61850 standard. In addition, the **SV-Ratio** card is used to determine the polarity of the signal, whereas the *CPC 100* serves as the signal source. The merging units generate the input voltages or currents.

The **SV-Ratio** test card can be accessed from CT, VT or Others. For further information, refer to 5.12 "Ratio with sampled values" on page 132.

## 9.8 CP TD high-voltage source

In addition to the Dissipation Factor (TanDelta)/Power Factor test, the *CP TD* can also be used as a high-voltage source for measuring, for example, partial discharge or conducting high-voltage tests on rotating machines.

To compensate capacitive currents, a parallel resonance circuit can be set up.

The compensation using the *CP CR* (*CP CR500* or *CP CR600*) compensation reactor is realized in two different ways: First, by parallel circuiting the compensation reactors to measure as close as possible to the resonance frequency when measuring with nominal frequency is required. Second, by setting the frequency to measure at exactly the resonance frequency. The longest output duration is achieved with testing at resonance frequency, in most cases accomplished by a combination of both procedures.

**Note:** The *CP CR500* can only be used with the *CP TD1*, while the *CP CR600* can only be used with the *CP TD12* or *CP TD15*.

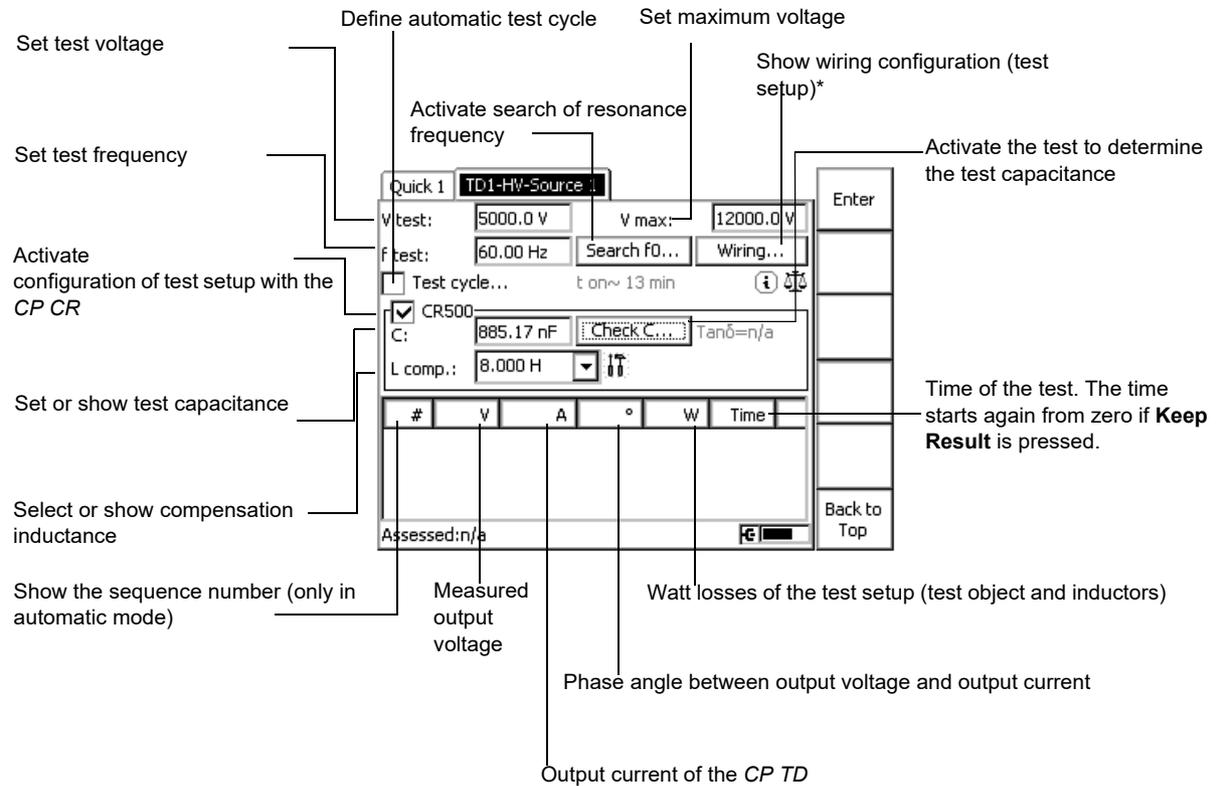
The **CP TD High-Voltage Source** test card can be used both for manual or fully automatic testing by toggling defined ramps and sequences. The test card is also helpful in setting up the optimum test configuration to achieve the best possible test duration.

### 9.8.1 Typical test procedure

For more information on typical test procedure refer to the following user manuals:

- CP TD1 User Manual and CP CR500 User Manual
- CP TD12/15 User Manual and CP CR600 User Manual

#### Main page



\*Wiring Information:

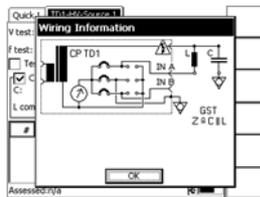


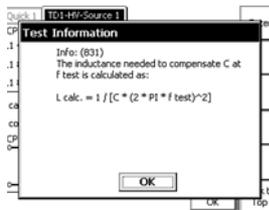
Figure 9-26: CP TD High-Voltage Source test card

## Test settings

Annotations for the TD1-HW-Source test settings menu:

- Set available CP CR
- Show minimum inductance possible with available CP CR
- Show maximum inductance possible with available CP CR
- Show calculated inductance for resonance frequency with f test and capacitance set in main page
- Select or show compensation inductance combinations possible with available CP CR
- Show configuration for selected L comp.
- Set test frequency
- Test information\*
- Shows resonance frequency with selected L comp. and capacitance set in main page

\*Test Information:



- Set your CP CR you have available. Press the **Save as Default** key. The settings will be saved for future use of the test card.

Figure 9-27: CP TD High-Voltage Source test settings

### Activate C test

1. Set your test voltage for the capacity test (**V test**).
2. Press the **Check C...** button.
3. The dialog shows the internal connection of the *CP TD* and the test mode ( $GSTg-A+B$ ), as well as the test setup:

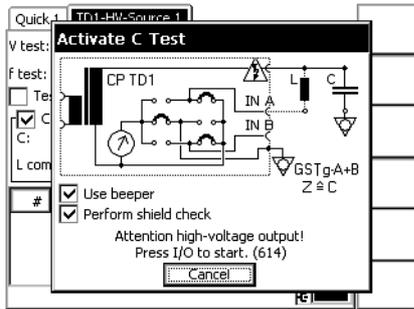


Figure 9-28: Activate C Test

4. **User beeper**: activate or deactivate beeper.
5. **Perform shield check**: activate or deactivate the shield check of the high-voltage cable.
6. Press the I/O (test start/stop) push-button to start the test.
7. The test progress is shown in the status bar. During the measurement, the test voltage can be set or changed.
8. **C** and **Tanδ** are shown during and after the test and the best **L comp.** is set for the frequency chosen and the measured capacity.

If the capacity cannot be compensated with the available *CP CR* set in the main page and the chosen frequency, an information symbol will appear next to the **L comp.** field. If you click this symbol, the warning message shows the **L calculated** for the resonance frequency with the given **C** and **f test**, and the **L comp.** which comes the closest to the **L calc.** and **f test**.

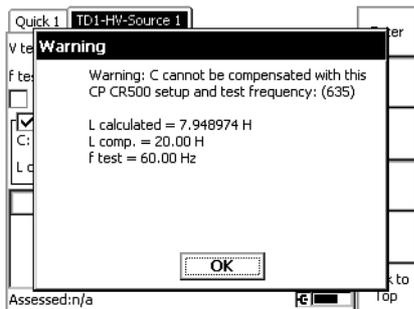


Figure 9-29: Warning message

### Search f0...

1. Set the test voltage (**V test**).
2. Press the **Search f0...** button.
3. The dialog shows the internal connection of the *CP TD* and the test mode (GST), as well as the test setup:

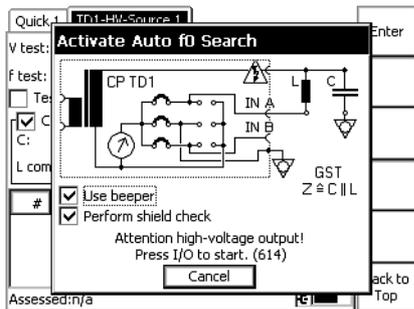


Figure 9-30: Activate Auto f0 Search

4. **User beeper**: activate or deactivate beeper.
5. **Perform shield check**: activate or deactivate the shield check of the high-voltage cable.
6. Press the I/O (test start/stop) push-button to start the search.
7. The search progress is shown in the status bar. During the measurement, the test voltage can be set or changed.
8. The resonance frequency  $f_0$  for the test setup is set in **f test**:

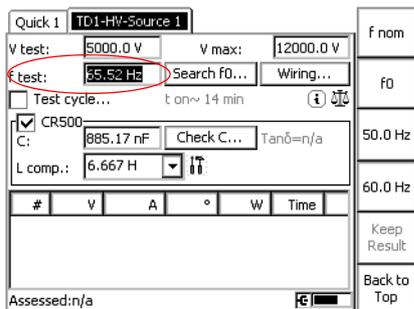


Figure 9-31: Set resonance frequency

- If the resonance frequency cannot be found with the frequency range of 15 Hz to 400 Hz, a warning message appears:

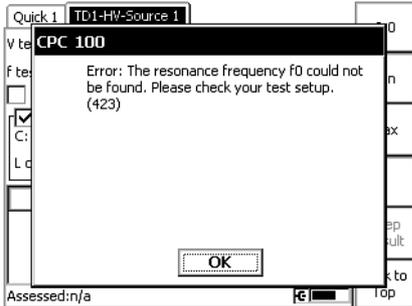
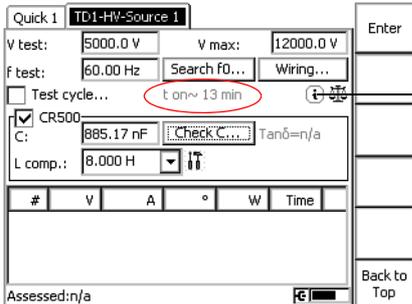


Figure 9-32: Warning message

### t on time

If the *CP CR* setting is selected, the calculated output time is shown for the given configuration (**C**, **L comp.** and **f test**). The output time is limited by the needed current of the *CP TD* or the duty cycle of the *CP CR*. The needed output current is defined by the losses of the test object, the losses of the inductors (*CP CR*) and the needed capacitive or inductive current if not testing at resonance frequency **f<sub>0</sub>**.

**Note:** The **t on** time is a rough calculation and is also dependent on the internal temperature of the *CP TD* high-voltage transformer. Therefore, the real output time can be longer or shorter.



Appears only if use **CR500/CR600** is enabled

**Note:** Depending on the connected *CP TD* device, the *CPC 100* either switches to the *CP CR500 (CP TD1)* or *CP CR600 (CP TD12 or CP TD15)* mode.

Figure 9-33: t on time

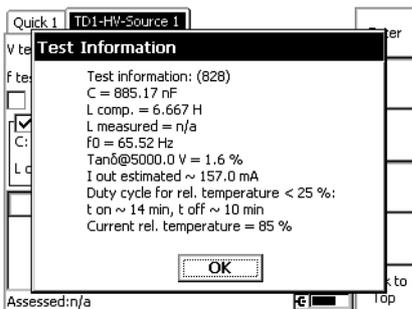


Figure 9-34: Test information

**Test Information** dialog: The test information dialog shows the known values and details of the test setup. The **rel. temperature** is the relative temperature of the *CP TD* high-voltage transformer (0 to 100%). The **t on** time is always calculated for a rel. temperature < 25%. The **I out estimated** is the calculated current needed from the *CP TD*. The actual **I out** can be higher or lower.

### Test cycle

If the **Test cycle** check box is selected, the *CP TD* performs an automated test defined by the test cycle.

Set the sequence for the test. Up to 16 sequences can be defined

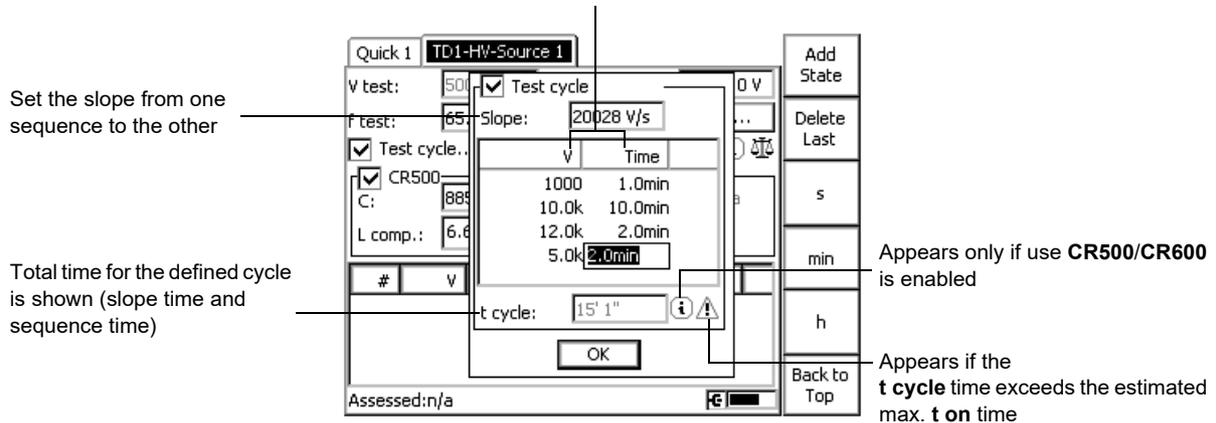


Figure 9-35: Test cycle

If the warning symbol is selected and the handwheel or return button is pressed, the warning message will appear:

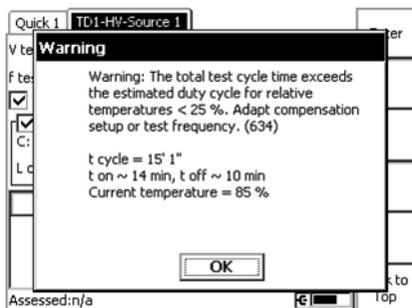


Figure 9-36: Warning message

Pressing the I/O (test start/stop) push-button of the CPC 100 will display the following dialog.

1. The dialog shows the internal connection of the CP TD and the test mode (GST), as well as the test setup:

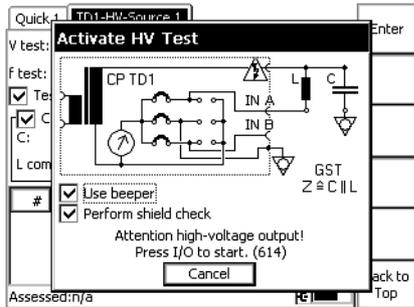


Figure 9-37: Activate HV Test

2. **User beeper**: activate or deactivate beeper.
3. **Perform shield check**: activate or deactivate the shield check of the high-voltage cable.
4. Press the I/O (test start/stop) push-button to start the test cycle.
5. After completing the test, a result line for each sequence is generated:

#	V	A	°	W	Time
*1	1000	4.1945m	-89.85	10.90m	1' 0"
2	9996	41.872m	-89.81	1.3871	10' 0"
3	12002	50.279m	-89.81	1.9985	2' 0"
4	4993	20.913m	-89.81	347.2m	1' 0"

Figure 9-38: Results of the HV test

## 9.9 HV Resonance Test System

The **HV Resonance Test System** test card is used for generic high-voltage tests on GIS with a resonance circuit in combination with the *CP RC1* or *CP RC2* test system.

For more information on typical test procedure refer to the following user manuals:

- CP RC1 User Manual
- CP RC2 User Manual

### 9.9.1 Test settings

The output voltage is displayed very clearly on the main page of the test card. The frequency has to be set manually or by pressing **Search f0...**. The location indicator shows the controlled input channel. The location indicator is placed either above **V out** (External Booster) or above **VT** (V1 AC).

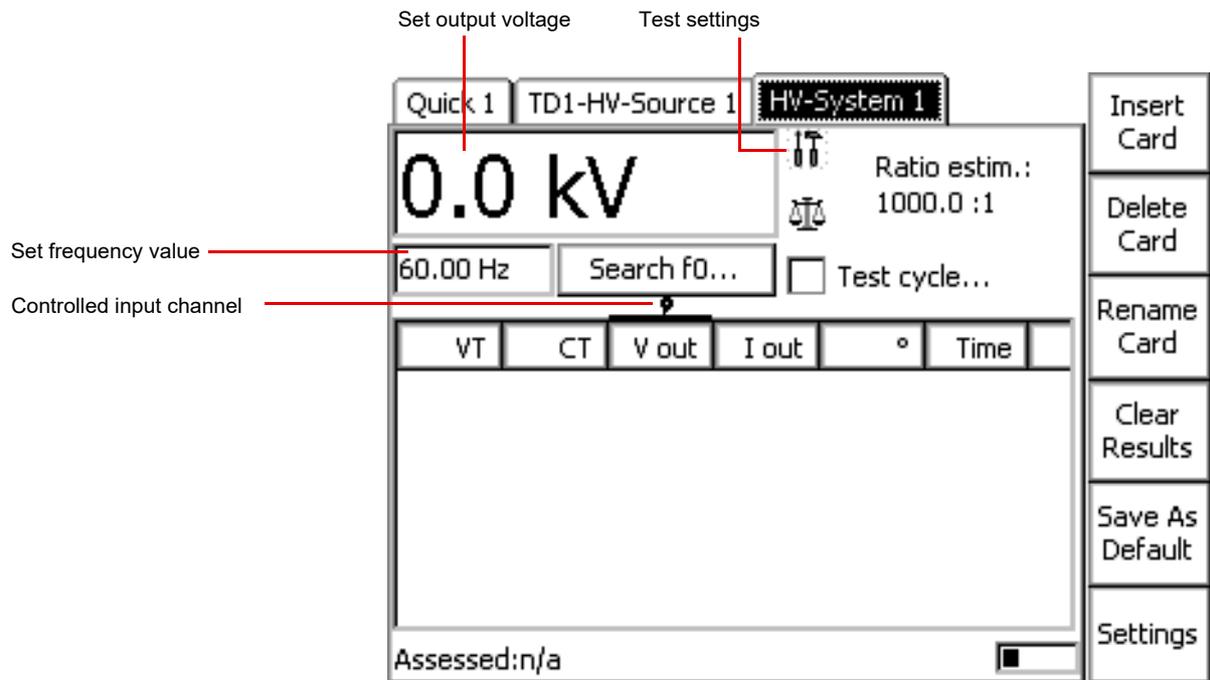
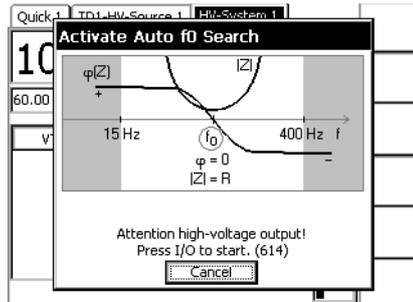


Figure 9-39: HV Resonance Test System test card

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

Ratio estim.:	Estimated VT ratio
Search f0...:	Automatic search of resonance frequency. Pressing this key will open the following dialog:



Test cycle:	Define/set automatic test cycle
VT:	Voltage as defined in the settings page.
CT:	Current as defined in the settings page.
V out:	Output voltage at <b>CPC 100 Ext. Booster</b> output
I out:	Output current at <b>CPC 100 Ext. Booster</b> output
°:	The ° shows the phase angle of I out relative to V out.
Time:	Time elapsed for this measurement

To set the test cycle:

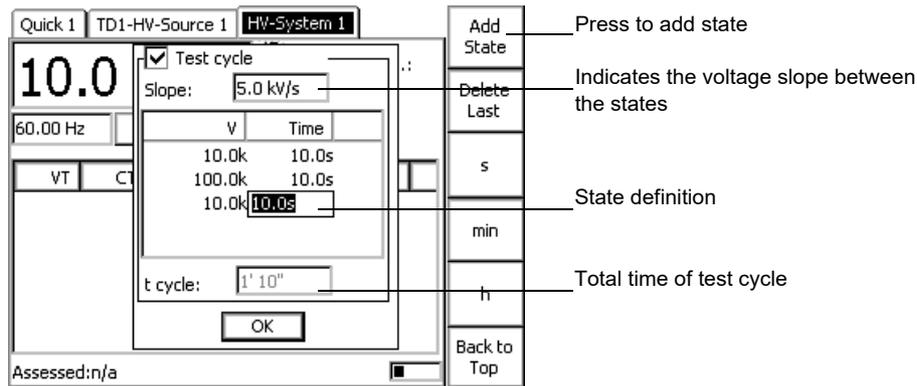


Figure 9-40: Test cycle settings

Settings Pressing the **Settings** menu key opens the settings page.

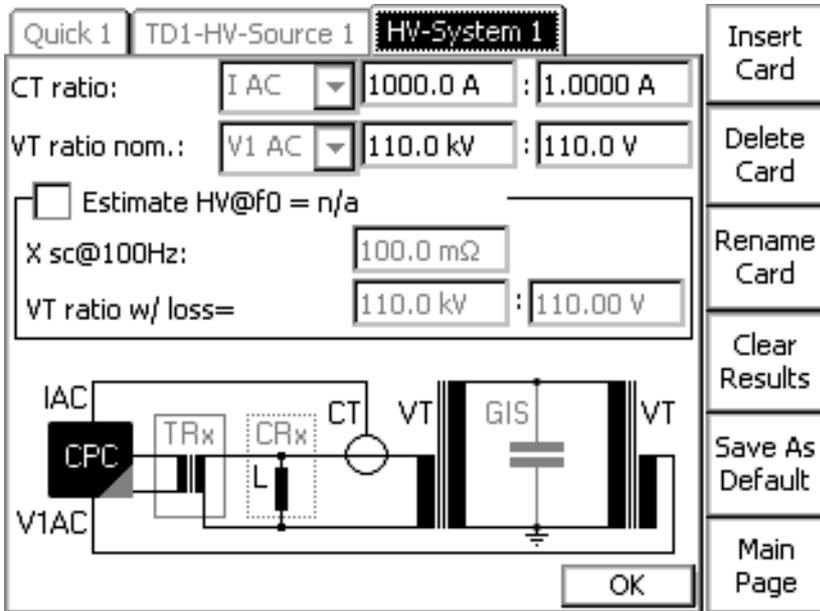
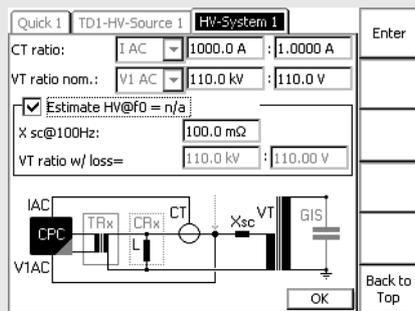


Figure 9-41: Settings page of the **HV Resonance Test System** test card

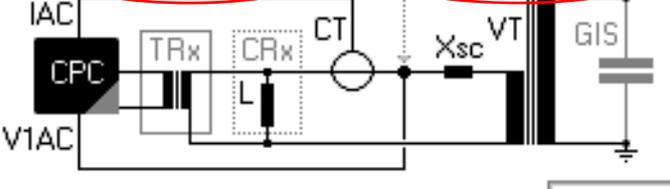
CT ratio:	Nominal CT ratio according to CT nameplate
VT ratio nom.:	Nominal VT ratio according to VT nameplate
Estimate HV@f0=n/a:	Select if no measurement VT is available. Selecting this check box will show a different circuit diagram on the test card:



X sc@100Hz:	Short-circuit impedance of the power VT at 100 Hz
VT ratio w/ loss=:	Estimated power VT ratio with losses

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After determining the resonance frequency, the settings page will show additional information (marked in red):

Quick 1	TD1-HV-Source 1	<b>HV-System 1</b>	Insert Card
CT ratio:	I AC	1000.0 A : 1.0000 A	Delete Card
VT ratio nom.:	V1 AC	110.0 kV : 110.0 V	Rename Card
<input checked="" type="checkbox"/> Estimate HV@f0 =	43.35 Hz		Clear Results
X <sub>sc</sub> @100Hz:	100.0 mΩ		Save As Default
VT ratio w/ loss=	110.7 kV : 110.00 V		Main Page
<b>I0=430.0 mA@f0</b> <b>V0=10.000 V@f0</b>			OK
			

## 10 Common functions

This chapter describes functions and procedures that repeat in all or various test cards. Since these functions are operated in the same fashion on all test cards, they are explained only once in a central place.

### 10.1 Test assessment

The test assessment is a manual procedure carried out by the user.

The example below shows an assessment made at a **VTRatio** test card. However, the assessment procedure is carried out in the same fashion on all test cards.

The screenshot shows the VTRatio test card interface. At the top, there are tabs for 'VTRatio 1', 'VTBurden 1', 'VTElectronics 1', and 'TF'. Below the tabs, there are several input fields and checkboxes. The 'V prim.' field is set to '10000.0 V' and the 'V sec.' field is set to '100.0 V'. There are three checkboxes for '1/√3', with the first one checked. The 'V test' field is set to '2000.0 V' and the 'f' field is set to '50.00 Hz'. There are two checkboxes for 'Auto', with the first one checked. The 'V prim.' field is set to '2.000 kV' and the 'V sec.' field is set to '20.087 V'. There is a '0.25 °' field and a 'Manual input' checkbox. The 'Ratio' field is set to '10000.0/√3:100.43/√3' and the '0.433 %' field is set to '0.433 %'. The 'Polarity' field is set to 'OK'. At the bottom left, there is an 'Assessed:n/a' field. At the bottom right, there is a scale icon and an 'Exit Card' button. On the right side of the screen, there are buttons for 'OK', 'Failed', 'Clear Assess.', and 'Exit Card'.

Figure 10-1: **VTRatio** test card - test assessment



After the test, set the focus on the assessment symbol by turning the handwheel.

If this symbol is selected, the test card's bottom line shortly shows "Change test assessment [OK/Failed]", and then returns to "Assessed: n/a".

The scale symbol designates that no manual assessment was done yet.

The context-dependent menu keys now provide the option to manually assess the test as either **OK** or **Failed**.

Assessing the test appends the actual date and time to the bottom line string "Assessed:" and displays a corresponding icon on the screen:

- ✓ Test OK
- ✗ Test failed

Pressing **Clear Assess.** clears both the assessment and the assessment's date/time stamp in the bottom line, and lets you renew your assessment.

## 10.2 The String Editor

The *String Editor* is used to name or rename test cards, tests and templates as well as to fill out the Comment card.

Every time such an operation becomes necessary, the *String Editor* starts automatically.

The number of available characters to choose from depends on the *String Editor's* use. If, for example, a user-defined comment is to be entered in the Comment card, the number of available characters is bigger as if a test is to be renamed. This difference are special characters such as !, ?, \_, [ ], etc.

### Important special characters:

- ↵ carriage return (line feed)
- tab (special function in Form Editor mode; refer to 9.5.1 "Form editor - text editor:" on page 258).

When started from Test Card View, Test Procedure Overview or File Operations, the *String Editor's* respective entry field shows a default name.

To accept the default name, press the menu key **OK** or **Save**.

To change the default name, and to enter a name of your choice

- ▶ delete the default name by repeatedly pressing the backspace key
- ▶ enter the new test or folder name by consecutively selecting the characters of your choice from the "on-screen keyboard" with the **Up / Down** keys or by navigating to it with the handwheel
- ▶ acknowledge every selected character by pressing the handwheel or **Enter**

Use the *String Editor's* arrow buttons to move the cursor to the position of your choice. These buttons are only available if the focus is on the character selection.

On the **Comment** card, pressing **Carriage Return** starts a new line. Otherwise, **Carriage Return** is disabled.

Once the new name is entered, press the context-dependent menu key **OK** or **Save** - depending on the mode - to exit the *String Editor*.

Pressing **Cancel** closes the *String Editor* discarding all changes.

## 10.2.1 Template phrases

The *String Editor* provides a feature that allows you to save phrases, that is, names of test cards, tests, templates, folders and files. Once these phrases are saved, they can then be selected as template phrases from the combo box "Select a phrase".

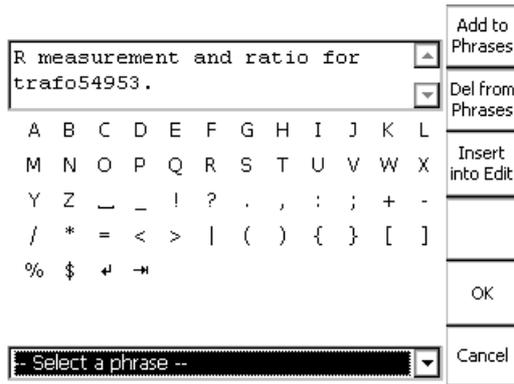


Figure 10-2: *CPC 100 String Editor* with focus on "Select a phrase"

### How to save a phrase:

- ▶ enter a name of your choice in the way described above
- ▶ put the focus on the combo box "Select a phrase"



- ▶ press **Add to Phrases** to add this name to the list of template phrases.

### How to select a template phrase:

- ▶ put the focus onto the combo box
- ▶ press the handwheel and turn it to browse through the list of available, that is, previously saved, template phrases
- ▶ highlight the template phrase of your choice, and press the handwheel or the context-dependent menu key **OK**. The template phrase is then automatically added to the upper entry field.

### How to insert a template phrase:

- ▶ select a template phrase as described above



- ▶ once the template phrase of your choice is highlighted, press **Insert into Edit**. The phrase is then automatically inserted into the upper entry field at the cursor position (refer to Figure 10-2).

### How to delete a template phrase:

- ▶ highlight a template phrase as described above



- ▶ press **Del from Phrases** to delete the selected phrase template from the list.

**Note:** The **Restore defaults** menu key at the **Options** tab **Device Setup** (refer to "Device Setup" on page 56) resets all user-specific settings made in the *CPC 100* software to factory-defined defaults. This also includes the *String Editor's* template phrases.

# 11 CPC 100 in a network

## 11.1 General

The interface to access the *CPC 100* built-in ePC is an Ethernet board. The *CPC 100* can be connected with a 10BaseT ("twisted pair") connection cable to either a stand-alone PC, or an existing PC network. For this, the Ethernet board provides one RJ-45 connector (for *CPC 100* V1):

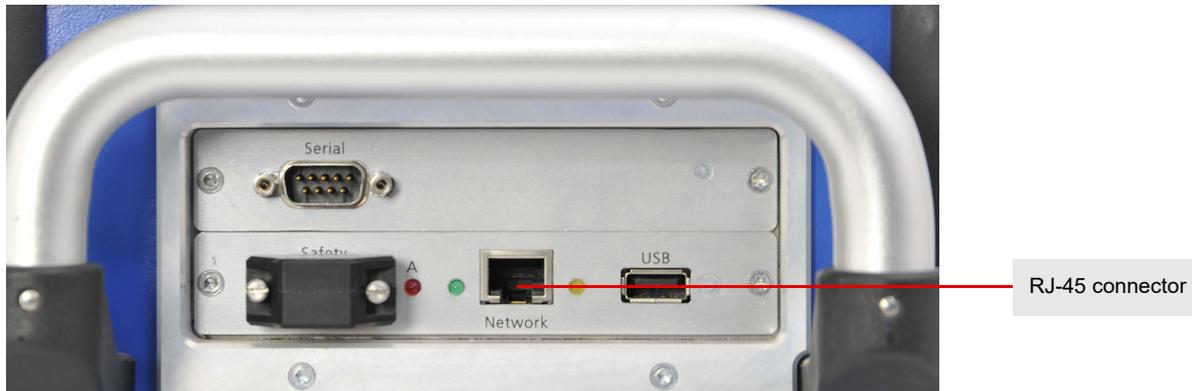


Figure 11-1: RJ-45 connector of the *CPC 100*

The communication protocol is the TCP/IP protocol.

## 11.2 Setting the communication parameters

### 11.2.1 *CPC 100*

For two devices to communicate using TCP/IP (the most-commonly used protocol for Ethernet), both devices need a unique network address, that is, an address that is different from all other addresses within this network.

In addition, these devices need an identical subnet mask.



The *CPC 100* communication parameters are set on the **Network** tab of the **Options** view (refer to "Network" on page 58).

#### DHCP/Auto-IP

Most PC networks have a DHCP (**D**ynamic **H**ost **C**onfiguration **P**rotocol) server that provides an address for every device connected to the network and defines the subnet mask. When connected to such a network, setting the *CPC 100* to DHCP/Auto-IP mode enables it to obtain an address from the DHCP server. If there is no DHCP server (for example, because the *CPC 100* is directly connected to a PC), the *CPC 100* generates its address automatically (Auto-IP).

Older versions of Microsoft Windows, such as Windows 95 or NT 4.0, support DHCP but not Auto-IP. For details about how to establish a communication via a direct connection, refer to the section "Because there is no DHCP server present when a CPC is connected directly to a PC (point to point), the CPC 100 is capable of providing the PC with a valid address as long as there is no server detected and the

CPC 100 Start Page is running on the PC. The address is chosen from the Auto-IP address range, so it does not interfere with other addresses within the network. It is also assured that only those PCs are provided with an IP address that run the CPC 100 Start Page." on page 279 of this chapter.

## Static IP

In smaller PC networks, all computers have individual static IP addresses. The system administrator has to assure that no IP address is used twice. He provides you with a unique address and all other settings for the *CPC 100*.

If, by mistake, an IP address is used twice in the network, communication of one or both of the devices will fail to work.

If you are in doubt, set the PC and *CPC 100* to DHCP/Auto-IP.

## IP address

This is the unique network address of *CPC 100*. You need this setting only if static IP addresses are used. Your system administrator will provide you with a valid static IP address.

## Subnet mask

This is the filter for the IP address. It has to be identical for all devices within one network. You need this setting only if static IP addresses are used. Your system administrator will provide you with a valid subnet mask.

## Default gateway

This is the address of a local IP router on the same network the *CPC 100* is in. It is used to enable data traffic to destinations beyond the local network.

Commonly, the default gateway is not needed and can therefore be set to 0.0.0.0 for DHCP/Auto IP. This setting is only accessible if static IP addresses are used. Your system administrator will provide you with details.

## DNS

This is the address of the **Domain Name System** server. Commonly, this address is not needed and can therefore be set to 0.0.0.0. This setting is only accessible if static IP addresses are used. Your system administrator will provide you with details.

## 11.2.2 PC or Notebook

If your PC or notebook is capable of communicating in a PC network, communication with your *CPC 100* either within a network or via a direct connection to the *CPC 100*, should work without changing any of your PC settings.

**Note:** To avoid possible communication problems, we recommend first fully booting the *CPC 100*, then connecting the *CPC 100* to the PC and eventually starting the *CPC 100 Start Page*.

Computers with a Windows 95 or a NT 4.0 operating system need a special setup. These details are explained in chapter "Because there is no DHCP server present when a CPC is connected directly to a PC (point to point), the CPC 100 is capable of providing the PC with a valid address as long as there is no server detected and the CPC 100 Start Page is running on the PC. The address is chosen from the Auto-IP address range, so it does not interfere with other addresses within the network. It is also assured that only those PCs are provided with an IP address that run the CPC 100 Start Page." on page 279.

In a network with static IP addresses, your system administrator will provide you with valid settings for the *CPC 100*.

In a network with dynamic address configuration (DHCP or Auto-IP), set your *CPC 100* to "DHCP/Auto-IP". This way, both the addresses of your PC and *CPC 100* will be generated automatically.

### Troubleshooting in case of communication problems

Should communication problems occur, the *CPC 100 Start Page* will assist you in accessing the *CPC 100* through the network, and, if possible, make useful suggestions about the settings to enter. Generally, all you need to do is to press **OK** a few times to acknowledge suggested settings.

Since the *CPC 100* may re-boot, make sure to save your data beforehand.

If your *CPC 100* is not listed on the *CPC 100 Start Page* although correctly connected, you need to check the Ethernet connection cable:

### Connection from the *CPC 100* network port (RJ-45) to the PC

Connect and disconnect the 10BaseT connection cable several times and check whether the link indicator light<sup>1</sup> near the PC's port turns on and off.

**Note:** In general, a communication is established quicker, however, under certain circumstances it may take up to 2 minutes until a proper communication is set up. During this phase, we recommend clicking the Refresh button on the *CPC 100 Start Page* from time to time.

If you still don't get a connection, try another 10BaseT connection cable on a different port of the hub.

If the link indicator light works but you still cannot establish communication, try to deactivate firewall and/or antivirus software on your computer since applications like these may interfere and prevent proper communication.

If it still does not work, call the OMICRON hotline (see "Support" on page 335).

### Firewall configuration

A correct firewall configuration is essential to successfully establish a communication between the *CPC 100* and your computer.

**Note:** Any change to the firewall settings mentioned below requires administrator rights on your computer.

### Windows Firewall

The configuration of the Windows Firewall is carried out automatically during the installation of the *Primary Test Manager*. However, in certain cases this may have no immediate effect.

- ▶ To prevent the Windows Firewall from blocking communication, (temporarily) disable it via the Windows Control Panel.

If you are now able to successfully establish communication, the Windows Firewall was the reason for the blocked communication between your test set and your computer.

- ▶ Reconfigure the Windows Firewall in order to enable a permanent use of the test set without having to disable the Windows Firewall.  
For more information see "Manual firewall configuration" below.

---

1. Indicator light close to your PC's Ethernet connector that displays data traffic by going on and off.

## Third-party firewall

- ▶ If you are using a firewall other than the Windows Firewall, temporarily disable it to see if this firewall may be the cause for the blocked communication.

For more information on configuring a third-party firewall to allow a permanent communication between the *CPC 100* and your computer, refer to "Manual firewall configuration" below.

**Note:** Numerous computer security programs or anti-virus packages also contain an integrated firewall function.

## Manual firewall configuration

If you would like to manually configure your firewall settings, the following ports/services have to be open in order to get a functional communication.

Table 11-1: Inbound rules

Program/service name	Rule name	Protocol type	Local Port	Remote Port	Local IP	Remote IP
OMFind.exe <sup>1</sup>	OMICRON OMFind 4987 (UDP-In)	UDP	4987	Any	Any	Any
	OMICRON OMFind 4988 (UDP-In)	UDP	4988	Any	234.5.6.7	Any
	OMICRON OMFind 4987 (UDP-In)	UDP	4987	Any	Any	Any
	OMICRON OMFind 4988 (UPD-In)	UDP	4988	Any	234.5.6.7	Any

1. Default installation path:  
64-bit: C:\Program Files (x86)\Common Files\OMICRON  
32-bit: C:\Program Files\Common Files\OMICRON

Table 11-2: Outbound rules

Program/service name	Rule name	Protocol type	Local Port	Remote Port	Local IP	Remote IP
Excel.exe	OMICRON Excel File Loader FTP CMD (TCP-Out)	TCP	Any	21	Any	Any
	OMICRON Excel File Loader FTP DATA (TCP-Out)	TCP	Any	3000 - 3020	Any	Any
	OMICRON Excel File Loader TFTP (UDP-Out)	UDP	Any	69	Any	Any
Any	OMICRON OMFind (ICMPv4-Out)	ICMPv4	Any	Any	Any	Any
	OMICRON Primary Test Manager (ICMPv4-Out)	ICMPv4	Any	Any	Any	Any
ODBFileMonitor.exe <sup>1</sup>	OMICRON Device Browser File Monitor FTP CMD (TCP-Out)	TCP	Any	21	Any	Any
	OMICRON Device Browser File Monitor FTP DATA (TCP-Out)	TCP	Any	3000 - 3020	Any	Any

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Table 11-2: Outbound rules (continued)

Program/service name	Rule name	Protocol type	Local Port	Remote Port	Local IP	Remote IP
OMFind.exe <sup>1</sup>	OMICRON OMFind 4988 (UDP-Out)	UDP	Any	4988	Any	234.5.6.7
CPCEditor.exe <sup>2</sup>	OMICRON CPCEditor FTP CMD (TCP-Out)	TCP	Any	21	Any	Any
	OMICRON CPCEditor FTP DATA (TCP-Out)	TCP	Any	3000 - 3020	Any	Any
	OMICRON CPCEditor TFTP (UDP-Out)	UDP	Any	69	Any	Any
CPCStart-Page.exe <sup>2</sup>	CPCStartPage FTP CMD (TCP-Out)	TCP	Any	21	Any	Any
	CPCStartPage FTP DATA (TCP-Out)	TCP	Any	3000 - 3020	Any	Any
	CPCStartPage TFTP (UDP-Out)	UDP	Any	69	Any	Any
CPCUp-grade.exe <sup>2</sup>	CPCUpgrade FTP CMD (TCP-Out)	TCP	Any	21	Any	Any
	CPCUpgrade FTP DATA (TCP-Out)	TCP	Any	3000 - 3020	Any	Any
	CPCUpgrade TFTP (UDP-Out)	UDP	Any	69	Any	Any
PTM.exe <sup>2</sup>	OMICRON Primary Test Manager 6642 (TCP-Out)	TCP	Any	6642	Any	Any
explorer.exe	OMICRON Device Browser FTP CMD (TCP-Out)	TCP	Any	21	Any	Any
	OMICRON Device Browser FTP DATA (TCP-Out)	TCP	Any	3000 - 3020	Any	Any
	OMICRON Device Browser TFTP (UDP-Out)	UDP	Any	69	Any	Any

1. Default installation path:  
64-bit: C:\Program Files (x86)\Common Files\OMICRON  
32-bit: C:\Program Files\Common Files\OMICRON
2. Default installation path: C:\Program Files\OMICRON\PTM

## DHCP allocator service

In most PC networks there is a DHCP server that provides the connected network nodes with valid addresses. That way, every PC in the network is assigned a unique address.

Because there is no DHCP server present when a CPC is connected directly to a PC (point to point), the *CPC 100* is capable of providing the PC with a valid address as long as there is no server detected and the *CPC 100 Start Page* is running on the PC. The address is chosen from the Auto-IP address range, so it does not interfere with other addresses within the network. It is also assured that only those PCs are provided with an IP address that run the *CPC 100 Start Page*.

## 12 OMICRON Device Link

### 12.1 General

**OMICRON Device Link** manages the communication between a PC and OMICRON devices. It offers the required infrastructure to access and configure all devices connected to your computer via USB, Ethernet, or Wi-Fi.

For devices with internal storage like the *CPC 100*, in addition the **OMICRON File Browser** can be used for file exchange and preparation.

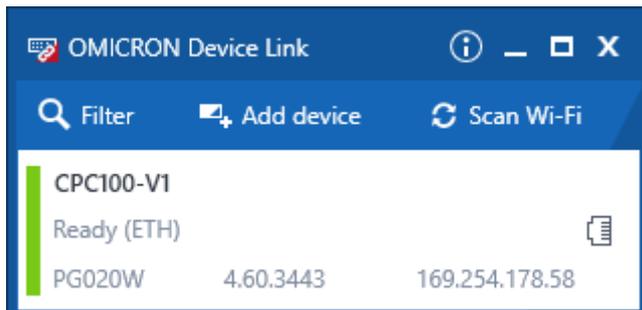


Figure 12-1: **OMICRON Device Link**

### 12.2 Installation of OMICRON Device Link

The **OMICRON Device Link** software is included on the *Primary Test Manager (PTM)* DVD and will be automatically installed together with *Primary Test Manager*.

**Note:** When installing *PTM*, beside **OMICRON Device Link**, **OMICRON Device Link extensions** for enabling the **OMICRON File Browser** are installed as well.

#### 12.2.1 System requirements

For the installation requirements, see 2.5.1 "System requirements" on page 70.

### 12.3 Using OMICRON Device Link

#### 12.3.1 Starting OMICRON Device Link

**OMICRON Device Link** can be accessed via:

- the **OMICRON Device Link** icon on the Desktop
- the **CPC Start Page > Tools > OMICRON Device Link**
- the **PTM Home View > Device > Start OMICRON Device Link**

### 12.3.2 OMICRON File Browser

The **OMICRON File Browser** enables access to the internal storage of the *CPC 100*. Within the *CPC 100* storage, test data as well logfiles are organized.

The **OMICRON File Browser** is designed in a side by side view, whereas the left part displays the PC storage and the right the *CPC 100* storage.



Figure 12-2: **OMICRON File Browser**

### 12.3.3 Functionality of the OMICRON File Browser

#### File Copy

Copy a file to the device from the PC and vice versa.

- UI Element: **Copy to device**, **Copy to Computer**
- Shortcut key: CTRL + S

**Note:** Operation is enabled, once a file has been selected.

#### Context menu

The context menu can be accessed, by performing a right-mouse button click on a file.

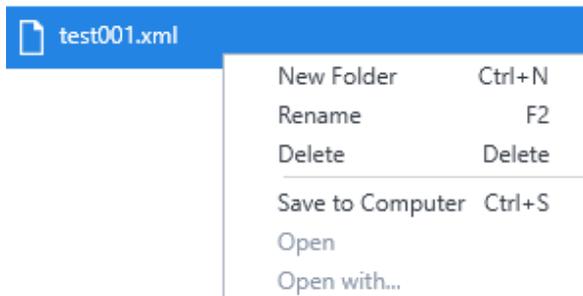


Figure 12-3: **OMICRON File Browser** context menu

### Create New folder

Create a new folder on the PC or device.

- UI Element: **Context menu > New Folder**
- Shortcut key: CTRL + N

### Rename

Rename a file or folder on the PC or device.

- UI Element: **Context menu > Rename**
- Shortcut key: F2

### Delete

Delete a file or folder on the PC or device.

- UI Element: **Context menu > Delete**
- Shortcut key: Del

### Navigation to previous location

Navigate to a folder on a higher hierarchy

- UI Element: **↑** symbol

**Note:** You can also select a folder directly by left-clicking on an entry in the **Address bar**,

- Shortcut key: ALT + Up Arrow

**Note:** User drives usually are organized within C: Users > [UserName]

## 12.4 Updating the *CPC 100* embedded software

The *CPC 100* embedded software must be compatible with the *Primary Test Manager* software. You can update the *CPC 100* embedded software by using one of the following procedures.

### 12.4.1 Updating via *PTM* Home view

To update the *CPC 100* embedded software in the *Primary Test Manager* home view:

1. In the home view, select the device you want to update from the list.
  2. Click **More** beneath the **Connect** button, and then click **Update device software**.
  3. In the **Select CPC Upgrade Image** dialog box, double-click the *UpgradeV1.upg* file.
- Alternatively, select the device you want to update from the list, and then click **Connect**. *Primary Test Manager* will prompt you to update the *CPC 100* embedded software, if necessary.

## 12.4.2 Updating software via OMICRON Device Link

To update the *CPC 100* embedded software by using **Device Link**:

1. Exit *Primary Test Manager* if it is running.
2. Double-click the **OMICRON Device Link** icon  on the desktop.
3. In the **Device Link** window, left-click the *CPC 100* device you want to update, and then click **Update firmware** to progress to the file selection screen.
4. Left-click the **Choose image** button to open the file selection dialogue.
5. You can find the update file:
  - On the *Primary Test Manager* DVD at  
 .\\_EmbeddedSoftware\CPC100\V1 device\UpgradeV1.upg
  - On the hard disk of your computer at  
 C:\Program Files (x86)\Common Files\OMICRON\Upgradelmages\CPC100\UpgradeV1.upg
  - ▶ Alternatively, for embedded Chinese language support, choose UpgradeV1\_CHS (Chinese Simplified) or UpgradeV1\_CHT (Chinese Traditional)
6. After the update has finished, *CPC 100* reboots automatically.
7. Restart *Primary Test Manager* after the update procedure has finished.

## 12.4.3 Upgrading licenses via Device Link

To update a *CPC 100* license by using **OMICRON Device Link**:

1. Exit *Primary Test Manager* if it is running.
2. Double-click the **OMICRON Device Link** icon  on the desktop.
3. In the **Device Link** window, left-click the *CPC 100* device you want to update, and then click **Manage licenses** to progress to the file selection screen.
4. Select the license upgrade package (.upg) and click **Open**.
5. Click **Yes** to proceed with the license upgrade when prompted.
6. After the update has finished, reboot the *CPC 100* device.

For detailed information, contact your local OMICRON sales representative or distributor.

## 13 *CPC Editor*

### 13.1 General

The *CPC Editor* is used for offline test preparation, that is to set up single test cards and/or entire tests with all of their test-specific settings on a PC, independent from the availability of a *CPC 100*.

The prepared test file (.xml file<sup>1</sup>) is then uploaded to the *CPC 100* using the OMICRON <product\_name>Device Browser.

The *CPC Editor* also opens executed and assessed test files that were downloaded from the *CPC 100* to your computer to view them, edit them, and, if required, save them on your computer's hard disk.

Additionally, a test file can be saved as test procedure template, that is a user-defined template containing one or more test cards with all of their specific test settings. To learn more about templates in general, please refer to 2.4.11 "Creating defaults and templates" on page 67.

#### 13.1.1 Installing the *CPC Editor*

For the installation procedure, see 2.5 "Installation of the CPC 100 Toolset" on page 69.

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1. An .xml file is a test with all of its test cards and specific settings. It may also contain test results and assessments that were stored together with the settings as report in the *CPC 100* file system for archiving purposes.



### 13.2.1 Appending a test card

Appending a test card means:

- appending it to an empty list, that is, make it the first test card
- appending it to the last position of an already existing list of test cards.

When the *CPC Editor* starts, the list view pane is empty. To insert a test card, either

- ▶ right-click the list view pane to open the shortcut menu and click **Insert Test Card...**

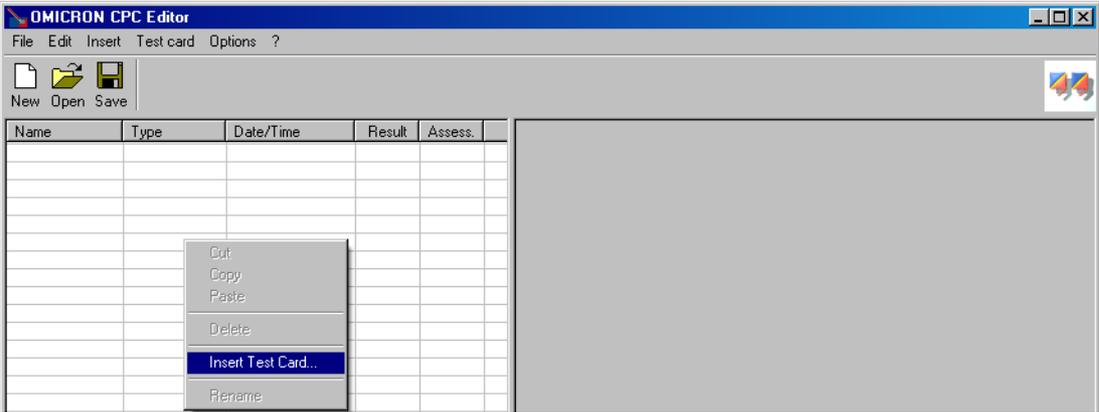


Figure 13-2: Shortcut menu of the list view pane

- ▶ or select the pull-down menu item **Insert | Test Card...**

In the **Insert Test Card** dialog box, select the test card of your choice and click **Append**.

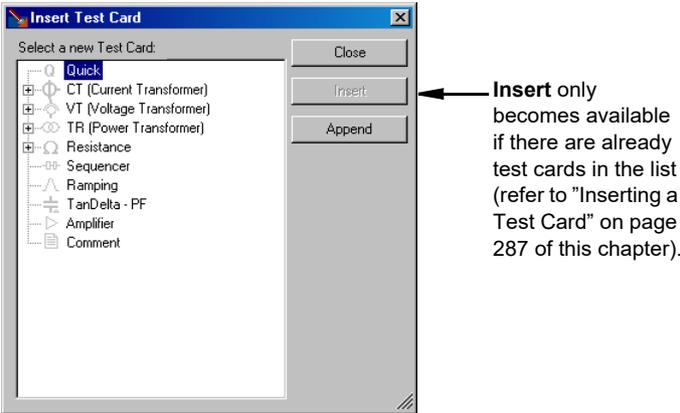


Figure 13-3: **Insert Test Card** dialog

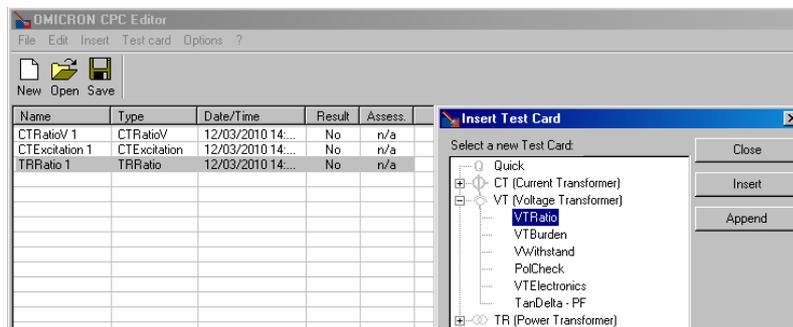
## 13.2.2 Inserting a Test Card

Inserting a test card means: inserting it into an already defined list of test cards.

The procedure of inserting resembles the one of appending a test card (described in "Appending a test card" on page 286 of this chapter). The difference is that the inserted test card is positioned in the list right *before* the currently selected test card rather than appended to the end.

Name	Type	Date/Time	Result	Assess.
CTRatioV 1	CTRatioV	12/03/2010 14:...	No	n/a
CTExcitation 1	CTExcitation	12/03/2010 14:...	No	n/a
TRRatio 1	TRRatio	12/03/2010 14:...	No	n/a

Already defined list of test cards, **TRRatio** selected.



Select

- **Insert|TestCard**
- **VTRatio**
- **Insert**

Name	Type	Date/Time	Result	Assess.
CTRatioV 1	CTRatioV	12/03/2010 14:...	No	n/a
CTExcitation 1	CTExcitation	12/03/2010 14:...	No	n/a
VTRatio 1	VTRatio	12/03/2010 14:...	No	n/a
TRRatio 1	TRRatio	12/03/2010 14:...	No	n/a

**VTRatio** is inserted before the selected **TRRatio** test card.

Figure 13-4: Example: inserting a **VTRatio** test card to an existing list of test cards

## 13.2.3 Inserting from file

Select **Insert | From File...** to browse for a previously saved **.xml** file. This **.xml** file is a test file that was either

- previously created with the *CPC Editor*, and saved to the computer's hard disk
- or previously created (and even executed and assessed) with the *CPC 100*, and then uploaded to the computer's hard disk by means of the OMICRON <product\_name>Device Browser.

Just like inserting a single test card, inserting an **.xml** file means, positioning its entire contents (one or more test cards) in the list right before the currently selected test card.

## 13.2.4 Copying a test card

In most cases, it is easier to copy/paste an existing and already parametrized test card, and to rename it accordingly, than to start a new one from the beginning.

To copy a test card either

- ▶ right-click the list view pane to open the shortcut menu and click **Copy**
- ▶ or select **Edit | Copy**.

This copies the selected test card to the Clipboard.

You now have three choices.

1. Insert the test card from the Clipboard into your list view:
  - ▶ either right-click the list view pane to open the shortcut menu and click **Insert Copied Test Card**
  - ▶ or select **Insert | Test card copied**

**Note:** Note that the inserted test card is positioned in the list right *before* the currently selected test card.

2. Paste the test card from the Clipboard into the list view overwriting a test card of your choice:
  - ▶ either right-click the list view pane to open the shortcut menu and click **Paste**
  - ▶ or select **Edit | Paste**

**Note:** Note that the selected test card is overwritten by the one pasted from the Clipboard.

3. Paste the test card from the Clipboard into the list view of another running instance of the *CPC Editor*:  
Change to the other running instance of the *CPC Editor*, or start the *CPC Editor* once more and
  - ▶ insert the test card either via the shortcut menu item **Insert Copied Test Card** or the pull-down menu item **Insert Copied Test Card**
  - ▶ or overwrite the selected test card with the test card from the Clipboard either via the shortcut menu item **Paste** or the pull-down menu item **Edit | Paste**.

## 13.2.5 Renaming a test card

To rename the currently selected test card to any new name of your choice

- ▶ either right-click the list view pane to open the shortcut menu and click **Rename**
- ▶ or select **Test card | Rename**

Enter the name of our choice (256 characters max.) and press **Enter**.

### 13.2.6 Saving a test



Click the **Save** icon or select **File | Save** with the "Save as type:" option "CPC files (\*.xml)" to save the currently open test, that is, the test card(s) listed in the list view with all of their settings, under its actual name.

If this test does not have a name yet, the **Save As** dialog box opens. Browse to the destination folder of your choice, and name your test accordingly.



**Note:** The file name extension `.xml` is appended automatically. Do not enter any other file name extension as the **File Open** command will then not show this file anymore.

### 13.2.7 Saving a test as template

Using the **File | Save As...** command with the "Save as type:" option "CPC templates (\*.xmt)", any test file can be saved as a test procedure template, that is, a user-defined template containing one or more test cards with all of their specific test settings but without test results.

**Note:** To learn more about templates in general, please refer to 2.4.11 "Creating defaults and templates" on page 67.

In this process, the settings of the original `name.xml` file are taken over to the newly created test procedure template `name.xmt`. Possible test results in the `name.xml` file, however, are not taken over. The original file `name.xml` remains unchanged.

The template is then uploaded to the *CPC 100* using the OMICRON *<product\_name>Device Browser*.

**Note:** The file name extension `.xmt` is appended automatically. Do not enter any other file name extension as the *CPC 100* will not recognize it as a valid template.

### 13.2.8 Deleting a test card

To delete a test card from a test or a test procedure template

- ▶ either right-click the list view pane to open the shortcut menu and click **Delete**
- ▶ or select **Edit | Delete**

**Note:** To delete an entire test or template, that is, an `.xml` or `.xmt` file, from your computer, use Windows Explorer.

### 13.2.9 Preparing a test offline using a PC

Outline of a typical proceeding for an offline test preparation with a PC using the *CPC Editor* and OMICRON <product\_name>Device Browser.

We recommend creating subfolders in a tree structure that corresponds with the substation, for example:

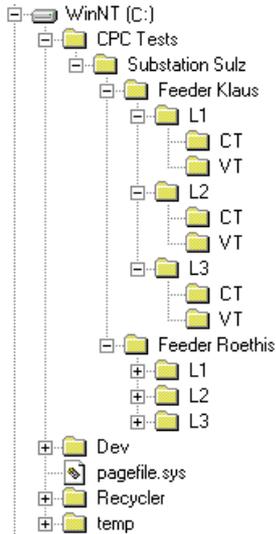
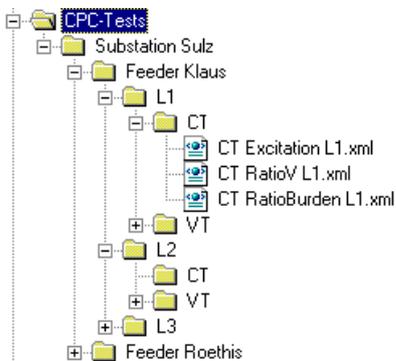


Figure 13-5: Representation of the substation "Sulz" with its two 3-phase feeders "Klaus" and "Roethis" in a folder tree structure

- ▶ Start the *CPC Editor*
- ▶ Set up the required test card(s) for this substation, compose your entire test, and eventually save the test in the appropriate folder that you created before.

**Note:** If single test cards or entire tests are similar or even identical, use the *CPC Editor's* copy/paste functionality, rather than creating new tests from the beginning.

For example:



- ▶ Right-clicking a test file and selecting **Open With** and **OMICRON CPC Editor** from the context menu starts the *CPC Editor*, loads the file and lets you edit it.

- ▶ Once all tests are composed, use the OMICRON <product\_name>Device Browser's upload function to transfer the entire tree structure from your PC to the *CPC 100* at once. Single files can be transferred directly from the *CPC Editor* using **Save as...** from the **File** menu.

## 14 *CPC Excel File Loader*

### 14.1 General

The *CPC Excel File Loader* allows loading XML files into Microsoft Excel templates for post processing. The *CPC Excel File Loader* is installed with the *CPC 100 Start Page*. After the installation, you can start the *CPC Excel File Loader* directly from the *CPC 100 Start Page* by clicking on the respective icon.

#### 14.1.1 System requirements

For the installation requirements, see 2.5.1 "System requirements" on page 70.

#### 14.1.2 Installing the *CPC Excel File Loader*

For the installation procedure, see 2.5 "Installation of the CPC 100 Toolset" on page 69.

### 14.2 Working with the *CPC Excel File Loader*

The *CPC Excel File Loader* allows loading XML files generated with the *CPC 100* into Microsoft Excel templates for post-processing. Every test card within an XML file is represented by a sheet of a Microsoft Excel workbook. You can load new XML files into the Microsoft Excel template by generating all sheets or by loading data into existing sheets of the workbook. The mapping between the data in the file and in the sheets is done by using the same name for the *CPC 100* test card and the corresponding sheet.

**Note:** Due to the mapping of the data, use unique names for the test cards in the XML files.

Because the results are converted into Microsoft Excel compatible numbers, post-processing of the data is straightforward. In a blank customer sheet, you can reference to the data in the sheets designed by OMICRON using Microsoft Excel formulas. Then, if the data in the OMICRON sheets is updated, the customer sheet is updated, too. By this means, special forms for post-processing of the data, the so-called templates, can be created easily.

### 14.3 Template usage

Templates are pairs of XML documents and Microsoft Excel templates designed by OMICRON 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, downloaded to the PC and 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.

**Note:** The version of the two templates must match. There is a version check. If an error message appears after loading the XML template, the templates do not match. Thus, use a template pair of the same version.

To run a test procedure according to a template:

1. Upload the XML template or a whole folder of templates for the intended application from the PC to the *CPC 100*.  
The XML templates (\*.xmt files) are available on the *CPC 100 Start Page*.
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 as a new file.
5. Open the corresponding Microsoft Excel template by double-clicking the \*.xlt file in the folder labeled with the test procedure name. A Microsoft Excel workbook appears.
6. Click the **Load XML-File** button and open the \*.xml file directly from your *CPC 100*. The *CPC Excel File Loader* loads the test results from the XML file to the Microsoft Excel template.
7. After all worksheets are filled with data, the test results are calculated and displayed.

# 15 Technical data

## 15.1 General

- In the following tables, all guaranteed input data are specified for an ambient temperature of  $23\text{ °C} \pm 5\text{ °C}$ , a power supply of 230 V AC, and after a warm-up time greater than 25 min.
- All guaranteed output data are valid for the period of one year after factory adjustment.
- The error values of each measurement range (listed under "Accuracy" in the following tables) are specified in

$$\% \text{ of the reading (rd)} + \% \text{ of full scale (fs)}$$

To obtain the exact measurement error, multiply the displayed measured value with the given reading error (rd), and add the full scale value multiplied with the given full scale error (fs).

Example:

- The *CPC 100* is set to the **800A AC** range.
- The display shows a measured value of 720 A at I Out.
- The guaranteed error is specified as 0.2% (rd) + 0.2% (fs).
- Therefore, the error is  $720\text{ A} \times 0.2\% \text{ (rd)} + 800\text{ A} \times 0.2\% \text{ (fs)}$   
 $= 1.44\text{ A} + 1.6\text{ A} = \mathbf{3.04\text{ A}}$ .

**Note:** All guaranteed specifications refer to standard AC or DC measurements. Other measurements, such as frequency-selective measurements, or measurements after a numeric integrator (like used with the **CTRogowski** test card) can have slightly higher errors.

- The listed value of the typical maximum output time "typical time  $t_{\text{max}}$ " applies
  - at the high-current **800A AC** and **400A DC** outputs to a load consisting of 2x6 m cables
  - at the other outputs to the respective typical output power.
- ▶ Do not connect the 2kV output to any of the inputs. The 2kV output is measured internally.
- A higher ambient and/or operational temperature reduces both the typical maximum output time "typical time  $t_{\text{max}}$ " and case by case the maximum output current accordingly.

Also refer to "Temperature monitoring" on page 52.

- When loaded with a high burden, the **800A AC**, **400A DC**, **6A AC** (also in the **3A AC** mode) and **6A DC** outputs can generate noise. This noise, however, is normal and no reason to worry.

**Note:** Only one output at a time can be used, that is, either **800A AC** or **400A DC** or **2kV AC** or...

All guaranteed AC specifications refer to frequencies of 45 Hz < f < 65 Hz. Frequencies above 400 Hz are filtered out. Measurements below 15 Hz are not stable.

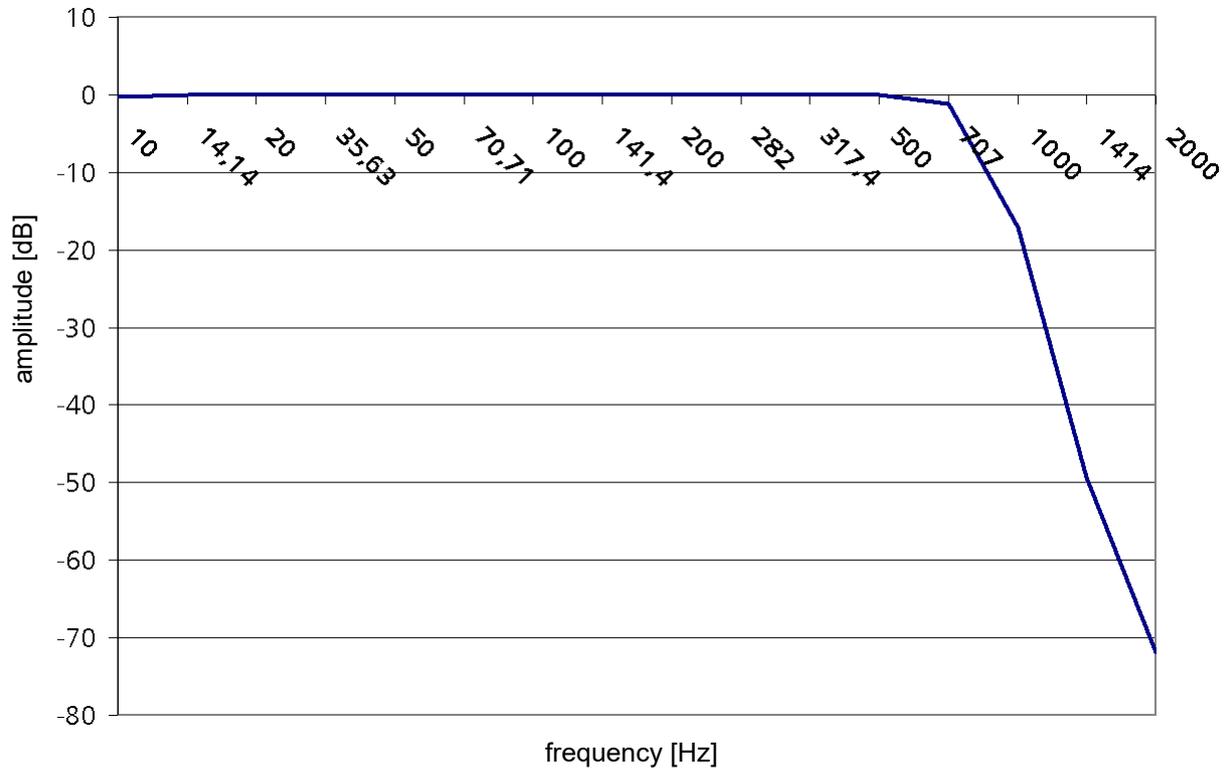


Figure 15-1: Typical frequency response of analog inputs: amplitude = f (frequency)

## 15.2 Power supply

**Note:** For safety-relevant issues regarding *CPC 100* power supply, also refer to 1.8 "Power supply" on page 20.

Table 15-1: Mains power supply technical data

Mains Power Supply	
Connection	AC voltage, 1 phase, connector IEC320/C20
Voltage single phase	
• nominal voltage	100 ... 240V AC
• permitted range	85 ... 264V AC
Power fuse	Automatic circuit breaker with magnetic overcurrent tripping at $I > 16 \text{ A}$
Power consumption	$< 7000 \text{ VA}$ short-term ( $< 10 \text{ s}$ )
Frequency	
• nominal frequency	50 / 60 Hz
• permitted range	45 ... 65 Hz

**Note:** If the power supply is  $\leq 190 \text{ V AC}$ , the *CPC 100* cannot provide the full output power at the **800A AC** output. The same applies when an external booster is used. Therefore, in order to gain the full output power, provide a sufficient power supply (190V ... 240V AC).

## 15.3 CPC 100 outputs

**Note:** Due to safety-relevant issues regarding the *CPC 100* high-current and high-voltage outputs, also read 1.11 "High-voltage and high-current outputs" on page 23.

### 15.3.1 High-current and high-voltage outputs

The high-current and high-voltage outputs are all situated at the left-hand side of the *CPC 100*.

#### 800A AC output

**Note:** While using the **800A AC** output, disconnect any cables that may be plugged in to the **400A DC** output. These outputs are internally connected.

Table 15-2: **800A AC** output technical data

800A AC output				
Connection	10 mm connectors			
Insulation	Internally connected to the <b>400A DC</b> output, insulated against all other inputs and outputs.  Voltage with reference to earth must not exceed 300 V <sub>rms</sub> and 420 V <sub>peak</sub> on either socket.  Reinforced insulation against mains power supply, all interfaces and other safety low-voltage circuits.			
Output power at:	typical app. power S <sub>max</sub>	typical time t <sub>max</sub>	duty cycle t <sub>on</sub> / t <sub>off</sub>	frequency
800 A	4800 VA	25 s	5 s / 55 s	50 ... 60 Hz
600 A	3780 VA	200 s	5 s / 25 s	
400 A	2560 VA	500 s	5 s / 5 s	
300 A	1940 VA	15 min	10 s / 5 s	
200 A	1300 VA	> 2 h	cont. ON	
Measurement	Internal precision current measurement from 0 ... 800A AC			
	Abs. max. rating:	limited through output		
	Accuracy:	typ. error < ± 0.1% (rd) ± 0.1% (fs), guaranteed < ± 0.2% (rd) ± 0.2% (fs)		
		Possible crest factor: < 1.5		
	Phase tolerance at full scale:	typ. error < ± 0.1°, guaranteed < ± 0.2°		
	Resolution:	Measurement	Display	
100 mA/bit		10 mA		
Connection:	internally connected			

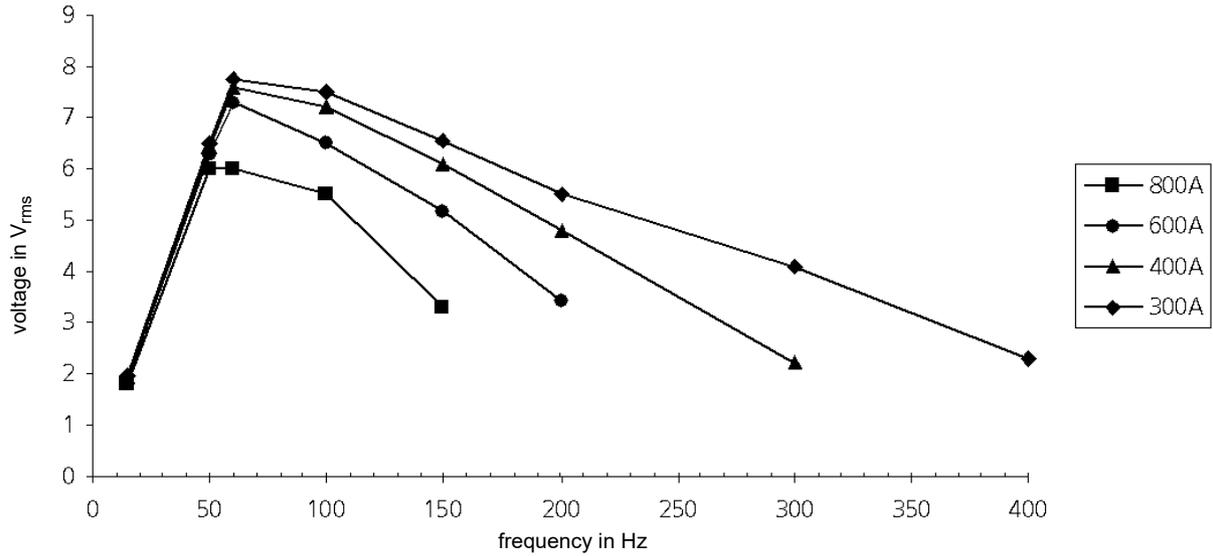


Figure 15-2: Typical maximum output voltage of **800A AC** output depending on frequency and current

**Note:** The signal for the **800A AC** output is generated by an internal transformer. To avoid saturation, sudden magnitude changes are suppressed and the signal is output as a ramp. For several applications the magnitude change is deferred even more, for example, for CT ratio measurements.

The ramp changes for a full magnitude are

- one period of the signal, regardless of the size of the change for an increase ramp
- 300 ms for a decreasing ramp, or accordingly less if the magnitude change is only a fraction of its full value.

### 400A DC output

**Note:** While using the **400A DC** output, disconnect any cables that may be plugged in to the **800A AC** output. These outputs are internally connected.

Table 15-3: **400A DC** output technical data

400A DC output			
Connection	10 mm connectors		
Insulation	Internally connected to the <b>800A AC</b> output, insulated against all other inputs and outputs.  Voltage with reference to earth must not exceed $300V_{\text{rms}}$ and $420V_{\text{peak}}$ on either socket.  Reinforced insulation against mains power supply, all interfaces and other safety low-voltage circuits.		
Output power at:	typ. power $P_{\text{max}}$	typical time $t_{\text{max}}$	
400 A	2600 W	140 s	
300 A	1950 W	3 min	
200 A	1300 W	> 2 h	
100 A	630 W	>> 2 h	
Measurement	Internal precision current measurement from 0 ... 400A DC		
	Abs. max. rating:	limited through output	
	Accuracy:	typ. error $< \pm 0.2\%$ (rd) $\pm 0.05\%$ (fs), guaranteed $< \pm 0.4\%$ (rd) $\pm 0.1\%$ (fs)	
	Resolution:	Measurement	Display
		100 mA/bit	10 mA
Connection:	internally connected		

**2kV AC output**

**Note:** While using the **2kV AC** output, disconnect any cables that may be plugged in to any of the high-current outputs (**800A AC** or **400A DC**).

Table 15-4: Technical data of **2kV AC** output - all ranges

<b>2kV AC output - all ranges</b>		
Connection	High-voltage sockets	
Insulation	Insulated against all other inputs and outputs.	
	Voltage with reference to earth must not exceed $2000V_{rms}$ and $2800V_{peak}$ on either socket.	
	Reinforced insulation against mains power supply, all interfaces and other safety low-voltage circuits.	
Measurement	Internal precision current and voltage measurement, integrated in the <i>CPC 100</i> (for details, see tables below).	
	Abs. max. rating:	limited through output
	Connection:	internally connected

Table 15-5: Technical data of **2kV AC** output at a voltage range of 2000V

<b>2kV AC output at a voltage range of 2000V</b>			
Maximum current	Peak current $I_{peak} < 3.0 \text{ A}$ Effective current $I_{rms} < 1.25 \text{ A}$		
Output power at:	typical apparent power $S_{max}$	typical time $t_{max}$	frequency
2000 V / 1.25 A	2500 VA	60 s	50...200 Hz
2000 V / 1 A	2000 VA	130 s	50...200 Hz
2000 V / 0.5 A	1000 VA	> 2 h	50...400 Hz
Measurement	Voltage and current		
Voltage	Range:	0 ... 2000V AC	
	Accuracy:	typ. error $< \pm 0.05\% (rd) \pm 0.05\% (fs)$ , guaranteed $< \pm 0.1\% (rd) \pm 0.1\% (fs)$ Possible crest factor: $< 1.5$	
	Phase tolerance at full scale:	typ. error $< \pm 0.1^\circ$ , guaranteed $< \pm 0.2^\circ$	
	Resolution:	Measurement	Display
		100 mV/bit	10 mV
Current	Ranges (automatic range selection):	0 ... 5A AC 0 ... 500mA AC	
	Accuracy:	5A: typ. error $< \pm 0.2\% (rd) \pm 0.05\% (fs)$ , guaranteed $< \pm 0.4\% (rd) \pm 0.1\% (fs)$ 500mA: typ. error $< \pm 0.05\% (rd) \pm 0.05\% (fs)$ , guaranteed $< \pm 0.1\% (rd) \pm 0.1\% (fs)$ Possible peak value: $\pm 20A$	
	Resolution:	Measurement	Display
		5A: 1 mA/bit 500mA: 100 $\mu$ A/bit	
	Phase tolerance at full scale:	typ. error $< \pm 0.1^\circ$ , guaranteed $< \pm 0.2^\circ$	

Table 15-6: Technical data of **2kV AC** output at a voltage range of 1000V

<b>2kV AC output at a voltage range of 1000 V</b>			
Maximum current	Peak current $I_{peak} < 6.0 \text{ A}$ Effective current $I_{rms} < 2.5 \text{ A}$		
Output power at:	typical apparent power $S_{max}$	typical time $t_{max}$	frequency
1000 V / 2.5 A	2500 VA	60 s	50 ... 200 Hz
1000 V / 2 A	2000 VA	130 s	50 ... 200 Hz
1000 V / 1 A	1000 VA	> 2 h	50 ... 400 Hz
Measurement	Voltage and current		
Voltage	Range:	0 ... 1000V AC	
	Accuracy:	typ. error $< \pm 0.05\% (rd) \pm 0.05\% (fs)$ , guaranteed $< \pm 0.1\% (rd) \pm 0.1\% (fs)$ Possible crest factor: $< 1.5$	
	Phase tolerance at full scale:	typ. error $< \pm 0.15^\circ$ , guaranteed $< \pm 0.3^\circ$	
Current	Ranges (automatic range selection):	0 ... 5A AC 0 ... 500mA AC	
	Accuracy:	5A: typ. error $< \pm 0.2\% (rd) \pm 0.05\% (fs)$ , guaranteed $< \pm 0.4\% (rd) \pm 0.1\% (fs)$ 500mA: typ. error $< \pm 0.05\% (rd) \pm 0.05\% (fs)$ , guaranteed $< \pm 0.1\% (rd) \pm 0.1\% (fs)$ Possible peak value: $\pm 20A$	
	Resolution:	Measurement	Display
		5A: 1 mA/bit	
	500mA: 100 $\mu A$ /bit		
	Phase tolerance at full scale:	typ. error $< \pm 0.1^\circ$ , guaranteed $< \pm 0.2^\circ$	

Table 15-7: Technical data of **2kV AC** output at a voltage range of 500 V

<b>2kV AC output at a voltage range of 500V</b>			
Maximum current	Peak current $I_{peak} < 12.0 \text{ A}$ Effective current $I_{rms} < 5.0 \text{ A}$		
Output power at:	typical apparent power $S_{max}$	typical time $t_{max}$	frequency
500 V / 5 A	2500 VA	60 s	50 ... 200 Hz
500 V / 4 A	2000 VA	130 s	50 ... 200 Hz
500 V / 2 A	1000 VA	> 2 h	50 ... 400 Hz
Measurement	Voltage and current		
Voltage	Range:	0 ... 500V AC	
	Accuracy:	typ. error $< \pm 0.05\% (rd) \pm 0.05\% (fs)$ , guaranteed $< \pm 0.1\% (rd) \pm 0.1\% (fs)$  Possible crest factor: $< 1.5$	
	Phase tolerance at full scale:	typ. error $< \pm 0.2^\circ$ , guaranteed $< \pm 0.4^\circ$	
Current	Ranges (automatic range selection):	0 ... 5A AC 0 ... 500mA AC	
	Accuracy:	5A: typ. error $< \pm 0.2\% (rd) \pm 0.05\% (fs)$ , guaranteed $< \pm 0.4\% (rd) \pm 0.1\% (fs)$  500mA: typ. error $< \pm 0.05\% (rd) \pm 0.05\% (fs)$ , guaranteed $< \pm 0.1\% (rd) \pm 0.1\% (fs)$  Possible peak value: $\pm 20A$	
	Resolution:	Measurement	Display
		5A: 1 mA/bit	
	500mA: 100 $\mu$ A/bit		
	Phase tolerance at full scale:	typ. error $< \pm 0.1^\circ$ , guaranteed $< \pm 0.2^\circ$	

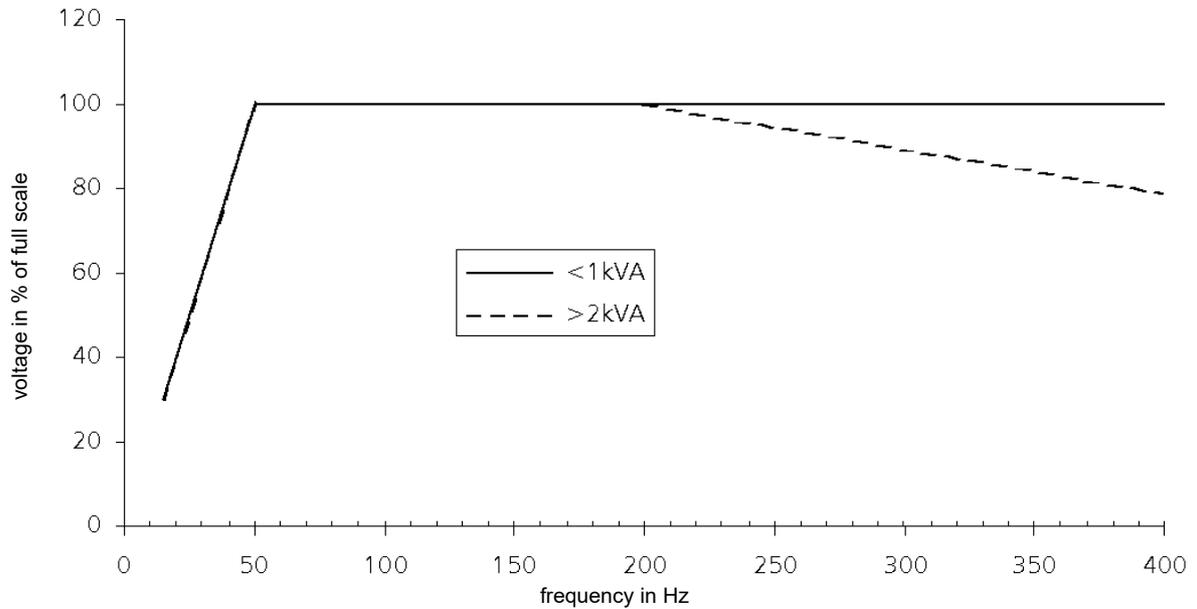


Figure 15-3: Typical maximum output voltage of **2kV AC** output depending on frequency and power

**Note:** The 2kV AC output signal is generated by an internal transformer. To avoid saturation, sudden magnitude changes are suppressed. The signal is output as a ramp. For several applications the magnitude change is deferred even more, for example, for **Voltage Withstand** to avoid stress of the device under test.

The fastest possible ramp changes for a full magnitude are

- 1200 ms for an increasing ramp
- 300 ms for a decreasing ramp.

The ramps need accordingly less if the magnitude change is only a fraction of its full value.

The **2kV AC** output is electronically controlled to provide the nominal voltage. Consequently, the output impedance is of no importance.

### 15.3.2 Outputs on the CPC 100 front panel

**Note:** The outputs of the CPC 100 front panel are not controlled.

Furthermore, there is no internal measurement provided. To measure a front panel output signal, connect it to a measuring input:

- current measurement: **IAC/DC** input
- voltage measurement: **V1 AC** or **V DC** input

#### 6A / 130V AC output

**Note:** While using the **6A / 130V AC** output, disconnect any cables that may be plugged in to any of the high-current outputs (**800A AC** or **400A DC**), or to the **6A DC** output.

Table 15-8: Technical data of **6A / 130V AC** output - all ranges

<b>6A / 130V AC output - all ranges</b>	
Connection	4 mm banana sockets
Insulation	The <b>6A/130V AC</b> output is internally connected with the <b>6A DC</b> output. Apart from this, the output is insulated against all other inputs and outputs.  Voltage with reference to earth must not exceed 200 Vrms and 280 V peak on either socket.  Reinforced insulation against mains power supply, all interfaces and other safety low-voltage circuits.
Measurement	No internal measurement provided. To measure this output signal, connect it to a measuring input:  current measurement: at <b>IAC/DC</b> input  voltage measurement: at <b>V1 AC</b> input

Table 15-9: Technical data of **6A / 130V AC** output in 130V AC mode

<b>6A / 130V AC output in 130V AC mode</b>			
Output power at:	typical apparent power $S_{max}$	typical time $t_{max}$	frequency
130V	390 VA	> 2 h	50 ... 400Hz
Fuses	Type: 3.15A T The 3.15 Amps slow-acting wire fuse 5x20 mm, situated at the front panel's <b>AC OUTPUT</b> group, protects the <b>AC OUTPUT</b> in 130V voltage mode.  6.3A T If the 6.3 Amps fuse is blown, the 130V AC output mode does not work either.		

**Note:** The 130V AC output has a setting range of 150 V. The set voltage represents the no-load voltage, that is, when a load is connected, the voltage at the 130V output will reduce by approx. 5 V / A

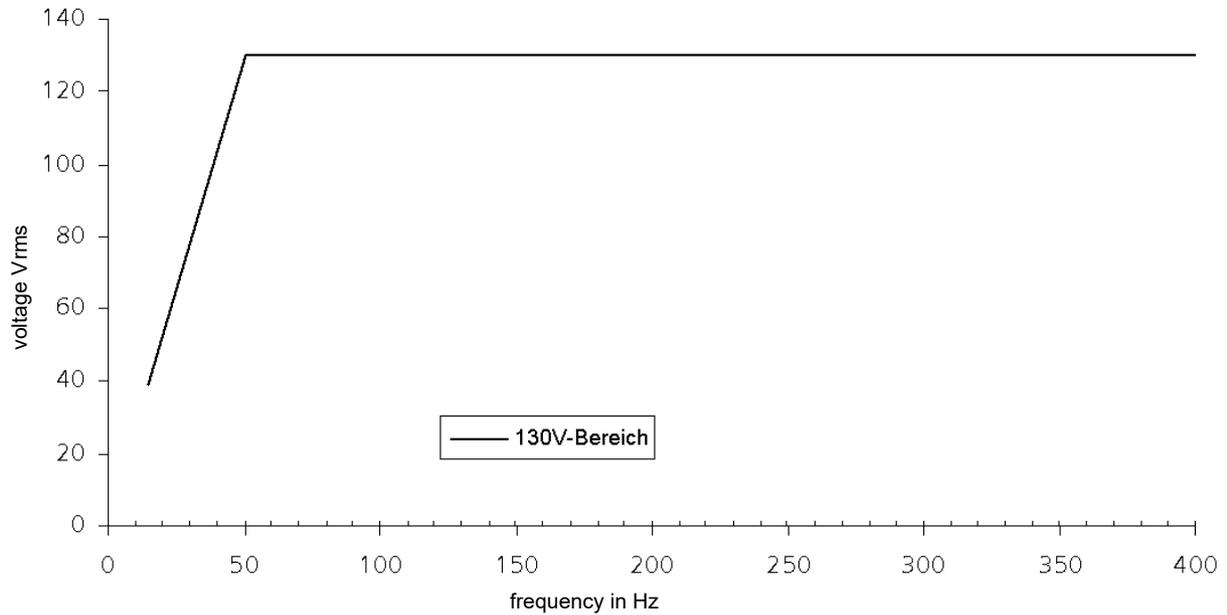


Figure 15-4: Typical maximum output voltage of **6A / 130V AC** output in 130V AC mode depending on frequency

Table 15-10: Technical data of **6A / 130V AC** output in 6A AC mode

<b>6A / 130V AC output in 6A AC mode</b>			
Output power at:	typical apparent power $S_{max}$	typical time $t_{max}$	frequency
6.0A	330 VA	> 2 h	50 ... 200 Hz
Fuse	Type: 6.3A T The 6.3 Amps slow-acting wire fuse 5x20 mm, situated at the front panel's <b>AC OUTPUT</b> group, protects the <b>AC OUTPUT</b> in 6A AC and 3A current mode and the <b>DC OUTPUT</b>		

Table 15-11: Technical data of **6A / 130V AC** output in 3A AC mode

<b>6A / 130V AC output in 3A AC mode</b>			
Output power at:	typical apparent power $S_{max}$	typical time $t_{max}$	frequency
3.0A	330 VA	> 2 h	50 ... 200 Hz
Fuse	Type: 3.15A T The 3.15 Amps slow-acting wire fuse 5x20 mm, situated at the front panel's <b>AC OUTPUT</b> group, protects the <b>AC OUTPUT</b> in 3A current mode. 6.3A T If the 6.3 Amps fuse is blown, the 3A AC output mode does not work either.		

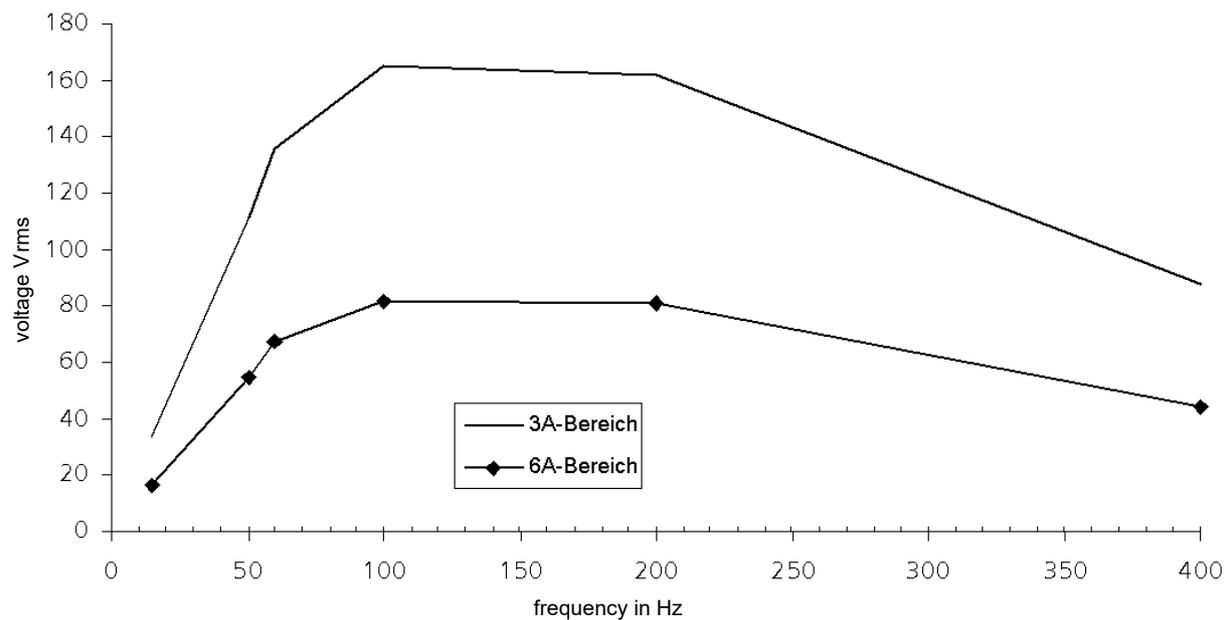


Figure 15-5: Typical maximum output voltage of **6A / 130V AC** output in 3 and 6A AC mode depending on frequency and current

## 6A DC current output

**Note:** While using the **6A DC** output, disconnect any cables that may be plugged in to any of the high-current outputs (**800A AC** or **400A DC**), or to the **6A / 130V AC** output.

Table 15-12: **6A DC** output technical data

6A DC output		
Connection	4 mm banana sockets	
Insulation	<p>The <b>6A DC</b> output is internally connected with the <b>6A / 130V AC</b> output. Apart from this, the output is insulated against all other inputs and outputs.</p> <p>Voltage with reference to earth must not exceed 200 Vrms and 280 V peak on either socket.</p> <p>Reinforced insulation against mains power supply, all interfaces and other safety low-voltage circuits.</p>	
Protection	<p>If a large inductance is connected, and the output is switched off, an internal arc-suppression diode protects the user from voltage spikes from the inductance.</p> <p>Additionally, a surge arrester with a short circuit spring that, in case of an overload, applies a short circuit to the output and protects the user if the arc-suppression should not be sufficient.</p> <p>The existence of a discharge voltage potential is also indicated by a lit indicator light - even if the <i>CPC 100</i> is switched off. This indicator light is situated at the right-hand side of the <b>6A DC</b> output sockets.</p>	
Current / voltage measurement	<p>No internal measurement provided. To measure this output signal, connect it to a measuring input:</p> <p>current measurement: at <b>IAC/DC</b> input</p> <p>voltage measurement: at <b>V DC</b> input</p>	
Output power at:	typical power $P_{max}$	typical time $t_{max}$
6.0 A	360 W	> 2 h
3.0 A	180 W	>> 2 h
Fuse	<p>Type: 6.3A T</p> <p>The 6.3 Amps slow-acting wire fuse 5x20 mm, situated at the front panel's <b>AC OUTPUT</b> group, protects both the <b>AC OUTPUT</b> in 3A and 6A current mode and the <b>DC OUTPUT</b></p>	

Unlike other test cards, **RWinding** (winding resistance) and **TRTapCheck** (tap changer winding resistance and on-load tap changer interruption check) provide special additional safety functions.

- ▶ Do not connect a large inductance to this output in any other test card but **RWinding** and **TRTapCheck**.
- ▶ If a test object with a large inductance is connected to the *CPC 100*, earth both ends of the test object before you disconnect it from the *CPC 100*.

### 15.3.3 Output "Ext. Booster" (option)

The output "Ext. Booster" does not have own specifications. They are determined by the device connected to this output, for example, by the current booster *CP CB2*.

► For more information about boosters, please refer to 16 "Accessories" on page 321.

The connector "Ext. Booster" is *always* galvanically connected to mains, even if an external booster is selected on the software tab **Options | Device Setup**, the green signal light (0) is on, the outputs are turned off or the **Emergency Switching off** button is pressed.

- Do not use any booster cables other than those supplied by OMICRON electronics.
- Handle with extreme caution.

### 15.3.4 Output to input synchronization



The feature **Synch w/ V1 AC** synchronizes the output frequency with the **V1 AC** input frequency (refer to "Sync w/ V1AC" on page 83).

The **Amplifier** test card provides the possibility to synchronize to various inputs.

The *CPC 100* filters the input signals, therefore, if mains is connected to, for example, the **V1 AC** input, possible signal interferences and/or noise do not affect the synchronization considerably. The fundamental wave of the input signal serves as reference for the synchronization.

Table 15-13: Output to input synchronization

	Test cards Quick, Sequencer	Test card Amplifier
Frequency Range	48 ... 62 Hz	
Synchronization inputs	V1 AC (automatic range switching)	V1 AC, V2 AC, I AC (fixed to maximum range)
Input magnitude	10% of input range full scale	
Output magnitude	5% of output range full scale	
Settling time	100 ms after 5% of output magnitude is reached	1000 ms after 5% of output magnitude is reached
Signal changes	All quantities must be ramped within 20 signal periods	No changes of frequency and phase. Magnitude changes without limitation. Output follows within 250 ms.
Phase tolerance	0.5° within the limits as specified above	

## How long does the synchronization take?

Example for the **2kV AC** output in **Quick**:

**Note:** As explained on page 304 of this chapter, the **2kV AC** output needs 1200 ms to ramp up to its full magnitude, and accordingly less for a smaller magnitude.

Total synchronization time = time to reach 5% of full magnitude + settling time.

- The output ramps linear, therefore reaches 5% of its full magnitude after 5% of 1200 ms = **60 ms**
- Then the **100 ms** settling time elapses
- Therefore, the entire synchronization lasts 60 ms + 100 ms = **160 ms**.

## 15.4 CPC 100 inputs

### 15.4.1 BIN IN binary input

Table 15-14: **BIN IN** binary input technical data

Binary input BIN IN	
Connection	4 mm banana sockets
Insulation	Insulated against all other inputs and outputs. Voltage with reference to earth must not exceed $300V_{\text{rms}}$ and $420V_{\text{peak}}$ on either input socket. Reinforced insulation against mains power supply, all interfaces and other safety low-voltage circuits.
Sampling frequency	1 kHz
Max. voltage	$330V_{\text{rms}}$
Resolution	1 ms
Operation	potential-free or external DC voltage operation
• ext. DC voltage	nominal voltage active: 100V DC (min. > 0 V) inactive: input open or voltage < -20 V
• potential-free	$R_{\text{on}} < 10 \text{ k}\Omega$ $R_{\text{off}} > 1 \text{ M}\Omega$
Input resistance	> 100 k $\Omega$

## 15.4.2 10A IAC/DC input

► Never connect the 2kV output to any of the inputs. The 2kV output is measured internally.

Table 15-15: 10A IAC/DC input technical data

10A IAC/DC input					
Connection	4 mm banana sockets				
Measurement ranges (autoranging)	0 ... 10 A 0 ... 1 A				
Insulation	Insulated against all other inputs and outputs. Voltage with reference to earth must not exceed $270V_{\text{rms}}$ and $380V_{\text{peak}}$ on either input socket. Reinforced insulation against mains power supply, all interfaces and other safety low-voltage circuits.				
Protection	The 10A IAC/DC current input is fuse-protected (see below). For measuring currents on high inductances, the input is protected before the fuse. This is done by an internal surge arrester with a short circuit spring that, in case of an overload, applies a short circuit to the output, and protects the user in case the fuse is blown, and a current is still forced through the input with a high voltage.				
Maximum current	$11A_{\text{rms}}$				
Accuracy					
• AC operation (autoranging)	<table border="1"> <tr> <td>10A:</td> <td>typ. error <math>&lt; \pm 0.05\%</math> (rd) <math>\pm 0.05\%</math> (fs), guaranteed <math>&lt; \pm 0.1\%</math> (rd) <math>\pm 0.1\%</math> (fs)</td> </tr> <tr> <td>1A:</td> <td>typ. error <math>&lt; \pm 0.05\%</math> (rd) <math>\pm 0.05\%</math> (fs), guaranteed <math>&lt; \pm 0.1\%</math> (rd) <math>\pm 0.1\%</math> (fs)</td> </tr> </table>	10A:	typ. error $< \pm 0.05\%$ (rd) $\pm 0.05\%$ (fs), guaranteed $< \pm 0.1\%$ (rd) $\pm 0.1\%$ (fs)	1A:	typ. error $< \pm 0.05\%$ (rd) $\pm 0.05\%$ (fs), guaranteed $< \pm 0.1\%$ (rd) $\pm 0.1\%$ (fs)
10A:	typ. error $< \pm 0.05\%$ (rd) $\pm 0.05\%$ (fs), guaranteed $< \pm 0.1\%$ (rd) $\pm 0.1\%$ (fs)				
1A:	typ. error $< \pm 0.05\%$ (rd) $\pm 0.05\%$ (fs), guaranteed $< \pm 0.1\%$ (rd) $\pm 0.1\%$ (fs)				
	Possible crest factor: $< 3.0$				
	Phase tolerance at full scale:				
	<table border="1"> <tr> <td>10A:</td> <td>typ. error <math>&lt; \pm 0.1^\circ</math> guaranteed <math>&lt; \pm 0.2^\circ</math></td> </tr> <tr> <td>1A:</td> <td>typ. error <math>&lt; \pm 0.15^\circ</math> guaranteed <math>&lt; \pm 0.3^\circ</math></td> </tr> </table>	10A:	typ. error $< \pm 0.1^\circ$ guaranteed $< \pm 0.2^\circ$	1A:	typ. error $< \pm 0.15^\circ$ guaranteed $< \pm 0.3^\circ$
10A:	typ. error $< \pm 0.1^\circ$ guaranteed $< \pm 0.2^\circ$				
1A:	typ. error $< \pm 0.15^\circ$ guaranteed $< \pm 0.3^\circ$				
• DC operation (autoranging)	<table border="1"> <tr> <td>10A:</td> <td>typ. error <math>&lt; \pm 0.03\%</math> (rd) <math>\pm 0.08\%</math> (fs), guaranteed <math>&lt; \pm 0.05\%</math> (rd) <math>\pm 0.15\%</math> (fs)</td> </tr> <tr> <td>1A:</td> <td>typ. error <math>&lt; \pm 0.03\%</math> (rd) <math>\pm 0.08\%</math> (fs), guaranteed <math>&lt; \pm 0.05\%</math> (rd) <math>\pm 0.15\%</math> (fs)</td> </tr> </table>	10A:	typ. error $< \pm 0.03\%$ (rd) $\pm 0.08\%$ (fs), guaranteed $< \pm 0.05\%$ (rd) $\pm 0.15\%$ (fs)	1A:	typ. error $< \pm 0.03\%$ (rd) $\pm 0.08\%$ (fs), guaranteed $< \pm 0.05\%$ (rd) $\pm 0.15\%$ (fs)
10A:	typ. error $< \pm 0.03\%$ (rd) $\pm 0.08\%$ (fs), guaranteed $< \pm 0.05\%$ (rd) $\pm 0.15\%$ (fs)				
1A:	typ. error $< \pm 0.03\%$ (rd) $\pm 0.08\%$ (fs), guaranteed $< \pm 0.05\%$ (rd) $\pm 0.15\%$ (fs)				
Input resistance	$< 100\text{ m}\Omega$				

Table 15-15: **10A IAC/DC** input technical data

10A IAC/DC input		
Resolution		Display
	10A: 1 mA/bit	
	1A: 100 µA/bit	10 µA
Fuse	Type: 10A FF The 10 Amps very quick-acting wire fuse 5x20 mm, situated at the front panel's INPUT group, protects the 10A IAC/DC current measuring input. Make sure the fuse you use is a <b>10A FF</b> fuse. Do not use any other type of fuse!	

### 15.4.3 300V V1 AC input

► Never connect the 2kV output to any of the inputs. The 2kV output is measured internally.

Table 15-16: **300V V1AC** input technical data

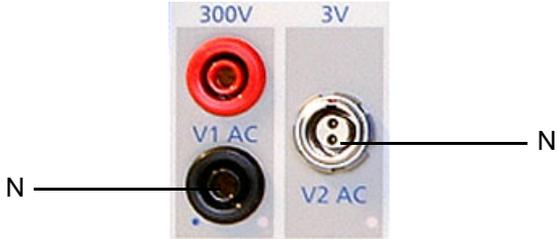
300V V1AC input	
Connection	4 mm banana sockets
Measurement ranges (autoranging)	0 ... 300 V / 0 ... 30 V / 0 ... 3 V / 0 ... 300 mV
Insulation	<p>N (black socket) is connected to N of the <b>V2 AC</b> input</p>  <p>Apart from this, the input is insulated against all other inputs and outputs. Voltage with reference to earth must not exceed <math>300V_{rms}</math> and <math>420V_{peak}</math> on either input socket.</p> <p>Reinforced insulation against mains power supply, all interfaces and other safety low-voltage circuits.</p>
Maximum voltage	$330V_{rms}$ / $470V_{peak}$

Table 15-16: **300V V1AC** input technical data

<b>300V V1AC input</b>			
Accuracy	300 V:	typ. error < $\pm 0.05\%$ (rd) $\pm 0.05\%$ (fs), guaranteed < $\pm 0.1\%$ (rd) $\pm 0.1\%$ (fs)	
	30 V:	typ. error < $\pm 0.05\%$ (rd) $\pm 0.05\%$ (fs), guaranteed < $\pm 0.1\%$ (rd) $\pm 0.1\%$ (fs)	
	3 V:	typ. error < $\pm 0.1\%$ (rd) $\pm 0.05\%$ (fs), guaranteed < $\pm 0.2\%$ (rd) $\pm 0.1\%$ (fs)	
	300mV:	typ. error < $\pm 0.15\%$ (rd) $\pm 0.05\%$ (fs), guaranteed < $\pm 0.3\%$ (rd) $\pm 0.1\%$ (fs)	
	Possible crest factor: < 1.5		
Phase tolerance at full scale of all ranges:		typ. error < $\pm 0.1^\circ$ guaranteed < $\pm 0.2^\circ$	
Input resistance	500 k $\Omega$		
Resolution		Measure-ment	Display
	300 V:	15 mV/bit	
	30 V:	1.5 mV/bit	
	3 V:	150 $\mu$ V/bit	
	0.3 V:	15 $\mu$ V/bit	5 $\mu$ V

### 15.4.4 3V V2 AC input

Table 15-17: 3V V2AC input technical data

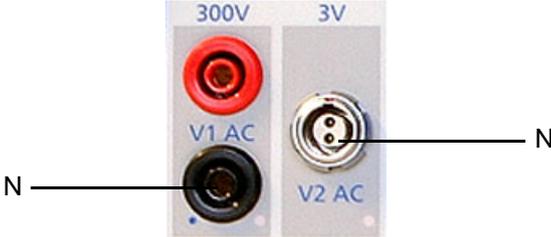
3V V2 AC input		
Connection	Odu connector GX1B0C-L020009-00A1	
Measurement ranges (autoranging)	0 ... 3 V / 0 ... 300 mV / 0 ... 30 mV	
Insulation	<p>N is connected to N of the <b>V1AC</b> input (black socket).</p>  <p>Apart from this, the input is insulated against all other inputs and outputs. Voltage with reference to earth must not exceed <math>300V_{rms}</math> and <math>420V_{peak}</math> on either input socket.</p> <p>Reinforced insulation against mains power supply, all interfaces and other safety low-voltage circuits.</p>	
Maximum voltage	$10V_{rms} / 15V_{peak}$	
Accuracy	3 V:	typ. error $< \pm 0.03\%$ (rd) $\pm 0.08\%$ (fs), guaranteed $< \pm 0.05\%$ (rd) $\pm 0.15\%$ (fs)
	300 mV:	typ. error $< \pm 0.08\%$ (rd) $\pm 0.08\%$ (fs), guaranteed $< \pm 0.15\%$ (rd) $\pm 0.15\%$ (fs)
	30 mV:	typ. error $< \pm 0.1\%$ (rd) $\pm 0.25\%$ (fs), guaranteed $< \pm 0.2\%$ (rd) $\pm 0.5\%$ (fs)
	Possible crest factor: $< 1.5$	
	Phase tolerance at full scale	
	3 V	typ. error $< \pm 0.1^\circ$ guaranteed $< \pm 0.2^\circ$
300 mV	typ. error $< \pm 0.1^\circ$ guaranteed $< \pm 0.2^\circ$	
30 mV	typ. error $< \pm 0.15^\circ$ guaranteed $< \pm 0.3^\circ$	
Input resistance	$10 M\Omega$	

Table 15-17: **3V V2 AC** input technical data

<b>3V V2 AC input</b>		
Resolution	Mea-surement	Display
3 V:	150 $\mu$ V/bit	
300 mV:	30 $\mu$ V/bit	
30 mV:	3 $\mu$ V/bit	10 $\mu$ V

**Note:** When using the **CTRogowski** test card, the **3V V2 AC** input uses an additional software-based integration method.

In the range of 50 Hz < f < 60 Hz, this results in a phase shift of 90° as well as an additional phase error of +/- 0.1° and an additional amplitude error of +/- 0.01%.

For frequencies in the range of 15 Hz < f < 400 Hz, the phase error is not specified, and the amplitude error can be up to +/- 0.50% higher.

### 15.4.5 10V V DC input

Table 15-18: **10V VDC** input technical data

<b>10V VDC input</b>	
Connection	4 mm banana sockets
Measurement ranges (autoranging)	0 ... 10 V 0 ... 1 V 0 ... 100 mV 0 ... 10 mV
Insulation	Insulated against all other inputs and outputs. Voltage with reference to earth must not exceed 140V <sub>rms</sub> and 200V <sub>peak</sub> on either input socket. Reinforced insulation against mains power supply, all interfaces and other safety low-voltage circuits.
Maximum voltage	50V <sub>rms</sub> / 75V <sub>peak</sub>
Accuracy	10 V: typ. error < ± 0.03% (rd) ± 0.08% (fs), guaranteed < ± 0.05% (rd) ± 0.15% (fs) 1 V: typ. error < ± 0.03% (rd) ± 0.08% (fs), guaranteed < ± 0.05% (rd) ± 0.15% (fs) 100 mV: typ. error < ± 0.05% (rd) ± 0.1% (fs), guaranteed < ± 0.1% (rd) ± 0.2% (fs) 10 mV: typ. error < ± 0.05% (rd) ± 0.15% (fs), guaranteed < ± 0.1% (rd) ± 0.3% (fs)
Input resistance	500 k $\Omega$

Table 15-18: **10V VDC** input technical data

<b>10V VDC input</b>		
Resolution	Mea- surement	Display
10 V:	400 $\mu$ V/bit	
1 V:	75 $\mu$ V/bit	
100 mV:	4 $\mu$ V/bit	
10 mV:	0.4 $\mu$ V/bit	0.1 $\mu$ V

## 15.5 CPC 100 combined specifications

### 15.5.1 Resistance measurement

The accuracy of the combined measurements can be calculated from the respective input and output specifications.

The tables below give some examples.

4-wire measurement with 400A DC output and 10V VDC input				
Current	Resistance	Voltage	Typ. error	Guaranteed
400 A	10 $\mu\Omega$	4 mV	0.70%	1.35%
400 A	100 $\mu\Omega$	40 mV	0.55%	1.10%
400 A	1 m $\Omega$	400 mV	0.50%	0.95%
400 A	10 m $\Omega$	4 V	0.50%	0.95%

4-wire measurement with 6A DC output and 10V VDC input				
Current	Resistance	Voltage	Typ. error	Guaranteed
6 A	100 m $\Omega$	0.6 V	0.35%	0.60%
6 A	1 $\Omega$	6 V	0.35%	0.60%
1 A	10 $\Omega$	10 V	0.25%	0.40%

2-wire measurement with 10V VDC input				
Current	Resistance	Voltage	Typ. error	Guaranteed
< 5 mA	100 $\Omega$		0.60%	1.20%
< 5 mA	1 k $\Omega$		0.51%	1.02%
< 5 mA	10 k $\Omega$		0.50%	1.00%

## 15.6 ePC interfaces

### 15.6.1 PC and network interfaces (CPC 100 V0 only)

The *CPC 100 V0* supports the 10BaseT (twisted pair) Ethernet interface for connecting the *CPC 100* to a PC, a notebook or a network hub. *CPC 100 V0* is equipped with two RJ-45 connectors. The connector labeled "PC" connects the *CPC 100* to a PC or a notebook, and the connector labeled "Network" connects the *CPC 100* to a network hub. These two connectors differ only in one cross-connection in the "PC" connector.

**Note:** Connect only one RJ-45 connector at a time.

### 15.6.2 Network interface (CPC 100 V1 only)

The network connection of the *CPC 100 V1* is implemented by the 10/100BaseTX (twisted pair) Ethernet interface. The *CPC 100 V1* is equipped with one RJ-45 connector labeled “Network” for connecting the *CPC 100* to a PC, a notebook or a network hub.

### 15.6.3 USB interface (CPC 100 V1 only)

The *CPC 100 V1* supports the USB interface for connecting the USB memory stick shipped with the *CPC 100*. The USB interface is compliant with the Universal Serial Bus (USB) Specification, Revision 1.1 and 2.0.

**Note:** The full functionality is guaranteed only for the USB memory stick delivered with the *CPC 100*.

### 15.6.4 Serial interface connector

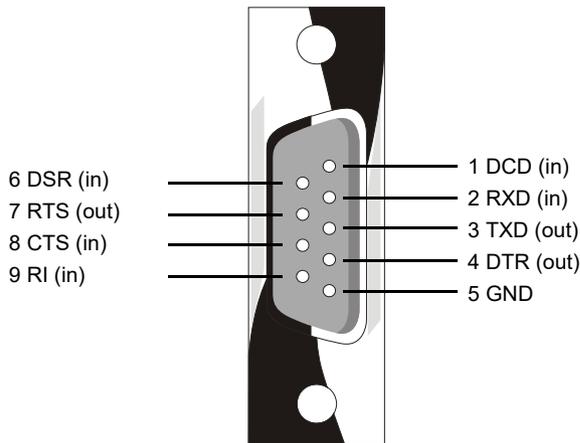


Figure 15-6: Serial interface connector

Table 15-19: Legend

• DCD	Data Carrier Detect
• RXD	Receive Data
• TXD	Transmit Data
• DTR	Data Terminal Ready
• GND	Ground
• DSR	Data Set Ready
• RTS	Request To Send
• CTS	Clear To Send
• RI	Ring Indicator

## 15.7 Environmental conditions

Table 15-20: Environmental conditions - climate

Characteristic		Rating
Temperature	Operating	-10 °C ... +55 °C / +14 °F ... +131 °F
	Storage	-30 °C ... +70 °C / -22 °F ... +158 °F
Max. altitude	Operating	2,000 m / 6,550 ft
	Storage	12,000 m / 40,000 ft

## 15.8 Standards conformity

Table 15-21: 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, IEC/EN/UL 61010-2-30


**Note:** This only applies to devices that have the respective indication on their nameplate.

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 Hz...150 Hz, acceleration 2 g continuous (20 m/s <sup>2</sup> /65 ft/s <sup>2</sup> ), 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	IP22 (in upright position) according to IEC/EN 60529

## 15.9 Mechanical data

Table 15-22: Mechanical data: weight and dimensions

Characteristic	Rating
Dimensions (w × h × d)	468 × 394 × 233 mm, 18.6 × 15.5 × 9.2 in
Weight	29 kg/64 lb; case without protection cover

## 16 Accessories

This chapter lists test cards that are optionally available to extend the functionality of the *CPC 100* packages.

It furthermore describes hardware equipment that is optionally available for the *CPC 100* primary test system, and provides ordering information for spare parts.

For information on the *CP CU1* coupling unit and the *CP TD* high-precision test system, see the *CP CU1* User Manual and the *CP TD1* and *CP TD12/15* User Manuals respectively on the *CPC 100 Toolset* DVD.

### 16.1 Test cards

#### 16.1.1 CT test cards

**Scope:**

- CTRatio (and Burden)
- CTBurden
- CTExcitation (Knee point)
- CTRatioV
- CTRogowski (Ratio)
- CTLow Power (Ratio)
- Winding Resistance
- Voltage Withstand (2kV)

#### 16.1.2 VT test cards

**Scope:**

- VTRatio
- VTBurden
- Voltage Withstand (2kV)
- VTElectronics

#### 16.1.3 Transformer test cards

**Scope:**

- TRRatio (per tap)
- TRTabCheck (for OLTC)
- Winding Resistance
- Voltage Withstand (2kV)
- Vector Group Check
- DRM/OLTC scan

### 16.1.4 Resistance test cards

**Scope:**

- Contact Resistance ( $\mu\Omega$  ...  $m\Omega$ )
- Winding Resistance ( $\mu\Omega$  ...  $k\Omega$ )

### 16.1.5 Earth Resistance

**Scope:**

- software (test card **RGround**)
- earth resistance accessory set (see below)

### 16.1.6 Ramping

Programmable ramping generator and determination of thresholds

### 16.1.7 Sequencer

For automatic testing with different states in real time

### 16.1.8 Amplifier

To set the *CPC 100* to an "amplifier-like" mode.

## 16.2 Earth resistance accessory set

Consists of:

- 4 electrodes
- cable reel red, 50 m
- cable reel black, 100 m

**Note:** The earth resistance accessory set is included in "Earth Resistance" and does not work without it.



Figure 16-1: Earth resistance accessory set

## 16.3 Current booster *CP CB2*

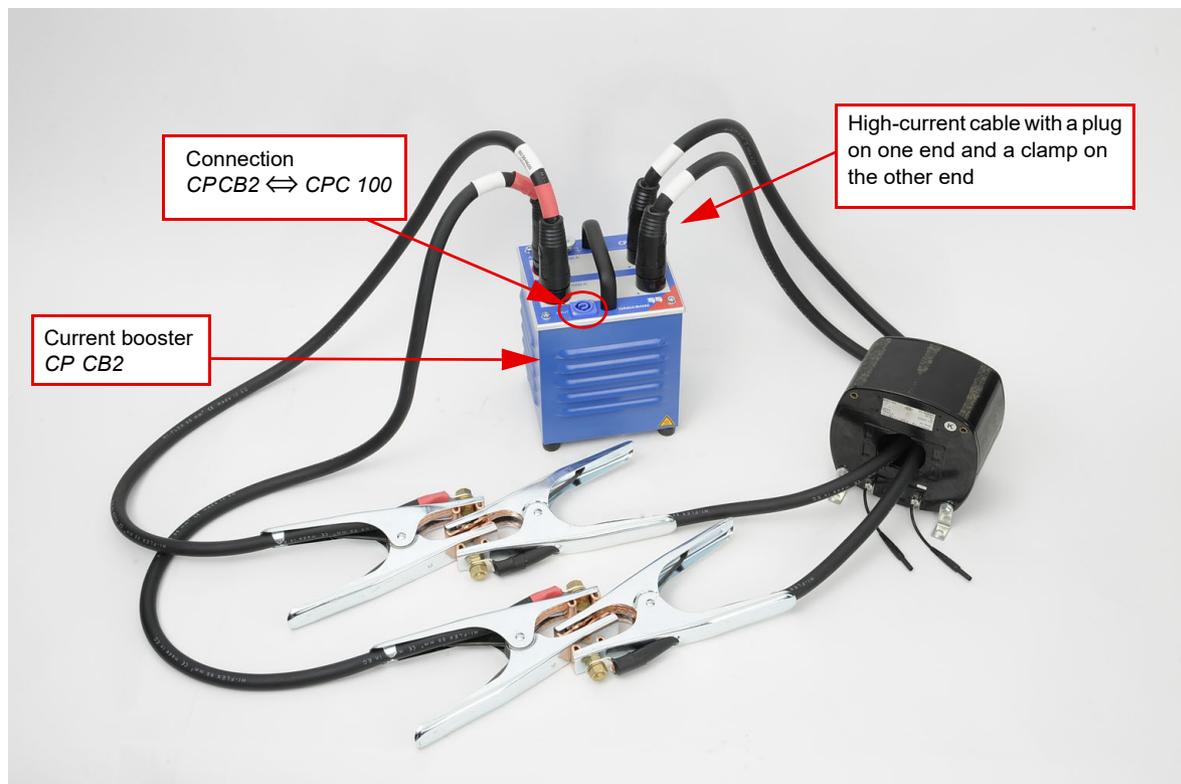


Figure 16-2: Current booster *CP CB2*

The *CP CB2* is equipped with an over-temperature protection. In case the *CP CB2* develops an internal temperature that is too high, it shuts off automatically. There is no according on-screen message shown on the *CPC 100* monitor.

If such an automatic shut-off occurs, let the *CP CB2* cool down for about ½ hour.

### WARNING



#### Death or severe injury resulting from falling

Opening the *CP CB2*'s clamps requires using both hands.

- ▶ Secure yourself against falling by using a safety harness.

### CAUTION



#### Minor or moderate injury caused by hot surfaces possible

During operation, the current booster's housing as well as the high-current cables (95 mm<sup>2</sup>) and their clamps can develop a rather high temperature.

- ▶ To prevent burns, use gloves when touching the housing or the cables during or shortly after operation.

### 16.3.1 Technical data of the CP CB2

Table 16-1: Technical data of the CP CB2 - all operating modes

Characteristic	Rating
Accuracy of current at 50/60 Hz	Typ. error $< \pm 0.13\%$ (rd) $\pm 0.13\%$ (fs), Guaranteed $< \pm 0.25\%$ (rd) $\pm 0.25\%$ (fs)
Phase tolerance at full scale	Typ. error $< \pm 0.25\%$ Guaranteed $< \pm 0.5\%$

More technical data can be found at 16.3.2 "Operation modes of the CP CB2" on page 326.

Table 16-2: Climate

Characteristic	Rating
Operating temperature	-10 ... +55 °C (+14 ... 131 °F)
Storage and transportation	-20 ... +70 °C (-4 ... 158 °F)
Max. altitude	2000 m (6562 ft)

Table 16-3: Mechanical data

	Weight	Dimensions (W x H x D)
<b>Test set</b>	16 kg (35.3 lb)	186 x 166 x 220 mm (7.3 x 6.5 x 8.7"), without handle
<b>Test set &amp; case</b>	25 kg (55.1 lb)	700 x 450 x 360 mm (27.6 x 17.7 x 14.2")

Table 16-4: Standard conformity

Standard conformity	
Safety	IEC/EN/UL 61010-1 

### 16.3.2 Operation modes of the CP CB2

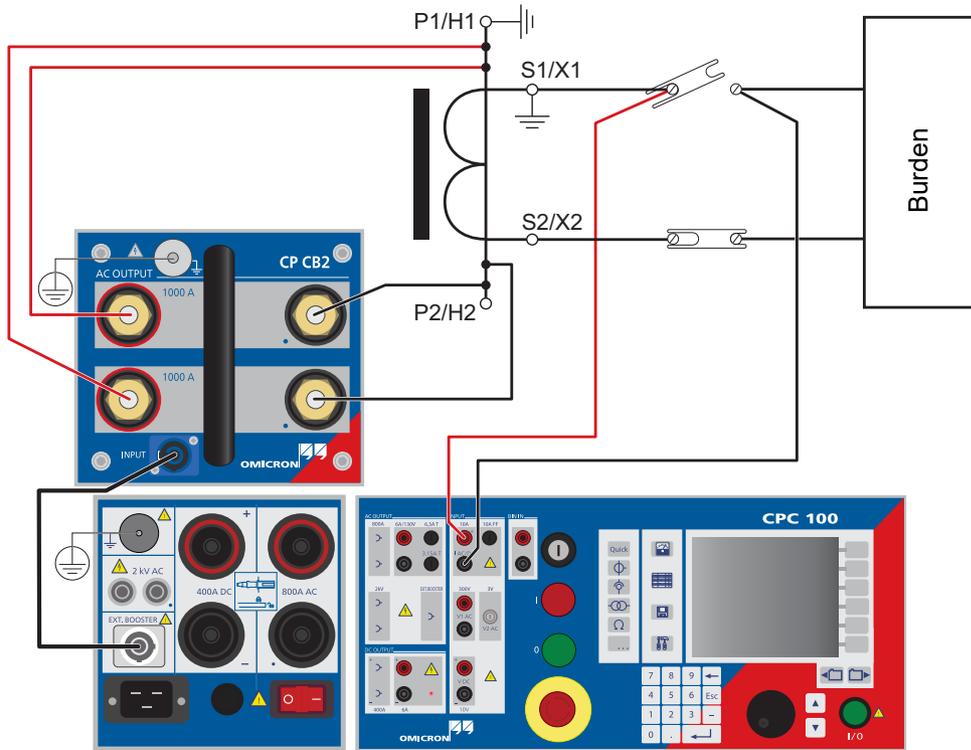


Figure 16-3: Current booster CP CB2 in 2000A mode for a CT ratio measurement

Table 16-5: Technical data of current booster CP CB2 in 2000A mode

Technical data of the CP CB2 in 2000A mode				
Connection	Input:	booster connector to connect the current booster CP CB2 with the CPC 100		
	AC output:	both CP CB2 outputs in parallel		
Measurement	Measurement in the CPC 100			
Output power at:	typ. apparent power $S_{max}$	typical time $t_{max}$	duty cycle $t_{on} / t_{off}$	frequency
2000 A	4900 VA	25 s	5 sec / 55 sec	50 ... 60 Hz
1800 A	4400 VA	3 min	5 sec / 40 sec	
1600 A	3950 VA	5 min	5 sec / 30 sec	
1400 A	3450 VA	10 min	5 sec / 25 sec	
1200 A	2950 VA	18 min	5 sec / 15 sec	
1000 A	2500 VA	30 min	5 sec / 9 sec	
600 A	1500 VA	> 2 h	cont. ON	
1500 A	3500 VA	5 min	5 sec / 30 sec	15 ... 150 Hz

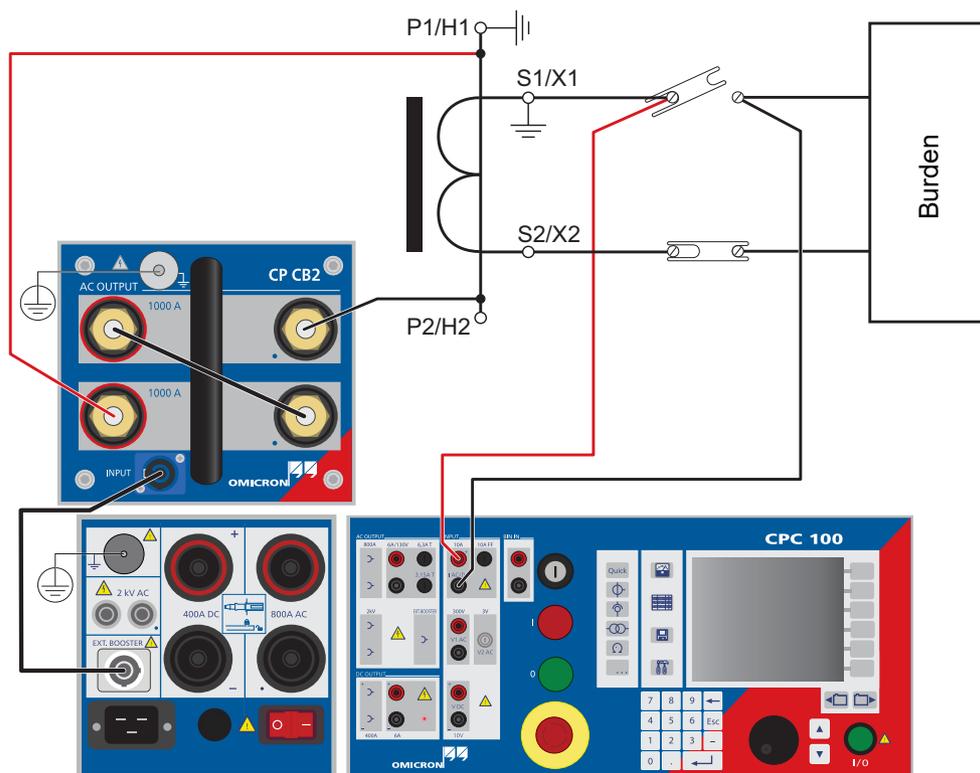


Figure 16-4: Current booster CP CB2 in 1000A mode

Table 16-6: Technical data of current booster CP CB2 in 1000A mode

Technical data of the CP CB2 in 1000A mode				
Connection	Input:	booster connector to connect the current booster CP CB2 with the CPC 100		
	AC output:	both CP CB2 outputs in series		
Measurement	Measurement in the CPC 100			
Output power at:	typ. apparent power $S_{max}$	typical time $t_{max}$	duty cycle $t_{on} / t_{off}$	frequency
1000 A	4900 VA	25 s	5 sec / 55 sec	50 ... 60 Hz
900 A	4400 VA	3 min	5 sec / 40 sec	
800 A	3950 VA	5 min	5 sec / 30 sec	
700 A	3450 VA	10 min	5 sec / 25 sec	
600 A	2950 VA	18 min	5 sec / 15 sec	
500 A	2500 VA	30 min	5 sec / 9 sec	
300 A	1500 VA	> 2 h	cont. ON	
750 A	3500 VA	5 min	5 sec / 30 sec	15 ... 150 Hz

## 16.4 CP SA1



Figure 16-5: CP SA1

The CP SA1 must be connected to the CPC 100 V DC input sockets when using the 400A DC output to protect yourself and the CPC 100 from high-voltage hazards.

The CP SA1 is a surge arrester unit providing extra protection to the operating staff and the CPC 100 against high-voltage hazards while performing transformer winding resistance measurements. In case of unwanted disruption of the current path, high voltage due to the inductance of the transformer's winding appears on the transformer's terminals and the current can flow through the voltage path to the CPC 100 V DC input. If high voltage appears for a short time on the transformer's terminals, an arc discharges the voltage and extinguishes without destroying the CP SA1. If the arc persists for a longer time period, the surge arrester insulator melts and thereby short-circuits the terminals to ground. Figure 16-6 below shows the circuit diagram of the CP SA1.

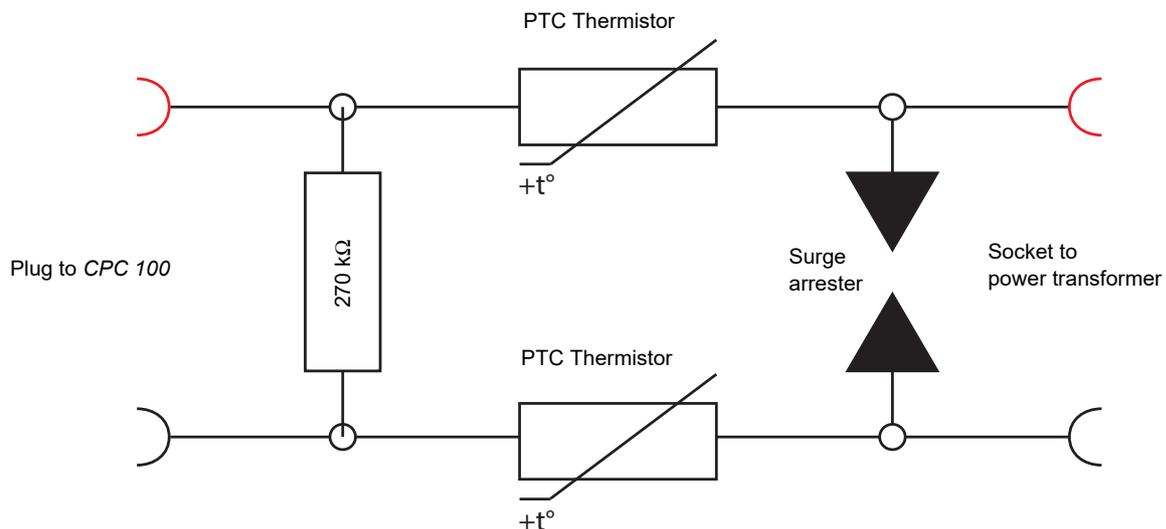


Figure 16-6: CP SA1 circuit diagram

Before using the CP SA1, check whether it is intact as follows:

1. Select the **Resistance** test card.
2. Select the V DC (2-wire) output range.

3. Connect the *CP SA1* to the *CPC 100 V DC* input.
4. Short-circuit the *CP SA1*'s output and measure the resistance.  
If the measured resistance is  $< 40 \Omega$ , the test is passed.
5. Remove the short circuit and measure the resistance again.  
If the measured resistance is  $> 20 \text{ k}\Omega$ , the test is passed.

### 16.4.1 Assembly instructions for Odu MINI-SNAP plug

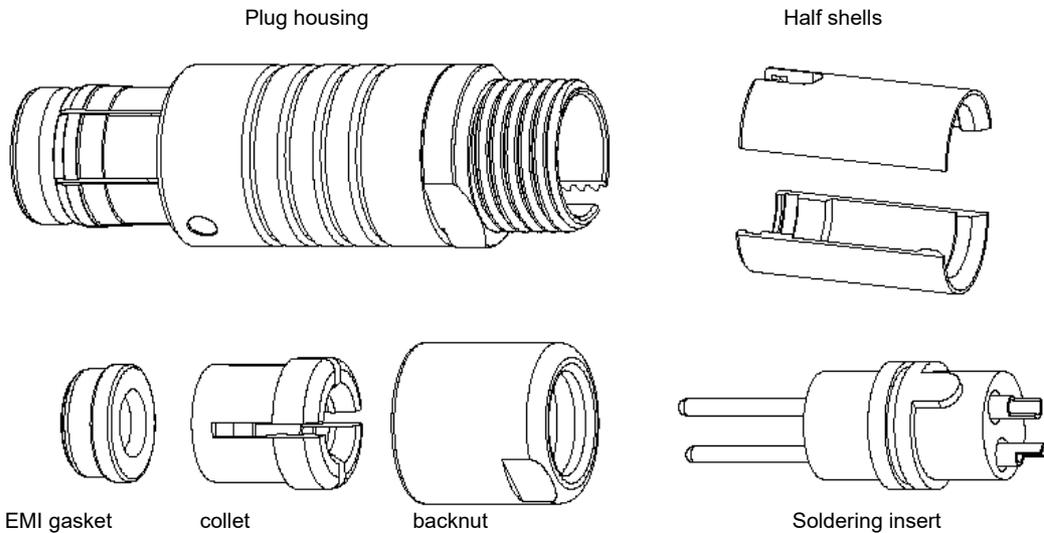
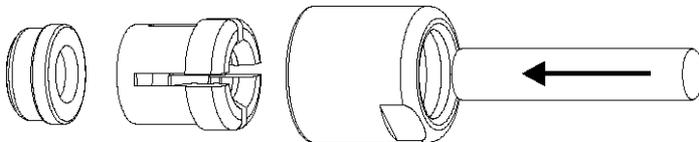


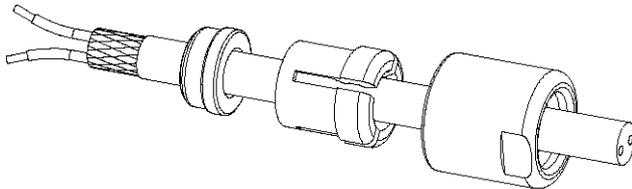
Figure 16-7: Assembly components for Odu MINI-SNAP plug

#### How to assemble the Odu MINI-SNAP plug

1. Slide cable into backnut, collet and gasket.

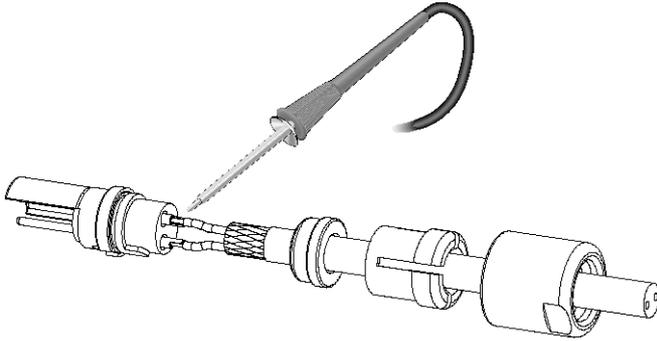


2. Strip cable and wire

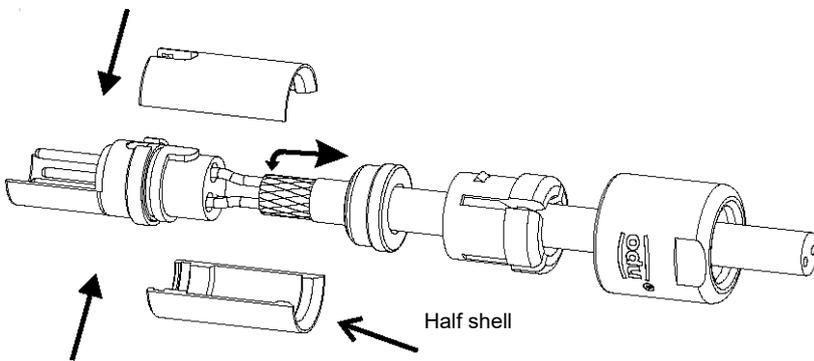


We recommend tinning the strands with a soldering iron.

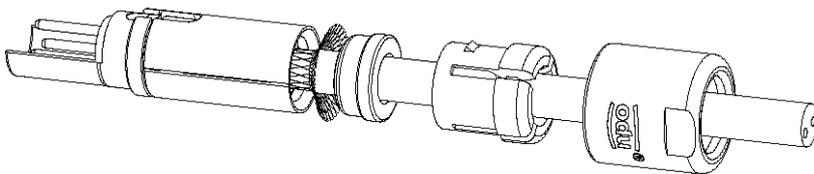
3. Solder each wire to its corresponding contact of the insert.



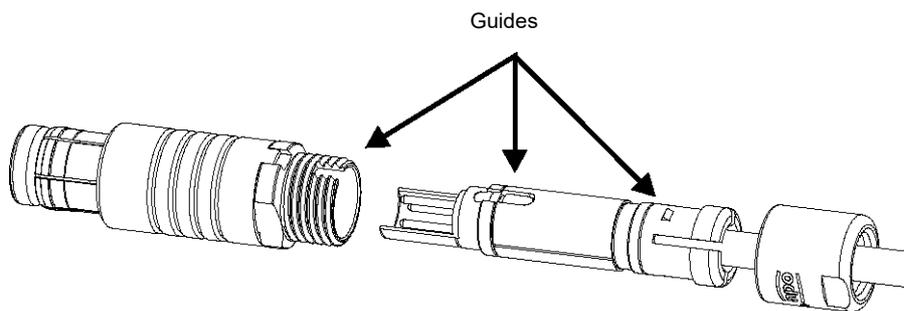
4. Bend cable screen outwards, and place the two half shells on either side of the insulation body.



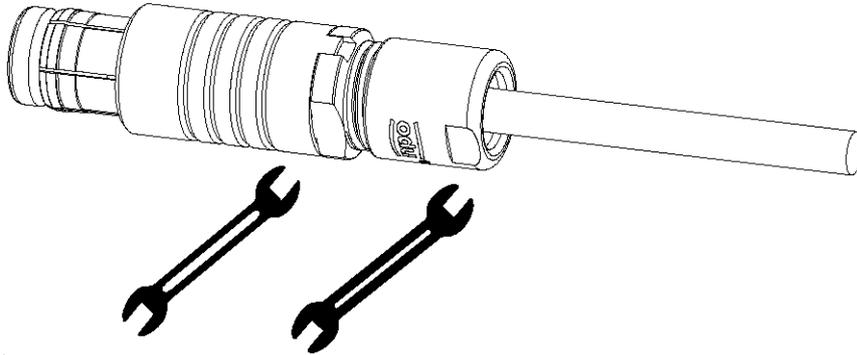
5. Slide gasket and collet against the half shells, and clamp the screen between gasket and half shells.



6. Trim protruding screen strands, and push the cable assembly into the housing, orientating the guides to the slots.



7. Finish the assembly by screwing the backnut to the housing, and by tightening them with wrenches.



# Copyright information

## The OMICRON Bootloader software

The OMICRON Bootloader software includes software parts developed by:

- Intel Corporation (IXP400 SW Release version 2.3)
- Intrinsic Software (Intrinsic Bootloader)
- Swedish Institute of Computer Science, Adam Dunkels (lwIP TCP/IP stack)
- Mark Adler (puff - decompress the deflate data format)
- Jean-loup Gailly and Mark Adler ("zlib" general purpose compression library)

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## lwIP TCP/IP stack

Author: Adam Dunkels <adam@sics.se>

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Mark Adler <madler@alumni.caltech.edu>

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Mark Adler <madler@alumni.caltech.edu>

Jean-loup Gailly <jloup@gzip.org>

The data format used by the zlib library is described by RFCs (Request for Comments) 1950 to 1952 in the files ftp://ds.internic.net/rfc/rfc1950.txt (zlib format), rfc1951.txt (deflate format) and rfc1952.txt (gzip format).

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