OMICRON

COMPANO 100

User Manual

Manual version: ENU 1122 05 07 — Year: 2023

Contents

1 Welcome

Welcome to OMICRON! We are happy that you have chosen a *COMPANO 100* test set.

COMPANO 100 is a lightweight, highly flexible fully electronic current or voltage source for various checks in an electrical energy system, such as generation, transmission, distribution, railways or industry. It is battery-operated; you do not need any additional power source for the test set. The battery is rechargeable. We are certain that you will enjoy using this product. The following guide will provide you with information related to the package and services that will enable you to use this product with confidence.

License

The license for working with *COMPANO 100* is already integrated into your test set. You do not need an additional activation key to use *COMPANO 100*.

Get started

For information on how to get started with the *COMPANO 100* test set, refer to the chapters "Safety instructions", "Battery", "Test set overview" and "Product startup". These chapters are identical in **Getting Started** manual and **User Manual**.

Care for your device

This document contains information on how to maintain your device and its battery (see "Battery" chapter).

► If you do not use the *COMPANO 100* for a longer period of time, charge the battery before storing it and recharge once every 6 months.

  Deep discharge irreversibly damages batteries.

Stay informed

Our **Customer Portal** is an international knowledge exchange platform full of useful information. Here you can inform yourself about the latest product and application features and software updates. You can also find up-to-date articles, conference papers, user manuals and much more.

Furthermore, you can share your own experiences in the OMICRON User Forum.

Register today: www.omicronenergy.com/customer.

Learn more

You can learn more about your new product in one of the customized training courses offered by the OMICRON Academy.

For more details have a look at: www.omicronenergy.com/academy.

Get support

Well-educated and competent technicians are available to answer all of your questions on our technical support hotline. All around the clock.

Make use of our 24/7 international technical support hotline: → Support on page 175.

Scope of documentation

The printed **Getting Started** manual guides you through the first steps and actions with the *COMPANO 100* test set.

The *COMPANO 100* **User Manual**, available as PDF and invocable in chapters by scanning the according QR code in the test set's lid with your smart phone, was written for professional specialists in electronics and electrical engineering. Its purpose is to familiarize you with the *COMPANO 100* test set and its various application fields. It contains helpful instructions on how to use *COMPANO 100* safely, properly, and efficiently. Read the User Manual thoroughly.

At **Google Play** and in the **Apple App Store (iOS)** you find an app called "COMPANO Knowledge Access Point" with a QR code reader for offline access to the manuals.

Check out the **OMICRON Video Channel** (visit https://www.omicronenergy.com/COMPANO100-Videos). There we provide you with the latest videos about proper test set usage and typical application examples.

2 About this manual

This manual was written for professional specialists in electronics and electrical engineering. Its purpose is to familiarize you with the *COMPANO 100* test set and its various application fields. It contains helpful instructions on how to use *COMPANO 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 *COMPANO 100*.

Note: Use *COMPANO 100* in observance of all existing safety requirements from national standards for accident prevention and environmental protection.

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

Safety symbols used in this manual

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

3 Safety instructions

WARNING

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

- ► The *COMPANO 100* test set can output life-hazardous voltages and currents.
- ► Before operating any such electrical equipment, carefully read the **Safety Instructions** section of this manual.
- ► Do not use (or even turn on) any electrical equipment without understanding the information in its manual.
- ► Existing national safety standards for accident prevention and environmental protection may supplement the equipment's manual.
- ► Only trained personnel should work with *COMPANO 100*.

For your own safety always follow the 5 basic safety rules:

1. Disconnect completely.
2. Secure against re-connection.
3. Verify that the installation is dead.
4. Carry out grounding and short-circuiting.
5. Provide protection against adjacent live parts.

3.1 Operator qualifications

- ► Working on high-voltage assets can be extremely dangerous. Testing with *COMPANO 100* must be carried out by qualified, skilled and authorized personnel, only. Before starting to work, clearly establish the responsibilities.
- ► Personnel receiving training, instructions, directions, or education on *COMPANO 100* must be under constant supervision of an experienced operator while working with the equipment. Testing with *COMPANO 100* must comply with the internal safety instructions as well as additional relevant documents.
- ► Personnel operating the *COMPANO 100* must be familiar with all necessary personal safety equipment.

3.2 Rules for use

- *COMPANO 100* is exclusively intended for the application area specified in this manual. The manufacturer/distributors are not liable for damage resulting from a use other than the specified operation.
- Use both the *COMPANO 100* test set and its accessories only when they are in a technically sound condition.
- The *COMPANO 100* test set does not contain any serviceable parts. Do not open the test set, or remove any of its housing components. The test set's lid with the attached QR code sticker is removable, though.
- Do not carry out any modifications, extensions or adaptations at the *COMPANO 100*.
- Use *COMPANO 100* in observance of all existing safety requirements from national and international standards for accident prevention and environmental protection.
- Always keep the manual either printed or as PDF file at the site where *COMPANO 100* is used. The manual must be read by all people working with *COMPANO 100*.
  In addition to the manual and the applicable regulations for accident prevention in the country and at the site of operation, heed the accepted technical procedures for safe and competent work.
- Always be aware of the dangers of high voltages. Pay attention to the safety information provided in the documentation.
- When testing a current transformer by feeding a test current into its primary winding, make sure that all secondary windings are shorted.
- 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 10,000:100 V, induces a voltage of 10,000 V in the transformer’s primary winding.
- The mains cable (cable to the OMICRON-supplied battery charger) must be rated for the nominal voltage and current specified in chapter Technical Data ► Battery Charger on page 95. We recommend to only use *COMPANO 100* in combination with the original cable supplied by OMICRON accessories together with the test set.
- Test leads wired to tall test objects must be sufficiently mechanically secured. Be aware of the hazard of falling adapters or cables.
- Do not block access to safety-relevant test set components, such as the emergency stop button. In a case of emergency, such components need free and quick access.
- Only operate the *COMPANO 100* test set under the environmental conditions specified in chapter Technical Data ► Environmental conditions on page 104.
- Do not operate the *COMPANO 100* test set when explosive gas or vapors are present.
- Do not use *COMPANO 100* during rain or in condensing environments.
- Do not use *COMPANO 100* above an altitude of 4000 m (13,000 feet).
- When setting up the *COMPANO 100* test set, make sure the ventilation holes remain unobstructed.
- Do not insert objects (for example, screwdrivers) into any input/output socket.

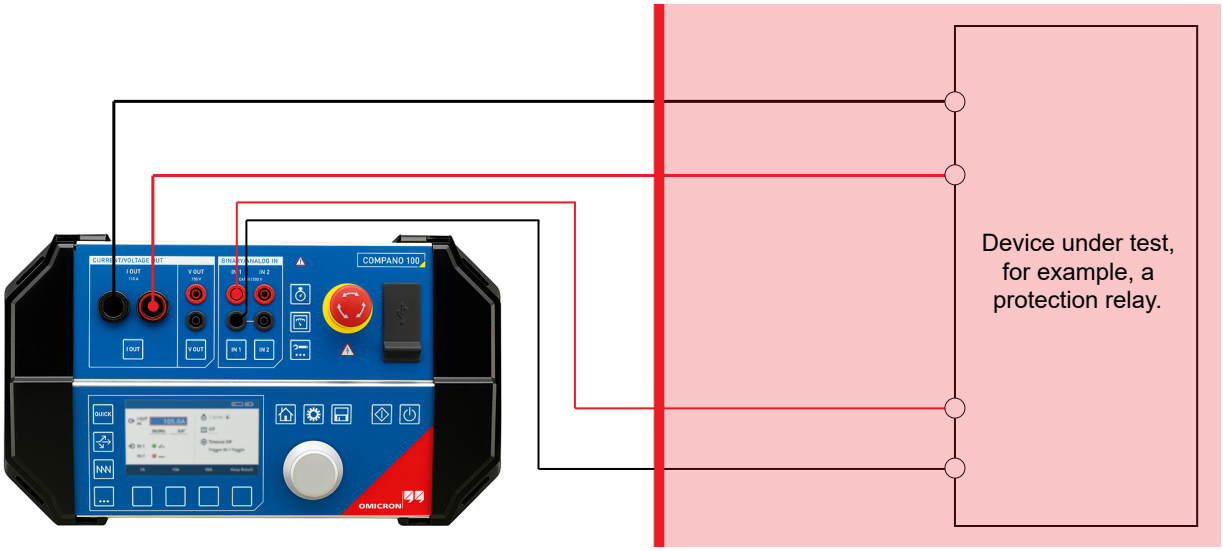
► If the *COMPANO 100* test set does not seem to function properly, contact OMICRON Support (→ Support).

3.3 Cleaning

To clean the *COMPANO 100* test set, use a cloth dampened with isopropanol alcohol. Prior to cleaning, always switch off the On/Off power switch and unplug the battery charger.

3.4 Safe operation procedures

3.4.1 Wiring and Safe Connection



Work area Dangerous area

To carry out tests with *COMPANO 100*, proceed as follows:

1. Always press the **emergency stop** button first.
2. Secure the device under test by following the 5 basic safety rules (see The 5 basic safety rules on page 10):
3. Connect the cables to the device under test.
4. Connect the banana plug cables to *COMPANO 100* (see Safe use of test leads and adapters on page 14).
5. Release the **emergency stop** button and power up *COMPANO 100*. Do not enter the dangerous area anymore now (see image above).
6. Start the test at *COMPANO 100*.

   While testing, do not enter the dangerous area. Stay clear from the cable ends at the device under test. Quite often these devices have connectors that can easily be touched. The same applies to some connection adapters of *COMPANO 100*. Always stay in the safe area (see image above).

When the test is finished and you want to leave the site, proceed as follows:

1. Power down *COMPANO 100*, and press the **emergency stop** button.
2. To prevent the *COMPANO 100* from unauthorized usage or from being powered up again accidentally, pull off the dongle (the connector for external safety functions; see side view on page 24).
3. Disconnect the cables from *COMPANO 100*.
4. Disconnect the cables from the device under test.

3.4.2 Safe use of test leads and adapters

Test leads

WARNING

Death or severe injury caused by high voltage possible

The outputs of the *COMPANO 100* are controlled by the software running in the device. Note that just turning off the outputs in the controlling software is not sufficiently safe.

- ► Do not work on connected touchable test objects, connections or teminals while the *COMPANO 100* is active (Start/stop pressed) .
- ► Always make sure that the **emergency stop** button is pressed, the test set is secured against reactivation, and all parts in the working area are powerless before you work on touchable test objects, connections or terminals (see Wiring and Safe Connection on page 13).

The *COMPANO 100* test set is supplied with flexible test lead adapters (2 x black, 2 x red) that have an angled connector at one end, and a retractable sleeve at the other end.

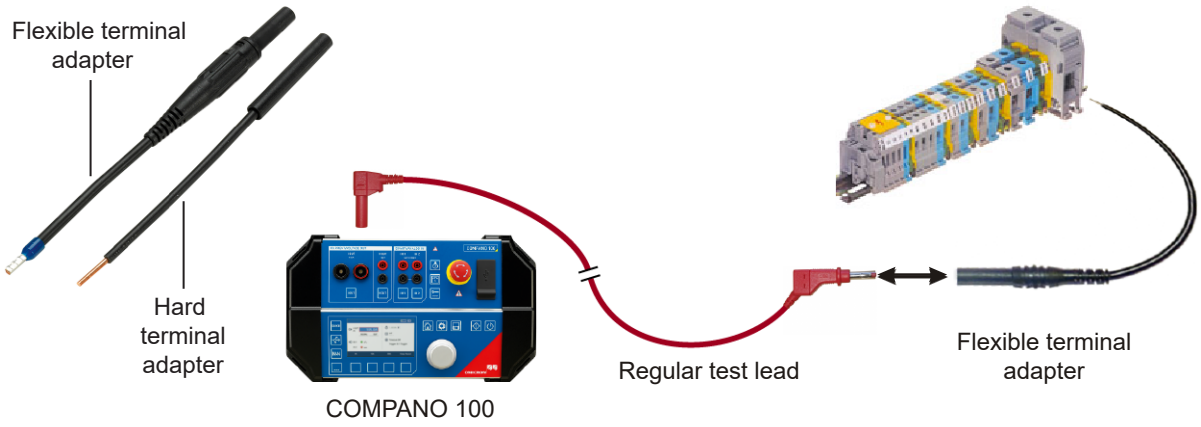
Never directly insert one of the retractable sleeves into a *COMPANO 100* socket at the front of the test set. This does not comply with the designated purpose of these leads and is contrary to the safety regulations.

To connect a test object to *COMPANO 100*, always use the angled connectors for the test set's sockets:

At the test object, use the test lead's retractable sleeve side:

Terminal adapters

Use flexible or hard terminal adapters to connect regular test leads to screw-clamp terminals.



WARNING

Death or severe injury caused by high voltage possible

The terminal adapters have blank ends.

- ► Before connecting the terminal adapters, press the **emergency stop** button on the COMPANO's front panel and secure the test set against reactivation (see Wiring and Safe Connection on page 13).
- ► Always insert the terminal adapter with its blank end first into the terminal strip, and fasten it before connecting it to a test lead.

3.4.3 Grounding COMPANO 100

COMPANO 100 is of protection class II. Therefore, grounding is not as critical as with devices that are grounded via a power cord. Nevertheless, due to internal capacities you could still sense some coupled voltages at the housing. Grounding is therefore recommended.

Grounding is ***mandatory*** in the following scenarios:

- If *COMPANO 100* is connected to other devices via Ethernet or USB cables.
- If *COMPANO 100* is used outdoors and there is the risk of rain or condensation, e.g. due to changing weather conditions
- If *COMPANO 100* is used in a substation environment.

► Use a ground connection with a diameter of at least 2.5 mm^2 (see side view on page 24).

► Ground *COMPANO 100* as close to the operator as possible.

3.4.4 Setting COMPANO 100 into operation

- Follow the instructions in chapter Product Startup on page 25 that describe how to properly and safely set *COMPANO 100* into operation.
-  The warning symbol on the *COMPANO 100* front panel indicates that the device is activated, and that its outputs may carry dangerous voltages.
  Even if the test set does not indicate dangerous output voltage, it's safe to always consider the outputs live. The indicator could be defective. Also a software error or remote command could accidentally start the test set. You may assume the outputs to be free of dangerous voltage when the emergency stop button is pressed (see Wiring and Safe Connection on page 13).

3.4.5 Safety instructions for grounding system tests

The grounding system application modules of *COMPANO 100* allows for output voltages of up to 150 V used for grounding system tests in medium- and high-voltage systems according to EN 50522 and IEEE Std 80/81. *COMPANO 100* is only intended for current injection using an auxiliary current probe.

► Refer to the descriptions of the corresponding application modules for more information:

→ Ground impedance on page 53

→ Step and touch voltage on page 68

→ Soil resistivity on page 79

WARNING

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

Employ the proper test set.

► Never use *COMPANO 100* to directly inject currents into power cables or overhead lines. If this should become inevitable, use the CPC 100 test set together with *CP CU1* and *CP GB1*.

The auxiliary current probe can carry life-threatening voltages during the test. In case of an error, unexpected high voltages can occur at output **I OUT** or **V OUT** at any time. Also the step voltage around the auxiliary current probe can be quite high.

► Always press the emergency stop button before working with these connectors.

► Use the provided warning flag*) to mark the auxiliary current probe, or use grounding spikes with safety handle.

► Mark an area of 5 m/15 ft around the electrode as dangerous zone, and position a guard outside this area to keep people from entering the dangerous zone.

In case of a high-current ground fault within the substation or at the transmission tower during the test, high voltages may occur in any wire connected to the grounding grid or leading away from it.

► Do not touch the current probe, the potential probe or any wire without insulating gloves.

► First insert the current probe, then connect it to the provided crocodile clamp. Before removing the current probe, disconnect the crocodile clamp.

*) Warning flag for auxiliary current probes provided by OMICRON.

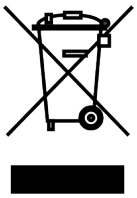
3.4.6 Required maintenance

COMPANO 100 contains safety-relevant mechanical components like the emergency stop button. To ensure the safe operation over long times, the device must be sent to OMICRON for inspection at least after every 10 years of use. This inspection is part of the calibration or repair process (→ Support).

3.4.7 Accessories

Only use *COMPANO 100* in combination with original OMICRON accessories as explained in the user manual. Only use *COMPANO 100* accessories with other OMICRON devices when this usage is described in the respective device's user manual.

3.4.8 Information for disposal and recycling



The test set and all of its accessories are 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 (WEE directive). As part of our legal obligations under this legislation, OMICRON offers to take back the test set and to ensure that it is disposed of by an authorized recycling facility.

However, if there are any signs of a defective lithium-ion battery, transportation is not allowed.

For customers outside the European Economic Area

Contact the authorities in charge for the relevant environmental regulations in your country, and dispose of the OMICRON test set in accordance with your legal local requirements.

see Handling defective lithium-ion batteries on page 21.

4 Battery

The internal battery of the *COMPANO 100* test set is a 152 Wh rechargeable lithium-ion battery. When working with rechargeable lithium-ion batteries, certain safety issues apply:

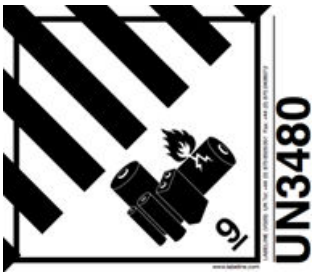
- There is a risk of fire and burns when handled inappropriately. Do not drop or crush the battery, and refrain from opening it. Do not short out the battery contacts, and never expose the battery to high temperatures. Dispose of properly. The battery may explode if damaged or disposed of in fire.
- Do not immerse in any liquid. Avoid the battery to come in contact with chemicals.
- Before charging the battery, read the relevant chapters of the manual. Use the OMICRON-supplied charger, only. Do not charge the battery in a flammable environment. Charge/discharge the battery in the permitted temperature range, only (see **Technical ► Data Battery** on page 95). To avoid damaging the battery, charging is terminated automatically when the temperature exceeds that range. You can check the battery status and temperature at **Setup**.
- In order to ensure a long lifetime, a battery should not be charged at extreme temperatures. Therefore, *COMPANO 100* controls the permissible temperature range for the battery to be charged. If the battery inside the test set is either too hot or too cold, *COMPANO 100* automatically prevents charging.

  More information about the charging temperature of the battery on page 95.
- If the battery is fully charged, the charger stops charging. If kept connected, the charger restarts charging automatically if the battery is down to approximately 90 %. If the charger is reconnected to the power supply, charging will start immediately (as long as the battery temperature is within the specified range).
- If you do not use the *COMPANO 100* test set for a longer period of time, recharge the battery once every 6 months.

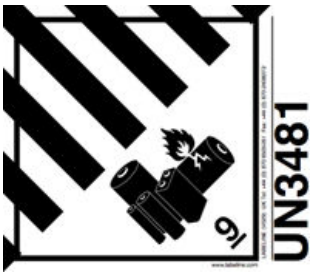
4.1 Transportation of COMPANO 100 with built-in battery

The *COMPANO 100* battery is specified as **Dangerous Goods Class 9**.

- Battery stand-alone: **UN 3480**, Lithium-ion battery.
- *COMPANO 100* with built-in battery: **UN 3481**, Lithium-ion battery contained in equipment or packed with equipment.



Dangerous Good Class 9 label combined with the **UN 3480** number.



Dangerous Good Class 9 label combined with the **UN 3481** number.

Depending on the way of transportation, different rules apply.

1. **Transport of COMPANO 100 by a person on land.**
   Craftsman exemption: The craftsman exemption is a special regulation in the ADR that allows users of a device to ignore the requirements stated below at "4. Shipment of COMPANO 100 on land on page 20". This exemption becomes effective under the following preconditions:
   - Battery and/or test set are transported by a company and their employees.
   - The reason for the transportation is job-related; for example, the test set is used for tests or measurements, brought for repair or maintenance, etc.
   - As long as you do not transport more than 10 *COMPANO 100* test sets at a time, the maximum load of the dangerous good is not exceeded
   - Check whether local regulations supplement the craftsman exemption, or suspend it as a whole or in portions.
2. **Transport of COMPANO 100 by a person on a plane.**
   - In its original case and as initially labeled with information stickers, the *COMPANO 100* test set complies with the IATA (International Air Transport Association) and the ADR (European Agreement concerning the International Carriage of Dangerous Goods by Road) regulations. The built-in battery is **UN 38.3** and **UL** certified.
   - It is possible to either check in the test set, or to take it on board as carry-on luggage. However, since the battery has more than 100 Wh but less than 160 Wh, the approval of the airline is needed. No special labeling is required.
   - Note that these regulations change frequently. Double-check the current status whenever applicable, or, if in doubt, contact OMICRON Support (→ Support).
   - The signing the IATA Shipper's Declaration must be done by a person who is IATA DGR-certified for category 1. That is a person either of the company that ships out the equipment, or of the transportation company.
3. **Shipment of COMPANO 100 on land.**
   - Shipping lithium-ion batteries on land by a car/truck underlies special regulations. Select a qualified shipping company that is aware of those regulations and complies with it. The shipping company must be a qualified **Dangerous Good** carrier with an according permit. If in doubt, contact OMICRON Support for shipment regulations (→ Support).
   - Make sure to comply with all requirements listed at **General requirements when packing test sets with built-in batteries** below.
   - Properly label the *COMPANO 100* test set with a **Dangerous Good Class 9** sticker combined with the **UN 3481** number (see page 19).
4. **Shipment of COMPANO 100 by plane:**
   - Shipping lithium-ion batteries by plane underlies special regulations. Make sure to select a qualified shipping company that is aware of those regulations and complies with it. The shipping company must be a qualified **Dangerous Good** carrier with an according permit. If in doubt, contact OMICRON Support for shipment regulations (→ Support).
   - Properly label the *COMPANO 100* test set with a **Dangerous Good Class 9** sticker combined with the **UN 3481** number (see page 19).
   - Ship the test set in the yellow *COMPANO 100* case, or a likewise solid transportation box, only.

General requirements when packing test sets with built-in batteries

- Protect the test set against damage that may be caused by movement or placement within the packaging. The packaging must be strong enough to withstand the shocks and loadings normally encountered during carriage, including trans-shipment between different transport units and/or warehouses.
- Test set and battery must be packed in a way that under normal conditions of carriage the battery they cannot break, be punctured or be damaged in any other way.
- If you pack the *COMPANO 100* test set with the battery inside, prevent any accidental operation of the test set during transportation.
- Shipping spare batteries underlies stricter regulations. For details, please contact OMICRON Support (→ Support).

4.2 Storing lithium-ion batteries

The following regulations apply to short- and long-term storage:

- Store the *COMPANO 100* with an almost fully charged battery at a low temperature (we recommend below 25 °C/77 °F) and in a low humidity environment.
- To avoid deep discharge of the battery, recharge it about every 6 months. Note that higher temperatures result in a drastically higher self-discharge rate of the battery.
- Do not store the battery in places with direct sunlight, or near a stove.
- Do not expose the battery to condensation, water drop or not to store it under frozen condition.
- Do not store the battery in places where it is exposed to abnormal static electricity.

4.3 Handling defective lithium-ion batteries

- Consider a lithium-ion battery defective when you notice a mechanical damage, deformation, leaking fluid, an unusual smell or similar abnormal symptoms.
  Note: A battery not showing any of the above mentioned symptoms, however revealing a noticeable capacity loss, does not need to be handled like a defective battery.
- Do not try to continue using a defective lithium-ion battery.
- Do not store or ship a defective lithium-ion battery. Hand it over to an appropriate disposal facility. Regulations and laws pertaining to the recycling and disposal of lithium-ion batteries vary from country to country as well as by state and local governments. Check the laws and regulations of your home region.

4.4 State of health (SOH) of the battery

► For information on the state of health (SOH) of the battery go to the **Setup** menu (see Setup ► Battery Info on page 90).

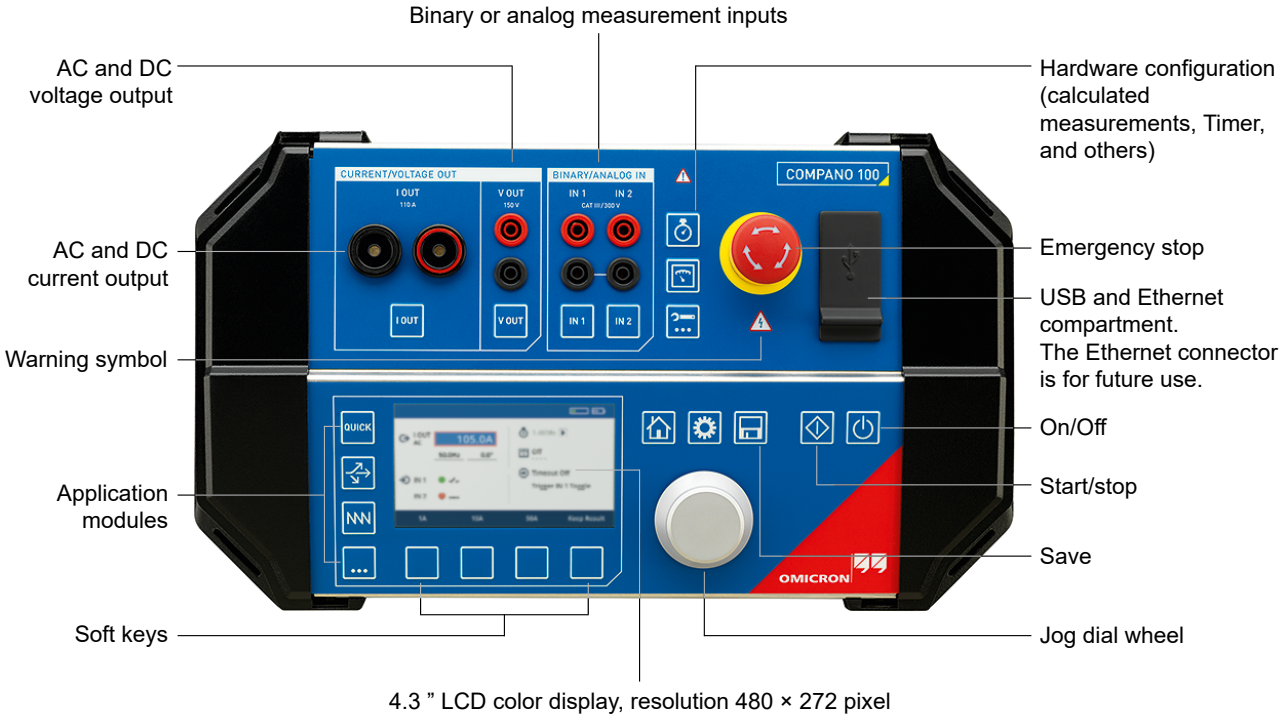
Note that the SOH is the "digital image" of a chemical process, and therefore not an accurate representation. It can change in both directions over time. The SOH is updated with every full discharge-charge cycle.

► Please contact OMICRON Support if the battery state has significantly deteriorated compared to when it was new.

5 Test set overview

COMPANO 100 is a lightweight, highly flexible fully electronic current or voltage source for various checks in an electrical energy system, such as generation, transmission, distribution, railways or industry. *COMPANO 100* is battery-operated; you do not need any additional power source for the test set. The battery is rechargeable.

Top view:

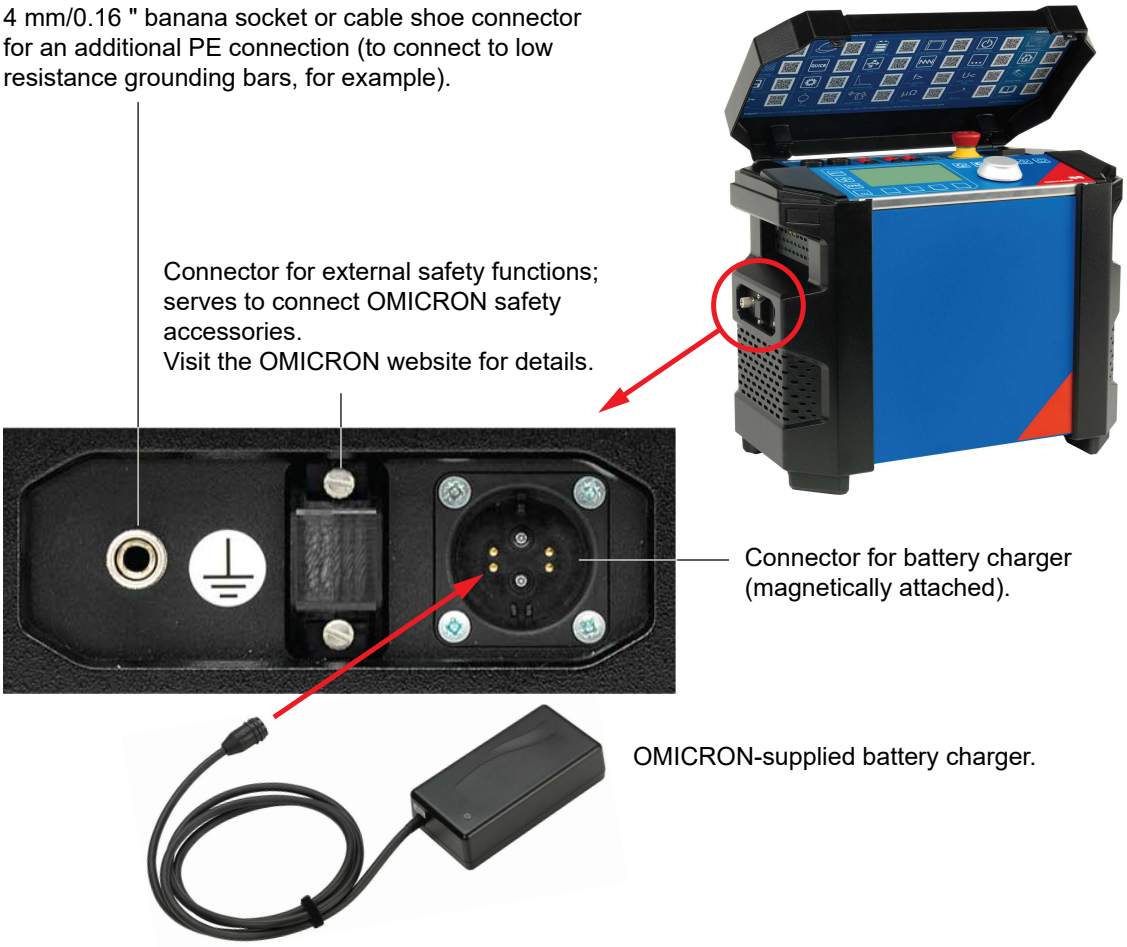


The warning symbol indicates that the device is activated, and that its outputs may carry dangerous voltages (for details see Setting *COMPANO 100* into operation on page 16).

For details see chapter **Front panel operation**, front panel upper half on page 27.

For details see chapter **Front panel operation**, front panel lower half on page 29.

Side view:



Note: You can remove the dongle shown in the picture above (the connector for external safety functions) to protect *COMPANO 100* from unauthorized usage.

WARNING

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

The OMICRON-supplied charger has a magnetically attached power connector. Magnets can impact the function of pace makers and implantable cardioverter-defibrillators (for example, actuation of reed switch).

► Keep a minimum distance of 20 cm/8 inch between the magnetic connector and the implanted devices to prevent malfunction and danger to health.

6 Product startup

First, charge the battery

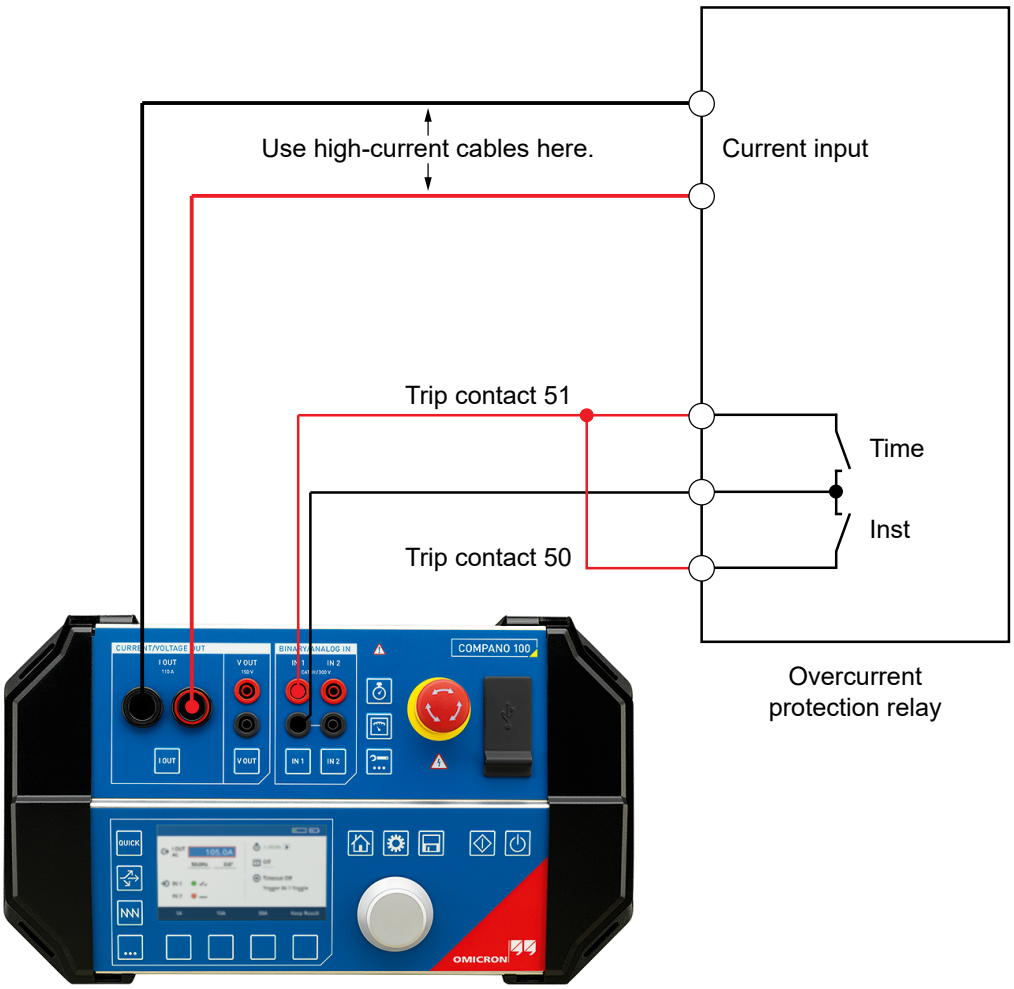
When shipped, the battery inside the *COMPANO 100* test set is partly charged, and the test set can be used immediately. To fully charge the battery, grant a charging time of about 90 minutes.

Use the OMICRON-supplied charger, only. That charger has a magnetically attached power connector. Such a connector has the advantage that, when it is tugged — for example, by someone tripping over the cord — it will pull out of the test set's socket without damaging the connector or the socket.

Then connect COMPANO 100 to the device you would like to test

For safety reasons, press the emergency stop button while connecting, and secure the test set against reactivation (see Wiring and Safe Connection on page 13).

The illustration below shows current output **I OUT** connected to an overcurrent protection relay. The relay's potential-free trip contact is connected to binary input **IN 1**.



Power up COMPANO 100

Press the **On/Off** key to power up *COMPANO 100*. Grant the test set about 30 s to boot up. The test set starts in QUICK (see chapter QUICK on page 40).

Power down COMPANO 100

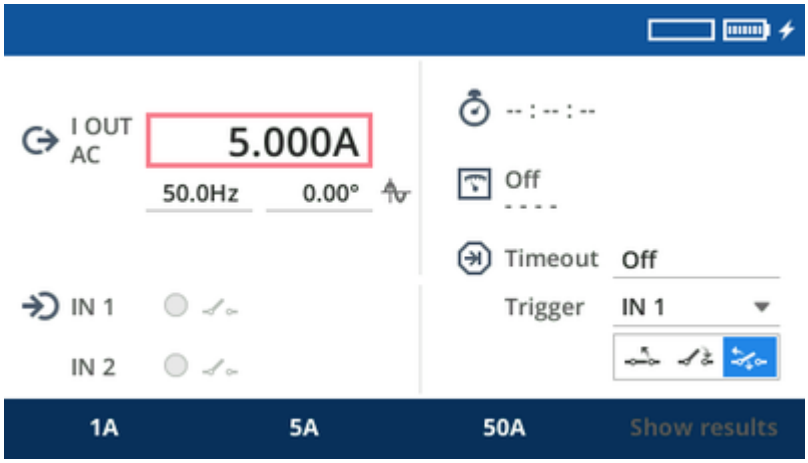
While *COMPANO 100* is running, press the **On/Off** key again to turn off the test set. *COMPANO 100* does not shut off instantly, but performs a controlled shutdown instead.

To abort the controlled shutdown, press any other key of your choice at the front panel control.

A battery running low also initiates a system shutdown, shortly before a looming power supply loss.

Check out the ***COMPANO 100* Product Startup** video on the **OMICRON Video Channel** (visit https://www.omicronenergy.com/COMPANO100-Startup).

6.1 Testing a relay in QUICK

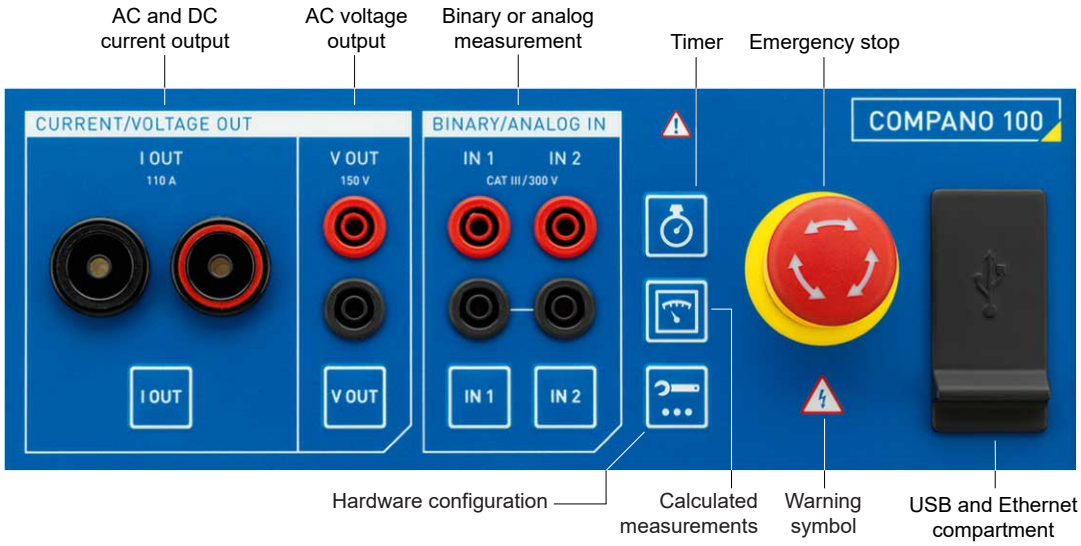


1. Turn the jog dial wheel until the focus is on the output current field.
2. Press the jog dial wheel, set the current to a value of your choice (that is, a value that will make the relay trip for sure), then press the jog dial wheel again.
3. By default, the timer is configured to start when you press the **Start/Stop** key, and to end when there is a change at the dry contact connected to **IN 1**. Therefore, for many applications it may not be necessary to change the timer from its default.
4. Press the **Start/Stop** key. The current is issued at the current output.
5. The current output is turned off by default as soon as the binary contact of the relay switches.
6. The timer records the duration of the relay trip time, that is, the time it took the relay to trip starting from the moment of the current injection.

7 Front panel operation

Check out the ***COMPANO 100*** **Front Panel Operation** video on the **OMICRON Video Channel** (visit https://www.omicronenergy.com/COMPANO100-Frontpanel).

Front panel upper half



- **I OUT** - AC (110 A) and DC (100 A) current output: see Configuring I OUT on page 33.

  The sockets of **I OUT** allow connecting high-current plugs as well as regular 4 mm/0.16 " banana plugs.

WARNING

Death or severe injury caused by high voltage possible
Inductive loads may contain a lethal amount of energy if charged with current. The amount of energy depends on the size of the inductive load, the strength of the applied current, and the frequency. To give an example, 350 mJ are assumed as safe according to the safety standard IEC 61010-1. Particularly critical devices are potential transformers or current transformers, but also the inductive part of other test objects can be critical.

► If you connect loads >0.3 mH to the *COMPANO 100* current output **I OUT**, do not touch the outputs or anything that is connected to them.

- **V OUT** - AC (150 V) and DC (220 V) voltage output: see Configuring V OUT on page 34.
- **IN 1** and **IN 2** can be configured to be either:
  - **binary** inputs to connect dry (potential-free) or wet contacts (carrying potential when closed),
  - or **analog** voltage or current inputs.
    By means of a current clamp or a shunt, you can use **IN 1** and **IN 2** to measure current (see Configuring IN 1/IN 2 on page 35).

WARNING

Death or severe injury caused by high voltage possible
The binary and/or analog inputs **IN 1** and **IN 2** may conduct hazardous voltages. The insulation against other potential hazardous voltages is implemented as functional insulation, and they are not isolated against each other (common N).

► Never connect touchable test objects to the inputs without having secured the dangerous area.

- **Timer:** see Configuring the Timer on page 38.
- **Calculated measurements:** see Configuring calculated measurements on page 39.
- **Hardware configuration:** see Hardware Configuration on page 33.

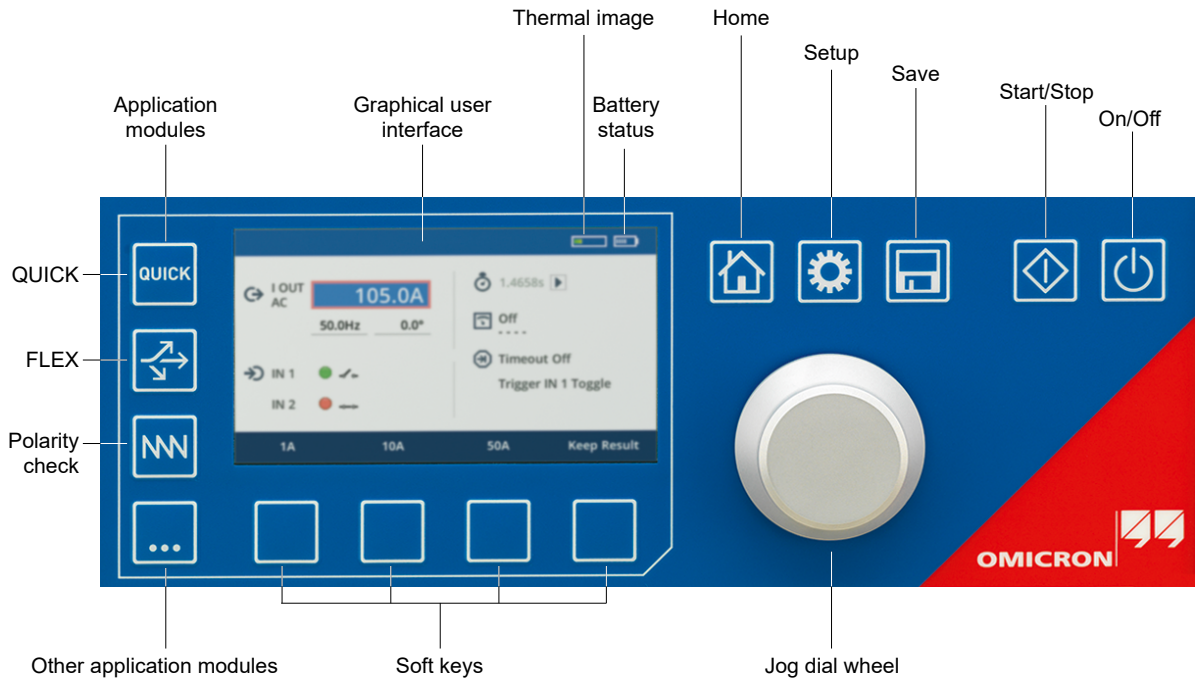
WARNING

Death or severe injury caused by high voltage possible
Although the output voltages of the current generators are within touch-safe limits, the insulation to other input and output groups is implemented as basic insulation only. Therefore, the outputs can conduct life-threatening voltages in case of a single failure.

► If it is not possible to use the safety test leads and safety sockets, observe the wiring instructions and safety precautions given in chapter Wiring and Safe Connection on page 14.

► Do not touch the current signals while the *COMPANO 100* is powered up.

Front panel lower half



Jog dial wheel:

Each screen that is displayed on the graphical user interface has its "focus" on a particular control element. Text or numbers in entry fields appear black on white background, which indicates that you are in Navigation Mode. Turn the jog dial wheel to move the focus to other control elements of this screen. Once the focus is on the element of your choice, press the wheel.

Depending on the control you have selected, pressing the wheel may lead you to a next level screen, toggle a setting, or enter a field for changing a value or a setting. If you pressed the wheel on an entry field, text or numbers in that entry field appear white on blue background, which indicates that you are in Setting Mode.

Application modules:

→ QUICK on page 40
→ FLEX on page 42
→ Polarity check on page 48
→ Other application modules on page 51

Soft keys: → Soft keys on page 31.

General purpose keys:

→ Home on page 86
→ Setup on page 90
→ Save on page 87

Battery status:

The battery status icon indicates the battery's state of charge.

If the icon blinks red, the battery is running low, and an automatic system shutdown will be initiated very soon. To prevent the shutdown, connect the charger.

A flash symbol next to the battery status icon indicates that the battery is charging.

If the flash symbol next to the battery status icon temporarily disappears while charging the battery, you draw more power from the battery than the charger is able to provide in that moment.

Too hot for charging. A thermometer symbol next to the battery status icon indicates that the battery is too hot to be charged. Let the test set and the battery cool down, then try again to charge it.

Too cold for charging. A snow flake symbol next to the battery status icon indicates that the battery is too cold to be charged. Slowly warm up the test set, then try again to charge it.

Thermal image:

The thermal image icon represents a progress bar-like temperature gauge displaying the actual temperature conditions of the *COMPANO 100* test set. *COMPANO 100* monitors its operational temperature at various places; this temperature gauge reflects the highest temperature value.

Test set temperature OK.

Test set temperature getting critical.

When the temperature limit is reached, that is before an overheating condition causes a damage, the outputs switch off automatically, and the test stops.

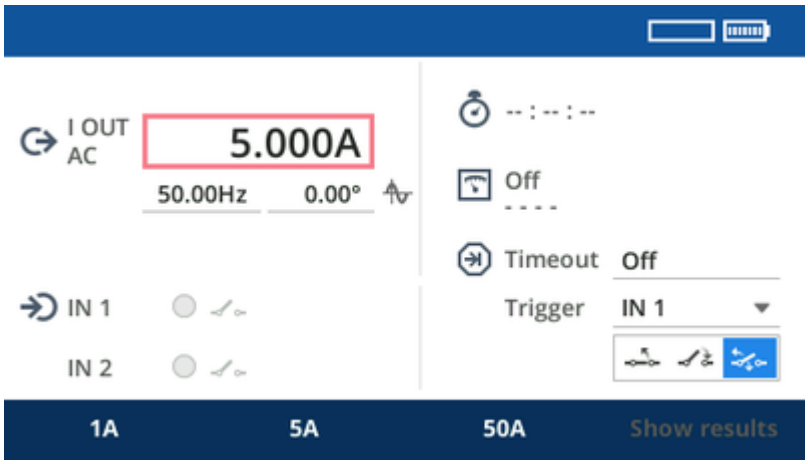
Test set temperature too high; current output was ended by the temperature exceeding its limit.

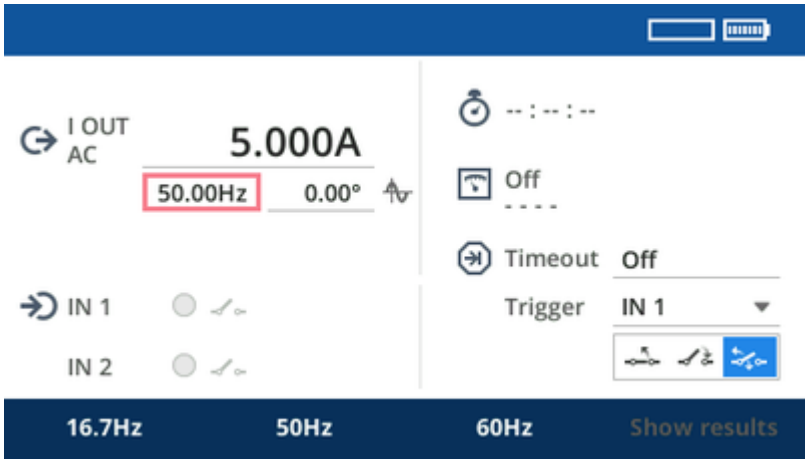
With switched off outputs, the thermal image icon represents an indicator how much the test set has already cooled off.

7.1 Soft keys

Below the graphical user interface, there are four soft keys.

Their functions vary, depending on the screen and the position of the focus. A key's present function is indicated at the bottom of the screen right above the menu key. In some cases these keys act as acceleration keys to set a specific value, in other cases they provide a certain functionality:





7.2 Keyboard backlight pattern

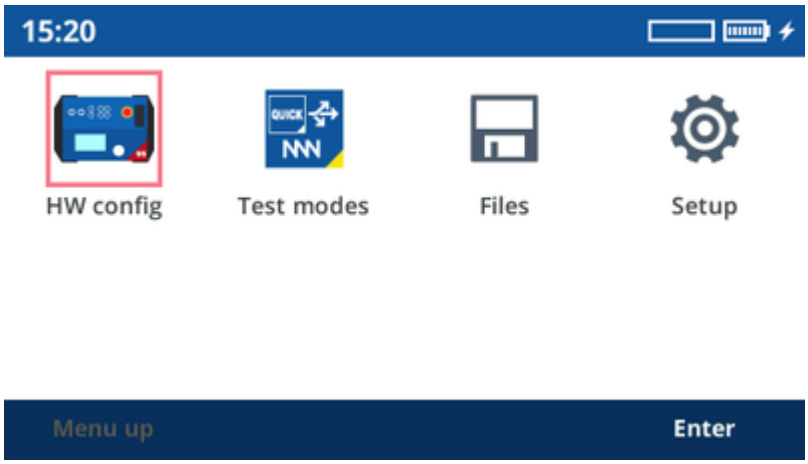
COMPANO 100 comes with a sophisticated keyboard backlighting. The pattern of the backlighting is meant to provide you with status information at one glance.

Backlight color	Meaning
Green	The function is ready to start, or there is a binary contact open. Examples: • **Start**/**Stop** key: test set is ready to be started; **Start**/**Stop** key was not pressed yet. • Input **IN 1** or **IN 2** configured to be binary: input is ready but presently the contact connected to it is open. • Timer: Timer is presently running.
Red	Voltage could be present. Examples: • Input **IN 1** or **IN 2** configured to be analog: currently measuring. • Input **IN 1** or **IN 2** configured to be binary: binary contact is closed. • **I OUT** or **V OUT**: output is active. • Timer: the Timer has stopped.
Red blinking	Alarm. Examples: • Input **IN 1** or **IN 2** configured to be analog: the measurement is out of range. • **I OUT** or **V OUT**: output is overloaded.
Blue	The focus is on this function. There is always only one key blue at a time.
White	The function is configured and ready for operation, but presently not in use. This is, for example, because the function is not activated.
No backlight	The function is not ready for operation. Nevertheless you can press that key; in some cases you might be able to activate the function.

8 Hardware Configuration

Check out the ***COMPANO 100*** **Hardware Configuration** video on the **OMICRON Video Channel** (visit https://www.omicronenergy.com/COMPANO100-Hardware).

Access all individual hardware configurations from the **Home** screen by selecting the **HW Config** icon.



Alternatively, just press the respective key below each input/output.

8.1 Configuring I OUT

Press the **I OUT** key.

Whenever you have made a selection, you are automatically forwarded to the next tab presenting you a new selection to pick from. After the last choice, press the respective application module key to continue measuring.

You have the choice between a 110 A and a 20 A output mode.

Note that the 20 A output limitation provides a slightly more accurate output for small signals than the full-range mode and has a slightly lower compliance voltage. Additionally, the granularity is higher in small current values. In general, in the 20 A mode, currents can be output for a longer period of time. For normal everyday testing, however, this minor accuracy advantage has no big significance.

For measurement purposes, for example, it makes sense to disable both outputs, current and voltage. In such a case the amplifier module is powered down to save battery power.

Note that some application modules overrule the settings of the respective input or output. For example, I OUT is always configured to be a 100 A DC output in **Micro-ohm**, or always AC in **Polarity Check**.

8.2 Configuring V OUT (voltage output)

The voltage output **V OUT** is optional. Please order separately (→ Support on page 175).

Press the **V OUT** key.

You have the choice between output modes **AC**, **DC**, and **AUX DC**.

Whenever you have made a selection, you are automatically forwarded to the next tab presenting you a new selection to pick from. After the last choice, press the respective application module key to continue measuring.

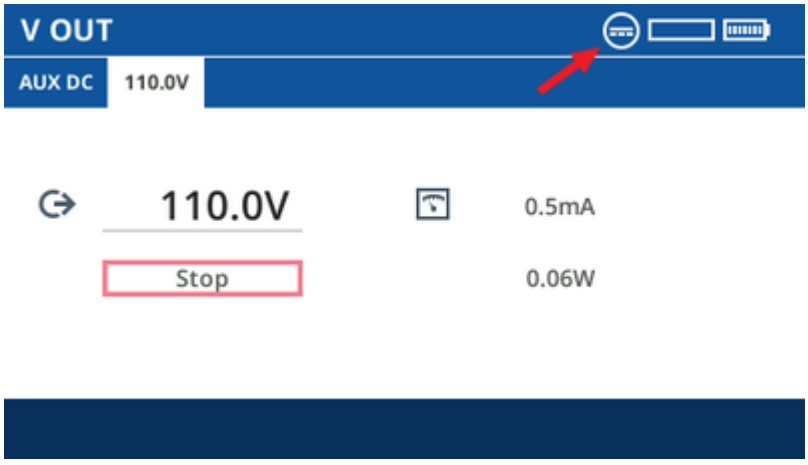
8.2.1 AUX DC

In the **AUX DC** mode, the *COMPANO 100* can output a higher current and more power – if required even while no test is running.

In the **AUX DC** view you can set the output voltage, and start and stop the AUX DC voltage output.

The measured current and apparent power are displayed on the right side.

As long as the **AUX DC** mode is active, the corresponding icon is displayed in the top right corner of every view:



DANGER

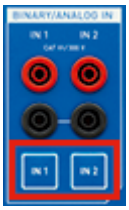
Death or severe injury caused by high voltage

When the warning symbol on the *COMPANO 100* front panel is lit and/or the **AUX DC** icon is displayed, **V OUT** carries potentially life-hazardous voltage.

- ► Do not leave *COMPANO 100* unattended while outputs are active.
- ► Stop the **AUX DC** mode if you are not actively using *COMPANO 100*.

When you press the emergency stop button, the **AUX DC** mode is automatically stopped and is *not* automatically restarted when the emergency stop button is released.

8.3 Configuring IN 1/IN 2 (binary or analog inputs)



Press the **IN 1** or **IN 2** key.

Whenever you have made a selection, you are automatically forwarded to the next tab presenting you a new selection to pick from. After the last choice, press the respective application module key to continue measuring.

IN 1 and **IN 2** can be configured to be either:

- **binary** inputs to connect dry contacts (potential-free) or wet contacts (carrying potential when closed),
- or **analog** voltage or current inputs.

By means of a current clamp or a shunt, you can use **IN 1** and **IN 2** to measure current.

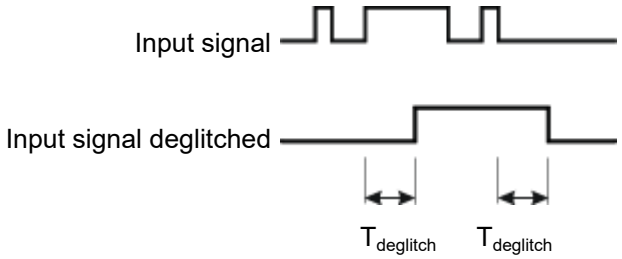
If you do not need these inputs, set them to Off. This keeps the user interface clear because functions set to Off are hidden in, for example, QUICK and FLEX.

IN 1/IN 2 binary

Symbol	Dry	Wet
	Connected contact open	Input voltage below configured threshold or connected contact open.
	Connected contact closed	Input voltage above configured threshold. Internally uses a voltage hysteresis to suppress interferences.

Deglitching input signals:

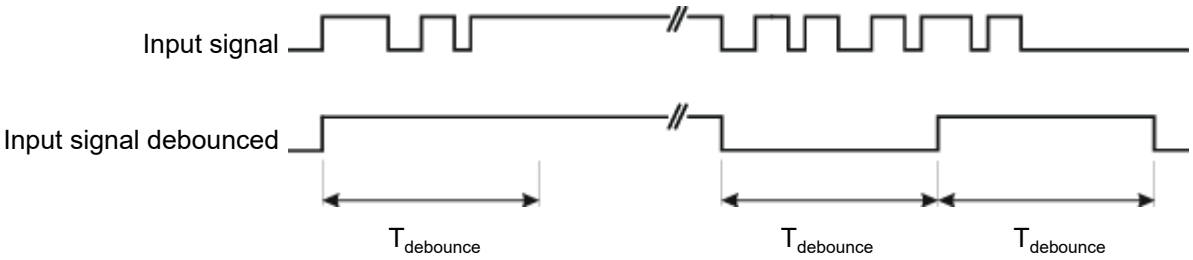
In order to suppress short spurious pulses, you can configure a deglitching algorithm. The deglitch process results in an additional dead time and introduces a signal delay. In order to be detected as a valid signal level, the level of an input signal must have a constant value at least for the deglitch time.



Debouncing input signals:

For input signals with a bouncing characteristic, you can configure a debounce function. That means, the first bounce of the input signal causes the debounced signal to be changed, too, and then kept on this value for the duration of the debounce time.

The figure below illustrates the debounce function. At the right-hand side of the figure, the debounce time is set too short. As a result, the debounced signal changes to “high” once again, even while the input signal is still bouncing, and does not drop to low level until the expiry of another $T_{debounce}$ period.



IN 1/IN 2 analog

Being an analog input, **IN 1**/**IN 2** measures voltage signals up to 300 V AC or DC. By means of a current clamp or a shunt, you can use **IN 1**/**IN 2** to measure current.

- **DC**:
  This mode measures a low-pass filtered mean value of the signal. This equals the DC component of the signal, and it might differ from the RMS value.
- AC - **Fast**:
  This mode measures an RMS value within one period of a signal, for example, for a 50 Hz signal the RMS reading is correct after 20 ms. The fundamental frequency is chosen as described at Reference signals on page 38. The RMS value correctly reflects DC, AC fundamental, and harmonic frequencies. Non-harmonic frequencies can not be correctly measured with this measurement principle.
- AC - **Accurate**:
  This mode requires more time for averaging but delivers results with a higher accuracy, particularly when the signals have a high level of noise. The RMS value includes the whole measurement frequency spectrum, including DC.
- AC - **fsel**:
  fsel stands for "frequency selective measurement". This mode only measures the frequency of the signal that is generated by the device or an alternative source (see Reference signals on page 38).
  For example, when you set the output current to 80 Hz, only signals with that frequency are measured. Other frequencies, such as 50 Hz or 60 Hz are suppressed with a factor above 1000. Hence, this values does not include the DC component.

COMPANO 100 only measures voltages on **IN 1**/**IN 2** after you have activated the test set by pressing the **Start** key. Else no measuring takes place. In case you wish to ***only*** measure voltage, disable all outputs. Then activate the test set by pressing the **Start** key.

Note that some application modules overrule the settings of the respective input or output. For example, I OUT is always configured to be a 100 A DC output in **Micro-ohm**, or always AC in **Polarity Check**.

8.4 Configuring the timer

The timer can be started and stopped by events you choose. By default, the timer is on.

Examples of timer start/stop events:

- An opening and/or closing binary contact at a binary input (which is regarded a "changing value").
- A transition from one sequence step to the next in the FLEX application module.
- An occurring or clearing overload.
- A user pressing the **Start**/**Stop** key in order to start a test.

Note: In principle, you can define all kinds of triggers you want, regardless whether or not they are feasible. You can, for example, set a transition from sequence step 5 to sequence step 6 in FLEX as trigger having defined three sequence steps, only. In such a case, the trigger condition is never met.

COMPANO 100 only measures timer start/stop events after you have activated the test set by pressing the **Start** key. Else no measuring takes place. In case you wish to ***only*** measure and test timer start/stop events, disable all outputs. Then activate the test set by pressing the **Start** key.

When the timer stops, the respective screen shows the result. The timer does not restart in such a case; you need to clear the results beforehand. This is why it makes sense, in particular in FLEX applications, not to define an end condition. The timer does not stop, however, with the sequence changes, intermediate results are recorded anyway.

The overload indicator is delayed by 200 ms in either direction, coming and going. This is necessary to suppress short spikes of the detection, on one hand, and, on the other hand, to reliably evaluate that the overload has finally cleared instead of just disappearing temporarily like, for example, during zero crossing. This means, if you do a time measurement using "Overload" triggers, add to or deduct from the result 200 ms, accordingly.

8.5 Reference signals

For phase calculations and certain features, such as the frequency selective measurement (**fsel**), *COMPANO 100* uses an AC reference signal.

This selected reference signal directly affects the measurements done by *COMPANO 100* by means of the input signals at **IN 1** and **IN 2**. Should the reference signal be implausible or invalid, all quantities calculated from the reference signal will be wrong. This can happen when, for example, there is nothing connected to the **I OUT** output or the **IN 1**/**IN 2** inputs but they are set to be a reference signal.

The search for reference signals is done in the below listed order from 1 ... 4. If one of them succeeds to become a reference signal, the rest is ignored.

1. If **I OUT** is configured to be an AC output, I OUT is used as reference signal.
2. Else, if **V OUT** is configured to be an AC output, V OUT is used as reference signal.
3. Else, if **IN 1** is configured to be an AC input, IN 1 is used as reference signal.
4. Else, if **IN 2** is configured to be an AC input, IN 2 is used as reference signal.

8.6 Configuring calculated measurements

Define a calculated measurement from a combination of two source quantities, such as output current and an input voltage. Depending on the source 1/source 2 combination, different measurements are possible. For example: from an AC voltage and an AC current you can calculate quantities like Z, P or even Rs and Ls. Other combinations, however, such as a binary input and an DC current, do not allow calculated measurements.

- Resistance R, and either inductance Ls in H (series equivalent circuit), capacity Cp in F (parallel equivalent circuit), or capacity Cs in F (series equivalent circuit) are just another representation of the impedance Z measurement; Z is displayed in its components.

  Using Rs and Ls, the impedance is given by: $Z = Rs + j\ \omega Ls$, where $\omega = 2 \pi f$, and the frequency of the Reference Signal (→ 8.5 Reference signals on page 38) is used for the calculation.

  Using Rp and Cp, the admittance is given by: $1 / Z = 1 / Rp + j\ \omega Cp$, where $\omega = 2 \pi f$, and the frequency of the Reference Signal (→ 8.5 Reference signals on page 38) is used for the calculation.

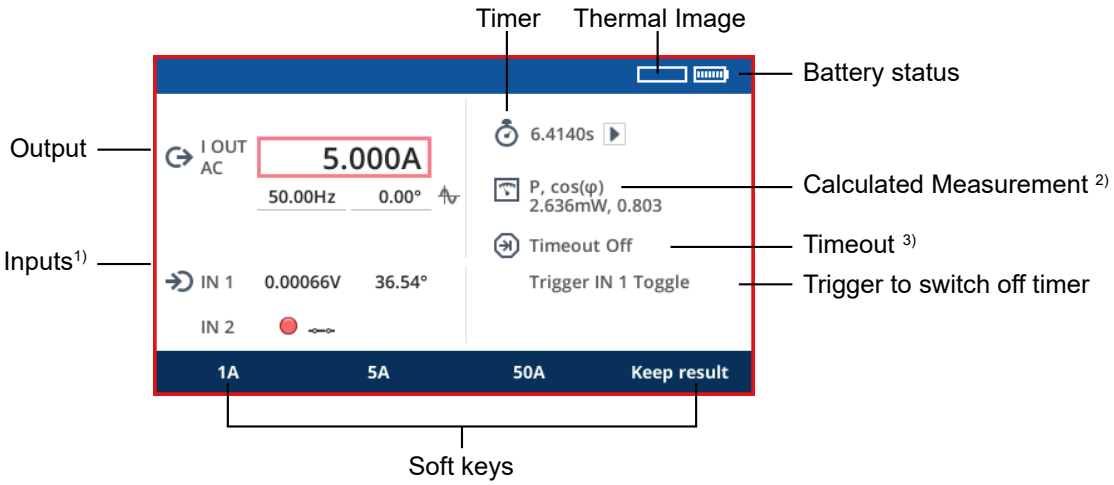
  Using Rs and Cs, the impedance is given by: $Z = Rs + 1 / (j\ \omega Cs)$, where $\omega = 2 \pi f$, and the frequency of the Reference Signal (→ 8.5 Reference signals on page 38) is used for the calculation.
- Cs and tan(δ) is another representation of Rs and Cs with $\tan(\delta) = Rs / |Xc|$ and $Xc = 1 / (j\ w\ Cs)$.
- Calculated measurements use frequency-selective settings if the analog input **IN 1** is set to "frequency selective measurement" (see IN 1/IN 2 analog ► fsel on page 37).

COMPANO 100 only carries out a calculated measurement after you have activated the test set by pressing the **Start** key. Else no measuring takes place. In case you wish to ***only*** measure, disable all outputs. Then activate the test set by pressing the **Start** key.

9 QUICK

Check out the ***COMPANO 100*** **QUICK** video on the **OMICRON Video Channel** (visit https://www.omicronenergy.com/COMPANO100-Quick).

Use QUICK to directly set the test set's current output magnitude as well as the frequency of I OUT.



1) In this example, the **IN 1** input is configured to be a voltage input. It could as well be a current input, a wet binary input or dry binary input. To change that configuration, press then **IN 1** key.

2) **Calculated measurement** is configured to calculate a power (P) from, for example, current output **I OUT** and measured voltage at **IN 1**.

3) You can set a timeout between 1 ms (0.06 cycles at 60 Hz) up to 1 day. While the outputs are active, the timeout counts down. When it reaches zero, the outputs are turned off.

Entering parameters in QUICK:

1. Turn the jog dial wheel until the focus is on the field of your choice.
2. Press the jog dial wheel, then turn it again to set a value. Alternatively, rather than turning the wheel, press a soft key of your choice to apply its value to the input field. By turning the jog dial wheel again, you can change that value.
3. Press the jog dial wheel again to acknowledge your set value and to leave the edit mode. Then navigate to the next field.

To output the set magnitudes at the outputs, and to start the measurements, press the **Start**/**Stop** key.

Alternatively, you can activate the test set first, and then set the output values of your choice.

Note: by selecting/clearing the I OUT field, the displayed value toggles between the value of your choice (blue background) and the measured value (white background).

WARNING

Since it is possible to adjust values in real-time by turning the jog dial wheel, death or severe injury can occur if the appropriate safety instructions are not observed.

- ► Avoid touching the jog dial wheel by mistake with your body or loose clothing.
- ► Make sure that no one stands close to the cable ends at the device under test and/or is able to accidentally touch them while the outputs are on.

Recording results

While the outputs are active, press the **Keep result** soft key. All values present at the moment of pressing the key are now recorded to an extra tab. You can press **Keep result** repeatedly; every use of this function will create a new tab. The tabs are numbered consecutively.

One additional tab is created automatically with all present values of the moment you either press the **Start**/**Stop** key to turn off the outputs, the timeout feature turns off the outputs, or the trigger to switch off (overload/binary trigger) occurs.

When the measurement is completed, the QUICK tab will be hidden; you will only see the result tabs.

Press the **Save** soft key to save the results to a USB stick (see Save on page 87).

Note: The QUICK application module supports a special open/close detection function. Very fast changes of the output load are detected as open/close transition, temporarily limiting the output driving voltage and control parameters for about 100 ms to optimize the output behavior for sudden changes between the three states: open circuit, normal load, and short circuit.

10 FLEX

Use FLEX to define and output a sequence of steps. Such a sequence step can be a signal state (a constant current or voltage output, for example), a ramp, or a pulse ramp. Each sequence step has a trailing transition that you can parameterize.

Contrary to QUICK, in FLEX you define the output parameters prior to the output generation. While the outputs are active, you cannot change the parameters anymore.

Entering parameters:

1. Turn the jog dial wheel until the focus is on the field of your choice.
2. Press the jog dial wheel, then turn it again to set a value. Alternatively, rather than turning the wheel, press a soft key of your choice to apply its value to the input field. By turning the jog dial wheel again, you can change that value.
3. Press the jog dial wheel again to acknowledge your set value, then navigate to the next field.

Example: You have set an **I OUT** of 9.5 A for sequence step 1. If you now define a timeout of 1 s (60 cycles) for that sequence step, you have defined a start value for your test of 9.5 A at **I OUT** that after 1 s progresses to the sequence step transition, and from there to sequence step 2.

Sequence step transition

The transition from one sequence step to another can be:

- a step (see Sequence step transition "step" on page 43)
- a ramp (see Sequence step transition "ramp" on page 43)
- a pulse ramp (see Sequence step transition "pulse ramp" on page 44)
- a smooth ramp (see Sequence step transition "smooth ramp" on page 46)

Note: The open/close detection as described in chapter QUICK (see QUICK ► note reg. the open/close detection function on page 41) is disabled in the FLEX application module for full dynamic response to sudden load changes, for example, when electro-mechanical relays pick up.

10.1 Sequence step transition "step"

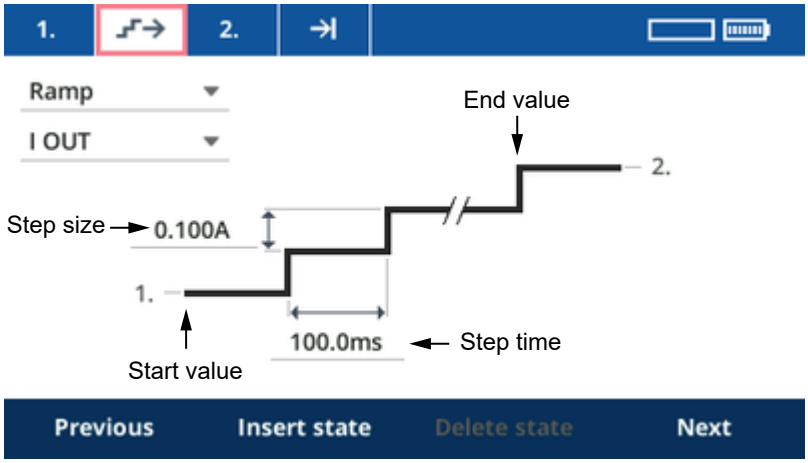
"Step" is a non-configurable transition at the end of a sequence step. Nothing happens in this transition; the sequence step *n* progresses immediately to the next sequence step *n+1*.

With such step transitions in between the individual steps you can define a sequence whose steps are either triggered by events such as overloads or binary triggers, or by timeouts.

The overload indicator is delayed by 200 ms in either direction, coming and going. This is necessary to suppress short spikes of the detection, on one hand, and, on the other hand, to reliably evaluate that the overload has finally cleared instead of just disappearing temporarily like, for example, during zero crossing. This means, if you do a time measurement using "Overload" triggers, add to or deduct from the result 200 ms, accordingly.

10.2 Sequence step transition "ramp"

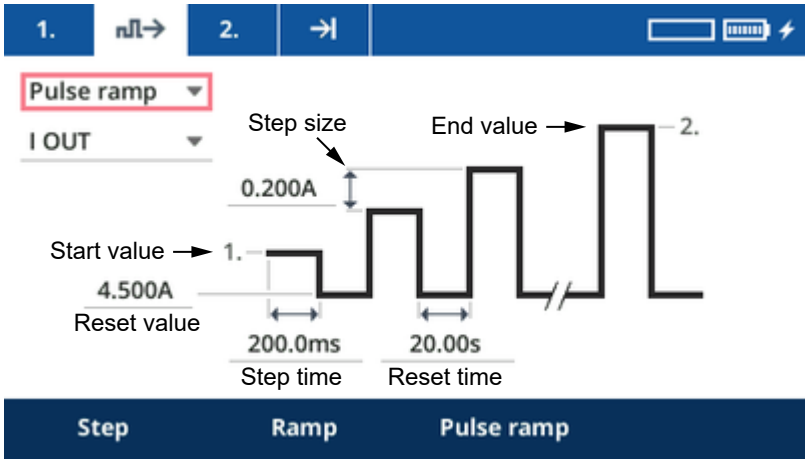
The transition from sequence step *n* to the next sequence step *n+1* is a ramped signal.



- The ramp's start value is the output value defined in this sequence step *n*.
- The ramp's end value is the output value you will specify on the tab of sequence step *n+1*. When the ramp reaches that value, FLEX progresses to sequence step *n+1*.
  If a trigger is defined in the sequence step *n+1*, the ramp ends when the trigger condition is met and therefore does not reach its end value.
- Specify both, the ramp's step size and the step time in the according entry fields. If you want to ramp down, enter a negative value for the step size, for example, -100 mA. (The upward ramp illustration will not change, though.)

10.3 Sequence step transition "pulse ramp"

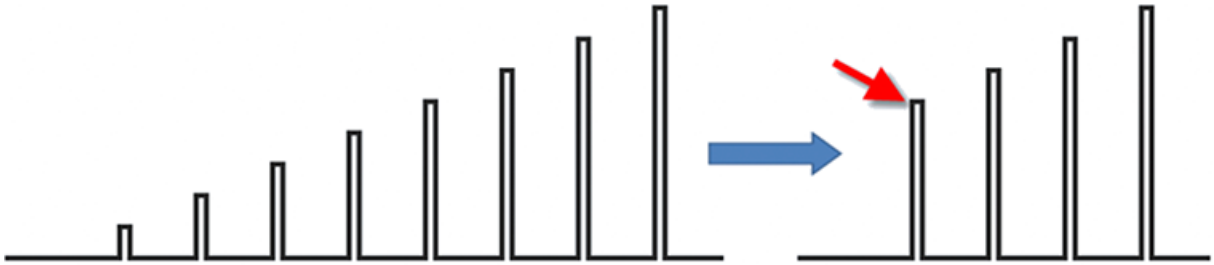
The transition from sequence step *n* to the next sequence step *n+1* is a pulse-ramped signal.



- The pulse ramp's start value is the output value defined in this sequence step *n*.
- The reset value, that is the "fall-back" value between the individual pulses, can be set.
- The pulse ramp's end value is the output value you will specify on the tab of sequence step *n+1*. When the pulse ramp reaches that value, FLEX progresses to sequence step *n+1*.
  If a trigger is defined in the sequence step *n+1*, the pulse ramp ends when the trigger condition is met and therefore it does not reach its end value.
- Specify the pulse ramp's step size, pulse time and reset time in the according entry fields. If you want to ramp down, enter a negative value for the step size, for example, -100 mA. (The upward ramp illustration will not change, though.)

Tips & Tricks

In general, a pulse ramp would be defined as shown in the left part of the picture below.

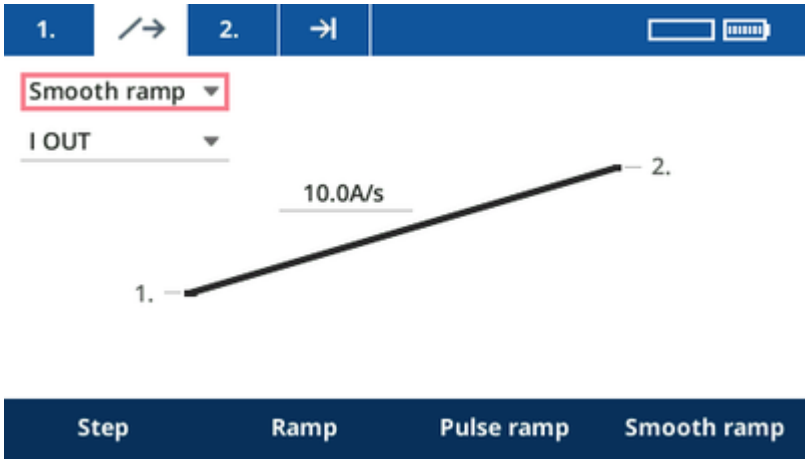


Testing, for example, the high setting of an instantaneous trip could take very long that way. There is a quicker way to do this:

1. Define a state with the pre-fault value and with a timeout as long as needed.
2. Define a second state with the start value of the pulse ramp (red arrow) and with a timeout of 1 ms, only. This will not considerably affect the first pulse, but it will define the start point.
3. Then define the pulse ramp with the same reset value like the one that you have set for the pre-fault state.
4. Setting a reset value other than zero (for example, the nominal value) can be advantageous. In many cases the relay needs that, and *COMPANO 100* can output a better signal quality if there is no complete interruption.

10.4 Sequence step transition "smooth ramp"

The transition from sequence step *n* to the next sequence step *n+1* is a continuous smooth ramp.

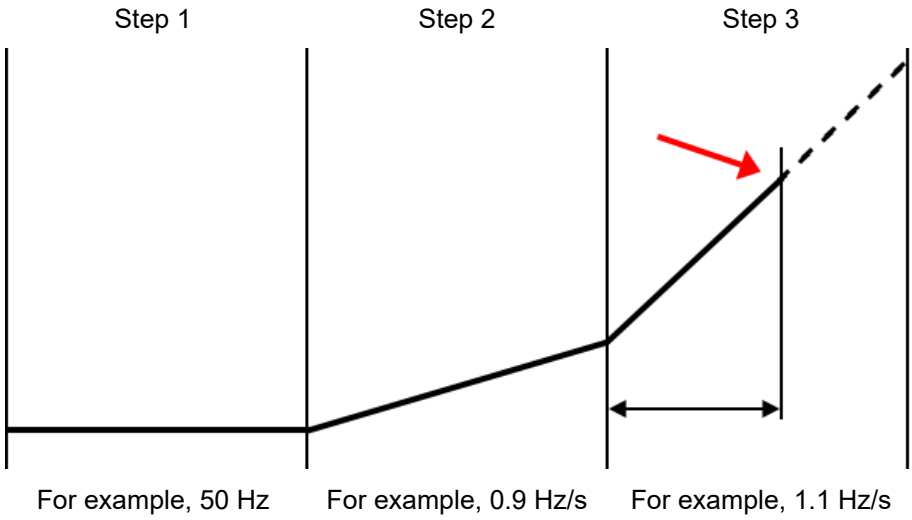


- The ramp's start value is the output value defined in this sequence step *n*.
- The ramp's end value is the output value you will specify on the tab of sequence step *n+1*. When the ramp reaches that value, FLEX progresses to sequence step *n+1*.
  If a trigger is defined in the sequence step *n+1*, the ramp ends when the trigger condition is met and therefore does not reach its end value.
- Specify the slew rate of the ramp. If you want to ramp down, enter a negative value for the slew rate, for example, -1.0 A/s. (Note that the upward ramp illustration will not change.)

The smooth ramp changes the output value frequently. In the default setting, the timer resets each time when the output changes. This means that, by default, it shows no meaningful value if smooth ramps are used. If you would like to use the timer to measure a trip time of a dI/dt or df/ft relay, instead of output change, reconfigure the timer to start at the state transition from the previous state to the current state.

Tips & Tricks

Usually, smooth ramps are used to test protection functions like df/dt or dI/dt. When the configured slew rate is exceeded, the relay must trip within a certain time.



Example of how this could be tested:

1. Define a state with the pre-fault value and with a timeout as long as needed.
2. Define a smooth ramp with a slew rate slightly below the one to test (for example, 0.9 Hz/s if the relay is configured to trip above 1.0 Hz/s).
3. Define a smooth ramp with a slew rate slightly above the one to test (for example, 1.1 Hz/s).
4. Configure the timer to start at the state transition to state 3, and to stop on output halt.

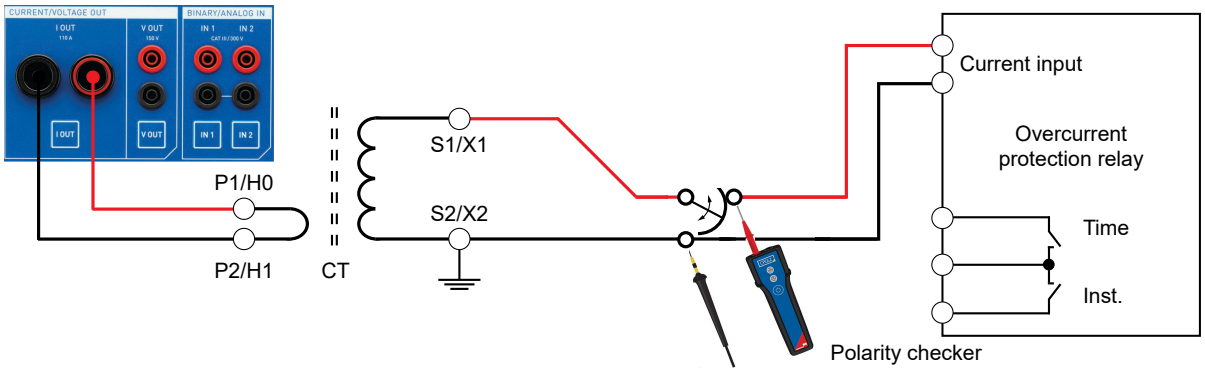
Press the **Start/Stop** key to execute the sequence.

- If the sequence stopped in step 2 with a trigger as reason, the relay tripped already below 1.0 Hz/s – there is no timer value available.
- If the sequence stopped in step 3 with a trigger as reason, the relay tripped, as intended, above 1.0 Hz/s – the timer shows the trip time.
- If the sequence ended without a trigger, the relay did not trip.

11 Polarity check

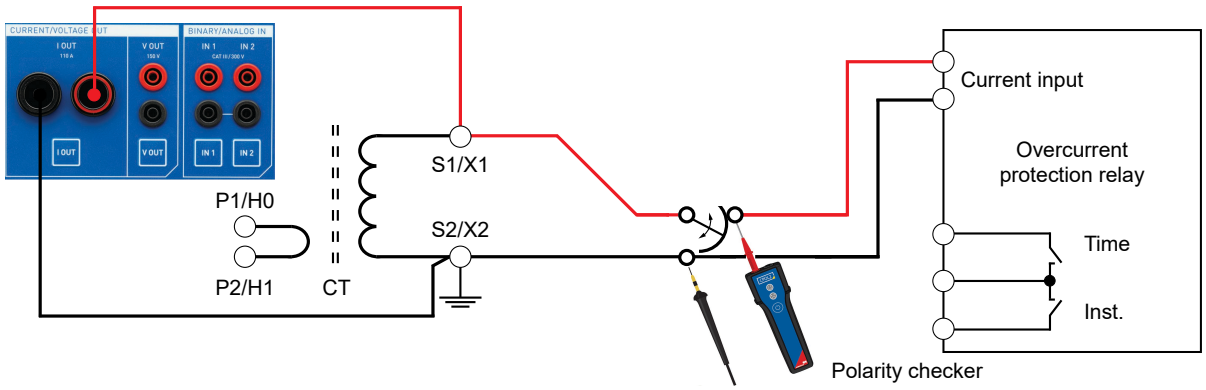
Use the Polarity Check application module to output a sawtooth-shaped signal for testing the secondary wiring of current transformers and voltage/power transformers. Correct polarity of instrument transformers is essential; it determines the direction of the secondary current values in relation to the primary current values.

Typical setup when injecting at the primary side of a CT: *COMPANO 100* injects a current, say 50 A, from **I OUT** positive to the primary terminal P1/H0 of the current transformer, and **I OUT** negative to P2/H1. To test the polarity, connect the OMICRON polarity checker *CPOL*, *CPOL2* or *CPOL3* to any contact pair of the secondary wiring.



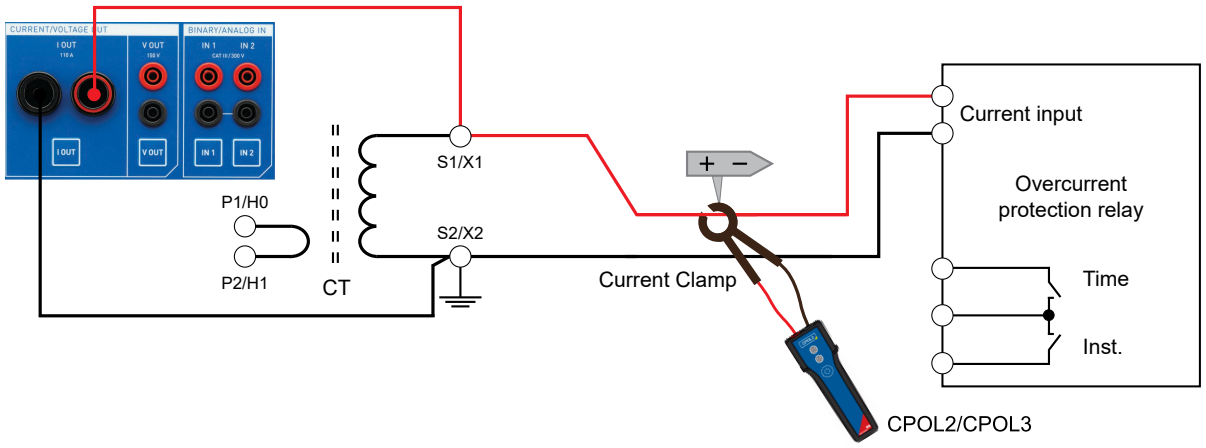
Because a high current cannot be injected permanently, it makes sense to output the current for a certain time, and then give *COMPANO 100* some time to cool down. Such an on/off time ratio for injecting a 50 A sawtooth signal would be, for example, t_{on} = 5 s, t_{off} = 55 s.

Typical setup when injecting at the secondary side of a CT: *COMPANO 100* injects a current, say 5 A, from **I OUT** positive to the secondary terminal S1/X1 of the current transformer, and **I OUT** negative to S2/X2. To test the polarity, connect the OMICRON polarity checker *CPOL*, *CPOL2* or *CPOL3* to any contact pair of the secondary wiring.



When injecting a 5 A sawtooth signal, there is no on/off time ratio required. *COMPANO 100* provides 5 A continuously (t_{on} = 60 s, t_{off} = 0 s).

Some self-supplied relays cause heavy distortions on the voltage as they are internally using a switched-mode power supply. *CPOL*, *CPOL2* and *CPOL3* are not able to detect such a distorted sawtooth signal.
For *CPOL2* and *CPOL3*, a solution for this problem is using a current clamp to measure the current instead of the voltage (shown below).



Interruption detection

As additional function, the Polarity Check application module provides an interruption detection, that is, it can detect short interruptions of the secondary path of a current transformer. Its purpose is to detect defective make-before-break switches. (Other commonly-used names in the English language for such "change-over make-before-break switches" are "relay test switch", "relay test connector", "shorting devices", or "superior switches".) Such devices short-circuit the current transformer, then disconnect it from the relay. The order of “making before breaking” is of utmost importance because if there is an interruption, even a very short one, high voltages will occur as long as there is a primary current on the CT.

1. To use the interruption detection, inject a current as close as possible to the CT on the secondary side. We recommend you permanently inject nominal current by setting for example, 1 minute/ 3600 cycles **on** time, and 0 seconds/cycles **off** time. Inject at least 1 A nominal current.
2. While injecting the nominal current, operate the make-before-break switch in the path several times.
3. If an interruption is detected, the Polarity Check application module will show its time span at **TMax. open**. Detected interruptions between 0.1 ms and 5 ms are displayed as such. If an interruption longer than 5 ms is detected, Polarity Check displays a value of **> 5ms**.

Setting a trigger

In case the make-before-break switch is physically far from the *COMPANO 100* test set, set a trigger to disable the output in case an interruption is detected. That way, even being away from the test set, you become aware that such an interruption occurred by noticing the absence of the test signal after operating the make-before-break switch. To do so, turn the jog dial wheel until the focus is on the option field below **Interrupt trigger**. Press the jog dial wheel to toggle the **Interrupt trigger** option. Alternatively, use the **Off**/**On** soft keys.

Note: two limitations apply to that test.

1. In case the inductance of the circuit behind the test switch is very high (due to an extensive wiring or a heavily inductive electro-mechanical relay, for example), a very short interruption may be detected even though the switch is operating properly.
   Such wrongly detected interruptions are generally very short, below 1 ms. If you are in doubt whether you have such a wrongly detected interruption, shorten the CT while the rest of the circuit is connected in parallel. If you then still detect such interruptions, you know that this is the cause for the detection.
2. If the CT connected to the I OUT output is extremely small, say, in the range of 1 VA, it could happen that not the entire 5 ms of interruption time are detected. Reason: before that time has elapsed, the current starts flowing through the CT again. In such cases, longer interruptions could be shown with values slightly smaller than 5 ms. To find out if that is the case, open the secondary circuit, and read out the display of COMPANO 100.

Note: The Polarity Check application module supports a special open/close detection function. Very fast changes of the output load are detected as open/close transition, temporarily limiting the output driving voltage and control parameters for about 100 ms to optimize the output behavior for sudden changes between the three states: open circuit, normal load, and short circuit.

12 Other application modules

Other application modules is a group holding various application modules.

12.1 Micro-ohm

WARNING

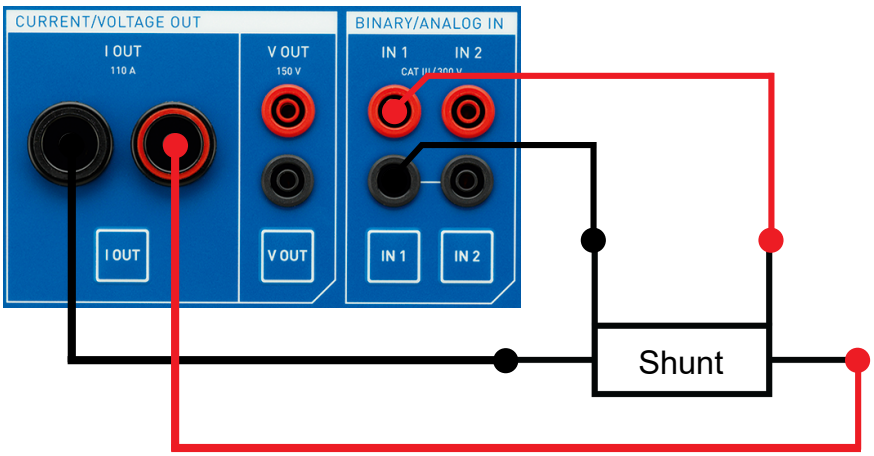
Death or severe injury caused by high voltage possible

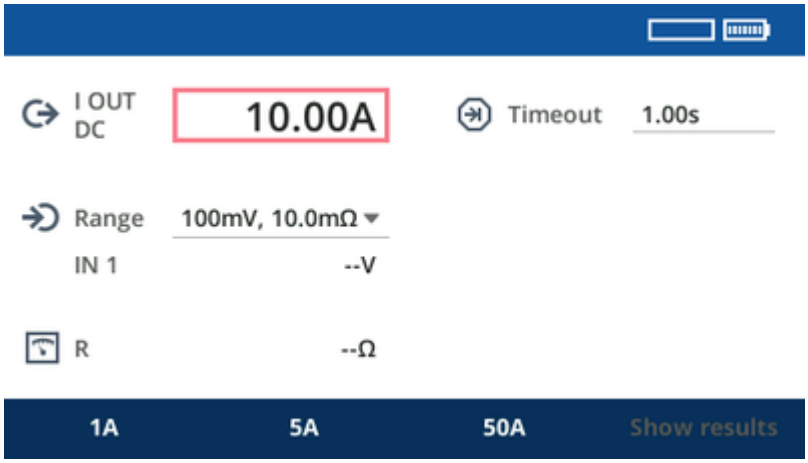
Inductive loads may contain a lethal amount of energy if charged with current. The amount of energy depends on the size of the inductive load, the strength of the applied current, and the frequency. To give an example, 350 mJ are assumed as safe according to the safety standard IEC 61010-1. Particularly critical devices are potential transformers or current transformers, but also the inductive part of other test objects can be critical.

- ► If you connect loads >0.3 mH to the *COMPANO 100* current output **I OUT**, do not touch the outputs or anything that is connected to them.
- ► Make sure that such inductive loads are short-circuited and completely discharged before disconnecting it. In doubt, do not execute resistance tests on inductive loads.

Use the **Micro-ohm** application module to measure a device under test, for example, a shunt or a closed circuit-breaker, or to verify the integrity of a grounding system by carrying out a ground grid continuity measurement. The ground grid continuity measurement involves measuring the point-to-point resistances within a ground grid. This is to ensure that all parts of the grounding system, e.g. raisers, are properly interconnected with one another. That way, this method detects improper construction work and deterioration.

► Refer to Micro-Ohm application module on page 100 for accuracy specifications, cable length, and the supported maximum resistance of the device under test.





1. Use the jog dial wheel to set a current value of your choice at I OUT.
2. Set the **Timeout**. 1 second is a good default value to start with.
   To disable the timeout, set it to **Off**.
3. Set a proper measurement range depending on the expected result. If in doubt, use the smallest range; the test set will notify you if the measurement range should not be sufficient.

   The 100 mV ranges in QUICK and Micro-ohm are different. The 100 mV range in the Micro-ohm application module uses an additional hardware low-pass filter to suppresses external interferences.

4. Press the **Start/Stop** key to start the current output.
5. It takes a short moment (around 500 ms) for the result to become stable. Then you will get to see the current that *COMPANO 100* injected into the device under test, the measured voltage at **IN 1**, and the resistance value at **R**.
6. The measurement stops automatically after the configured **Timeout**. Press the **Start/Stop** key to end the measurement manually.

- Even if the output switches off due to output current time limitations, the result is still valid.
- A typical measurement time of 1 second can prove insufficient if the device under test comprises current transformers, which may be the case in dead tank breakers with bushing current transformers (CTs), or in some cases in GIS stations (gas-insulated substations). In such cases we need currents with a longer "burn-in" time. Currents below 100 A and times above 1 second are recommended.
  If in doubt whether the time is sufficient, make measurements with different times. If the results depend significantly on the timeout, the timeout is generally too short. Some CTs may require times up to 60 seconds. In such a case, 10 A is a good test current.

12.2 Ground impedance

A good substation or transmission tower grounding system is crucial to protect people from injury and equipment from damage. International standards such as EN 50522, IEEE Std 80-2013 or IEEE Std 81-2012 give guidelines on how to measure the impedances of such grounding systems.

The Ground impedance application module can test smaller grounding systems with a diameter of up to 30 m/100 ft using an auxiliary current probe. **Note:** no other grounding system must be nearby.

For grounding systems beyond 30 m/100 ft, which can be found on medium and large distribution substations or transmission substations, preferably use OMICRON's *CPC 100* and *CP CU1*. With these devices you can use out of service power lines for current injection.

The fall-of-potential method, as it is called in the EN 50522 or IEEE standards, is a good solution for measuring the ground impedance of a substation. The current is fed into a remote ground via a long cable. This remote ground can be any ground from a simple grounding rod to another large grounding system. Usually a grounding rod, referred to as auxiliary current probe, is used.

The distance between this probe and the grounding system under test should be at least five times the diameter of the grounding system. A larger distance will provide more accurate results. In general, the setup must represent worst case conditions that may occur during a single-line fault. This must be clarified for each grounding system individually.

We recommend using an auxiliary current probe as remote ground in 150 m/450 ft distance for grounding systems up to a diameter of 30 m/100 ft.

Then measure the voltages with a second test probe at various distances around the grounding system under test. If possible, choose the measurement points in a 90 º angle (bird's-eye view) relative to the current path.

We recommend to avoid measuring close to the current path (< 60 º) to reduce the effect of mutual coupling.

The measured data at a large distance away from the grounding grid (typically three times the length of the grounding grid or, for example, 62 % of the injection distance) allow the calculation of the overall ground impedance.

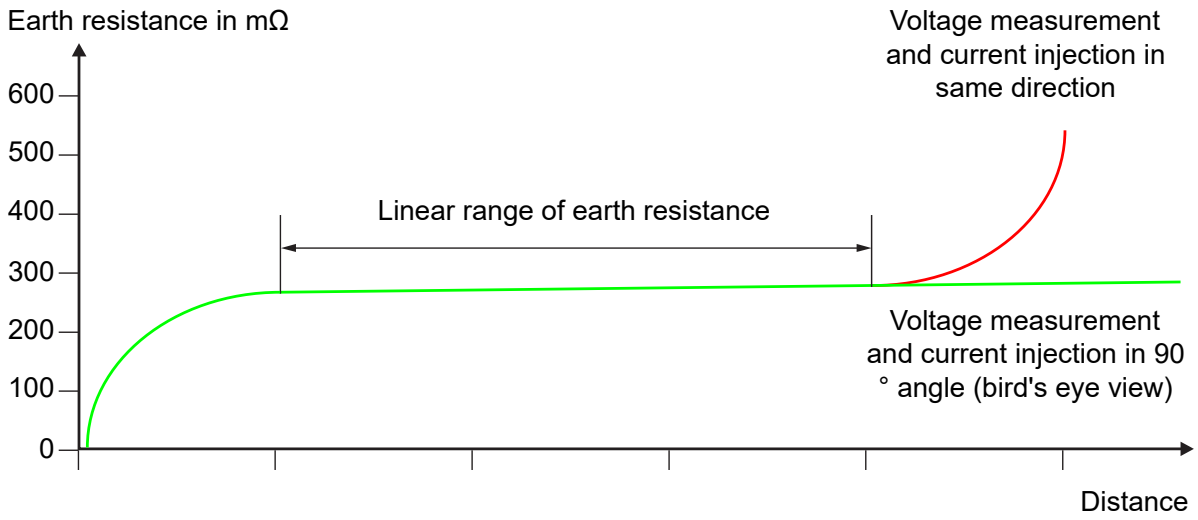
Distance	EN 50522	IEEE 81
Auxiliary current probe distance (injection)	≥ 4 times the maximum diameter of the grounding system under test but not less than 40 m (130 ft)	≥ 5 times the maximum diameter of the grounding system under test
Potential probe distance (measurement)	≥ 2.5 times the diameter of the grounding system in measurement direction but not less than 20 m (65 ft)	E.g. 62 % of the distance used for injection

We recommend to measure at different distances. If the distance is high enough, the measurement points should all show similar results. If the points are set too close to the grounding system under test, close to other grounding systems, or over buried pipes, the obtained results are not stable.

Even though this application module is optimized for the fall-of-potential method, it can also be used for the two-point and the three-point method.

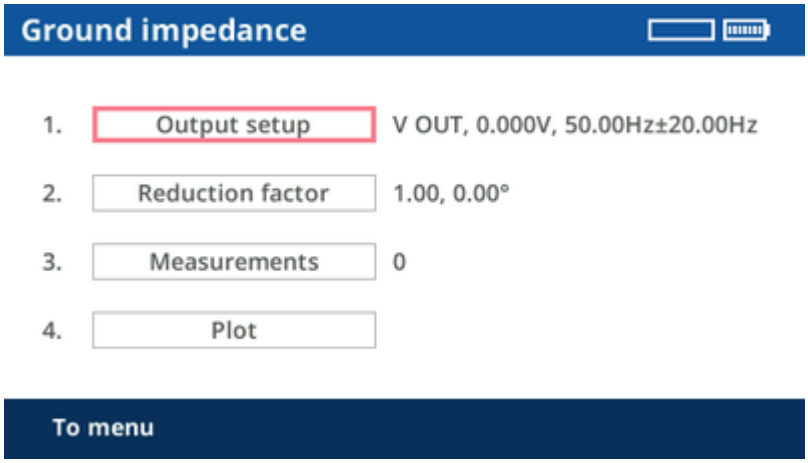
It is also possible to perform a test using the 62 % rule mentioned in IEEE Std 80-2013 and IEEE Std 81-2012. In this case, perform a single measurement at 62 % (for example, 62 m/200 ft) of the distance of the current probe (for example, 100 m/330 ft) with the current and the potential probe in the same direction.

The example below shows the plot of the resistance in different distances from the grounding grid under test. The ground impedance to distant earth will be about 280 mΩ. By choosing a 90 ° angle for the measurement, there is no risk to get into the influence zone of the auxiliary current probe (marked red below).



12.2.1 Guided workflow

The ground impedance test incorporates a guided workflow consisting of four steps that can be executed one after another.



It is always possible to return to the menu or to go back to a previous step. For example, it is possible to plot measurements, then go back to the menu and add additional measurements to the previous ones.

Some changes of the settings, such as the output setup, will invalidate results. In such a case, an explicit information dialog is shown.

12.2.2 Output setup

Use the **Output setup** feature to find the best output and setting for the measurement. Depending on the impedance of the auxiliary current probe, the best output can be either **V OUT** or **I OUT**. If the other output is expected to provide better results, advice is given during the output setup.

WARNING

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

Employ the proper test set.

► Never use *COMPANO 100* to directly inject currents into power cables or overhead lines. If this should become inevitable, use the CPC 100 test set together with *CP CU1* and *CP GB1*.

The auxiliary current probe can carry life-threatening voltages during the test. In case of an error, unexpected high voltages can occur at output **I OUT** or **V OUT** at any time. Also the step voltage around the auxiliary current probe can be quite high.

► Always press the emergency stop button before working with these connectors.

► Use the provided warning flag*) to mark the auxiliary current probe, or use grounding spikes with safety handle.

► Mark an area of 5 m/15 ft around the electrode as dangerous zone, and position a guard outside this area to keep people from entering the dangerous zone.

In case of a high-current ground fault within the substation or at the transmission tower during the test, high voltages may occur in any wire connected to the grounding grid or leading away from it.

► Do not touch the current probe, the potential probe or any wire without insulating gloves.

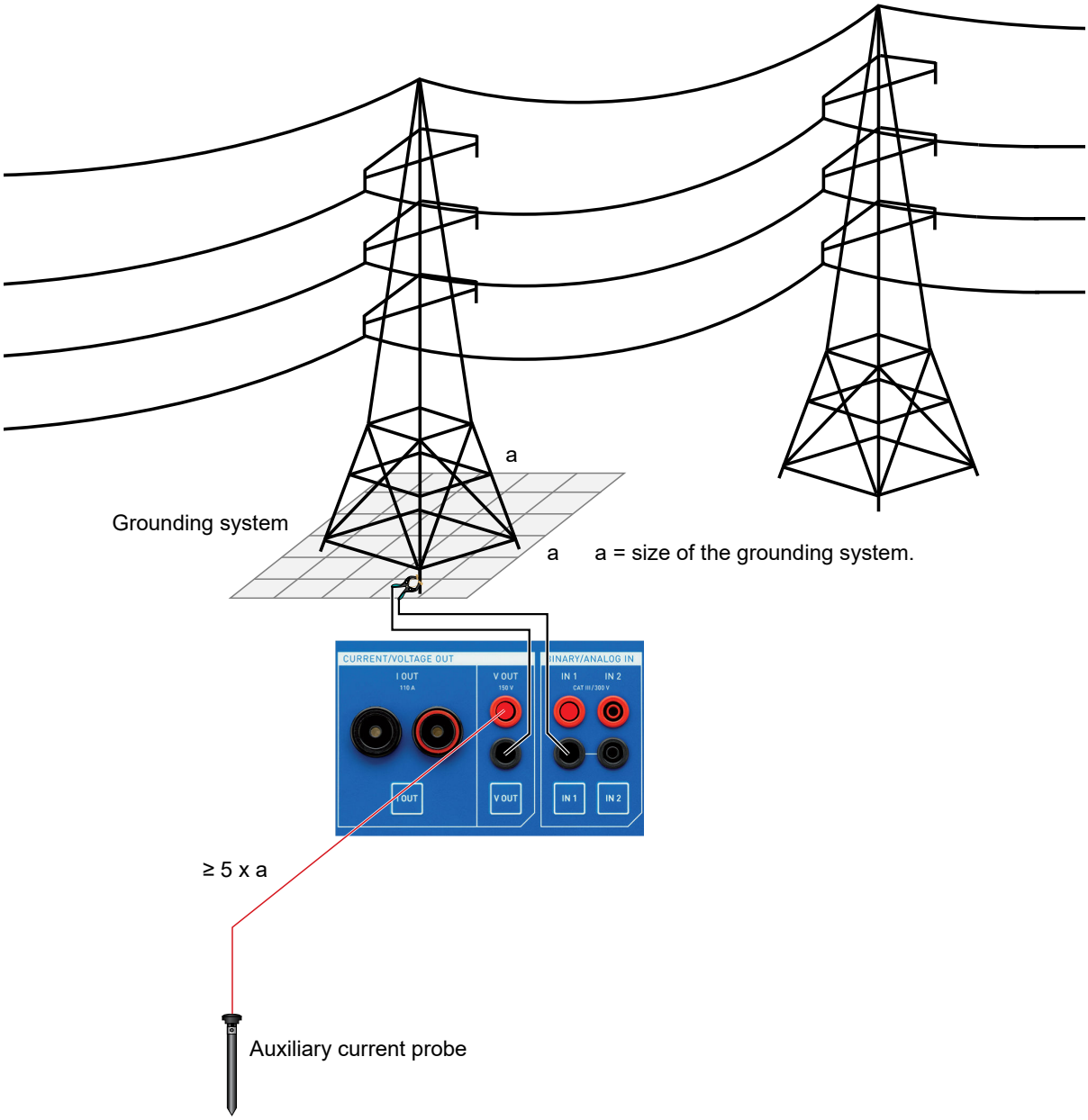
► First insert the current probe, then connect it to the provided crocodile clamp. Before removing the current probe, disconnect the crocodile clamp.

*) Warning flag for auxiliary current probes provided by OMICRON.

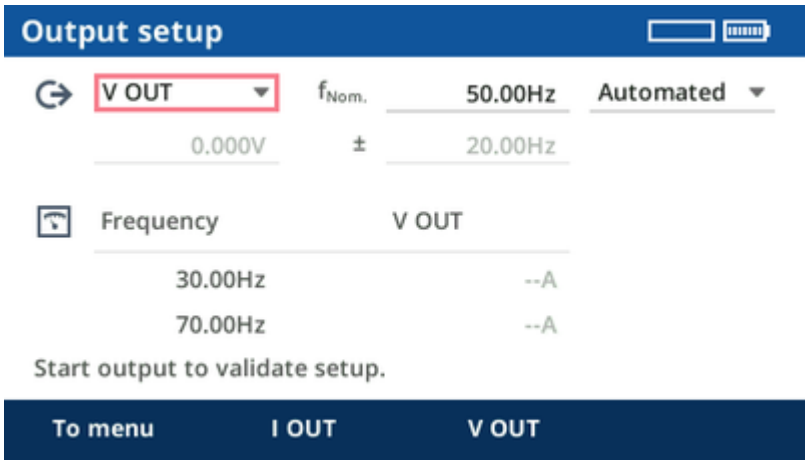
CAUTION

Minor or moderate injury caused by tripping over the measurement cable possible.

► If the measurement cable crosses obstacles such as roads or walkways, notify approaching persons about the cable to prevent accidents caused by tripping.


a
Grounding system
a
a = size of the grounding system.
CURRENT/VOLTAGE OUT
I OUT
110 A
V OUT
150 V
IN 1
IN 2
CAT III/300 V
I OUT
V OUT
IN 1
IN 2
≥ 5 x a
Auxiliary current probe

Turn the jog dial wheel until the focus is on **Output setup**. Then press the jog dial wheel once.



The *COMPANO 100* test set's **V OUT** is configured as output by default.

1. Connect the ground of the grounding system under test to the black socket of **V OUT** using a measurement cable. Depending of the grounding system, a Kelvin clamp, a Y clamp or Kelvin screws can be the preferred choice.
2. Depending on the used standard, position the auxiliary current probe at the required distance . If in doubt, choose a 150 m/450 ft distance for grounding systems up to a diameter of 30 m/100 ft.
3. Connect the auxiliary current probe to the red socket of **V OUT** using the cable drums and a crocodile clamp.

If at **Output setup** the power line frequency **fNom.** is set properly, the suggested frequencies should be 20 Hz above and 20 Hz below the power line frequency. The following steps of the guided workflow consist of two points per measurement with frequency-selective filtering to filter out disturbances of the power line frequency. The result is an interpolation of the two measurement points.

Automated output configuration

For most cases, it is sufficient to use the automated mode.

Press the **Start/Stop** button for *COMPANO 100* to search for the optimum output voltage for the current test setup.

In cases, however, where the ground injection point has a particularly low impedance, it could be that, after the automated setup, the lower part of the display suggests I OUT being the better choice for the output. In such a case, simply rewire from **V OUT** to **I OUT**, and repeat the automated setup.

Manual output configuration:

In certain cases, it makes sense to apply a manual output setup configuration. To do so, switch to **Manual** and set the individual parameters manually. The closer you set the **±** delta frequency value towards the nominal frequency **fNom.**, the steeper the used filters operate. Consequently, measurements very close to the nominal frequency have a better noise suppression, but they also need a bit longer. The default with ±20 Hz was primarily chosen for compatibility reasons with *CPC 100* and *HGT1* measurements.

Other frequency values can make sense when the system frequency differs from the power line frequency, for example, in 16.7 Hz or 25 Hz railway systems. In such cases, reducing the **±** delta frequency to a minimum value (> 0 Hz) proves advantageous. It is also possible to set the **±** delta frequency to 0 Hz in order to perform a measurement at a single frequency. This can be used if, for example, measurements at 128 Hz are required, which is a common measurement frequency for some grounding testers.

In general, we suggest to increase the magnitude as much as possible, whereat **V OUT** currents slightly above 200 mA are possible. When you are in manual mode, the lower part of the display shows hints helping you to find the best output configuration.

- In case the current you selected cannot be reached or an overload occurs, the contact resistance to the soil of the auxiliary current probe might be too high. To keep the resistance to the soil low, position several electrodes in a distance of a few meters from one another, and connect them all together. This also reduces the hazard of high voltages around the electrode.
- The point of current injection, which was defined and configured in this step, will not be altered in the subsequent chapters. It stays where it is throughout the whole procedure.

By pressing the **To menu** soft key you can return to the guided workflow overview. Nevertheless, the configured settings are remembered for the following steps.

12.2.3 Reduction factor

Turn the jog dial wheel until the focus is on **Reduction factor**. Then press the jog dial wheel once.

Reduction factors need to be considered on grounding systems if they are connected to other grounding systems, e.g. via overhead wires on transmission towers or via underground cables.

For typical examples of current reduction → Reduction factor on page 156.

The ratio (magnitude and phase angle) between effective local ground current and injected current is called current reduction factor r:

$$r = \frac{I_{local}}{I_{total}}$$

The term "current reduction factor" may be a bit misleading. Please note:

- a current reduction factor of 1 means there is **no** current reduction,
- a current reduction factor of 0 means there is **full** current reduction.

In *COMPANO 100*, the current reduction factor can be entered manually when it is known , or it can be measured.

Entering the current reduction factor manually:

When you know the current reduction factor, enter its magnitude and phase angle. A current reduction factor of 1 is common, for example, on a transmission tower with no ground wire or with an insulated one. For a current reduction factor of 1, generally 0 ° is set.

Measuring the current reduction factor:

Usually, the current reduction factor is unknown and needs to be measured.

You typically measure current reduction with a Rogowski coil. In many cases, like at a transmission tower, it is not possible to measure all currents in one step, so you have to carry out more than one measurements. These measurements can be performed one after another. *COMPANO 100* will then automatically calculate the resulting overall current reduction factor **r** based on magnitudes and phases of all measurements.

It is highly important to carry out the current reduction factor measurements very thoroughly. Each Rogowski coil has a small arrow imprinted on it. Make sure it points into the right direction. If one single measurement is accidentally done wrong, the result of the entire ground impedance measurement will be wrong.

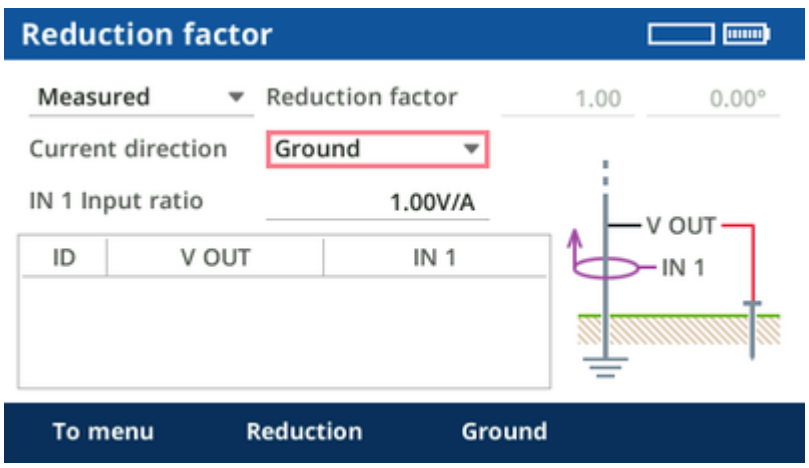
Some Rogowski coils have integrated power-off functions, which may switch off the measurement after a few minutes. The measurement result will be invalid in this case. Check the user documentation of your sensor on how this function works or how to disable it for the measurement. If in doubt, switch off the sensor and activate it again shortly before a measurement is performed.

It is possible to measure the current "above" or "below" the current injection point.

- **Measuring the current below the injection point:**

  Measure the current below the injection point when the current flow into soil is expected to be smaller than the current that flows upwards into the ground wire. The reason for this is that Rogowski coils have larger measurement errors than the integrated output current measurement of *COMPANO 100*. In general, it is therefore preferable to measure the smaller currents with the Rogowski coil to get a more accurate current reduction ratio.

  The current direction setting in that case is **Ground** because you measure the currents into ground.

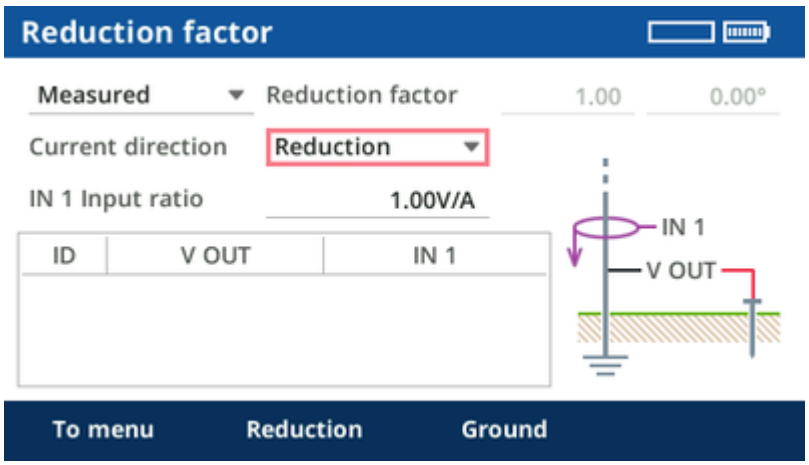


When the current measurement takes place below the source, the Rogowski coils on all legs of the transmission tower must point upwards. They must always point towards the source. It is important to measure on all points where current flows from the injection point to the local grounding system, for example on all legs of a transmission tower.

- **Measuring the current above the injection point:**

  Measure the current above the injection point when the current flow into the ground wire is expected to be smaller than the current that flows into the soil via the local grounding system.

  The current direction setting in that case is **Reduction** because you measure the currents that are reducing the effective ground current.



When the current measurement takes place above the source, the Rogowski coils on all legs of the transmission tower must point downwards. They must always point towards the source. It is important to measure on all points where current flows from the injection point to other grounding systems than the local one. For example, measure on ***all*** legs of a transmission tower, or on ***all*** underground cables that are connecting a distribution substation to other grounding systems.

As a rule of thumb: transmission towers with an earth wire on top usually have a current reduction ration of ⅓ (0.2 – 0.4). This means, most of the injected current will flow via the earth wire on top of the transmission tower to remote grounding systems, and only a smaller fraction will flow via the local grounding system.

Performing the measurement:

1. Configure the measurement range on the Rogowski coil. Use the smallest feasible range to increase measurement accuracy.
2. Set the **IN1** input ratio to the current measurement ratio of the Rogowski coil in the selected range, for example, 100.0 mV/A or 1.0 V/A.

   Tips:

   - If possible, put two or more turns of the Rogowski coil around the leg of the transmission tower. This will increase the measured current and reduce the measurement error. In this case, you will also have to adjust the **IN1** input ratio, for example, from 100.0 mV/A to 200.0 mV/A in case of two turns.

- Position the Rogowski coil symmetrically around the leg of the transmission tower or the connector of the underground cable.
- Do not place the latch of the Rogowski coil directly next to the conductor. The measurement error is higher next to the latch.
- You can use the included measurement cables to extend the connection to the Rogowski coil, for example, when measuring distant legs of the transmission tower. In this case, it is recommended to twist the measurement cables to reduce measurement errors caused by inductive coupling.

3. Install the Rogowski coil, for example, on a leg of the transmission tower or around a low voltage cable in a distribution substation, then connect it to the **IN1** input. Verify correct polarity.
4. Press the **Start/Stop** button of the *COMPANO 100* test set to output the test current and to carry out the measurement.

   The measurement will be performed with the configured frequencies, and interpolated to the specified nominal frequency. Additionally, the reduction factor value in the display will be updated.

   ► Check the current shown in the display. It should show approximately the same value as the current displayed during the output setup. If it is significantly lower, the cause may be a loose connection at the cables used for current injection.

   ► Check the voltage shown in the display. It should exceed 1 mV. If it is significantly lower, the cause may be a loose connection at the cables used to connect the potential probe.

5. Repeat steps 3 and 4, if needed (for example, on all four legs of a transmission tower or on all cable connections to other grounding systems).

All measurements have a unique ID number. If needed, individual measurements can be deleted. To do so, select the measurements using the jog dial wheel, press the wheel, select the measurement to delete, then press **Delete selected**.

We recommend to thoroughly document what ID is used for what current path. Add a photograph, if possible, showing the direction arrow of the Rogowski coil. For that reason, the IDs are not changed if a result is deleted later.

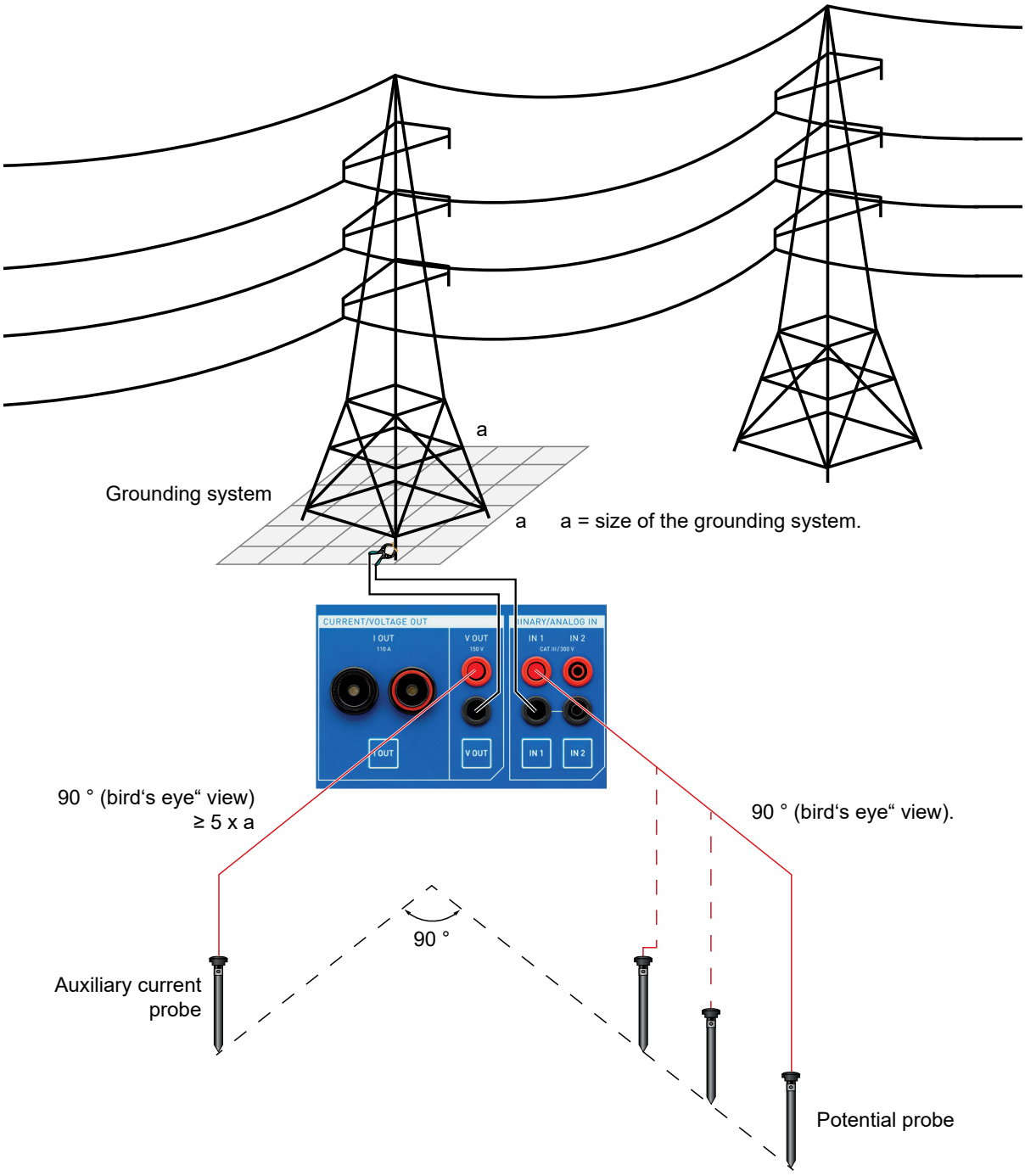
The current reduction factor is calculated from the measurements. If it goes beyond 1 or below 0, there is an error in the measurement setup.

Tip: If you doubt that your measurement is correct, you can carry it out with the other current direction, too. If there are major deviations, either an error occurred (for example, wrong direction of the arrow on the Rogowski coil, loose cable contact,...) or the injected current was too small for an accurate measurement result.

By pressing the **To menu** soft key you can return to the guided workflow overview. Nevertheless, the reduction factor (entered or measured) is remembered for the following steps.

12.2.4 Measurements

Measurement setup:



Note: The point of current injection, which was defined and configured in the step Output setup, will not be altered in this chapter. It stays where it is throughout the whole procedure.

WARNING

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

In case of a high-current ground fault within the substation or at the transmission tower during the test, high voltages may occur in any wire connected to the grounding grid or leading away from it.

- ► Do not touch the current probe, the potential probe or any wire without insulating gloves.
- ► First insert the current probe, then connect it to the provided crocodile clamp. Before removing the current probe, disconnect it.

1. Make sure that the auxiliary current probe connected to **V OUT** is positioned away from the *COMPANO 100* test set at least 5 × the diameter of the grounding system of the transmission tower (or the substation). For that purpose, OMICRON provides 150 m of cable.
2. Connect the black socket of the measurement input **IN 1** to the grounding grid under test, e.g. using the same Kelvin clamp, Y clamp or Kelvin screw as for the current injection (→ Output setup).
3. Position the potential probe into the soil at the required distance from the grounding system, and connect it with a crocodile clamp and the supplied cable drums to the red socket of the measurement input **IN 1**. If you apply the fall-of-potential method, we recommend an initial distance of 1 m/3 ft.
4. Turn the jog dial wheel until the focus is on **Measurements**. Then press the jog dial wheel once.
5. Enter the measured distance to the grounding system under test into the software, then press the **Start/Stop** key.

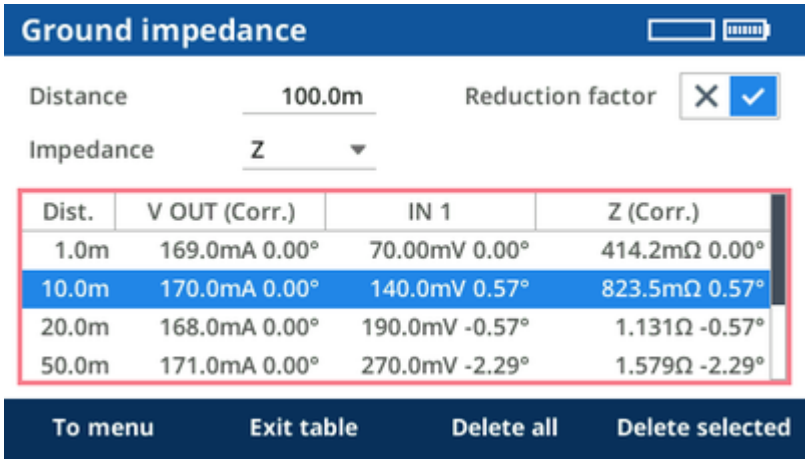
   Press the **Start/Stop** key

   After a short time, *COMPANO 100* will stop and show a first result.

   Check the current shown in the display. It should show approximately the same value as the current displayed during the output setup. If it is significantly smaller, the cause may be a loose connection at the cables used for current injection.

6. Now repeat that procedure by positioning the potential probe at several spots with "logarithmically" increasing distances, for example 2 m, 5 m, 10 m, 15 m, 20 m, 30 m, 40 m, 50 m, 70 m, 80 m, 100 m.

- We recommend injecting towards line, measuring in a 90 ° angle as shown in the figure above.
- If you use another measurement method, for example, the 62 % method mentioned in IEEE Std 80-2013 and IEEE Std 81-2012, refer to the according standard about the current injection and measurement directions.



The results can be displayed with or without the current **Reduction factor** taken into account.

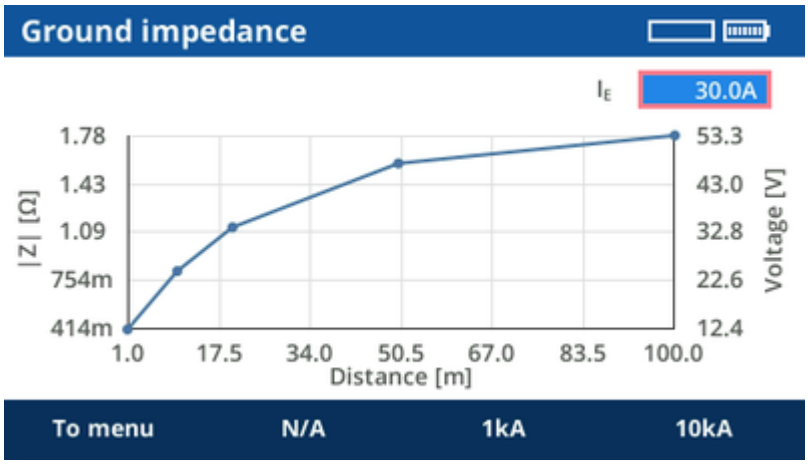
- Current reduction factor enabled ✓: the results represent the measurement results for the local grounding system.
- Current reduction factor disabled ×: the results represent the measurement results for the total grounding system (for example, including other connected transmission towers).

You can also switch between **Z/Phi** and **R/X** representation of the impedance values.

By pressing the **To menu** soft key you can return to the guided workflow overview. The results are kept.

12.2.5 Plot

The plot displays the measured impedances at the various distances and states whether a reduction factor applies.



You can enter an expected maximum current towards earth in case of a fault. The second axis of the graph displays the expected ground potential raise at the various distances.

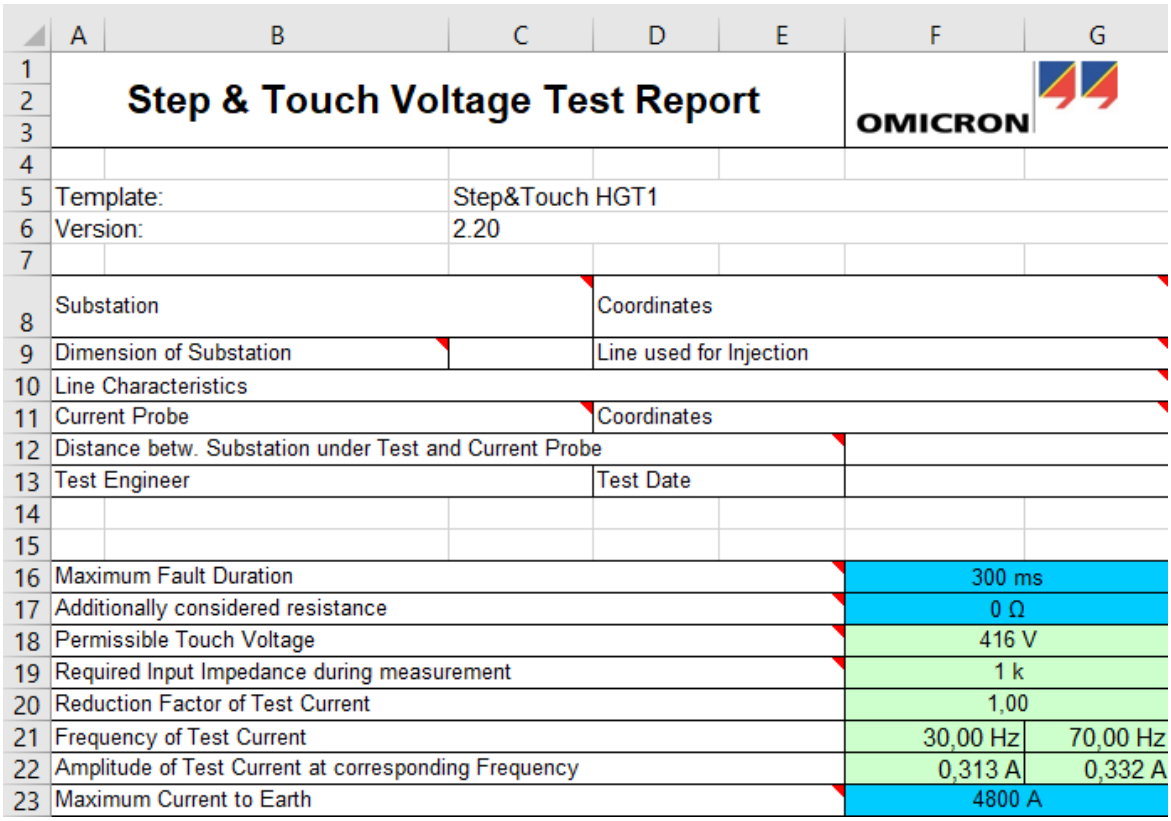
12.2.6 Results

The results can be stored on a USB stick.

Excel File Loader

The **Ground Impedance** EXCEL template, provided with the COMPANO *Excel File Loader*, can be used to load the measurement, and to generate a report.

► After the installation of the COMPANO *Excel File Loader* go to **OMICRON** > **COMPANO 100 Templates**. The default installation path is *C:\Program Files\OMICRON\COMPANO 100\Excel Reporting\Templates*.



	A	B	C	D	E	F	G
1							
2		**Step & Touch Voltage Test Report**				OMICRON	
3							
4							
5		Template:	Step&Touch HGT1				
6		Version:	2.20				
7							
8		Substation		Coordinates			
9		Dimension of Substation		Line used for Injection			
10		Line Characteristics					
11		Current Probe		Coordinates			
12		Distance betw. Substation under Test and Current Probe					
13		Test Engineer		Test Date			
14							
15							
16		Maximum Fault Duration				300 ms	
17		Additionally considered resistance				0 Ω	
18		Permissible Touch Voltage				416 V	
19		Required Input Impedance during measurement				1 k	
20		Reduction Factor of Test Current				1,00	
21		Frequency of Test Current				30,00 Hz	70,00 Hz
22		Amplitude of Test Current at corresponding Frequency				0,313 A	0,332 A
23		Maximum Current to Earth				4800 A	

► Refer to Excel File Loader on page 89 for more information.

12.3 Step and touch voltage

A step and touch voltage test is carried out to determine

- the worst-case touch voltage a person would face when touching a metallic object, for example a fence, in or around a substation in case of a ground fault (current flowing through the person's arm, body and legs towards earth)
- the worst-case step voltage a person would face in such a case when doing one step beyond the fence (current flowing into one leg, out the other).

The **Step and touch voltage** application module of *COMPANO 100* acts as a source for the *HGT1* accessory from OMICRON.

The *HGT1* is an FFT voltmeter, primarily designed for professional acoustical test applications. For step and touch voltage and ground impedance measurements, *HGT1* is delivered with an OMICRON software that allows measuring the frequency-selective voltage level by using a real-time Zoom FFT. *HGT1* works as an add-on device to *COMPANO 100*, *CPC 100* and *CP CU1*.

For more information about measuring with *HGT1* → Accessory HGT1 on page 118.

With *COMPANO 100*, it is possible to measure the step and touch voltages in smaller grounding systems with a diameter of up to 30 m/100 ft.

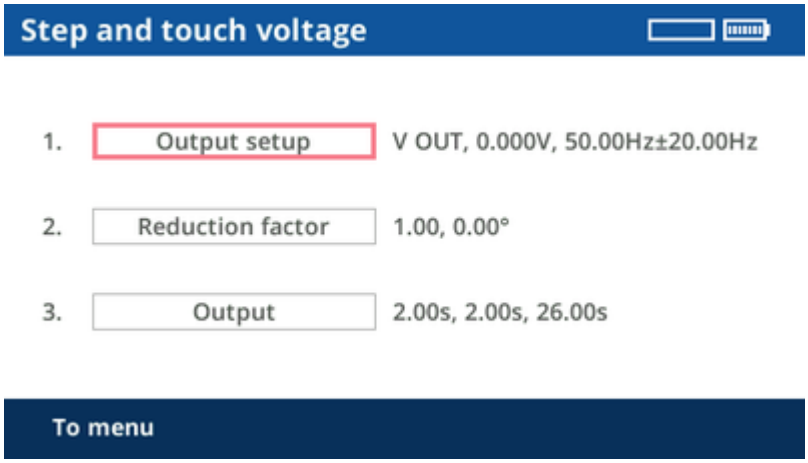
For grounding systems beyond 30 m/100 ft, which can be found on medium and large distribution substations or transmission substations, preferably use OMICRON's *CPC 100* and *CP CU1*. With these devices you can use out of service power lines for current injection.

During a step and touch voltage test, the current is fed into a remote ground via a long cable. This remote ground can be any ground from a simple grounding rod to another large grounding system. Usually a grounding rod, referred as auxiliary current probe, is used. The distance between this probe and the grounding system under test should be at least five times the diameter of the grounding system. A larger distance will provide more accurate results. In general, the setup must represent worst case conditions that may occur during a single-line fault. This must be clarified for each grounding system individually.

We recommend using an auxiliary current probe as remote ground in 150 m/450 ft distance for grounding systems up to a diameter of 30 m/100 ft.

12.3.1 Guided workflow

The step and touch setup incorporates a guided workflow that consists of three steps, which are executed one after another. The third step generates the desired output signal, only. Do the actual measurement with *HGT1*.



12.3.2 Output setup

Use the **Output setup** feature to find the best output and setting for the measurement. Depending on the impedance of the auxiliary current probe, the best output can be either **V OUT** or **I OUT**. If the other output is expected to provide better results, advice is given during the output setup.

WARNING

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

Employ the proper test set.

► Never use *COMPANO 100* to directly inject currents into power cables or overhead lines. If this should become inevitable, use the CPC 100 test set together with *CP CU1* and *CP GB1*.

The auxiliary current probe can carry life-threatening voltages during the test. In case of an error, unexpected high voltages can occur at output **I OUT** or **V OUT** at any time. Also the step voltage around the auxiliary current probe can be quite high.

► Always press the emergency stop button before working with these connectors.

► Use the provided warning flag*) to mark the auxiliary current probe, or use grounding spikes with safety handle.

► Mark an area of 5 m/15 ft around the electrode as dangerous zone, and position a guard outside this area to keep people from entering the dangerous zone.

In case of a high-current ground fault within the substation or at the transmission tower during the test, high voltages may occur in any wire connected to the grounding grid or leading away from it.

► Do not touch the current probe, the potential probe or any wire without insulating gloves.

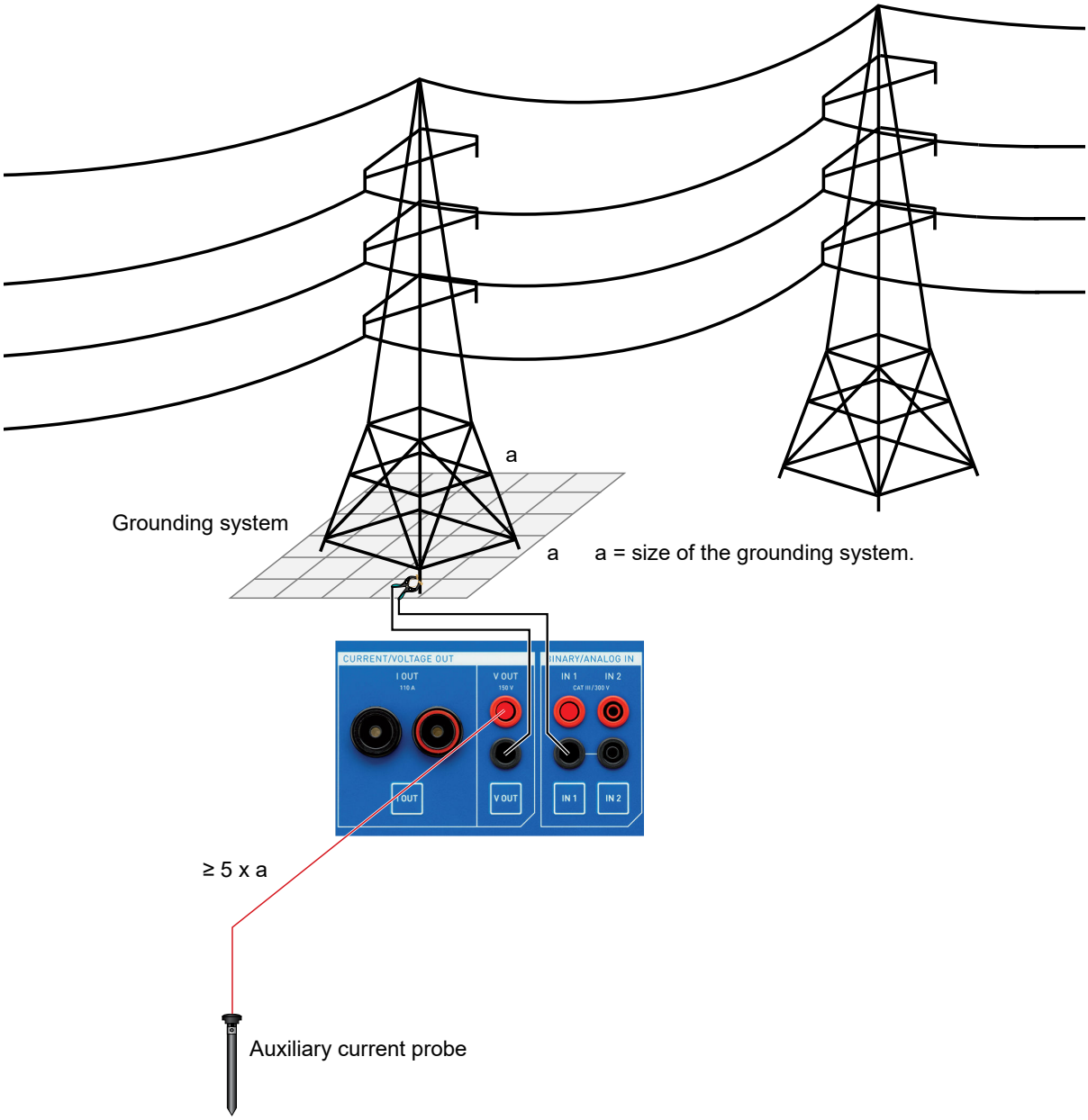
► First insert the current probe, then connect it to the provided crocodile clamp. Before removing the current probe, disconnect the crocodile clamp.

*) Warning flag for auxiliary current probes provided by OMICRON.

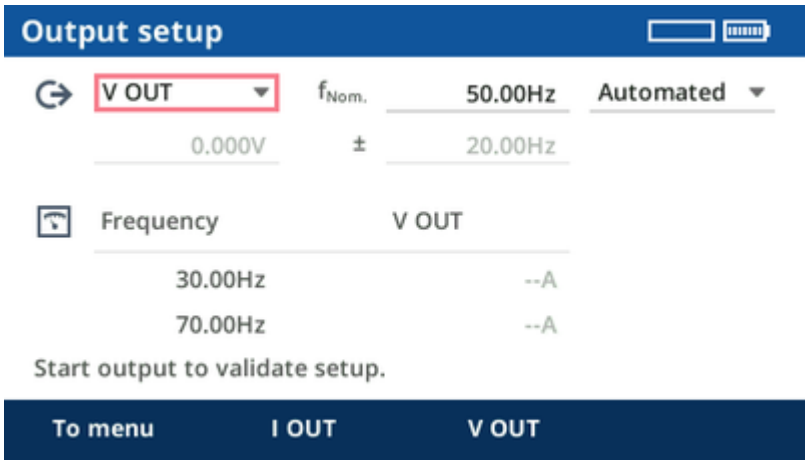
CAUTION

Minor or moderate injury caused by tripping over the measurement cable possible.

► If the measurement cable crosses obstacles such as roads or walkways, notify approaching persons about the cable to prevent accidents caused by tripping.


a
Grounding system
a
a = size of the grounding system.
CURRENT/VOLTAGE OUT
I OUT
110 A
V OUT
150 V
IN 1
IN 2
CAT III/300 V
I OUT
V OUT
IN 1
IN 2
≥ 5 x a
Auxiliary current probe

Turn the jog dial wheel until the focus is on **Output setup**. Then press the jog dial wheel once.



The *COMPANO 100* test set's **V OUT** is configured as output by default.

1. Connect the ground of the grounding system under test to the black socket of **V OUT** using a measurement cable. Depending of the grounding system, a Kelvin clamp, a Y clamp or Kelvin screws can be the preferred choice.
2. Depending on the used standard, position the auxiliary current probe at the required distance . If in doubt, choose a 150 m/450 ft distance for grounding systems up to a diameter of 30 m/100 ft.
3. Connect the auxiliary current probe to the red socket of **V OUT** using the cable drums and a crocodile clamp.

If at **Output setup** the power line frequency **fNom.** is set properly, the suggested frequencies should be 20 Hz above and 20 Hz below the power line frequency. The following steps of the guided workflow consist of two points per measurement with frequency-selective filtering to filter out disturbances of the power line frequency. The result is an interpolation of the two measurement points.

Automated output configuration

For most cases, it is sufficient to use the automated mode.

Press the **Start/Stop** button for *COMPANO 100* to search for the optimum output voltage for the current test setup.

In cases, however, where the ground injection point has a particularly low impedance, it could be that, after the automated setup, the lower part of the display suggests I OUT being the better choice for the output. In such a case, simply rewire from **V OUT** to **I OUT**, and repeat the automated setup.

Manual output configuration:

In certain cases, it makes sense to apply a manual output setup configuration. To do so, switch to **Manual** and set the individual parameters manually. The closer you set the **±** delta frequency value towards the nominal frequency **fNom.**, the steeper the used filters operate. Consequently, measurements very close to the nominal frequency have a better noise suppression, but they also need a bit longer. The default with ±20 Hz was primarily chosen for compatibility reasons with *CPC 100* and *HGT1* measurements.

Other frequency values can make sense when the system frequency differs from the power line frequency, for example, in 16.7 Hz or 25 Hz railway systems. In such cases, reducing the **±** delta frequency to a minimum value (> 0 Hz) proves advantageous. It is also possible to set the **±** delta frequency to 0 Hz in order to perform a measurement at a single frequency. This can be used if, for example, measurements at 128 Hz are required, which is a common measurement frequency for some grounding testers.

In general, we suggest to increase the magnitude as much as possible, whereat **V OUT** currents slightly above 200 mA are possible. When you are in manual mode, the lower part of the display shows hints helping you to find the best output configuration.

- In case the current you selected cannot be reached or an overload occurs, the contact resistance to the soil of the auxiliary current probe might be too high. To keep the resistance to the soil low, position several electrodes in a distance of a few meters from one another, and connect them all together. This also reduces the hazard of high voltages around the electrode.
- The point of current injection, which was defined and configured in this step, will not be altered in the subsequent chapters. It stays where it is throughout the whole procedure.

By pressing the **To menu** soft key you can return to the guided workflow overview. Nevertheless, the configured settings are remembered for the following steps.

12.3.3 Reduction factor

Turn the jog dial wheel until the focus is on **Reduction factor**. Then press the jog dial wheel once.

Reduction factors need to be considered on grounding systems if they are connected to other grounding systems, e.g. via overhead wires on transmission towers or via underground cables.

For typical examples of current reduction → Reduction factor on page 156.

The ratio (magnitude and phase angle) between effective local ground current and injected current is called current reduction factor r:

$$r = \frac{I_{local}}{I_{total}}$$

The term "current reduction factor" may be a bit misleading. Please note:

- a current reduction factor of 1 means there is **no** current reduction,
- a current reduction factor of 0 means there is **full** current reduction.

In *COMPANO 100*, the current reduction factor can be entered manually when it is known , or it can be measured.

Entering the current reduction factor manually:

When you know the current reduction factor, enter its magnitude and phase angle. A current reduction factor of 1 is common, for example, on a transmission tower with no ground wire or with an insulated one. For a current reduction factor of 1, generally 0 ° is set.

Measuring the current reduction factor:

Usually, the current reduction factor is unknown and needs to be measured.

You typically measure current reduction with a Rogowski coil. In many cases, like at a transmission tower, it is not possible to measure all currents in one step, so you have to carry out more than one measurements. These measurements can be performed one after another. *COMPANO 100* will then automatically calculate the resulting overall current reduction factor **r** based on magnitudes and phases of all measurements.

It is highly important to carry out the current reduction factor measurements very thoroughly. Each Rogowski coil has a small arrow imprinted on it. Make sure it points into the right direction. If one single measurement is accidentally done wrong, the result of the entire ground impedance measurement will be wrong.

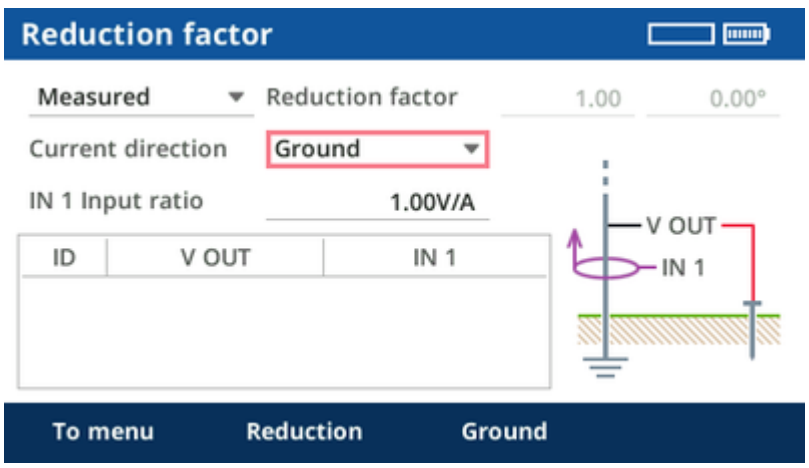
Some Rogowski coils have integrated power-off functions, which may switch off the measurement after a few minutes. The measurement result will be invalid in this case. Check the user documentation of your sensor on how this function works or how to disable it for the measurement. If in doubt, switch off the sensor and activate it again shortly before a measurement is performed.

It is possible to measure the current "above" or "below" the current injection point.

- **Measuring the current below the injection point:**

  Measure the current below the injection point when the current flow into soil is expected to be smaller than the current that flows upwards into the ground wire. The reason for this is that Rogowski coils have larger measurement errors than the integrated output current measurement of *COMPANO 100*. In general, it is therefore preferable to measure the smaller currents with the Rogowski coil to get a more accurate current reduction ratio.

  The current direction setting in that case is **Ground** because you measure the currents into ground.

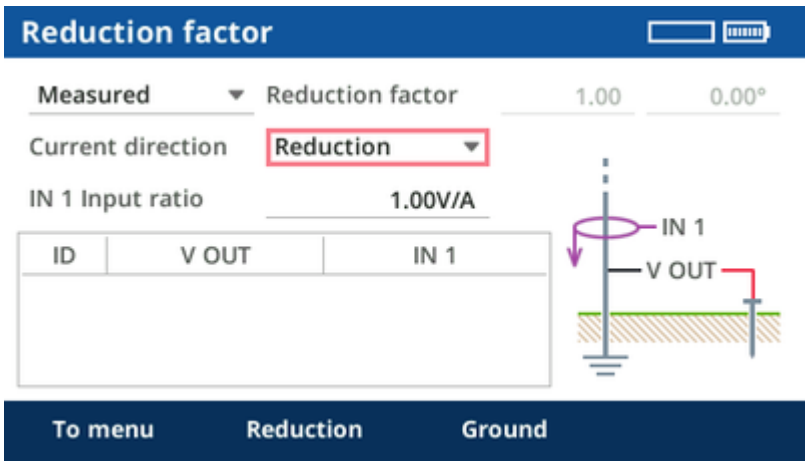


When the current measurement takes place below the source, the Rogowski coils on all legs of the transmission tower must point upwards. They must always point towards the source. It is important to measure on all points where current flows from the injection point to the local grounding system, for example on all legs of a transmission tower.

- **Measuring the current above the injection point:**

  Measure the current above the injection point when the current flow into the ground wire is expected to be smaller than the current that flows into the soil via the local grounding system.

  The current direction setting in that case is **Reduction** because you measure the currents that are reducing the effective ground current.



When the current measurement takes place above the source, the Rogowski coils on all legs of the transmission tower must point downwards. They must always point towards the source. It is important to measure on all points where current flows from the injection point to other grounding systems than the local one. For example, measure on ***all*** legs of a transmission tower, or on ***all*** underground cables that are connecting a distribution substation to other grounding systems.

As a rule of thumb: transmission towers with an earth wire on top usually have a current reduction ration of ⅓ (0.2 – 0.4). This means, most of the injected current will flow via the earth wire on top of the transmission tower to remote grounding systems, and only a smaller fraction will flow via the local grounding system.

Performing the measurement:

1. Configure the measurement range on the Rogowski coil. Use the smallest feasible range to increase measurement accuracy.
2. Set the **IN1** input ratio to the current measurement ratio of the Rogowski coil in the selected range, for example, 100.0 mV/A or 1.0 V/A.

   Tips:

   - If possible, put two or more turns of the Rogowski coil around the leg of the transmission tower. This will increase the measured current and reduce the measurement error. In this case, you will also have to adjust the **IN1** input ratio, for example, from 100.0 mV/A to 200.0 mV/A in case of two turns.

- Position the Rogowski coil symmetrically around the leg of the transmission tower or the connector of the underground cable.
- Do not place the latch of the Rogowski coil directly next to the conductor. The measurement error is higher next to the latch.
- You can use the included measurement cables to extend the connection to the Rogowski coil, for example, when measuring distant legs of the transmission tower. In this case, it is recommended to twist the measurement cables to reduce measurement errors caused by inductive coupling.

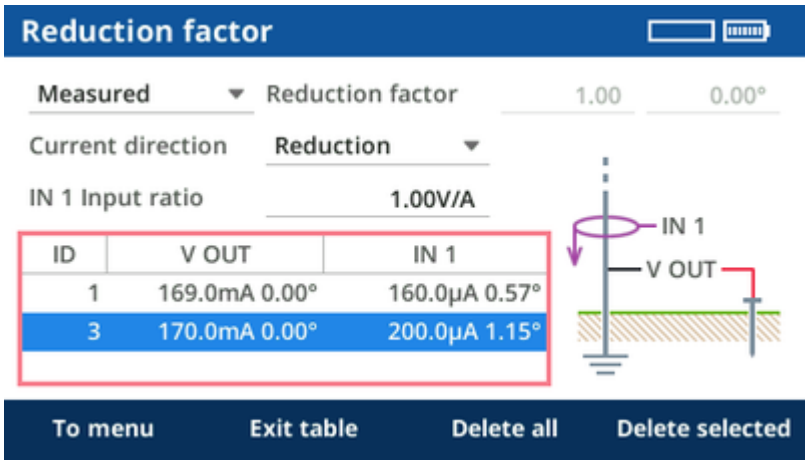
3. Install the Rogowski coil, for example, on a leg of the transmission tower or around a low voltage cable in a distribution substation, then connect it to the **IN1** input. Verify correct polarity.
4. Press the **Start/Stop** button of the *COMPANO 100* test set to output the test current and to carry out the measurement.

   The measurement will be performed with the configured frequencies, and interpolated to the specified nominal frequency. Additionally, the reduction factor value in the display will be updated.

   Check the current shown in the display. It should show approximately the same value as the current displayed during the output setup. If it is significantly smaller, the cause may be a loose connection at the cables used for current injection.

5. Repeat steps 3 and 4, if needed (for example, on all four legs of a transmission tower or on all cable connections to other grounding systems).

All measurements have a unique ID number. If needed, individual measurements can be deleted. To do so, select the measurements using the jog dial wheel, press the wheel, select the measurement to delete, then press **Delete selected**.



We recommend to thoroughly document what ID is used for what current path. Add a photograph, if possible, showing the direction arrow of the Rogowski coil. For that reason, the IDs are not changed if a result is deleted later.

The current reduction factor is calculated from the measurements. If it goes beyond 1 or below 0, there is an error in the measurement setup.

Tip: If you doubt that your measurement is correct, you can carry it out with the other current direction, too. If there are major deviations, either an error occurred (for example, wrong direction of the arrow on the Rogowski coil, loose cable contact,...) or the injected current was too small for an accurate measurement result.

By pressing the **To menu** soft key you can return to the guided workflow overview. Nevertheless, the reduction factor (entered or measured) is remembered for the following steps.

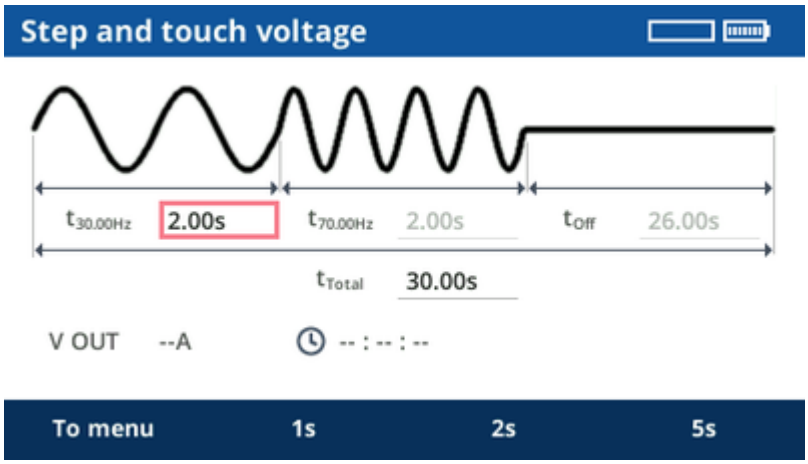
12.3.4 Output

Turn the jog dial wheel until the focus is on **Output**. Then press the jog dial wheel once.

You can vary the on, off and pause time to meet your needs. Press the **Start/Stop** key to start the output sequence. That sequence is repeated until manually stopped.

The pause time is meant to save battery power on long testing days.

We recommend synchronizing the start of the measurement with the beginning of a new minute. That way you can expect a new measurement of the *HGT1* at every full and half minute if, for example, a total time of 30 seconds is used. This is useful if measurement points are far away, and you are not sure whether or not you can still measure a signal.



For more information about measuring with *HGT1* → Accessory HGT1 on page 118.

12.3.5 Results

The results can be stored on a USB stick. They contain the used frequencies, the output current, and the reduction factor.

The **Step and Touch Voltage** EXCEL template, provided with the COMPANO *Excel File Loader*, can be used to load the data from both the *COMPANO 100* test set and the *HGT1*, and to generate a report.

For more information about the *Excel File Loader* → Excel File Loader on page 89.

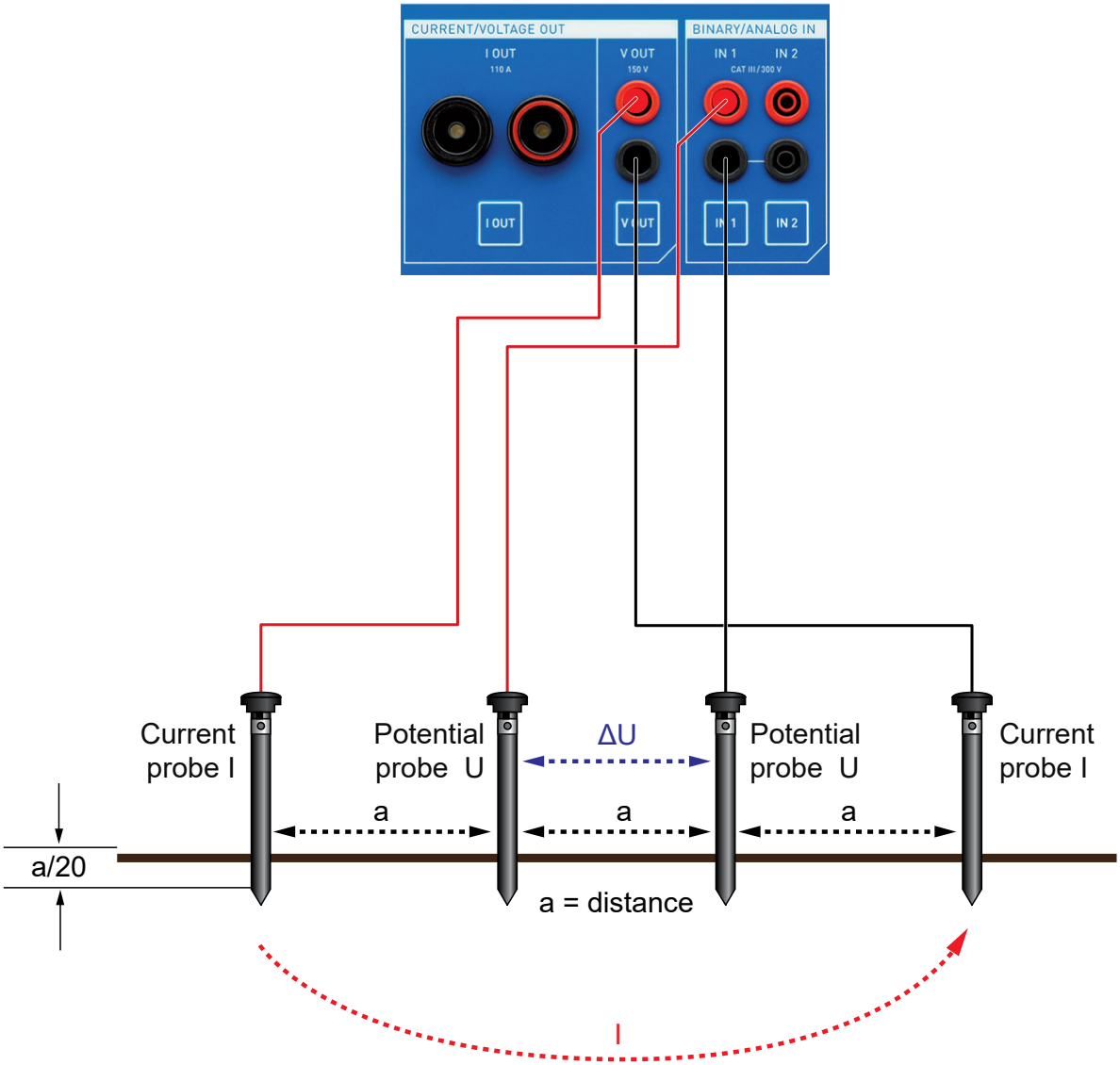
For more information about recording and saving step and touch voltage measurements with *HGT1*, please refer to the *HGT1* User Manual.

12.4 Soil resistivity

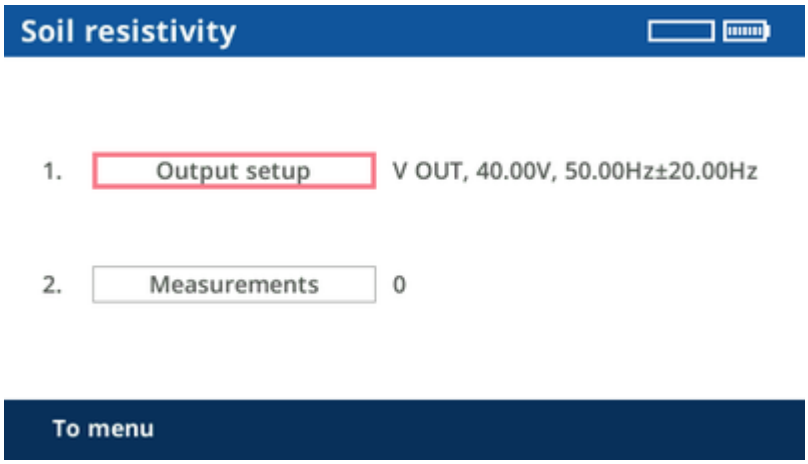
A soil resistivity test is performed prior to the construction of a grounding system in order to know about the resistivity of the soil in different layers. Its measurement results can be furthermore used in conjunction with grounding grid calculation and simulation software such as CDEGS.

The measurement delivers specific soil resistivity values for different distances between the used current and potential probes that allow drawing conclusions about the layers in the ground in larger depths.

The soil resistivity application module allows performing this test and directly evaluating the results using either the Wenner or Schlumberger method. For example, the Wenner method is shown below



The soil resistivity application module incorporates a guided workflow that consists of two steps, which can be executed one after another.



12.4.1 Output setup

WARNING

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

In the unlikely event of an internal error of the *COMPANO 100* test set, higher voltages than expected could occur at output **V OUT**.

- ► Always press the emergency stop button before working with these connectors.
- ► Mark an area of 5 m/15 ft around the electrode as dangerous zone, and position a guard outside this area to keep people from entering the dangerous zone.

The **Output setup** is configured to use **V OUT** with 40 V in the soil resistivity application module. Since for most cases, there is no need to change this configuration, you may skip this step and progress directly to the measurement step.

However, if there are exceptional circumstances, such as a very conductive soil, reduce the voltage as the resulting current might be too high for the voltage output. In such a case, the *COMPANO 100* test set would switch off with an error message. If this happens, reduce the voltage, and try again.

- Note that for safety reasons this application module is limited to an output voltage of 40 V.
- If there are animals close to the measurement location, for example, grazing cattle, it is advisable to reduce the voltage to approx. 10 V.

If the voltage needs to be adjusted, turn the jog dial wheel until the focus is on **Output setup**. Then press the jog dial wheel once.

A delta frequency value of ±20 Hz from the power line frequency is generally a good choice. If needed, the value can be changed, though. It is also possible to set it to 0 Hz in order to perform a measurement at a single frequency. This can be used, if you, for example, require measurements at 128 Hz, which is a common measurement frequency for some grounding testers.

You can test the output configuration by pressing the **Start/Stop** key.

- To get the worst-case value, we recommend starting with the smallest required distance.
- During each measurement, the output current is measured. Therefore, there is no need to repeat the output setup, even when replacing the probes.

By pressing the **To menu** soft key you can return to the guided workflow overview. Nevertheless, the configured settings are remembered for the following step.

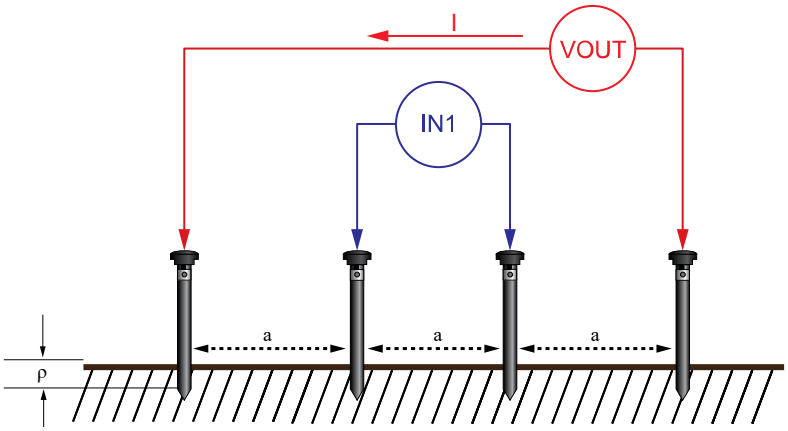
12.4.2 Measurements

The soil resistivity measurement screen displays the wiring setup.

COMPANO 100 supports three different methods for soil resistivity measurements.

- **Wenner simplified**
  The **Wenner simplified** method uses four probes. The two inner probes are potential probes, the two outer probes are current probes. All grounding probes are positioned with identical distance (a) from one another. They are driven into the ground to a depth not more than 1/20th of the distance between the individual grounding probes:
  $b = \leq \frac{a}{20}$.

  For very small distances (a), for example, ≤ 4 m/12 ft, use the Wenner method and a greater depth (b) rather than the Wenner simplifier method. In general, this will provide more accurate results.



  The following equation will be used by the device to calculate the soil resistivity ρ: ρ = 2πa|Z|.

- **Wenner**
  The **Wenner** method also uses four probes that are positioned with identical distance (a) from one another. The depth, however, that they are driven into the ground (b), can be specified. The Wenner method is also referred to as **equally-spaced agreement**.

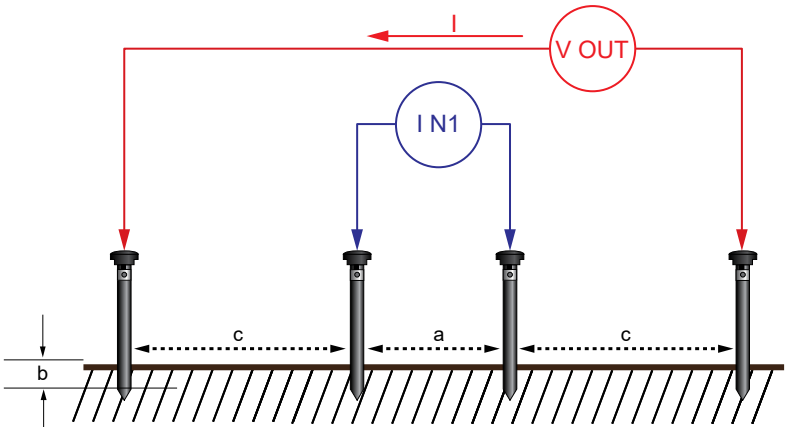
  The following equation will be used by the device to calculate the soil resistivity ρ:

$$\rho = \frac{4\ \pi\ a\ |Z|}{1 + \frac{2a}{\sqrt{a^2 + 4b^2}} - \frac{2a}{\sqrt{a^2 + b^2}}}$$

- **Schlumberger**

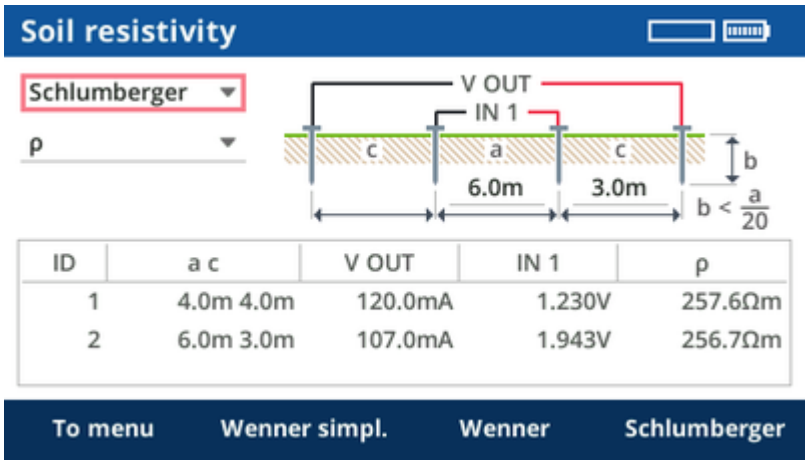
  The **Schlumberger** method allows two different distances between the grounding probes as shown in the image below (a & c). Therefore, since two grounding probes can be kept where they are, this method requires less rewiring efforts when you do several measurements at different distances.

  The Schlumberger method is also referred to as **Schlumberger-Palmer agreement** or **unequally spaced agreement**.



The following equation will be used by the device to calculate the soil resistivity ρ:

$$\rho = \pi \frac{c\,(c+a)}{a} |Z|$$



WARNING

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

In the unlikely event of an internal error of the *COMPANO 100* test set, higher voltages than expected could occur at output **V OUT**.

- ► Always press the emergency stop button before working with these connectors.
- ► Mark an area of 5 m/15 ft around the electrode as dangerous zone, and position a guard outside this area to keep people from entering the dangerous zone.

Performing the measurement:

1. Select the measurement method of your choice.

   The different methods (Wenner/Schlumberger) cannot be mixed.

2. Place the grounding probes as shown on the display.
3. Connect the probes to the **V OUT** output and the **IN 1** input of the *COMPANO 100* test set. To do so, use the provided measurement cables and crocodile clamps.
4. Enter the distances to the table of the **Soil resistivity** screen.
5. Press the **Start/Stop** key on the *COMPANO 100* test set to output the test current and to carry out the measurement. The measurement will be performed with the configured frequencies, and interpolated to the specified nominal frequency.
6. Repeat steps 3 to 5 for all measurement distances.

After the measurement, the result will be shown with a unique ID in the results list. To delete individual or all results, select the list with the jog dial wheel.

The result is shown as specific soil resistivity ρ in Ωm. Alternatively, you can also display them as raw impedance value |Z| in Ω. The raw values |Z| can be used to calculate the soil resistivity manually. This is useful if other methods are used, such as the **Pole-Dipole** or the **Dipole-Dipole** method.

Typical resistivity of 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
Stony, grassy soil	100 ... 300 Ωm
Glass sand	200 ... 3000 Ωm
Rock	300 ... 5000 Ωm
Granite, freestone	1500 ... 10000 Ωm

Soil resistivity is a major factor for the corrosiveness of soil:

Corrosiveness of soil	Soil resistivity
Severe	< 10 Ωm
Corrosive	10 ... 50 Ωm
Moderately corrosive	50 ... 100 Ωm
Slightly corrosive	100 ... 500 Ωm

12.4.3 Results

The results can be stored on a USB stick.

The COMPANO *Excel File Loader* can be used to load the data from the *COMPANO 100* test set. Afterwards, the data can be copied, for example, into a grounding system calculation software.

For more information about the *Excel File Loader* → Excel File Loader on page 89.

13 Home

The *COMPANO 100* software is organized in individual screens of a tree-like structure. **Home** represents the highest hierarchical level of the navigation. It provides access to all test and measurement modes, and to the most important functions.

Home may be a good starting point for navigating through the *COMPANO 100* software. However, you may find it more convenient to just press the according key next to the input/output, the test and measurement modes such as QUICK, FLEX or Polarity, or the keys for the specific hardware configurations for **Timer** or **calculated measurements**.

Turn the jog dial wheel to move the focus to the control element of your choice. Press the wheel to enter the selected screen.

You can get back to **Home** any time by pressing the **Home** key at the front panel.

14 Save

Use the **Save** feature to save test reports to a USB stick[1)], and configuration profiles to the test set's internal memory.

Reporting

When saving a test report, you do not need to assign a name to the file; it is assigned automatically based on date and time as defined in the test set (see Setup ► Date, Time on page 90). Test report files are saved in XML format, which can be read by MS Excel by means of the *COMPANO Excel File Loader* on page 89 (provided by OMICRON together with the *COMPANO 100* test set).

Reporting provides you with the means to customize a test report file to a certain extent:

- You can add a file name's prefix of your choice of up to 8 characters.
- You can add up tp two custom texts of up to 8 characters each, which are then written into the saved file. Such a text could be the serial number of the test object, the testers name, etc.

Make sure you have a USB stick plugged in to the test set's USB socket.

Note that *COMPANO 100* only ***saves*** files to a USB stick; it does not ***load*** files from the stick.

We recommend you use the **Eject device** feature before you remove the USB stick from the test set.

Copy autosave to USB:

The COMPANO software generates an autosave report every time the test set powers down, that is:

- *COMPANO 100* works in battery-powered mode, and you press the **Off** key,
- *COMPANO 100* works in battery-powered mode, and powers down automatically due to a timeout (see **Setup ► General ► Automatic shutdown timeout** on page 90),
- *COMPANO 100* is connected to the battery charger, and you press the **Off** key (the test set is then in charging mode).

COMPANO 100 then powers down and saves all result data to its internal memory. Next time you power up *COMPANO 100*, you can copy the auto-saved results to a USB stick.

Note that the autosave report only contains data in the above mentioned cases. Else it remains empty.

[1)] The internal *COMPANO 100* software supports FAT32-formatted USB devices, only (see Communication Ports on page 102).

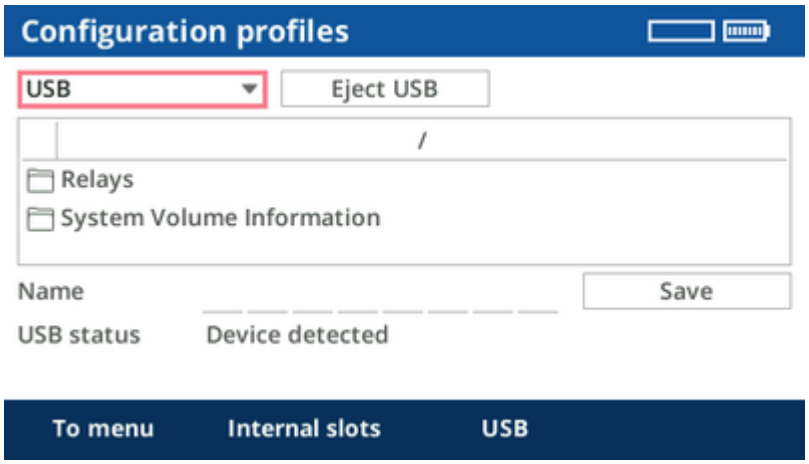
Config. profiles

In the **Configuration profiles** view, you save the configurations you have made for later reuse.

Note: You always save ***all*** settings, that is, all settings of **QUICK**, **FLEX**, the **IN 1** and **IN 2** configurations (binary/potential-free or wet, or analog voltage or current), the **Timer** settings, and so on. You do not save the test results.

You can save settings to the test set's internal memory or to a USB stick.

► Select the save location from the drop-down list:



► Select a slot or folder

► Enter a file name and press **Overwrite** or **Save**.

When you work on *COMPANO 100*, file names are kept short for better usability. On the computer, you can then create new directories, and rename and sort the files previously saved to the USB stick. When you load profiles from the USB stick to *COMPANO 100*, the folder hierarchy and full file names edited on the computer are displayed.

Options for working with a USB stick:

COMPANO 100	Computer
Short file names (when saving to the device memory)	Any supported file name and special characters
Save and load files	Delete, rename and sort files Create new directories

Once you have saved a file, the *COMPANO 100* software returns to the screen where you initially pressed the **Save** soft key.

14.1 Excel File Loader

The *COMPANO 100* **Excel File Loader** allows loading XML files created by *COMPANO 100* into Microsoft Excel for post-processing.

System requirements

Operating system:

- Windows 10 64 bit (recommended)
- Windows 8.1 64 bit
- Windows 8 64 bit
- Windows 7 SP1 64 bit and 32 bit

System:

- CPU Multicore system with 2 GHz or faster (recommended);
  CPU single-core system with 2 GHz or faster
- RAM 4 GB (recommended);
  RAM minimum 2 GB
- Hard disk with a minimum of 4 GB of available space
- DVD drive

MS Office:

- Microsoft Office 2013, Office 2010, Office 2007

Installing the COMPANO 100 Excel File Loader

Install the *COMPANO 100* **Excel File Loader** from the provided DVD, or download it from the **Software** section of the OMICRON Customer Portal (see Software update on page 92 to learn how to do that).

1. Close all other major applications running on your computer.
2. Insert the *COMPANO 100* **Excel File Loader** DVD into your computer's DVD drive.
3. If the Windows Autostart feature is enabled on your computer, the Setup Wizard starts automatically displaying the installation start screen.
   If the Setup Wizard does not start automatically, launch Windows Explorer, navigate to the root folder of your DVD, and double-click **Setup.exe**.
4. In the Setup Wizard, select the language of your choice, and follow the on-screen instructions.

Working with the COMPANO 100 Excel File Loader

There are several tabs in the Excel workbook. Click the **Load XML-File** button to start the import.

There is an **Overview** worksheet that summarizes the input. Furthermore, there is one worksheet per *COMPANO 100* application module containing data: one for all QUICK results, one for all FLEX results, and so on.

Note that there are some hidden columns, too. These column are of secondary importance, and may not be needed by all users.

15 Setup

Access the test set setup by pressing the **Setup** key at the front panel.

Use the jog dial wheel to navigate to a menu item of a choice, then press the wheel (or alternatively the **Enter** soft key) to enter the menu. Press the **Menu up** (or in some cases **To menu**) soft key to return to the next higher hierarchical level in the menu tree structure.

Default

At **Default**, you can reset the *COMPANO 100* configuration to **factory settings**, if needed. This includes the settings made at **General** and **Regional**. It excludes the **Date, Time** settings you have made; they are retained.

General

At **General**, you find the **Automatic shutdown timeout**. This is a time span you can set for the *COMPANO 100* test set to automatically power down if you let the test set idle for that time. The underlying idea is to go easy on the battery.

Note that in case *COMPANO 100* powers down automatically, it saves all result data to its internal memory. Next time you power up *COMPANO 100*, you can copy the auto-saved results to a USB stick. To do so, go to **Save ► Reporting**, then click **Copy autosave to USB** (see **Save ► Reporting** on page 87).

Date, Time

At **Date & Time**, set the test set's internal date and time.

If you make changes here, use the jog dial wheel to put the focus on **Apply**, then press the wheel.

Regional

At **Regional**, specify system settings such as software user interface language, nominal frequency (default 50 Hz), the date and clock format, the temperature unit (°C or °F), and the way you would like to have time intervals <1 min displayed (either in seconds, or as a multiplier of cycles, whereat 1 cycle = $1/f_{nom}$).

Any change you do at **Regional** requires the *COMPANO 100* software to reboot. Note that in case of a reboot, all data (for example, test results) are lost.

Battery info

- "Charge level (SOC)": SOC = state of charge. Displays the present charge level of the battery.
- "Health (SOH)": SOH = state of health. **Note:** if the battery's state of health shows a value below 75, the battery is likely to be exchanged with the next scheduled calibration at OMICRON. In general, after a test set's calibration, OMICRON carries out an entire discharge/charge cycle. If after that cycle the battery's state of health still shows a value below 75, the battery is exchanged.

Device Info

Voltage output capability:

- "No": the test set is not prepared for the activation of **V OUT**. To have the voltage output **V OUT** enabled, send *COMPANO 100* to your nearest OMICRON Service Center (→ Support on page 175).
- "Yes": the test set is prepared for the activation of **V OUT**. It only requires a software update to enable the voltage output **V OUT**. Contact your nearest OMICRON Service Center (→ Support on page 175).

Service

The **Service** menu comprises the following sub menus:

Licensing

The license for working with *COMPANO 100* is already integrated into your test set. You do not need an additional activation key to use *COMPANO 100*. At **Licensing** you can view your available licenses and, if applicable, change between multiple licenses in case you have purchased another one.

Legal notes

Parts of the embedded *COMPANO* software are under OMICRON license, other parts are under open source software licenses. Here, you can find all required software license information and notifications.

Diagnostics

You will actually need **Diagnostics** only, if OMICRON's Technical Support asks you to do so. At **Diagnostics** you can view detailed log files in order to investigate malfunctions of the test set. When needed, OMICRON's Technical Support will direct you what to do.

Diag. settings

At **Diag. settings**, various log levels are defined. Here the same applies as for **Diagnostics**: you will actually need to change these settings only, if OMICRON's Technical Support asks you to do so.

In case you experience an unusual behavior of the *COMPANO 100*, say the test set powered down unexpectedly, you can use the **Save dump** feature to store a log file to a USB stick. This log file is essential for the OMICRON Technical Support for investigating the cause of the behavior. In cases where **Save dump** should for any reasons not be possible after such an unusual behavior, these logged data will still be available after a software reboot. So, reboot and ***immediately*** perform a **Save dump**. Do not carry out any other actions between the reboot and that saving.

Software update

To update the *COMPANO 100* embedded software, download the corresponding image file (*.img) from the OMICRON Customer Portal:

1. Log in to the OMICRON Customer Portal (→ Support on page 175).
2. Click the menu icon on the top right and go to **Software**:

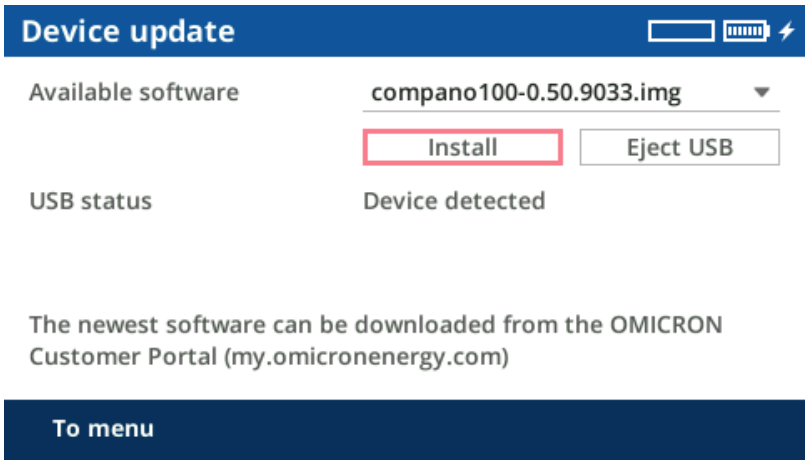
3. Click the **COMPANO 100** image:

COMPANO 100

4. Go to **Firmware**. Click the link to download the image file to your computer.
5. Copy the firmware file to the root of a USB stick (not into a sub-folder), and proceed as described below.

Software update via menu (software version 2.40 and above):

1. Connect the battery charger to *COMPANO 100*.
2. Select **Setup ► Device update**.
3. Insert the USB stick with the image file (→ Software update on page 92) into the USB and Ethernet compartment on the *COMPANO 100* front panel.
4. After the USB stick is detected, select the software version you would like to install from **Available software**.
5. Select **Install**.



6. The update will take about 10 minutes. There is no need for interaction from your side, this process runs automatically.

Manual software update (for software versions below 2.40):

1. Make sure that *COMPANO 100* is charged to at least 70 %.
2. Disconnect the charger.
3. Make sure that *COMPANO 100* is powered down.
4. Insert the USB stick with the image file (→ Software update on page 92) into the USB and Ethernet compartment on the *COMPANO 100* front panel.
5. Press and hold the **Setup** key. Press the **On/Off** key to power up the *COMPANO 100* test set.
6. Release the **Setup** key after about 5 seconds.
7. Upon request, press the **Save** key (now solid green) to start the update.
8. The update will take about 10 minutes. There is no need for interaction from your side, this process runs automatically.

In case of problems, contact OMICRON Support.

Note that downgrading to a lower software version number may delete configuration settings, such as stored profiles, or reset the regional settings to their default values.

16 Technical data

16.1 Battery

Type	Rechargeable lithium-ion battery.
Net weight	2.2 kg (4 lb).
Nominal voltage	50.4 V
Nominal capacity	3 Ah
Nominal energy	152 Wh
Charging	• Use the OMICRON-supplied charger, only. See Battery Charger below. • Charge in a battery temperature range of 5 °C ... 45 °C (41 °F ... 113 °F), only. • If you do not use the *COMPANO 100* test set for a longer period of time, recharge the battery once every 6 months.

The test set's battery is specified as **Dangerous Goods Class 9** (*Miscellaneous Dangerous Goods*):

- Battery stand-alone: **UN 3480** (lithium-ion battery).
- *COMPANO 100* with built-in battery: **UN 3481** (lithium-ion battery contained in equipment or packed with equipment).

For more details see chapter Battery on page 19.

16.2 Battery Charger

Connection	C14 connector according to IEC 60320-1.
Nominal voltage	115 V AC/230 V AC.
Permissible voltage range	95 V AC ... 132 V AC/198 V AC ... 264 V AC.
Nominal frequency	50/60 Hz
Maximum input current	2.1 A
Maximum output power	100 W
Overvoltage category	II

16.3 Outputs

16.3.1 AC/DC current output I OUT

The outputs are overload and short-circuit proof, and protected against over-temperature.

Output current	Current	t_{max} [1]	V_{max}	$Power_{max}$
110 A AC (15 ... 500 Hz)	80 ... 110 A	2.2 s	9.0 V	600 W[2]
	40 ... 80 A	4.2 s	12.5 V	
	0 ... 40 A	20 s	15.0 V	
20 A AC (15 ... 500 Hz)	15 ... 20 A	10 min	20.0 V	400 W
	0 ... 15 A	20 min	20.0 V	300 W
		>2 hrs	4.0 V	50 W[3]
100 A DC	80 ... 100 A	2.2 s	9.0 V	600 W[2]
	40 ... 80 A	4.2 s	12.5 V	
	0 ... 40 A	20 s	15.0 V	
20 A DC	15 ... 20 A	10 min	20.0 V	400 W
	0 ... 15 A	20 min	20.0 V	300 W
		>2 hrs	4.0 V	50 W[3]

1) Applies when using a 2 × 3 m (2 × 10 feet) high-current cable at an ambient temperature of 23 °C ± 5 °C (73 °F ± 9 °F).

2) Up to 1000 W with, for example, 50 A at 400 mΩ.

3) Limited by battery capacitance and charger.

16.3.2 AC/DC voltage output V OUT (optional)

Output range	Voltage	t_{max}	I_{max}	$Power_{max}$
150 V AC (15 ... 500 Hz)	75 ... 150 V	1 min	200 mA	30 W
	0 ... 75 V	1 min	200 mA	15 W
220 V DC	110 ... 220 V	1 min	200 mA	30 W
	0 ... 110 V	1 min	200 mA	22 W
AUX V DC	48 ... 220 V	1 s	900 mA	60 W
		> 2 h	500 mA	45 W

All values are guaranteed for one year under the following conditions:

- when *COMPANO 100* is operated at an ambient temperature of 23 °C ± 5 °C (73 °F ± 9 °F),
- within a frequency range of 45 ... 60 Hz, or at DC.

16.3.3 Accuracy of outputs

AC Range	Error guaranteed	Error typical[1)]
110 A	< 1.00 % of rd.[2)]	< 0.50 % of rd.
	+ 0.40 % of rg.[2)]	+ 0.20 % of rg.
20 A	< 1.60 % of rd.	< 0.80 % of rd.
	+ 0.40 % of rg.	+ 0.20 % of rg.
150 V	< 0.30 % of rd.	< 0.15 % of rd.
	+ 0.30 % of rg.	+ 0.15 % of rg.

AC Range	Phase error guaranteed[3)]	Phase error typical
110 A	0.3 °	0.1 °
20 A	0.3 °	0.1 °
150 V	0.3 °	0.1 °

DC Range	Error guaranteed	Error typical
100 A	< 1.20 % of rd.	< 0.60 % of rd.
	+ 0.80 % of rg.	+ 0.40 % of rg.
20 A	< 1.20 % of rd.	< 0.60 % of rd.
	+ 0.80 % of rg.	+ 0.40 % of rg.
220 V[4)]	< 0.30 % of rd.	< 0.15 % of rd.
	+ 0.30 % of rg.	+ 0.15 % of rg.

1) 98 % of all units possess an accuracy better than specified as *typical.*

2) rd = reading, rg = range. Accuracy values indicate that the error is smaller than ± ((*read value x reading error) + (full scale of the range x full scale error*)).

3) At full range magnitude.

4) Accuracy specifications only apply to currents of up to 200 mA.

All values are guaranteed for one year under the following conditions:

- when *COMPANO 100* is operated at an ambient temperature of 23 °C ± 5 ° (73 °F ± 9 °F),
- after a warm-up time of >10 minutes,
- within a frequency range of 45 ... 60 Hz, or at DC.

16.4 Measurement inputs IN 1 and IN 2

AC voltage range[1)]	Error guaranteed	Error typical[2)]
300 V	< 0.30 % of rd.[3)]	< 0.15 % of rd.
	+ 0.10 % of rg.[3)]	+ 0.05 % of rg.
30 V	< 0.30 % of rd.	< 0.15 % of rd.
	+ 0.10 % of rg.	+ 0.05 % of rg.
1 V	< 0.40 % of rd.	< 0.20 % of rd.
	+ 0.20 % of rg.	+ 0.10 % of rg.
100 mV	< 0.40 % of rd.	< 0.20 % of rd.
	+ 0.20 % of rg.	+ 0.10 % of rg.

AC Range	Phase error guaranteed	Phase error typical
300 V	0.3 °	0.1 °
30 V	0.3 °	0.1 °
1 V	0.3 °	0.1 °
100 mV	0.3 °	0.1 °

DC voltage range	Error guaranteed	Error typical
300 V	< 0.20 % of rd.	< 0.10 % of rd.
	+ 0.10 % of rg.	+ 0.05 % of rg.
30 V	< 0.30 % of rd.	< 0.15 % of rd.
	+ 0.10 % of rg.	+ 0.05 % of rg.
1 V	< 0.40 % of rd.	< 0.20 % of rd.
	+ 0.20 % of rg.	+ 0.10 % of rg.
100 mV	< 0.40 % of rd.	< 0.20 % of rd.
	+ 0.40 % of rg.	+ 0.20 % of rg.

Binary inputs	Timing accuracy
Binary wet >500 kΩ	0.2 ms
Binary dry >90 kΩ	0.2 ms

1) The measurement inputs IN 1 and IN 2 have an input resistance of approx. 500 kΩ.

2) 98 % of all units possess an accuracy better than specified as *typical.*

3) rd = reading, rg = range. Accuracy values indicate that the error is smaller than ± ((*read value x reading error) + (full scale of the range x full scale error*)).

All values are guaranteed for one year under the following conditions:

- when *COMPANO 100* is operated at an ambient temperature of 23 °C ± 5 °C (73 °F ± 9 °F),
- after a warm-up time of >10 minutes,
- within a frequency range of 45 ... 60 Hz, or at DC.

Measurement Category:

- CAT III/300 V.

Additional features of measurement inputs:

- Automatic range switching
- AC frequency range 15 ... 500 Hz

16.5 Micro-Ohm application module (IN1 only)

16.5.1 Accuracy

Range	Voltage range	Current	Error typical[1)]
0.5 µΩ ... 1 mΩ	100 mV	100 A	< 0.50 % rd[2)]
			+ 0.5 µΩ
5 µΩ ... 10 mΩ	1 V	100 A	< 0.50 % rd
			+ 5 µΩ
50 µΩ ... 100 mΩ	1 V	10 A	< 0.50 % rd
			+ 50 µΩ
1.5 mΩ ... 3 Ω	30 V	10 A	< 0.50 % rd
			+ 1.5 mΩ

1) 98 % of all units possess an accuracy better than specified as *typical*.
± ((*read value x reading error) + (full scale of the range x full scale error*)).

2 rd = reading. Accuracy values indicate that the error is smaller than
± ((*read value x reading error) + (absolute error specified*)).

16.5.2 Maximum supported burden

High-current cable set	Cable resistance [1)]	Maximum supported burden		
		at 100 A DC	at 20 A DC	at 10 A DC
Standard cable set (included)	~ 10 mΩ	40 mΩ	1 Ω	3 Ω
High-current cable set 6 m/19.5 ft (optional)	~ 15 mΩ	30 mΩ	1 Ω	3 Ω
Custom cable set (on request) Example with 25 m/80 ft length	~ 25 mΩ	10 mΩ	1 Ω	3 Ω

1) Single cable

16.6 System clock accuracy

All signals generated or measured by the *COMPANO 100* test sets refer to a common internal time base that is specified as follows:

Characteristic	Specification
Frequency drift (over time)	< ± 1 ppm/year (± 0.0001 %)
Frequency drift (over temperature range)	< ± 0.5 ppm (± 0.00005 %)
Frequency resolution (signal generator)	1 mHz

16.7 Synchronization of devices

Using FLEX it is possible to synchronize two devices by programming a sequence step that waits for a binary input signal, and then continue with another sequence step using absolute phase setting. The tolerance across devices to switch sequence steps on binary triggers is 0.1 ms. At 50 Hz or 60 Hz this results in a phase error of about 2 °.

In case of questions, contact OMICRON's Technical Support (→ Support on page 175).

16.8 Communication Ports

Ethernet port ETH

The Ethernet port **ETH** in the USB and Ethernet compartment at the test set's front panel is reserved for future use. Do not attempt to connect the device.

USB port

The internal *COMPANO 100* software supports FAT32-formatted USB devices, only. FAT32-formatted USB devices provide maximum compatibility across all devices with a USB port. USB 3.0/USB 3.1 memory sticks are not supported. They may work, though, if they are compatible to USB 2.0.

If *COMPANO 100* does not detect your USB stick, try a different USB 2.0-compatible stick.

If USB stick contains multiple partitions, COMPANO will always access the first partition, only.

The USB Port is a standard USB 2.0 Host Port, providing up to 500 mA. Most mobile devices can be charged via this port but may need a longer time until they are fully charged.

We recommend you use the **Eject device** feature before you remove the USB stick from the test set.

NOTICE

Equipment damage or loss of data possible

► We recommend not to connect other USB devices to this USB port than memory sticks. If they do not have a FAT32 file system, they may not work properly, and you could experience a data loss.

16.9 Electromagnetic compatibility (EMC), certified safety standards, protection class

Electromagnetic compatibility (EMC)	
Emission	
• Europe	• EN 55022; EN 61326-1; EN 61000-6-4
• International	• IEC 61326-1; IEC 61000-6-4
• USA	• FCC 47 Subpart B of Part 15 Class A
Immunity	
• Europe	• EN 61326-1; EN 61000-6-2; EN 61000-4-2/3/4/5/6
• International	• EN 61326-1; EN 61000-6-2; EN 61000-4-2/3/4/5/6

Certified safety standards	
• Europe	• EN 61010-1; EN 61010-2-030
• International	• IEC 61010-1; IEC 61010-2-030
• USA	• UL 61010-1; UL 61010-2-030
• Canada	• CAN/CSA-C22.2 No 61010-1; CAN/CSA-C22.2 No 61010-2-030

Prepared for tests conforming to	
• Europe[1)]	• EN 50191
• Germany	• VDE 104

1) *COMPANO 100* is not protected against unauthorized start up. If you want to do so, consider additional protection equipment.

16.10 Compliance statements

- **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.
- **Declaration of Conformity (UK)**
  The equipment adheres to the guidelines of the council of the United Kingdom for meeting the requirements of the member states regarding the electromagnetic compatibility (EMC) directive, the low voltage directive (LVD) and the RoHS directive.
- **Declaration of Conformity (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 Conformity (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.

16.11 Weight and dimensions

- Weight: 9.8 kg (21.6 lb); case without protection cover.
- Dimensions (w × h × d): 360 × 312 × 210 mm (14.2 × 12.3 × 8.3 in).

16.12 Environmental conditions

- Operating temperature: -10 °C ... +50 °C (14 °F ... 122 °F).
  (Output power degrading below 0 °C due to battery.)
- Storage and transportation temperature: -20 °C ... +50 °C (-4 °F ... 122 °F).
- Humidity: 5 % ... 95 % relative humidity, no condensation.
- Protection against ingress of water: IP20 according to EN 60529.
- Maximum altitude for operation: 4000 m (13,000 feet).
- Maximum altitude for storage: 15000 m (49,000 feet).

16.13 Shock and vibration

- **Shock:** 30 g[1)], 11 ms, half sine, 3 shocks in each axis. Tested according to IEC 60068-2-27.
- **Vibration:** 5 g RMS, frequency range 10 … 2 kHz; 30 min in each axis. Tested according to IEC 60068-2-64.

[1)] The unit g represents multiples of the acceleration of gravity.

Battery Material - Safety - Data Sheet

Version	1.6
Date of issue:	November 30, 2020
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Editor:	OMICRON electronics GmbH

This information is provided as a service to our customers and for their information only. The information and recommendations set forth herein are made in good faith and are believed to be accurate at the date of preparation. OMICRON electronics GmbH makes no warranty expressed or implied.

1. Product and company identification

Product name:	Batterysystem_14S2P_INR_18650_15M
Type:	152 Wh rechargeable lithium-ion battery (integrated in testing and measurement device *COMPANO 100*).
Identified use:	Tests and measurements on electrical systems. Battery must only by used in *COMPANO 100*. Only use chargers that are designated for this purpose.
Battery net weight:	2.2 kg (4.85 lb)
Item no.:	P0005542 (replacement battery)
Support Centers:	(→ Support on page 175).

EMERGENCY CONTACT: In case of chemical emergencies (spill, leak, fire, exposure or accident), call OMICRON's Technical Support at + 43 59495 4444.

2. Hazards identification

The rechargeable lithium-ion battery described in this Material - Safety - Data Sheet (MSDS) is sealed gastight and non-hazardous under normal handling and use. There is no physical danger of ignition or explosion and chemical danger of hazardous material leakage during normal use. If exposed to a fire, added mechanical shocks, decomposed, added electric stress by miss-use, the gas release vent will be operated and hazardous materials may be released.

Since electrolyte is flammable liquid, it should not be close to fire. It may cause severe eye irritation or dryness of the skin. Breathing of its mist, vapour or fume may irritate nose, throat and lungs. Exposure of electrolyte material in the area which contains water may generate hydrofluoric acid, which can cause immediate skin burns or severe eye burns. The ingestion of it can cause serious chemical burns of mouth, oesophagus and gastrointestinal tract.

3. Composition/Information on ingredients

Lithium–ion battery system.

Anode (negative electrode): based on intercalation graphite.

Cathode (positive electrode): based on lithiated metal oxide (Cobalt, Nickel, Manganese, Aluminium).

The listed chemicals are in a sealed housing, so there is no hazard when the measures for handling and storage are followed. In case of cell damage, a release of dangerous substances and a flammable gas mixture is possible.

Ingredients	%	CAS number
Aluminum Foil	2 ... 10 %	7429-90-5
Metal Oxide (proprietary)	20 ... 50 %	Confidential
Polyvinylidene Fluoride (PVDF)	<5 %	24937-79-9
Styrene Butadiene Rubber (SBR)	<5 %	9003-55-8
Copper Foil	2 ... 10 %	7440-50-8
Carbon (proprietary)	10 ... 30 %	7440-44-0
Electrolyte (proprietary)	10 ... 20 %	Confidential
Aluminum and inert materials	Remainder	n/a

4. First aid measures

For the first aider: always mind your self-protection!

In case of battery breakage or burst, evacuate employees from the contaminated area and ensure maximal ventilation in order to break-up corrosive gas, smoke and unpleasant odors. It such an event occurs, take the following actions:

Inhalation: Escaping gas may cause respiratory problems. Ensure sufficient supply of fresh air. In case of persistent symptoms, consult a doctor.

Skin Contact: Skin contact with battery fluids may cause skin irritations. Thoroughly clean skin with water and soap. In case of persistent symptoms, consult a doctor.

Eye Contact: Eye contact with battery fluids causes irritations. Rinse eyes immediately with plenty of water, also under the eyelids, for at least 15 minutes. Seek medical treatment by an eye specialist.

Ingestion: In case of ingesting electrolyte, thoroughly wash out your mouth with water, and drink plenty of water. Obtain immediate medical attention in any case.

5. Fire-fighting measures

Fire extinguishing agent

- Fire extinguisher fire protection class: D (dry powder).
- Cold water, dry powder or pyrobubbles in large amount are applicable. Use a metal fire extinction powder or dry sand if only a few cells are involved.

For safety reasons, **do not** use a water jet as extinguishing media.

Protective equipment and precautions for firefighters

To avoid contact with irritant fluids, wear self-contained breathing apparatus and protective suit. Evacuate all persons from the immediate area of fire. If possible, remove cell(s) from firefighting area. If heated above 125 °C, cell(s) can explode/vent. A cell is not flammable but internal organic material will burn if the cell is incinerated.

Do not re-enter the area until it has been adequately purged of fire vapour and extinguishing agent.

6. Accidental release measures

Personal precautions, protective equipment and emergency procedures

- Use protective clothing.
- Evacuate all persons from the immediate area until the fumes dissipate.
- Do not breathe vapours or touch liquids with bare hands.

Environmental precautions

- Do not discharge into the drains/surface waters/groundwater.
- Methods for cleaning up: pick up remnants mechanically rather than manually, and send them off for disposal.

Methods and material for containment and cleaning up

- Cell damage may cause leaked electrolytes. Seal the damaged cell in an airtight plastic bag, and add dry sand, chalk powder (CaCO3) or vermiculite.
- Clean up the leaked electrolyte fluid with an absorbent cloth. If there is a lot of leaked electrolyte, you should wear protection clothes, a gas mask for organic gases, safety goggles and safety gauntlets. Rinse thoroughly with clean water.

7. Handling and storage

WARNING

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

► Read these handling and storage information thoroughly, and comply with them.

Temperature:	Observe the permissible temperature ranges. • For charging: 5 °C ... 45 °C (41 °F ... 113 °F) battery temperature. • For operating: -10 °C ... +50 °C (14 °F ... 122 °F) battery temperature. • For storage and transportation: -20 °C ... +50 °C (-4 °F ... 122 °F) battery temperature.
Storage:	The following regulations apply to short- and long-term storage: • Store the *COMPANO 100* with an almost fully charged battery at a low temperature (we recommend below 25 °C/77 °F) and in a low humidity environment. • To avoid deep discharge of the battery, recharge it about every 6 months. Note that higher temperatures result in a drastically higher self-discharge rate of the battery. • Do not store the battery in places with direct sunlight, or near a stove. • Do not expose the battery to condensation, water drop or not to store it under frozen condition. • Do not store the battery in places where it is exposed to abnormal static electricity.
Handling:	• Do not drop. • Do not expose to mechanical impact. • Do not damage or dispose of in fire – danger of explosion! • Do not short-circuit or expose to any types of liquid. • Do not open or disassemble. • Follow local regulations for the handling of lithium-ion batteries.
Other:	• Use the OMICRON-supplied charger, only, and observe the charging requirements. • In case of abnormal heating of the battery, disconnect it immediately and dispose of it. • Do not charge the battery in a flammable environment.

Disposal:	• Consider a lithium-ion battery defective when you notice a mechanical damage, deformation, leaking fluid, an unusual smell or similar abnormal symptoms. • Do not try continue to use a defective lithium-ion battery. • Do not store or ship a defective lithium-ion battery. Hand it over to an appropriate disposal facility. Regulations and laws pertaining to the recycling and disposal of lithium-ion batteries vary from country to country as well as by state and local governments. Check the laws and regulations of your home region.

8. Exposure controls/personal protection

Ventilation:		Not necessary under normal conditions. Room ventilation is required in areas where there are open or leaking batteries.
Respiratory protection:		Not necessary under normal conditions. Avoid exposure to electrolyte fumes from an open or leaking battery. If unavoidable, wear a gas mask for organic gases. In all fire situations, use self-contained breathing apparatus.
Eye protection:		Not necessary under normal conditions. Wear safety glasses with side shields when handling an open or leaking battery.
Hand protection:		Not necessary under normal conditions. Use chemical-resistant gloves when handling an open or leaking battery, and thermal-protective gloves in case the battery temperature increases.

In case of released electrolyte, do not eat, drink or smoke. Wash hands before breaks and after work.

9. Physical and chemical properties

Form:	Solid
Color:	Various
Odor:	Odorless

10. Stability and reactivity

Conditions to avoid:	Heat beyond the temperature ranges specified in section 7. Handling and storage on page 108, deformation, mutilation, crushing, piercing, disassembling, short-circuits, and exposure to humid conditions over a long period.
Materials to avoid:	Strong mineral acids, alkali solutions, strong oxidising materials, and conductive materials.
Hazardous decomposition products:	HF (hydrogen fluoride), CO (carbon monoxide), CO2 (carbon dioxide).

11. Toxicological information

If appropriately handled, and if in accordance with the general hygienic rules, no hazards to health are known. Leaked electrolyte or fumes may cause chemical burns, burnings and skin irritations.

12. Ecological information

Ecological damage or influence is not known or expected at normal use. Do not flush into surface water or sanitary sewer system but dispose of acc. to **Disposal information** below.

13. Disposal considerations

WARNING

Death or severe injury can occur if the disposal information instructions are not observed.

► Read both the disposal information and the information regarding the handling of defective lithium-ion batteries thoroughlly, and comply with them.

Batteries are hazardous waste. Do not dispose of with common waste. If a battery is unserviceable, dispose of it according to your local recycling regulations. To avoid short-circuits and the associated heat, do not transport or store lithium-ion batteries in unprotected lose bulk.

→ Disposal of defective lithium-ion batteries on page 109.

14. Transport information

Only regularly instructed personnel is allowed to participate in the transportation of lithium-ion batteries! If lithium-ion batteries are transported by air, participating personnel must have been regularly trained as described in the **IATA Dangerous Goods Regulations**. In addition, check for national training requirements. In the following, the dangerous goods regulations of the corresponding carriers are cited in excerpts, only. OMICRON electronics GmbH excludes any liability!

	COMPANO 100	Spare Battery
UN number	UN 3481	UN 3480
UN shipping name	Lithium-ion batteries contained in equipment	Lithium-ion batteries
Transport hazard class	9	
Air transport (ICAO/IATA)	PI: 967 Sec. I	PI: 965 Sec. IA
Labeling		

Notes:

- The regulations regarding shipping of lithium-ion batteries vary by the mode of transportation (air, road, sea) as well as by country. Furthermore, these regulations change frequently. Double-check the current status whenever applicable, or, if in doubt, contact OMICRON's Technical Support (→ Support on page 175).
- For return shipments to OMICRON for repairs and calibrations, please contact OMICRON's Technical Support prior to shipping. Also consult your freight forwarder and/or a local dangerous goods expert prior to shipping the *COMPANO 100*
- Do not send a defective battery back to OMICRON. Neither transport a defective battery by plane. Properly dispose of it. If in doubt, consult local recycling experts.

The *COMPANO 100* test set with the lithium-ion battery included has passed the following tests:

Step	Result
UN 38.3.4.1 Altitude simulation	passed
UN 38.3.4.2 Thermal test	passed
UN 38.3.4.3 Vibration	passed
UN 38.3.4.4 Shock	passed
UN 38.3.4.5 External short-circuit	passed
UN 38.3.4.6 Impact	not required[1)]
UN 38.3.4.7 Overcharge	passed
UN 38.3.4.8 Forced discharge	not required[1)]

[1)] This test is not required for battery testing if it is already passed at the UN 38.3 test of the built-in cell. The certificate is valid with the associated test report, only.

15. Regulatory information

Regulations specifically applicable to the product:

- ACGIH and OSHA: see exposure limits of the internal ingredients of the battery in section 3. Composition/Information on ingredients on page 106.
- IATA/ICAO (air transportation): UN 3480 or UN 3481.
- Transportation within the US-DOT, 49 Code of Federal Regulations.
- IMDG (sea transportation): UN 3480 or UN 3481.
- Other regulations, limitations and prohibitive regulations.
- Substances of very high concern (SVHC) according to REACH, Article 57: none.
- Chemical safety assessment: not required.

16. Other Information

This information has been assimilated from various sources, whose data is considered to be accurate and reliable to the best of our knowledge as of the date of compilation. Nevertheless, no representation, warranty or guarantee is in any way expressed, implied or made to the accuracy, reliability or completeness of this information.

This information is only related to the specific materials mentioned in this scripture and therefore may not be valid for such materials in combination with any other material or in any other process. It's the responsibility of the user to satisfy himself with the suitability and completeness of this data for his particular use.

This information does not release the user from adhering to international standards, national or internal safety instructions, directives or other relevant documents.

OMICRON electronics GmbH does not bear responsibility for any damage or loss that may occur, whether direct, indirect, incidental or consequential from the use of this information.

Version	Released	Reason for change
1.3	01 March, 2017	Initial release
1.4	01 December, 2019	Minor updates of product identification, first aid measures, exposure controls, transport information, and regulatory information.
1.5	30 November, 2020	Update of item number
1.6	19 January, 2023	Update of item number

17 Accessories

The following chapters outline accessory equipment available for the *COMPANO 100* test set.

If you wish to purchase accessory equipment, or have a question in that context, contact OMICRON's Technical Support (→ Support on page 175).

17.1 AC/DC current clamp C-Probe 1

The current clamp *C-Probe 1* is an active AC and DC current clamp with voltage output.

- Measuring ranges:
  - 10 A AC/DC (100 mV/A)
  - 80 A AC/DC (10 mV/A).
- Frequency range: DC ... 10 kHz.
- Accuracy: Error < 2 % for currents up to 40 A and frequencies up to 1 kHz.
  Typically 5 ... 10 % error for 80 A.
  Phase error < 0.5 ° at 50/60 Hz.
- Control indicators for power supply (ON) and measurement range exceeded (overload).
- Maximum conductor size: 11.8 mm of diameter.
- Maximum opening of clamp jaws: 15 mm.
- Connecting cable: 2 m length, isolated plugs.
- Dimensions: 230 × 67 × 36 mm.
- Weight: 330 g (0.73 lb) with 9 V Alkali block battery, type 6 LR 61, included.
- Thumbwheel to precisely adjust the zero point.

For more details read the *C-Probe 1* User Manual. The User Manual also contains important safety instructions.

17.2 AC/DC current clamp Chauvin Arnoux E25

The current clamp *Chauvin Arnoux E25* is an active AC and DC current clamp with voltage output.

- Measuring ranges (refer to the Chauvin Arnoux user documentation for details):
  - 2 A AC/DC (1000 mV/A)
  - 80 A AC/DC (10 mV/A)
- Frequency range: DC ... 10 kHz.
- Accuracy: Error < 2 % for currents up to 1.5 A.
  Typically <4 % up to 40 A and < 12 % above.
- Control indicators for power supply (ON) and measurement range exceeded (overload).
- Maximum conductor size: 11.8 mm of diameter.
- Maximum opening of clamp jaws: 15 mm.
- Connecting cable: 1.5 m length, isolated plugs.
- Dimensions: 231 × 67 × 36 mm.
- Weight: 330 g (0.73 lb) with 9 V Alkali block battery, type 6 LR 61, included.
- Zero-adjustment button to adjust the zero point.

For more details and important safety instructions refer to the **Chauvin Arnoux E25** user documentation.

17.3 True RMS clamp meter Fluke 365 with detachable jaw

- Measuring ranges:
  - 200 A AC current (100 mA resolution).
  - 200 A DC current (100 mA resolution).
  - 600 V AC (100 mV resolution).
  - 600 V DC (100 mV resolution).
  - 600 Ω (0.1 Ω resolution).
  - 6000 Ω (1 Ω resolution).
- Maximum opening of jaw: 18 mm.
- Detachable jaw cable length: 900 mm
- Dimensions: 225 x 65 x 46 mm.
- Weight: 275 g (0.61 lb) with two AA (NEDA 15A, IEC LR6) size batteries included.

For more details and important safety information refer to the Fluke 365 Users Manual.

17.4 Polarity checkers CPOL2 and CPOL3

CPOL2 and *CPOL3* are designed to check a series of test points for correct polarity and for wiring errors. The checks can be performed on current and voltage transformers as well as on the connected wirings and terminals.

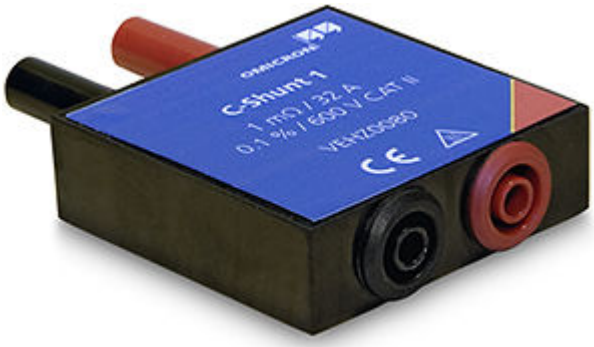
In addition, *CPOL3* can display the voltage and, if combined with a current clamp, the current of the measured signal (→ C-Probe 1 on page 113 and Chauvin Arnoux E25 on page 114).

Functional principle: Use *COMPANO 100* to generate a DC-free, sawtooth-shaped signal (voltage or current), which is detected by the polarity checker. Check the polarity at all terminals of your choice. Following this procedure provides a clear indication as to whether the polarity is OK (green happy face LED) or not OK (red sad face LED).

For more details and safety instructions refer to the corresponding User Manual.

17.5 C-Shunt

C-Shunt is a precision shunt for current measurements. Insert it directly into *COMPANO 100*'s BINARY/ANALOG inputs **IN 1** or **IN 2** to make the input a current input.



There are two variants available: *C-Shunt 1* and *C-Shunt 10*.

	C-Shunt 1	**C-Shunt 10**
Electrical resistance	0.001 Ω	0.01 Ω
Resistance tolerance	0.1 %	0.1 %
Temperature coefficient	≤ 30 ppm/K in the range of 0 ... 70 °C (+32 ... 158 °F)	≤ 15 ppm/K in the range of 0 ... 70 °C (+32 ... +158 °F)
Maximum current	32 A continuous	12.5 A continuous
Item number	B0620201	B0620301

When connecting the shunt, note the maximum current ratings imprinted on the shunt.

Configure the input **IN 1** or **IN 2** to be a current input using a shunt by pressing the respective input key and by stepping through the configuration order (see Configuring IN 1/IN 2 (binary or analog inputs) on page 35).

17.6 BNO1 binary output relay

The *BNO1* is a solid-state relay, designed for direct connection to the **V OUT** voltage output of *COMPANO 100*.

By outputting a DC voltage of 20 to 300 V DC, the *BNO1* will close its output. This function can be used to trip a circuit breaker or to trigger a logic function.

For more details read the *BNO1* User Manual. That manual also contains important safety instructions.

17.7 VBO4 voltage booster 150 V to 300 V/750 V

The *VBO4* is a voltage transformer accessory for *COMPANO 100*.

It transforms the *COMPANO 100* device's output voltages of **0 ... 150 V** to **0 ... 300 V** or **0 … 750 V**. This enables you to test over-voltage or frequency relays with *COMPANO 100* which require a voltage higher than 150 V.

Furthermore, it can be used to test voltage sensors or voltage transformers with voltages of over 150 V. You can also test renewable energy systems such as wind power, biogas, photovoltaic, small hydroelectric power, and combined heat and power plants. Furthermore, you can test industrial networks with voltage levels of over 150 V.

For more details read the *VBO4* User Manual. That manual also contains important safety instructions.

17.8 CBF1 accessory for self-supplied relays

The *CBF1* is a 10:1 current transformer for *COMPANO 100*, used to reduce distortions while testing self-supplied relays.

The *CBF1* input is directly connected to the high-current output of *COMPANO 100*. The *CBF1* output is then connected to the current input of the self-supplied relay under test. The *CBF1* transforms the *COMPANO 100* output current of up to 110 A into a smaller test current of up to 11 A.

For more details read the *CBF1* User Manual. That manual also contains important safety instructions.

17.9 HGT1 handheld grounding tester

The handheld grounding tester *HGT1* measures step and touch voltages. Using the *COMPANO 100* test set, test currents at variable frequencies can be safely fed into a distant current probe to simulate a ground fault. According to EN 50522 and IEEE 81 standards, *HGT1* measures step and touch voltages at various locations at the same time. Digital filtering makes noise suppression more effective and measurements more accurate.

WARNING

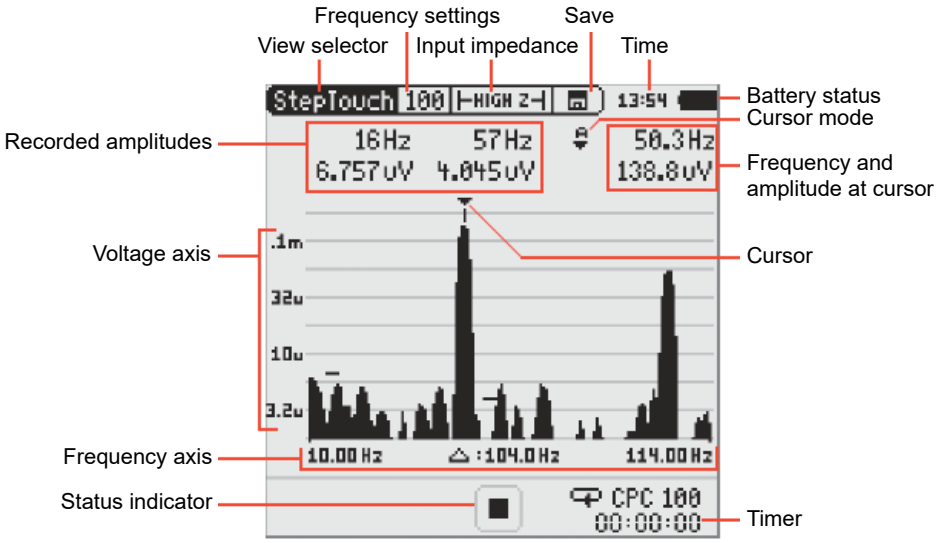
Death or severe injury caused by high voltage or current possible.

► Never use *COMPANO 100* to directly inject currents into power cables or overhead lines. If this should become inevitble, we recommend using *CPC 100* together with *CP CU1* and *CP GB1*.

Key features:

- Mobile, battery-operated handheld device; comes in a protective cover.
- Simulates body and shoe resistance.
- Frequency-selective measurements.
- Can be powered by either a rechargeable lithium polymer (Li-Po) battery, four AA batteries, or an additional DC power supply unit.
- Micro SD slot and USB port.
- When connected to a computer via USB, *HGT1* saves reports and screenshots to your harddrive.

HGT1 display:



For more details read the *HGT1* User Manual. The User Manual also contains important safety instructions.

17.10 SAA2 multifunctional warning lamp

The *SAA2* is a multifunctional safety accessory to increase safety awareness while working with dangerous voltages or currents. It consists of a control unit and one or more signal lamps which are fixed at or near the test object. Each signal lamp provides an emergency stop button to switch off all outputs of the main device immediately and to bring the test setup into a safe state. A green continuous or a red continuous/flashing light indicates the status of the main device.

Optionally, the signal lamps can generate an acoustic signal if an output of the main device is active.

The *SAA2* is compatible with various OMICRON test systems, including *COMPANO 100*.

The *SAA2* requires mains power. It can not be powered directly from *COMPANO 100*.

► For more information refer to the supplementary sheet "Functions and Handling of Safety Accessories".

17.11 SAA3 3-position remote safety switch

The *SAA3* 3-position remote safety switch is an emergency switch for use with various OMICRON test systems, including *COMPANO 100*.

The *SAA3* triggers the emergency stop of the connected test system.

The *SAA3* has three operating positions shown below:

Operating position	Action	Description
I	Do not press the switch.	Emergency stop is activated.
II	Press the switch into middle position.	No activation of emergency stop.
III	Press the switch all the way.	Emergency stop is activated.

► For more information refer to the supplementary sheet "Functions and Handling of Safety Accessories".

18 Overcurrent relay (application examples)

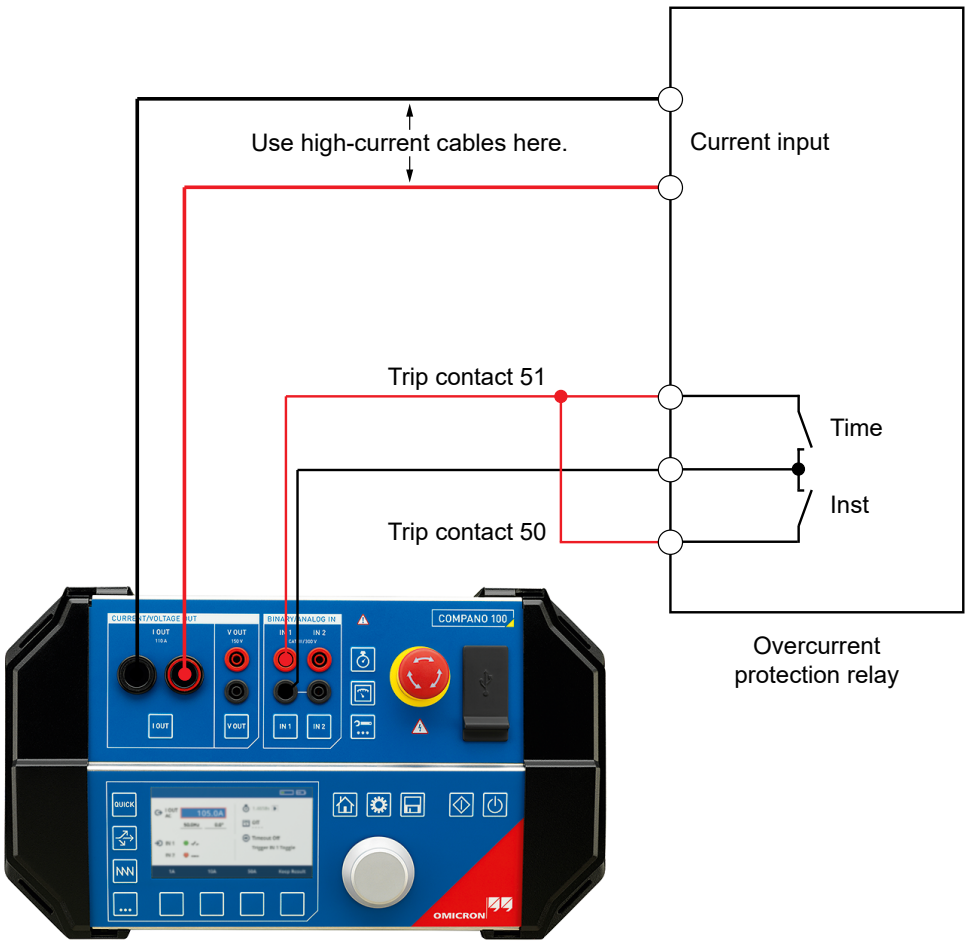
WARNING

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

- ► The *COMPANO 100* test set can output life-hazardous voltages and currents.
- ► Before operating any such electrical equipment, carefully read the **Safety Instructions** chapter in this manual (see Safety instructions on page 10).

This example outlines the working steps for acquiring the pick-up and drop-off current values of a non-directional overcurrent relay as well as the trip times of the relay at different currents. Using the QUICK application module, this test is performed manually. Using the FLEX application module, the test searches for the point where the relay trips instantaneously.

Connect *COMPANO 100* to the overcurrent relay



1. In a substation, the relay's input would be connected to a current transformer (CT) in order to monitor the current on the power line. To test the relay, connect these inputs to the *COMPANO 100* current output **I OUT** instead. Polarity does not matter for this tests. Plug in the angled cable connectors to the *COMPANO 100*, and the retractable sleeve connectors to the relay. For many relay types, this allows you to connect without having to use additional adapters.
2. In a substation, the relay's output (trip contact 51) would be connected to a circuit breaker (CB) to trip the breaker in case of a detected overcurrent. To test the relay, connect its output to a BINARY INPUT of the *COMPANO 100* (**IN 1** or **IN 2**).

18.1 Testing an overcurrent relay with QUICK

In the following example, the relay does not have a dedicated pick-up contact, therefore determine the pick-up by checking the display of the relay.

Determine and record the pick-up current

1. Turn the jog dial wheel until **I OUT** has the focus.
2. Press the jog dial wheel to enter the **I OUT** field in edit mode. Then turn the wheel to set the value to the nominal current of the relay under test.
3.  Press the **Start/Stop** key (now illuminated green).
   The **I OUT** field shows the measured value of the presently flowing current. Pressing the jog dial wheel at this point returns you to the edit mode showing the currently set value. Turning the wheel changes that value. Pressing the jog dial wheel again returns you to the display mode.
4. Make sure you are in the edit mode at **I OUT**. Press the jog dial wheel if you are not. Now turn the jog dial wheel very carefully clockwise to increase the current value at **I OUT** until the relay shows a pickup on its front-panel. Most relays have an indicator for that.
5. Press the **Keep result** soft key to record the pick-up current value.

Determine and record the drop-off current value

1. You should still be in the edit mode at **I OUT**.

   Else, turn the jog dial wheel until **I OUT** has the focus, and press the jog dial wheel to enter the **I OUT** field in edit mode.
2. Turn the wheel very carefully counter-clockwise to decrease the current value until the pick-up indicator at the relay changes its status again. Now you have reached the drop-off current value of the relay.
3. Press the **Start/Stop** key to end the test, and to stop the current output. By stopping the output you automatically record the result; there is no need to press the **Keep result** soft key. At the upper left-hand side of the QUICK application module screen you see the figures **1 2**, indicating that you have made two manual recordings.

Determine the trip times of the relay at different currents

Whenever you need to configure a timer, press the **Configuration** key. However, by default the timer starts on a value change, and stops when *COMPANO 100* detects a change at its binary input **IN 1**. Therefore, there is no configuration required for this test example.

1. Set an output current higher than the pick-up value in the manner described above.
2. Press the **Start/Stop** key (now illuminated green). The timer starts running.
3. *COMPANO 100* outputs the set current. The relay trips after a certain time span that depends on its setting, and closes the trip contact 51.
4. The closing trip contact has three effects on the *COMPANO 100* test set:
   - It stops the current output. Reason: by default, the QUICK application module is configured to trigger with a change at the **IN 1** binary input (reflected by the symbol at the lower right-hand side of the QUICK screen).
   - It stops the timer. Reason: when *COMPANO 100* stops the current output, it also stops the timer.
   - As the output was stopped, it automatically records the result.

The timer now shows the result of the test: a trip at a specific current after a specific time. Compare the acquired results with the wanted behavior of the relay.

Press **Continue** to repeat the test with different currents. For many relays, this results in times that are shorter the bigger the current is.

NOTICE

Relay damage caused by too high current.

► Before you start working with higher currents, set a timeout. A timeout guarantees that the test set switches off after a certain time if there is no trip signal from the relay.

Set a timeout:

1. In Navigation Mode, turn the jog dial wheel until **Timeout** has the focus.
2. Press the jog dial wheel to enter the **Timeout** field.
3. Then turn the wheel to set the value to, for example, 5 s.

Press the QUICK key to return to the QUICK application module. Now you can repeat the test with different currents, say 20 A, 50 A and 100 A.

Test results

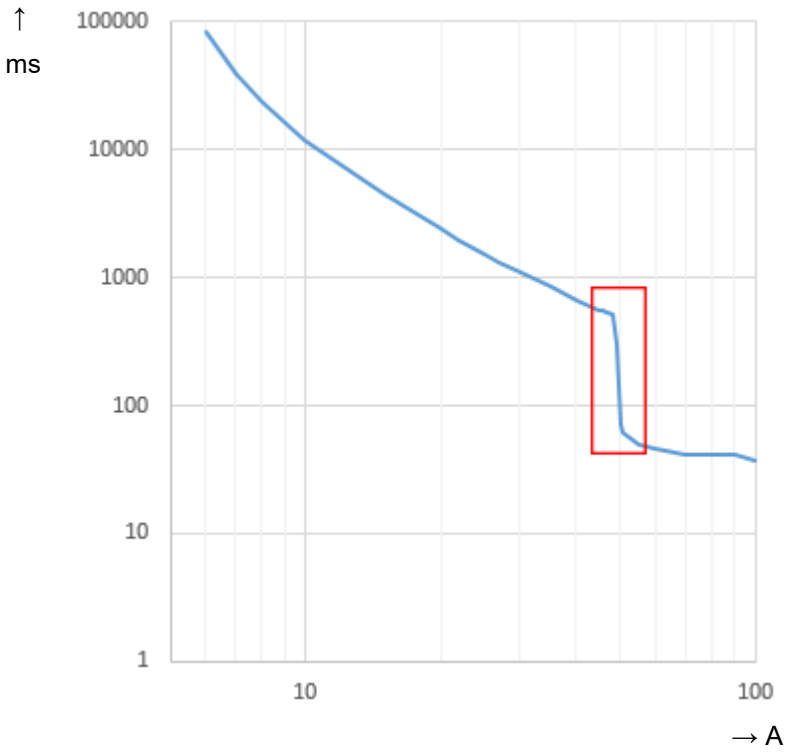
After the tests, move the focus to the top line of the screen. Press the **Previous** soft key to browse through the results recorded earlier.

If you would like to save the test results, open the black USB and Ethernet compartment cover at the *COMPANO 100* front panel. There you will find a USB port. Insert an USB stick and save the result in XML format to that stick (see Save on page 87).

18.2 Testing an overcurrent relay with FLEX

This chapter provides you with an example of how to search for the point where the relay trips instantaneously. To do so, use a pulse ramp.

A typical overcurrent-time characteristics:



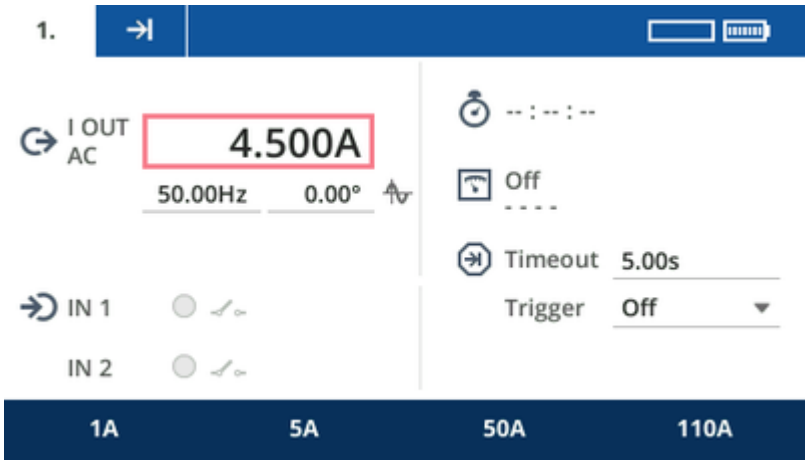
The point where the relay trips instantaneously is at around 50 A.

Start the search with a current of, say, 2 A below the expected value; in this case 48 A. Then ramp up to 2 A above the expected pick-up value (52 A) in steps of 0.5 A. The relay is expected to trip within approx. 100 ... 200 ms. Depending on the reset characteristics, typically needed reset times can vary between 500 ms and several minutes. In this example we assume a rotating disk, therefore we grant the relay 20 s between two shots.

Before searching for the pick-up value, bring the relay into a stable condition by applying a pre-fault condition. In this example, we apply 4.5 A to achieve this. To do so, define a first ramp state with an output current below the nominal current of the relay under test.

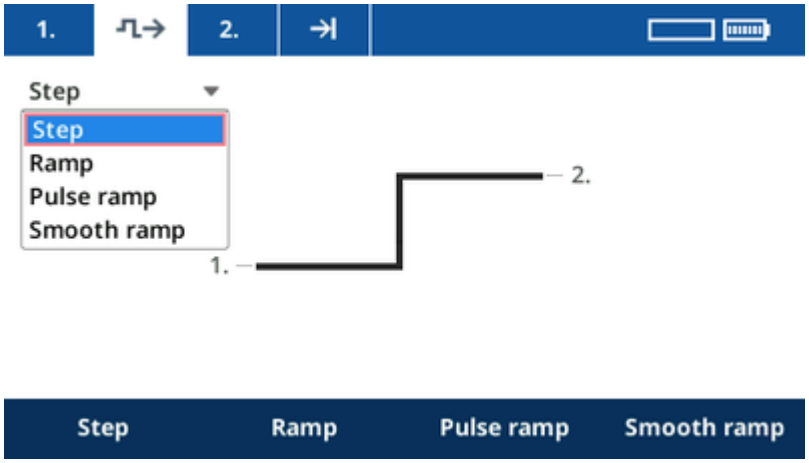
1. Enter the FLEX mode by pressing the FLEX key.

2. Use the jog dial wheel to set an output current below the pick-up current of the relay under test. In this example that is 4.5 A.



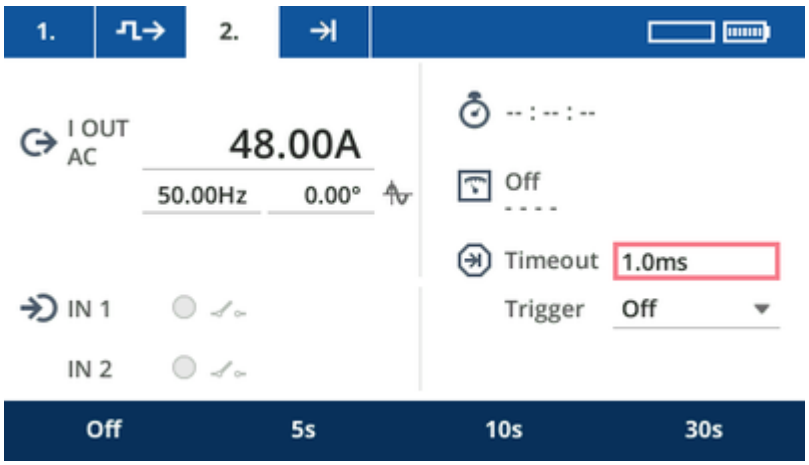
3. Turn the jog dial wheel to put the focus onto the top of the screen on sequence step **1**. Press the **Add state** soft key.

   Then press the **Next** soft key to proceed to the next tab to the right. This tab defines the transition from the first to the second sequence step. Define the transition to be a **Step**.



   Proceed to sequence step **2**.

4. In sequence step 2, define the value for the pulse ramp to start. As mentioned above, set a current of 48 A for **I OUT**, and a timeout of 1.0 ms.

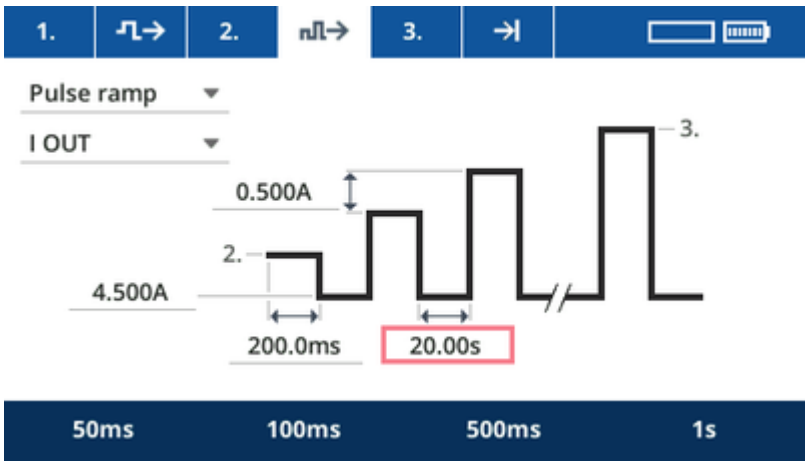


This intermediate sequence step is not to really to output the ramp; it is rather initiating the starting point of the following transition.

5. Turn the jog dial wheel to put the focus onto the top of the screen on sequence step **2** and press the **Add state** soft key to add sequence step 3. Press the **Next** soft key to navigate to the transition after sequence step 2.

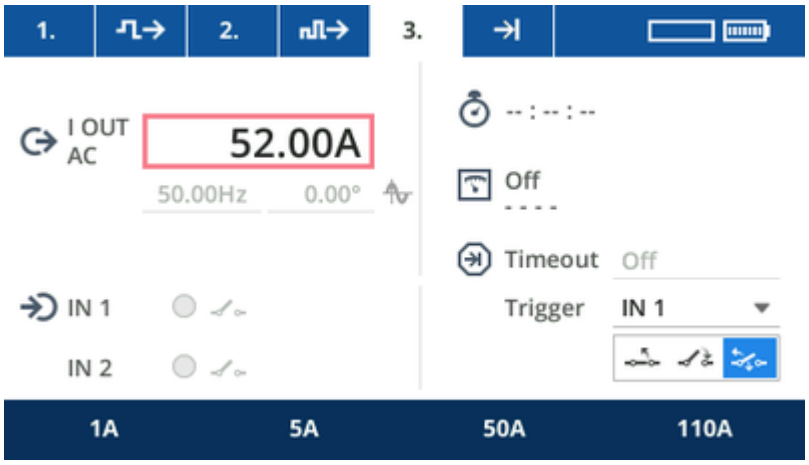
6. Now start generating a pulse ramp that slowly increases the output current until you reach that value that makes the relay switch off with maximum speed (I>>, "high setting"). Because some overcurrent relays do not have a separate output for the instantaneous trip signal, you need to use the trip signal to find out that value. This will slow down the process a bit. In this example we use a pulse ramp. As a result, you will acquire the current value that makes the relay switch off at its high setting.

   The pulse ramp of the transition sequence step from sequence step 2 to sequence step 3 could look like that:



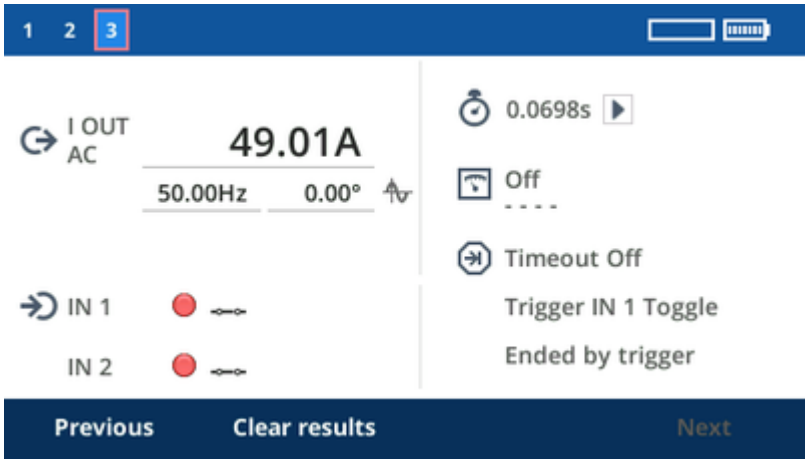
- The pulse ramp starts by putting out the value of sequence step 2, in this case 48 A for a time of 200 ms.
- If the relay does not trip within these 200 ms, the pulse ramp then resets the relay by applying a current of 4.5 A for 20 seconds.
- After that the pulse ramp outputs 48.5 A for 200 ms, and so on.

7. Turn the jog dial wheel to put the focus onto the top of the screen onto the pulse ramp symbol. Press the **Next** soft key or turn the wheel to proceed to sequence step **3**. In sequence step 3 now define:
   - The end value of the ramp; in this example that will be 52 A.
   - The trigger condition to end the ramp; in this example a toggle on input **IN 1**.



8. Press the **Start/Stop** key to run the sequence of steps.

   You will get to see the result in step 3. At **I OUT**, you see the value where the relay tripped.



19 Under-/overfrequency relay (application example)

WARNING

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

- ► The *COMPANO 100* test set can output life-hazardous voltages and currents.
- ► Before operating any such electrical equipment, carefully read the **Safety Instructions** chapter in this manual (see Safety instructions on page 10).

Frequency relays trip when the input frequency shifts away too far from the nominal frequency. Some of these frequency relays suppress very sudden frequency changes as these could result from transient events. Therefore, in this example the frequency relay is tested with a very slow frequency ramp.

Configuration:

1. Turn off the output **I OUT** by first pressing the **I OUT** key, and then by pressing the "Off" soft key.
2. Voltage output **V OUT** is configured to be AC by default.
3. Configure input **IN 1** to be a binary input to connect dry (potential-free) or wet contacts (carrying potential when closed), depending on the relay's contact.
4. Connect voltage output **V OUT** to the voltage input of the relay, and **IN 1** to the trip contact of the relay.

Running the test:

1. As a first sequence step, in FLEX configure **V OUT** to nominal voltage at nominal frequency, set the timeout to 5 seconds, and the trigger to "Off".
2. Add a second sequence step.
3. Configure the transition from sequence step 1 to sequence step 2 as ramp with f as the value to be ramped.
4. Set only short frequency steps of say 0.1 Hz or -0.1 Hz, and step times of, for example, 500 ms.
5. Configure the sequence step with the target frequency, and set the trigger to **IN 1**.
6. Start the test.
7. The result will show the frequency where the trip occurred.

Take into consideration that many overfrequency relays require a certain amount of time to determine the precise frequency value. This may be a time span of up to 200 ms, or more. So make sure that the time per individual ramp sequence step is significantly longer than the time the relay needs to determine the precise frequency value. Refer to the relay's user manual for more information.

20 Voltage relay (application example)

WARNING

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

- ► The *COMPANO 100* test set can output life-hazardous voltages and currents.
- ► Before operating any such electrical equipment, carefully read the **Safety Instructions** chapter in this manual (see Safety instructions on page 10).

Voltage relays trip when the monitored voltage considerably deviates from the nominal voltage. To test such a voltage relay, use output **V OUT** with a pulse ramp.

Configuration:

1. Turn off the output **I OUT** by first pressing the **I OUT** key, and then by pressing the "Off" soft key.
2. Voltage output **V OUT** is configured to be AC by default.
3. Configure input **IN 1** to be a binary input to connect dry (potential-free) or wet contacts (carrying potential when closed), depending on the relay's contact.
4. Connect voltage output **V OUT** to the voltage input of the relay, and **IN 1** to the trip contact of the relay.

Running the test:

1. In FLEX, as a first sequence step, configure **V OUT** to nominal voltage at nominal frequency, set the timeout to 5 seconds and the trigger to "Off".
2. Then add a second state.

   This state is exclusively used to determine the start value for the first pulse of the pulse ramp.

   Set the voltage in this state to the over- or undervoltage value that you would like to have for the first pulse.

   Set the timeout to 1 ms. The first pulse will be 1 ms longer but this does generally not affect the result.
3. Add a third state.

   Configure the transition from sequence step 2 to sequence step 3 as ramp with **V OUT** as value to be pulse-ramped.
4. Set the pulse duration long enough for the relay to be able to trip once the pickup voltage is reached.
5. Configure the third sequence step with the target voltage, i.e., the voltage that should make the relay trip in any case. Set the trigger to **IN 1**.
6. Start the test.
7. The result will show the voltage where the trip occurred in sequence step 3.

21 CT wiring tests (application examples)

WARNING

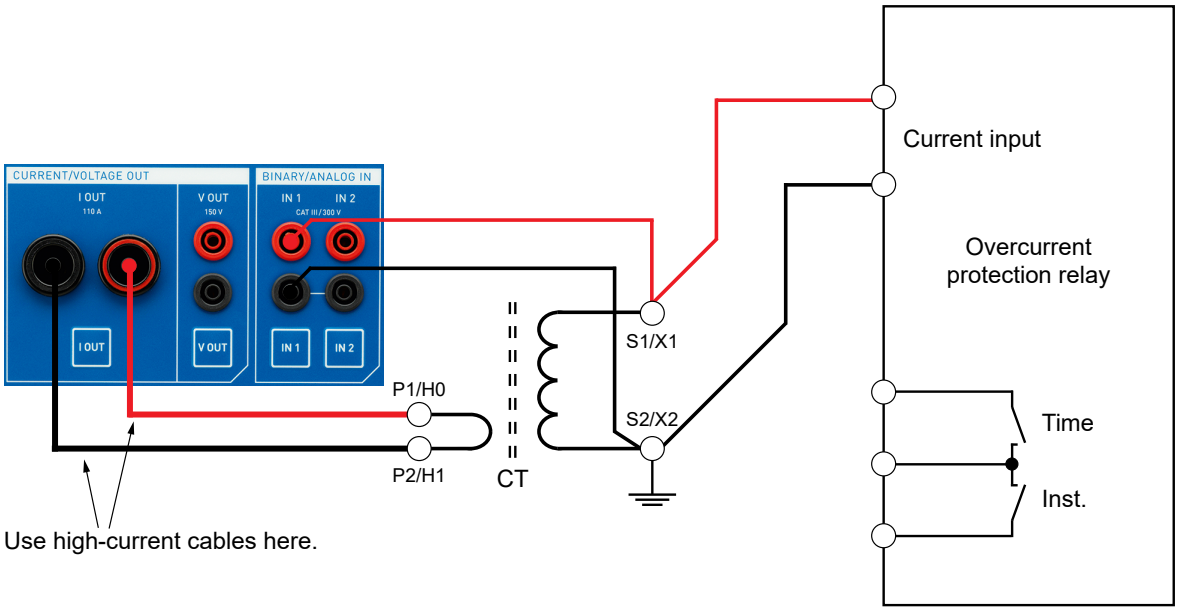
Death or severe injury can occur if the appropriate safety instructions are not observed.

- ► The *COMPANO 100* test set can output life-hazardous voltages and currents.
- ► Before operating any such electrical equipment, carefully read the **Safety Instructions** chapter in this manual (see Safety instructions on page 10).
- ► When injecting current into the CT's primary winding, make sure that no secondary windings are open.
- ► If a shunt is used to measure the current on the secondary side of a CT, check if the shunt if working properly before connecting it to the CT. A damaged shunt may have a high resistance and can lead to dangerous voltages.

If possible, us a current clamp to measure the current on the secondary side of a CT, as it does not require to open the secondary circuit.

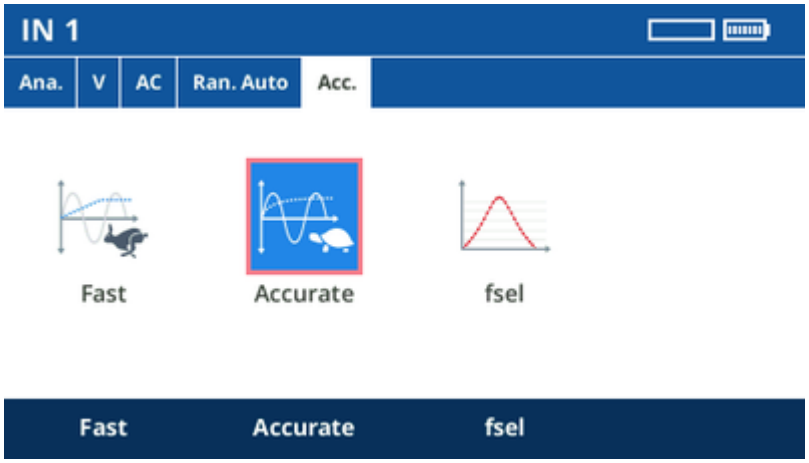
This chapter provides you with examples how to perform tests on a CT (current transformer) and its secondary wiring all the way to the protection relay, the meter, or to the control room display. If you check the wiring of a CT, the CT ratio or measure the CT burden with *COMPANO 100*, it is not necessary to open the secondary wiring.

21.1 Testing CT polarity



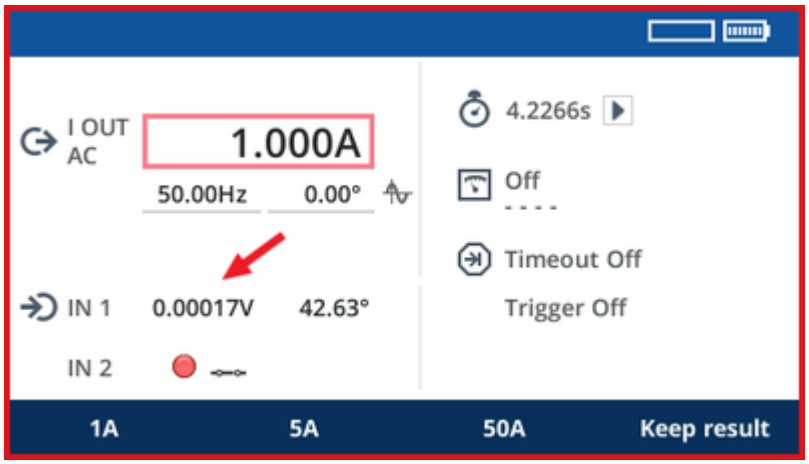
1. Connect *COMPANO 100*'s output **I OUT** to the CT's primary terminals P1/H0 and P2/H1 using the high current cables.
2. Connect the CT's secondary terminals **S1/X1** and **S2/X2** to the current input of the relay and to *COMPANO 100*'s input **IN 1**.

3. Configure *COMPANO 100*'s input **IN 1** to be a voltage input: press the **IN 1** key below the actual input. Press the following soft keys sequentially: **Analog ► Voltage ► AC ► Auto ► Accurate**.



Verify that the CT's secondary loop is closed and check the CT polarity

1. Inject an **I OUT** AC current of 1 A for a few seconds, and read out the voltage on **IN 1**. You should get to see a few millivolts, only.

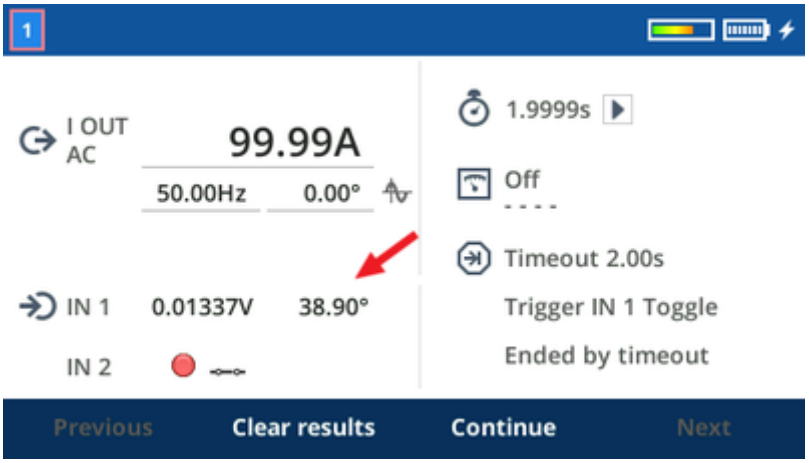


2. If you see a voltage value of say more than 1 V, the secondary loop of the CT might be not closed, which is a safety issue. You should stop the test in that case.

   Now set a timeout to 2 seconds, and inject an **I OUT** AC of say 100 A into the CT.

   The interesting result of this test is the phase angle of the voltage:

   - If it is between 0 ° and 90 °, the CT's polarity is correct.
   - If it is between -90 ° and -180 °, the polarity is not correct.

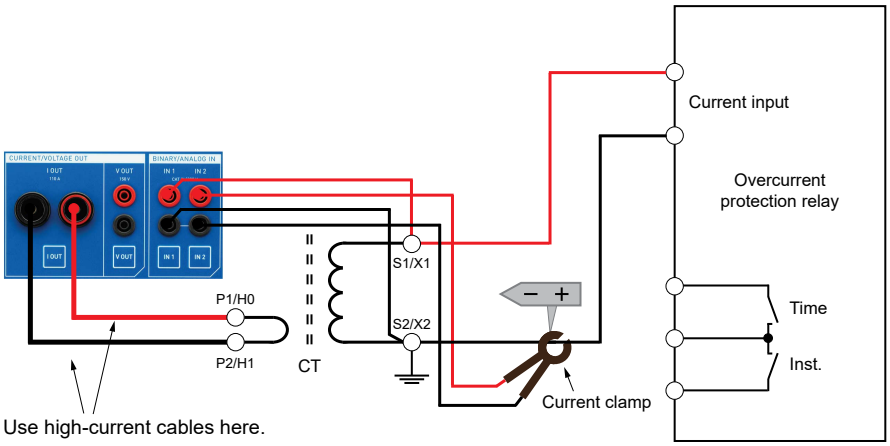


This first step now has verified that the secondary circuit of the CT is closed, and that the polarity of the CT is correct.

21.2 Testing CT ratio

1. Connect the current clamp to the *COMPANO 100* input **IN 2**.

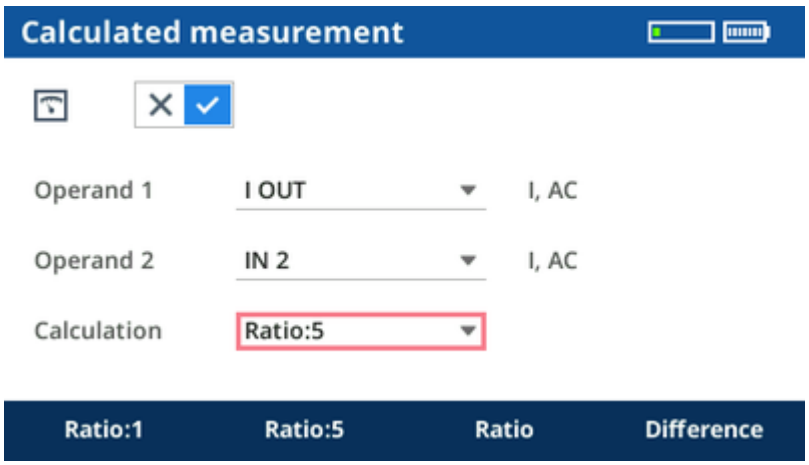
   Note: perform a DC current offset calibration on the current clamp before carrying the measurement.



2. At the current clamp, set a suitable current range, for example, 100 mV/A or 1 V/A, depending on the current clamp type and setting.
3. Configure *COMPANO 100*'s input **IN 2** to be a current input. Press the **IN 2** key below the actual input. Press the following soft keys sequentially: **Analog ► Clamp ► 100 mV/A* ► AC ► Auto ► Accurate**.

   ***Select the value corresponding to the current clamp. Use the jog dial wheel to set a value differing from the preset.
4. Press the **Calculated measurement** key  . Then press the jog dial wheel to turn it **On**.
5. Configure the calculated measurement by using the output current **I OUT** as operand 1, and the input current at **IN 2** as operand 2.

6. Because both operands currents, the **Calculation** setting provides the ratio options **Ratio:1** and **Ratio:5**. Select the proper ratio setting according to the secondary circuit 1 A or 5 A.



7. Return to the QUICK application module, inject a current of 100 A for 2 seconds, and read the ratio from the display.

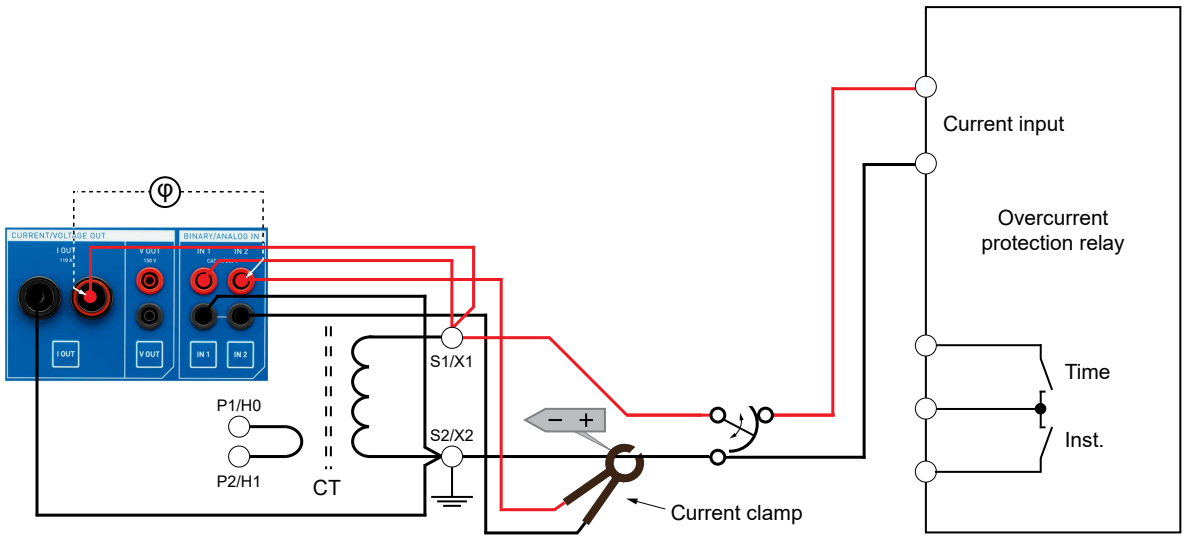
If the measurement result does not match the expected outcome, make sure that the current clamp range is sufficient for the expected current in the secondary circuit.

21.3 Testing CT burden

So far you have verified CT ratio and CT polarity. Now change from primary injection to secondary injection in order to obtain higher secondary currents for a longer period of time.

1. Connect the current output **I OUT** to the CT's secondary terminals **S1/X1** and **S2/X2**. For your convenience, you can use standard measurement cables this time instead of the high current cables.

   Note: perform a DC current offset calibration on the current clamp before carrying the measurement.



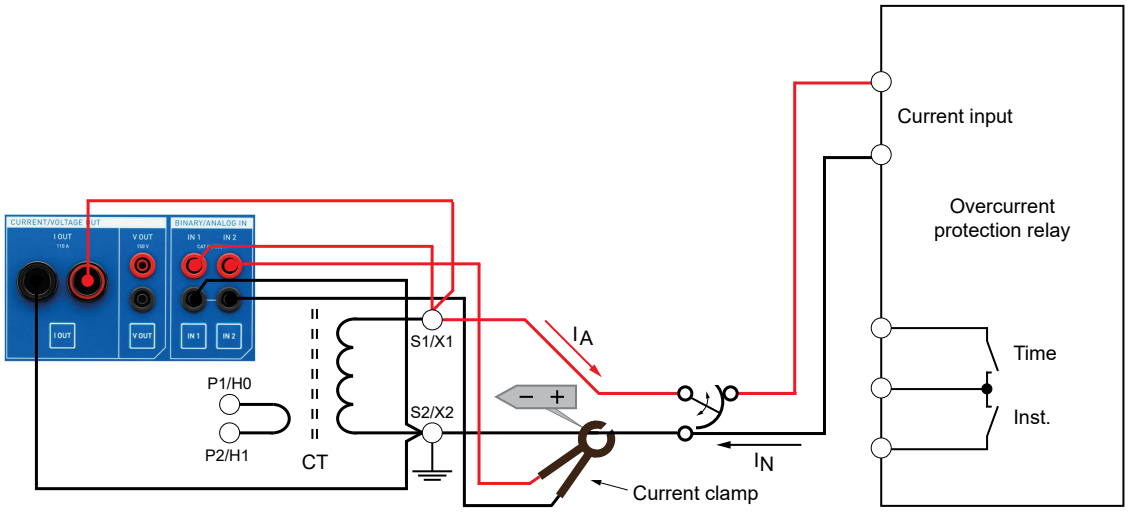
2. In the QUICK application module at **I OUT**, set the nominal secondary current of your choice.
3. Press the **Calculated measurement** key  . Then press the **On** soft key.
4. Configure the calculated measurement for apparent power by using the voltage at **IN 1** as operand 1, and the input at **IN 2** as operand 2.

   Because one operand is a current and the other one a voltage, the **Calculation** setting provides an **apparent power S** option.
5. Now return to the QUICK application module, and inject the nominal secondary nominal current for 2 seconds. The measurement shows the secondary burden of the CT.

21.4 Proper CT ground connection

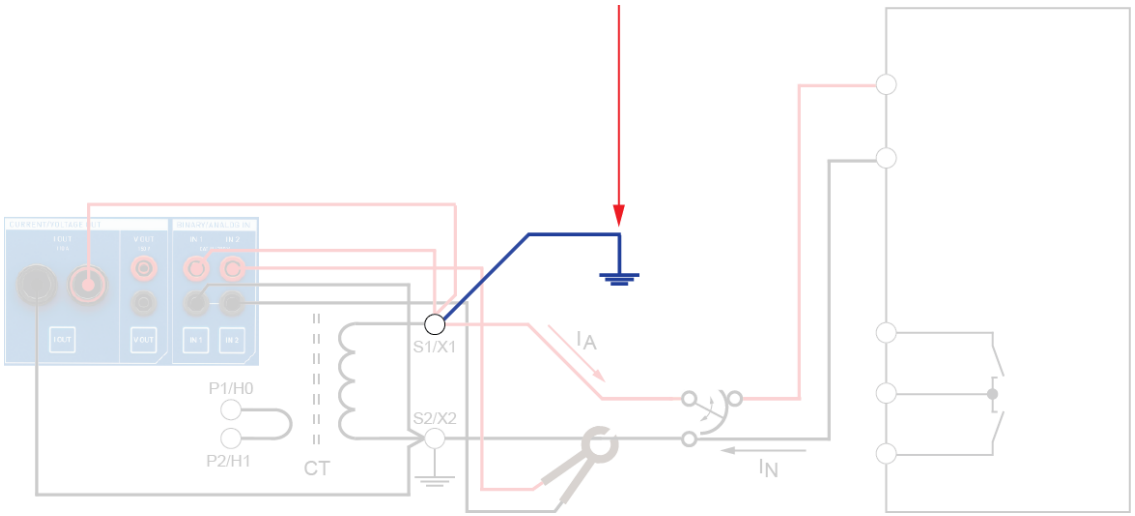
Apply the current clamp to the wire that grounds the CT between the actual grounding point and the relay.

Note: perform a DC current offset calibration on the current clamp before carrying the measurement.



You should read approximately the nominal current. If you only read a portion of the nominal value, there might be an unwanted ground connection on the high side of the wiring. If you only read approximately a third of the nominal value, the grounds of the other current transformers could be linked via connected grounds in the relay.

Now temporarily ground the high side of the CT:

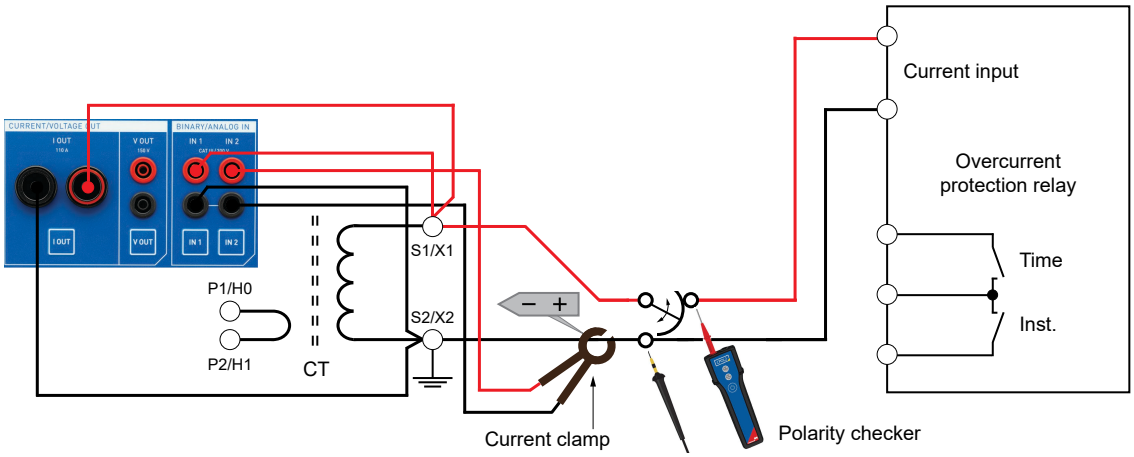


Now, the current reading should approximate zero. If this is not the case, the ground connection (in this example on S2/X2) might be missing. Remove the temporary ground then.

21.5 Testing the polarity of the secondary wiring of the CT

Note: perform a DC current offset calibration on the current clamp before carrying the measurement.

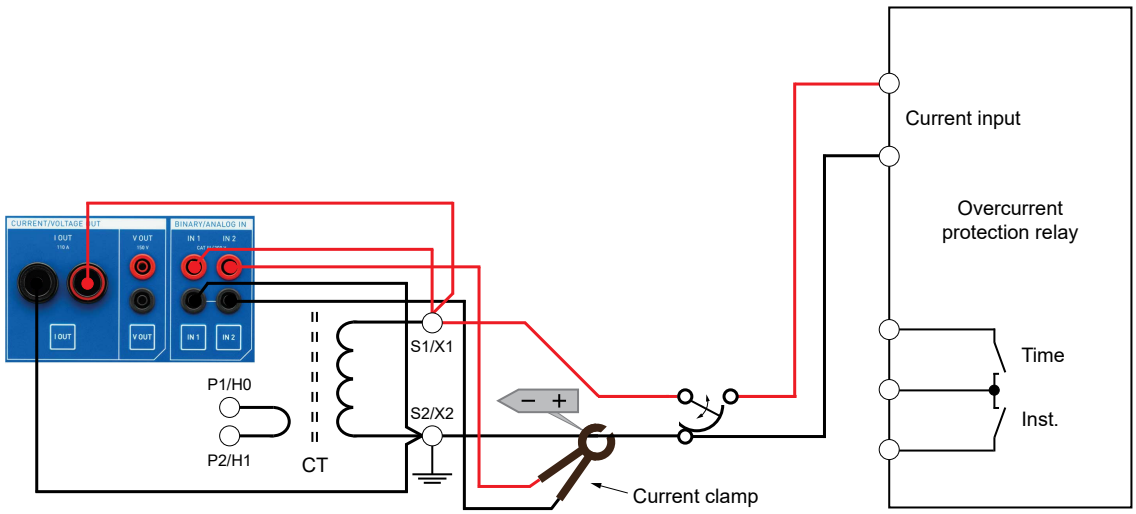
1. Switch to Polarity application module
2. Set it up to inject a polarity check signal of nominal magnitude for an injection time of 1 minute (pause time 0 seconds).
3. Press the **Start/Stop** key.
4. Press the power button of *CPOL*, *CPOL2* or *CPOL3* and verify all points between the CT and the relay: primary, secondary and directly at the relay.



You should see the green happy face LED light up.

21.6 Relay test switch

In case the secondary CT wiring incorporates a relay test switch with a make-before-break functionality to shorten out the CT before disconnecting the relay, you can test this by using a function that detects short interruptions. The moment the make-before-break contact interrupts the current path, the trigger will occur and deactivate the *COMPANO 100*. This is easy to detect, even on the other end of the substation: there is no more polarity check signal. Operate the switch several times to ensure proper operation.



Note: perform a DC current offset calibration on the current clamp before carrying the measurement.

Interruption detection

As additional function, the Polarity Check application module provides an interruption detection, that is, it can detect short interruptions of the secondary path of a current transformer. Its purpose is to detect defective make-before-break switches[1]. Such devices short-circuit the current transformer, then disconnect it from the relay. The order of “making before breaking” is of utmost importance because if there is an interruption, even a very short one, high voltages will occur as long as there is a primary current on the CT.

1. To use the interruption detection, inject a current as close as possible to the CT on the secondary side. We recommend you permanently inject nominal current by setting for example, 1 minute/ 3600 cycles **on** time, and 0 seconds/cycles **off** time. Inject at least 1 A nominal current.
2. While injecting the nominal current, operate the make-before-break switch in the path several times.
3. If an interruption is detected, the Polarity Check application module will shows its time span at **TMax. open**.
   Detected interruptions between 0.1 ms and 5 ms are displayed as such. If an interruption longer than 5 ms is detected, Polarity Check displays a value of **> 5ms**.

Setting a trigger

In case the make-before-break switch is physically far from the *COMPANO 100* test set, set a trigger to disable the output in case an interruption is detected. That way, even being away from the test set, you become aware that such an interruption occurred by noticing the absence of the test signal after operating the make-before-break switch. To do so, turn the jog dial wheel until the focus is on the option field below **Interrupt trigger**. Press the jog dial wheel to toggle the **Interrupt trigger** option. Alternatively, use the **Off**/**On** soft keys.

Note: two limitations apply to that test.

1. In case the inductance of the circuit behind the test switch is very high (due to an extensive wiring or a heavily inductive electro-mechanical relay, or example), a very short interruption may be detected even though the switch is operating properly.
   Such wrongly detected interruptions are generally very short, below 1 ms. If you are in doubt whether you have such a wrongly detected interruption, shorten the CT while the rest of the circuit is connected in parallel. If you then still detect such interruptions, you know that this is the cause for the detection.
2. If the CT connected to the I OUT output is extremely small, say, in the range of 1 VA, it could happen that not the entire 5 ms of interruption time are detected. Reason: before that time has elapsed, the current starts flowing through the CT again.

---

[1] Other commonly-used names for such "change-over make-before-break switches" are "relay test switch", "relay test connector", "shorting devices, or "superior switches".

22 CT tests (application examples)

WARNING

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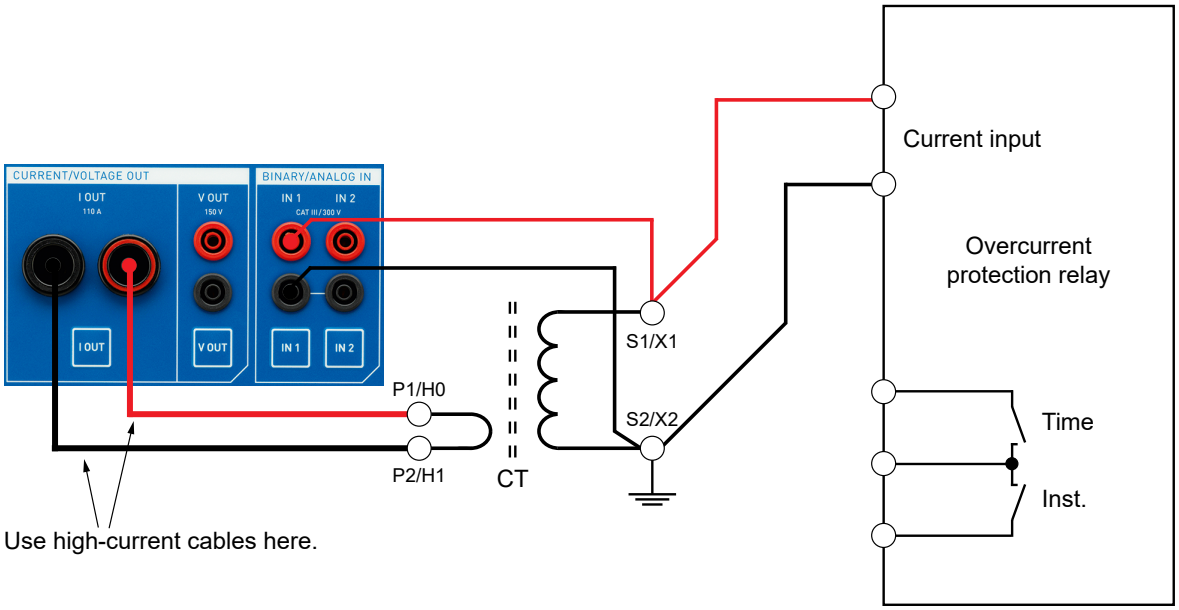
- ► The *COMPANO 100* test set can output life-hazardous voltages and currents.
- ► Before operating any such electrical equipment, carefully read the **Safety Instructions** chapter in this manual (see Safety instructions on page 10).

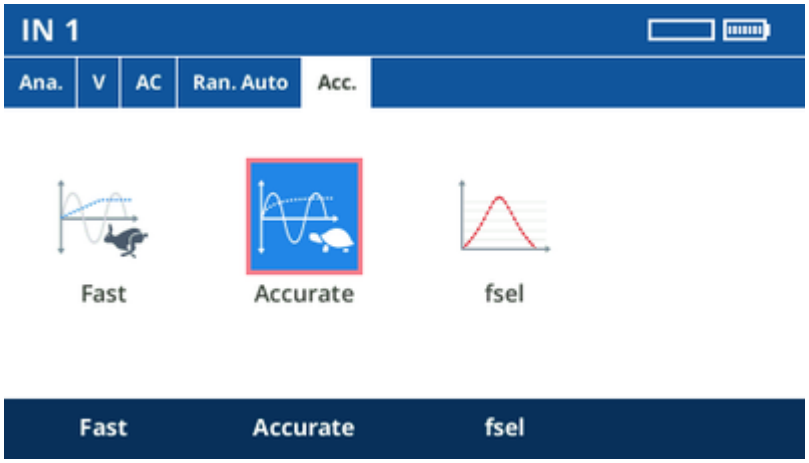
This chapter provides you with examples how to perform basic tests on a current transformer (CT). These tests are done as well when you check the secondary wiring of the CT (see Wiring tests (application example) on page 130). If you check the CT ratio or the CT burden with *COMPANO 100*, it is not necessary to open the secondary wiring.

22.1 Testing CT polarity



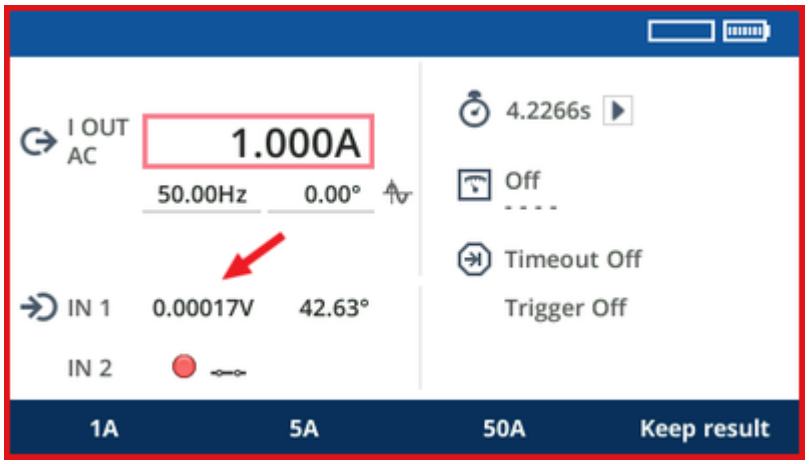
1. Connect *COMPANO 100*'s output **I OUT** to the CT's primary terminals P1/H0 and P2/H1 using the high current cables.
2. The CT's secondary terminals **S1/X1** and **S2/X2** are connected to the current input of the relay (pins 8 and 9).

3. Configure *COMPANO 100*'s input **IN 1** to be a voltage input: press the **IN 1** key below the actual input. Press the following soft keys sequentially: **Analog ► Voltage ► AC ► Auto ► Accurate**.



Verify that the CT's secondary loop is closed and check the CT polarity

1. Inject an **I OUT** AC current of 1 A for a few seconds, and read out the voltage on **IN 1**. You should get to see a few millivolts, only.

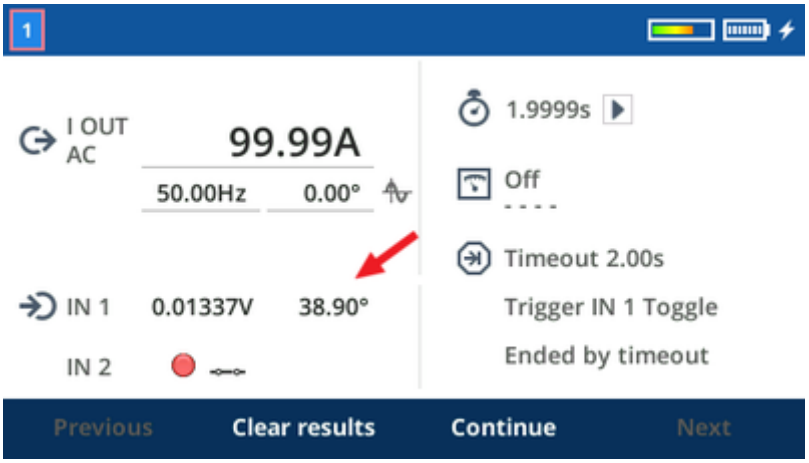


2. If you see a voltage value of say more than 1 V, the secondary loop of the CT might be not closed, which is a safety issue. You should stop the test in that case.

   Now set a timeout to 2 seconds, and inject an **I OUT** AC of say 100 A into the CT.

   The interesting result of this test is the phase angle of the voltage:

   - If it is between 0 ° and 90 °, the CT's polarity is correct.
   - If it is between -90 ° and -180 °, the polarity is not correct.

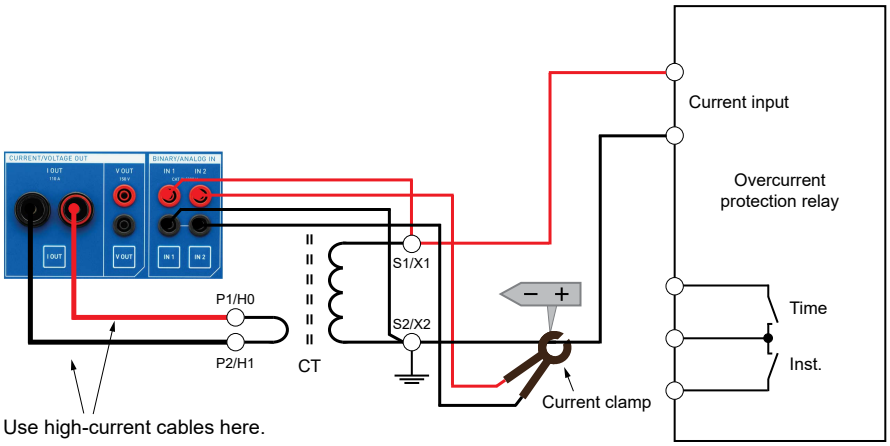


In this first step, we have now verified that the secondary circuit of the CT is closed, and that the polarity of the CT is correct.

22.2 Testing CT ratio

1. Connect the current clamp to the *COMPANO 100* input **IN 2**.

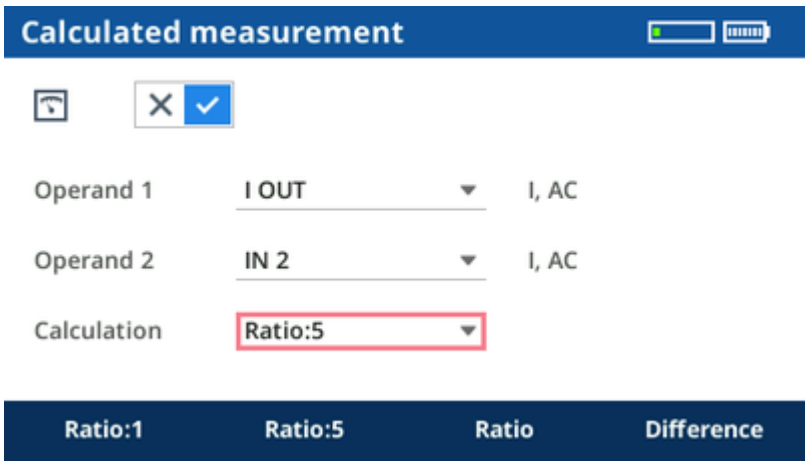
   Note: perform a DC current offset calibration on the current clamp before carrying the measurement.



2. At the current clamp, set a suitable current range, for example, 100 mV/A or 1 V/A, depending on the current clamp type and setting.
3. Configure *COMPANO 100*'s input **IN 2** to be a current input. Press the **IN 2** key below the actual input. Press the following soft keys sequentially: **Analog ► Clamp ► 100 mV/A* ► AC ► Auto ► Accurate**.

   ***Select the value corresponding to the current clamp. Use the jog dial wheel to set a value differing from the preset.
4. Press the **Calculated measurement** key  . Then press the jog dial wheel to turn it **On**.
5. Configure the calculated measurement by using the output current **I OUT** as operand 1, and the input current at **IN 2** as operand 2.

6. Because both operands currents, the **Calculation** setting provides the ratio options **Ratio:1** and **Ratio:5**. Select the proper ratio setting according to the secondary circuit 1 A or 5 A.



7. Return to the QUICK application module, inject a current of 100 A for 2 seconds, and read the ratio from the display.

If the measurement result does not match the expected outcome, make sure that the current clamp range is sufficient for the expected current in the secondary circuit.

23 VT/PT tests (application examples)

WARNING

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

- ► The *COMPANO 100* test set can output life-hazardous voltages and currents.
- ► Before operating any such electrical equipment, carefully read the **Safety Instructions** chapter in this manual (see Safety instructions on page 10).

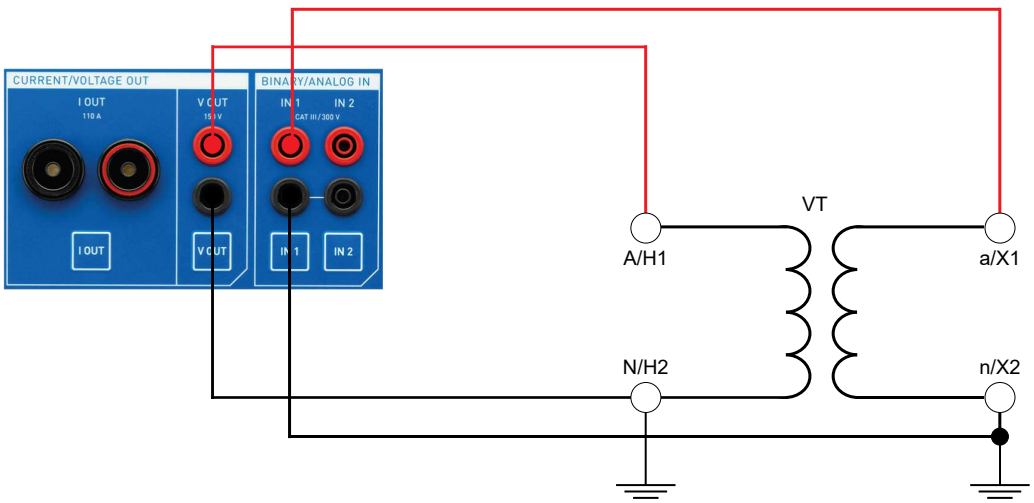
This chapter provides you with examples how to perform basic tests on a voltage/potential transformer (VT/PT). VT/PT circuits in general have an MCB (**M**iniature **C**ircuit **B**reaker) for overcurrent protection in the circuit. The MCB is open for all tests. Apart from that, it is not necessary to open any connections of the secondary wiring.

23.1 Testing VT/PT ratio and polarity

WARNING

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

- ► Inject voltage to the high voltage side of the VT/PT, only (primary contacts **A/H1** and **N/H2**). Injecting voltage to the low voltage side steps us the voltage, and hazardous voltage levels on the high voltage side can occur.



1. Connect the **V OUT** output of the *COMPANO 100* test set to the VT/PT's primary contacts **A/H1** and **N/H2**.
2. Connect the VT/PT's secondary contacts **a/X1** and **n/X2** to the **IN 1** input.
3. Turn off the output **I OUT** by first pressing the **I OUT** key, and then by pressing the "Off" soft key.

4. Voltage output **V OUT** is configured to be AC by default.
5. Configure **IN 1** to be a voltage input by first pressing the **IN 1** key, and then by pressing the following soft keys sequentially: **Analog ► Voltage ► AC ► Auto ► fsel**.

   The frequency-selective measurement is needed because the expected voltage is very small. To avoid interferences with other signals, a frequency different from mains frequency, for example 80 Hz, is used. The frequency-selective measurement assures that only the 80 Hz components of the input signal are measured.
6. Configure the calculated measurement to measure a ratio. Press the **Calculated measurement** key, switch on the measurement, select **V OUT** as operand 1, IN 1 as operand 2, and Ratio:1 as calculated measurement.

Check the ratio of the VT/PT

1. Go to the QUICK application module.
2. Set a **V OUT** AC voltage of 150 V.
3. Set the output frequency to 80 Hz.
4. Start the output for say 2 seconds, and deactivate the output manually after that time.
5. The ratio is displayed as calculated result in the QUICK screen.
6. The phase angle of IN 1 should be around 0 °. If it is around 180 °, the VT/PT has a wrong polarity (which is, in fact, very unlikely).

Note: CCTVs require higher testing voltages and cannot be tested with *COMPANO 100*. We recommend using an OMICRON *VOTANO* test set for such a purpose.

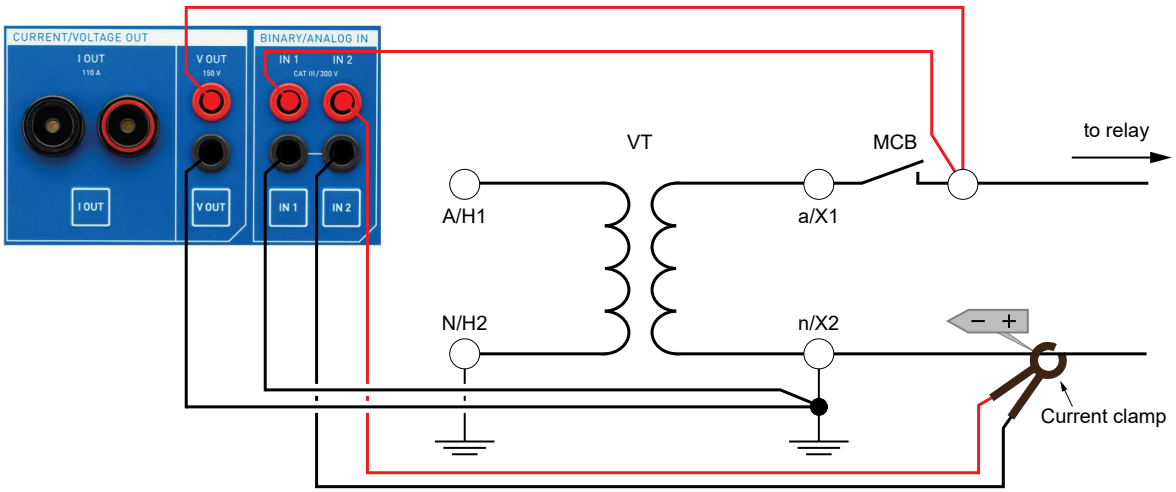
23.2 Testing VT/PT burden

WARNING

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

- ► The *COMPANO 100* test set can output life-hazardous voltages and currents.
- ► Before operating any such electrical equipment, carefully read the **Safety Instructions** chapter in this manual (see Safety instructions on page 10).

This chapter provides you with an example of how to measure the burden of a voltage/potential transformer (VT/PT).



1. Open the MCB (miniature circuit breaker) on the VT/PT's secondary side.
2. Connect the *COMPANO 100* test set's output **V OUT** to the VT/PT's secondary wiring ***behind*** the open MCB.

   Attention:

   - Make sure you do not accidentally inject voltage to the secondary side of the VT/PT (to the VT/PT's secondary contact **a/X1**, for example) as this would generate an unexpected high voltage on the primary side of the transformer.
   - Make sure the MCB is open.
3. Connect the *COMPANO 100* test set's input **IN 1** to the same point, using a second set of connection wires.

4. Configure *COMPANO 100*'s input **IN 1** to be a voltage input: press the **IN 1** key below the actual input. Press the following soft keys sequentially:

   Analog ► Voltage ► AC ► Auto ► Accurate

5. Connect a current clamp to the *COMPANO 100* input **IN 2**.

   Note: perform a DC current offset calibration on the current clamp before carrying the measurement.

6. At the current clamp, set a range corresponding to the clamp type. The secondary current on VT/PT circuits is usually very low. In most cases the smallest range of the current clamp is suitable.

7. Apply the current clamp around a secondary wire of the CT.

8. Configure *COMPANO 100*'s input **IN 2** to be a current input. Press the **IN 2** key below the actual input. Press the following soft keys sequentially:

   Analog ► Clamp ► 100 mV/A* ► AC ► Auto ► Accurate

   ***Select the value corresponding to the current clamp. Use the jog dial wheel to set a value differing from the preset.

9. Turn off the output **I OUT** by first pressing the **I OUT** key, and then by pressing the "Off" soft key.

10. **V OUT** is configured to be AC by default.

11. In the QUICK application module at **V OUT**, set the nominal secondary voltage of your choice.

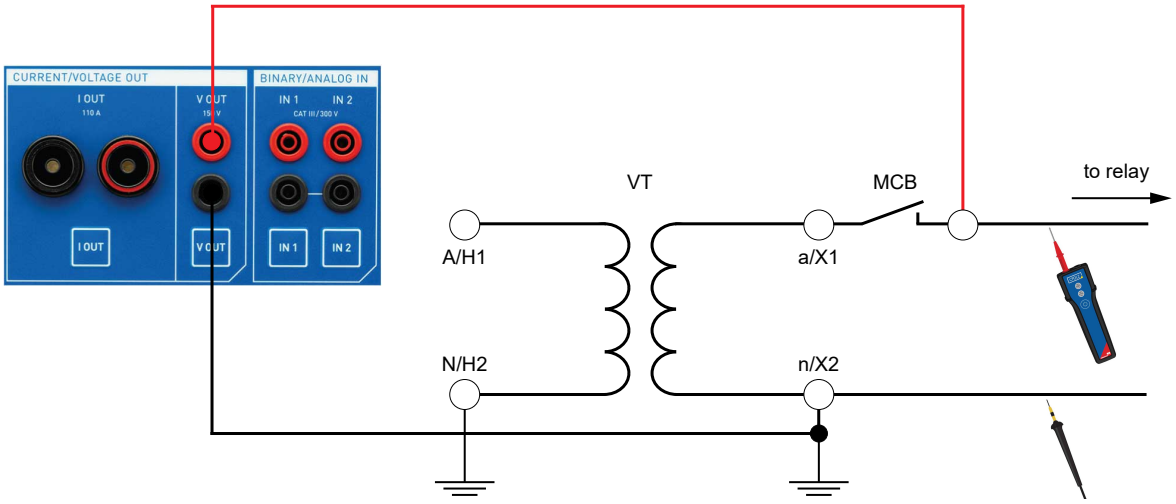
12. Press the **Calculated measurement** key  . Then press the **On** soft key.

13. Configure the calculated measurement for apparent power by using the voltage at **IN 1** as operand 1, and the input at **IN 2** as operand 2.

    Because one operand is a current and the other one a voltage, the **Calculation** setting provides an **apparent power S** option.

14. Now return to the QUICK application module, and inject the nominal secondary nominal voltage for 2 seconds. The measurement shows the secondary burden of the CT.

23.3 Testing VT/PT secondary wiring polarity



1. Open the MCB (miniature circuit breaker) on the VT/PT's secondary side.
2. Connect the *COMPANO 100* test set's output **V OUT** to the VT/PT's secondary wiring ***behind*** the open MCB.

   Attention:

   - Make sure you do not accidentally inject voltage to the secondary side of the VT/PT (to the VT/PT's secondary contact **a/X1**, for example) as this would generate an unexpected high voltage on the primary side of the transformer.
   - Make sure the MCB is open.
3. Turn off the output **I OUT** by first pressing the **I OUT** key, and then by pressing the "Off" soft key.
4. **V OUT** is configured to be AC by default.

Check the polarity of the VT/PT's secondary wiring

1. Start the Polarity Check application module.
2. Set an **V OUT** AC voltage of 50 V.
3. Start the output.
4. Check the secondary wiring using OMICRON's polarity checker *CPOL*, *CPOL2* or *CPOL3* by following the signal from the point of injection throughout the power utility to the relay or meter.

In voltage/power transformers with a high ratio, the secondary voltage might be too low for *CPOL*. Use *CPOL2* or *CPOL3*.

24 Grounding system tests (application examples)

WARNING

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

Unexpected high voltages can occur at output **I OUT** or **V OUT** at any time, and the auxiliary current probe carries the full output voltage of the *COMPANO 100* test set.

- ► Always press the emergency stop button before working with these connectors.
- ► Before activating the output, place a guard next to the auxiliary current probe who assures that nobody comes close to it or, even worse, accidentally pulls it out off the ground.

This chapter provides you with examples how to perform grounding system tests.

24.1 Grounding system integrity check

WARNING

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

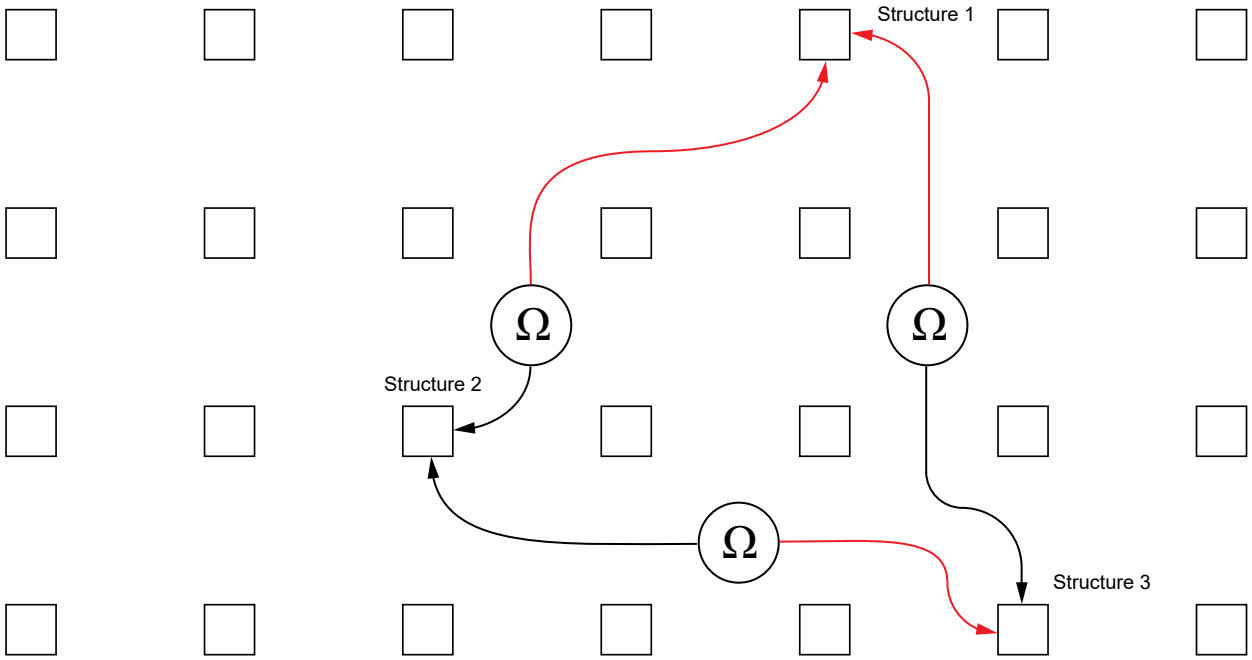
In the unlikely event of an internal error of the *COMPANO 100* test set, higher voltages than expected can occur at output **I OUT**.

- ► Always press the emergency stop button before working with this connector.

Within the fenced area of a substation there is generally a grounding system with literally hundreds of assets, fence posts, transmission towers and other metallic objects of the substation connected to it. Each one of these objects should have a proper connection that must be verified after erection, during commissioning or changes, or as a later routine test to prove that none of these connections is corroded or otherwise damaged. Should these tests be neglected, a corroded ground connection can result in fatal consequences in case of an earth fault and its fault current not finding a direct way to the station ground.

Ideally, all ground connections are referenced to a single proper ground connection point. The first task is to find such a good ground connection point. In order to do so, randomly pick three ground connection points, for example, grounded metallic structures, and measure them with *COMAPNO 100*'s **Micro-ohm** application (see image below).

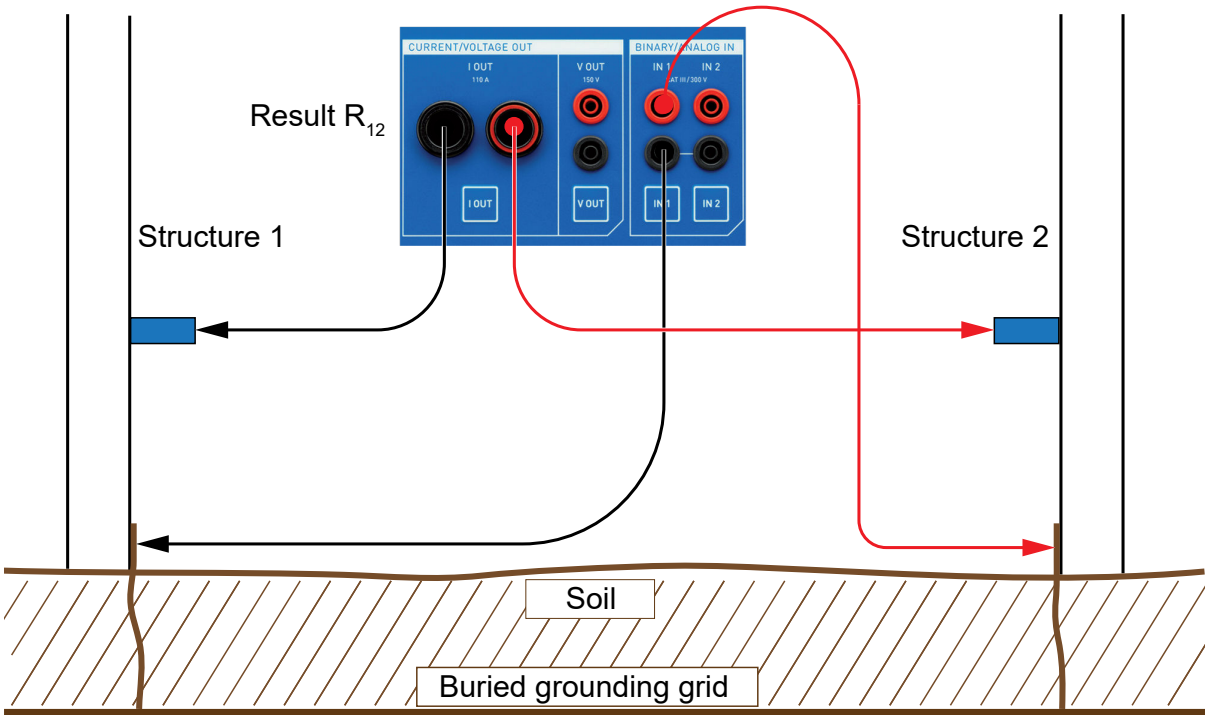
These points should have a certain distance to the *COMPANO 100* test set. The grounding packages that OMICRON provides come with 10 m (30 ft) cables. So we recommend a distance of 20 m (60 ft).



A test current of 100 A and a timeout of 1 second in the 100 mV range are generally a good choice.

The grounding packages that OMICRON provides come with three sets of 10 m (30 ft) measurement cables. If testing with a higher current is not possible, try to use two cables set in parallel for the injection (marked with **I**) and one cable for the measurement (marked with **V**). This reduces the power dissipated in the cables.
If the resistance is still to high, you can use the optional 6 m (19.5 ft) high-current cable set (P0006213) or contact OMICRON Support (→ Support on page 175) for a custom cable set.

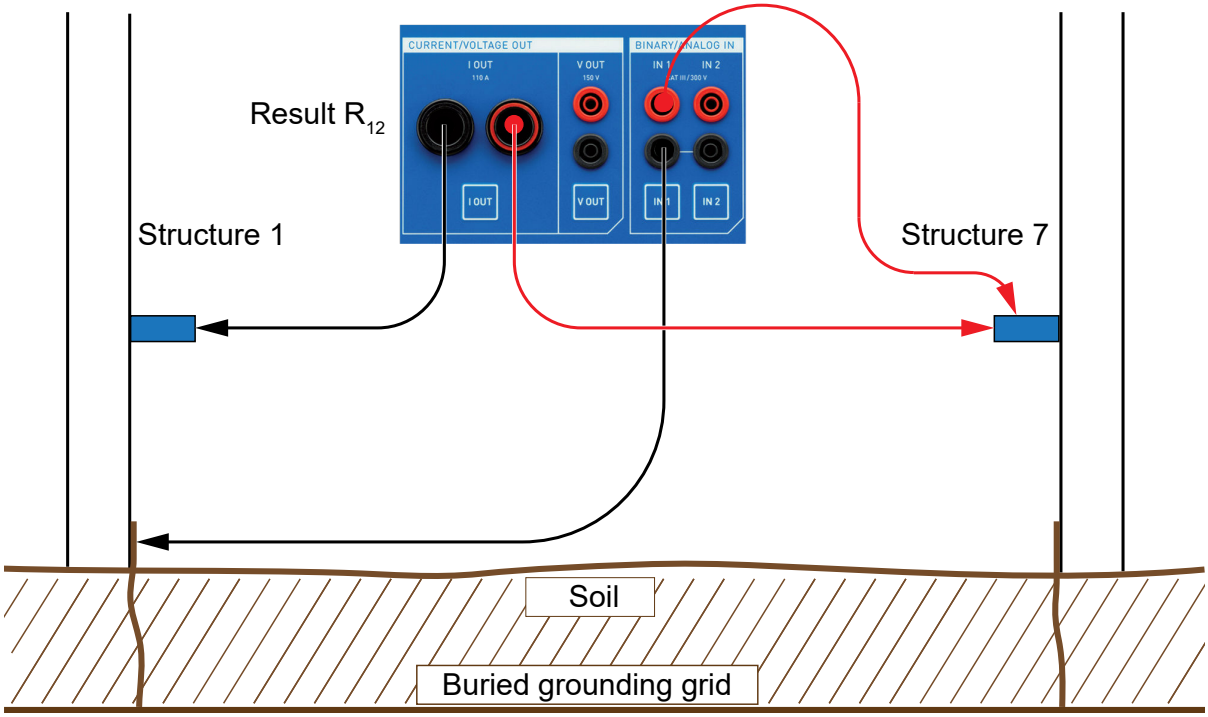
Do each of the three measurements using four wires, sensing (voltage input **IN1**) as close as possible to the grounding grid, and the current injection higher on the structure above ground (see image below).



Add together the two acquired results for each structure, for example, for structure 2 the results R12 + R23. Take the structure with the lowest sum as the reference point for the substation.

Of course you can invest more efforts in finding the perfect reference point, but in general any point of a substation that is in sound condition should be suitable to serve as reference point. Using that reference point, all ground connections and grounding points (ground studs) in the vicinity of the reference point are then tested and documented.

Effective testing of the other grounding points should ***not*** be done with the sensing wire (voltage input **IN1**) as close to the grounding grid as possible but rather at the test point itself.



In our example the structure 7 has a grounding stud. That stud must have proper connection to the grounding grid in case it is used to ground a part of the substation to protect the staff. Therefore, connect the measurement reference point directly at the stud, nevertheless keeping current and voltage path separated.

For grounding studs a Kelvin clamp, for threads a Kelvin screw can be a convenient accessory. Both devices clearly separate current and voltage path to guarantee a proper four-wires measurement.

Kelvin clamp

Kelvin screw

In case of a bigger substation, it may become necessary to have more than one reference point. In such cases, the method of finding a good reference point can be repeated. Before starting the second series of measurements, make sure to measure and thoroughly document the resistance between different reference points.

24.2 Grounding system measurements

Refer to the descriptions of the corresponding application modules for more information:

→ Ground impedance on page 53

→ Step and touch voltage on page 68

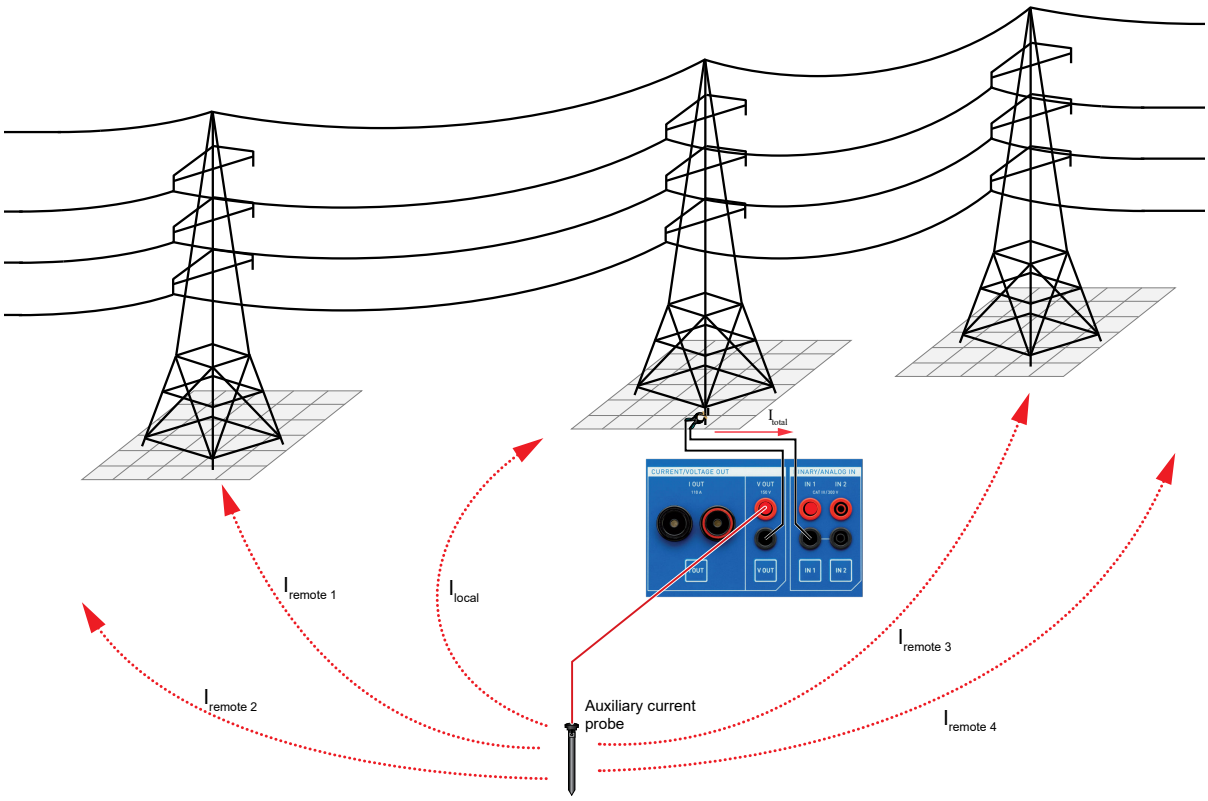
→ Soil resistivity on page 79

24.3 Reduction factor

A typical example for current reduction is the grounding system of a high voltage transmission tower. If such a tower has a ground wire, a part of the current that is injected into the grounding system (I_{total}) in fact flows through the local grounding system (I_{local}). Another part runs through the ground to other transmission towers (I_{remote}) and back via the ground wire, therefore reducing the current flow through the local grounding system.

The ratio between the current flowing through the local grounding system (I_{local}) and the total injected current (I_{total}) is the current reduction factor.

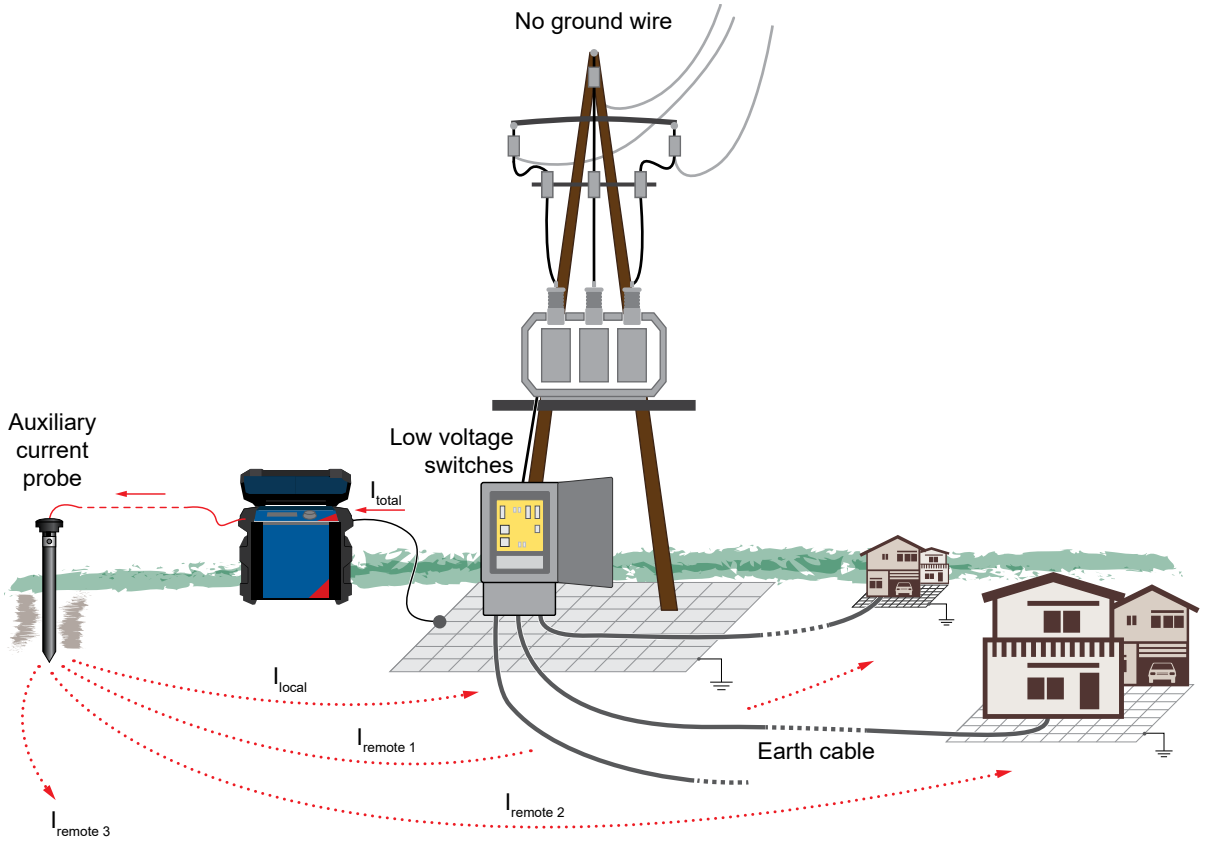
A Rogowski coil can be used the measure the current via the legs of the transmission tower. This measurement can be performed with *COMPANO 100* leg by leg. *COMPANO 100* will then calculate the resulting current reduction factor. Therefore, it is necessary to specify the position of the Rogowski coil in relation to the injection point (above or below). Refer to Reduction factor on page 59 for more details.



Another example would be a pole-mounted distribution substation like shown below. Here, a part of the injected current will flow through the local grounding system (I_{local}). Another part will flow through remote grounding systems, for example of buildings, and through the PEN conductors of low-voltage cables back to the substation.

A Rogowski coil can be used to measure the current flowing through the conductors of the cables. The currents on the phases will cancel themselves, except for the current flowing through the remote grounding system. This measurement can be performed with *COMPANO 100* cable for cable. If possible, it is advisable to measure multiple cables at once to reduce the impact of the measurement error of the Rogowski coil. For such an application scenario, the **Current direction** in the **Reduction factor** screen must be set to **Reduction**. Refer to Reduction factor on page 59 for more details.

If the pole-mounted distribution substation has a ground wire on top of the pole, this current must be measured as well since it reduces the current flowing through the local grounding system.



25 CB tests (application examples)

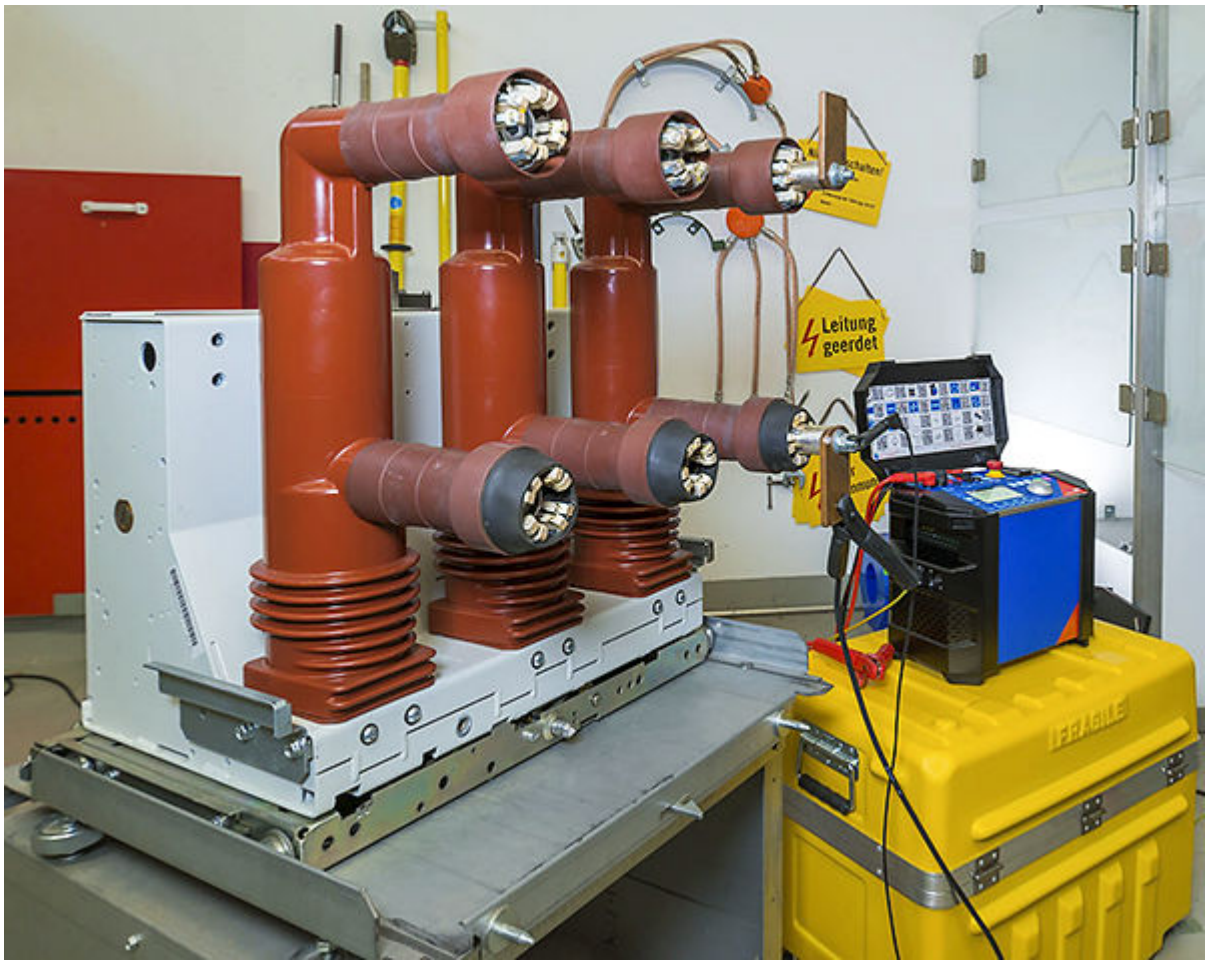
WARNING

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

- ► The *COMPANO 100* test set can output life-hazardous voltages and currents.
- ► Before operating any such electrical equipment, carefully read the **Safety Instructions** chapter in this manual (see Safety instructions on page 10).

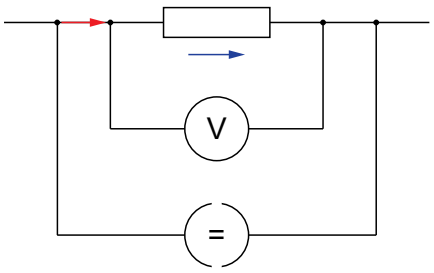
With *COMPANO 100* you can measure the resistance of a busbar joint or of a closed circuit breaker. Here, we give an example for the latter.

25.1 4-wire resistance measurement



In order to avoid any influence by the contact resistance of the clamps that are connected to the breaker's contacts, it is important to use the four wires (and four contact points!) technique. The current is injected using two wires, the voltage is measured using a second pair of wires.

Because there is only a neglectable current flowing on the voltage path, there no voltage drop created by the clamps of the current injection; means: there is no voltage drop that could possibly have an impact on the measurement result. It is important to understand that the point of connection of the voltage clamps determines what part of the resistance is measured.



When doing breaker measurements, you have two possibilities to measure:

1. Option one is to only measure the resistance of the contact itself. This is the value that breaker manufacturers quote in the breaker’s datasheet. This option makes sense to verify the breaker’s specifications. It is furthermore useful for "trending", that is, for surveying changes in the breaker's characteristics over the years.
2. Option two is including the breaker’s connectors to the measurement. Additionally testing the breaker's connectors may prove beneficial for certain maintenance measurements because the breaker’s resistance being within the limits is of little relevance when the breaker’s connectors to the busbar overheat in case of a fault.

On high voltage breakers it is generally easier selecting connection points since all points are easily accessible for connecting clamps.

25.2 Special connection accessories

On medium voltage breakers, for example breakers equipped with tulip contacts (see photo at the right), it is often not possible to access the breaker directly using the 4-wire technique since the fingers of the tulip contacts are interconnected high-ohmic, therefore ruining the result.

Therefore, in order to measure the total resistance of the breaker, insert stubs substituting the connection points of the busbar (see photo at the right).

To only measure the resistance of the breaker contact, the tulip contacts need to be removed from the breaker. In many cases it is then difficult to access the contact because there is literally only one single thread in a massive piece of metal. In such a case use a Kelvin screw (see photo at the right). A Kelvin screw makes a high current contact to the thread itself, and an independent voltage contact to the surface around the thread. Kelvin screws are available for several different threads that are common on breakers.

Kelvin clamps also provide the possibility of establishing two independent connections using one clamp, only. The two brackets of the clamp are insulated against each other. Such clamps are ideal when connecting to massive conductors like busbars or connector plates (spades) of a breaker.

For the actual measurement, connect the high current cables to the **I OUT** current output, and the voltage sense cables to the **IN 1** measurement input. Once the connection is properly done, the measurement itself is simple. Open the **Micro-ohm** application module, set the current, and press the **Start/Stop** key to carry out the measurement. Stop it after the result has stabilized.

Note that the **IN 1** measurement input is put into a special mode in the **Micro-ohm** application module, suppressing AC noise on a hardware level much more than this is possible in QUICK or FLEX.

In case the output stops automatically because the high current drove *COMPANO 100* to its thermal limit, the result is still valid.

Note: *COMPANO 100* can output 100 A DC for a few seconds, only. Consequently, breakers with included CTs (generally dead tank breakers) cannot be tested with *COMPANO 100*; such tests need a longer time to completely saturate all CTs before a measurement is taken.

26 MCB tests (application examples)

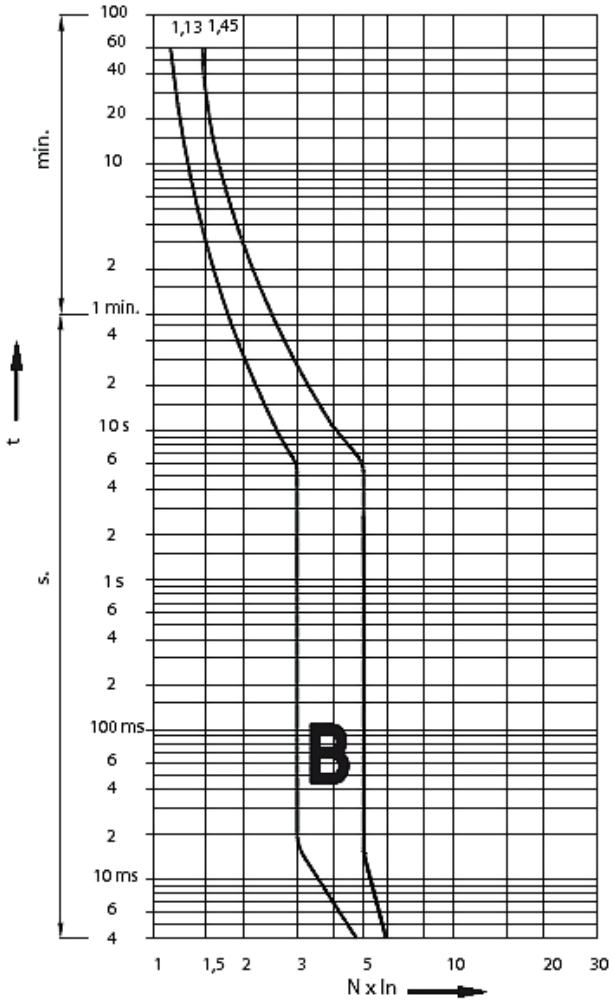
WARNING

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

- ► The *COMPANO 100* test set can output life-hazardous voltages and currents.
- ► Before operating any such electrical equipment, carefully read the **Safety Instructions** chapter in this manual (see Safety instructions on page 10).

MCBs (miniature circuit breaker) are factory-tested, and in general that is sufficient for the rest of their service life. Special circumstances, however, may require MCB tests. *COMPANO 100* is capable of testing approx. 90 % of the ≤13 A circuit breakers, and 80 % of the 16 A circuit breakers.

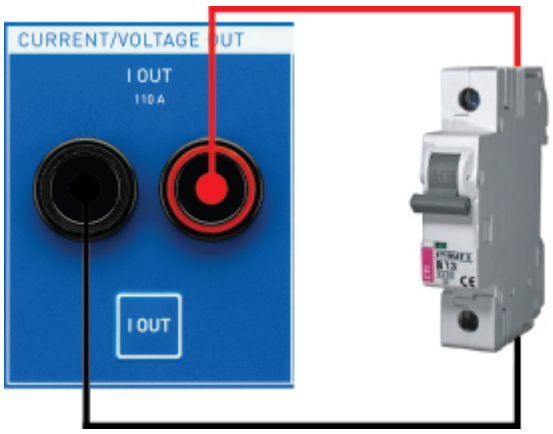
The higher the fault current detected by the MCB, the faster the circuit breaker trips. Most MCB have both a magnetic and a thermal overcurrent detection, so that above a certain level of current, the trip occurs particularly quick (see graph of a typical overcurrent-time characteristic).



With such a characteristic, the MCBs avoid nuisance trips, for example on inrush currents beyond the nominal current. The tolerances of these two curves are significant. In the example given, the trip times at three times the nominal current can vary from 6 seconds up to 30 seconds, still being within the tolerance.

26.1 Manual MCB testing with QUICK

1. For this test, disconnect the MCB from any other circuits.
2. Then connect the MCB to the **I OUT** output of the *COMPANO 100* test set:



3. To do a manual single test, use the QUICK application module. All you need to do is configuring the trigger to **I OUT Overload**, set an output current, and wait for the breaker to trip.

The overload indicator is delayed by 200 ms in either direction, coming and going. This is necessary to suppress short spikes of the detection, on one hand, and, on the other hand, to reliably evaluate that the overload has finally cleared instead of just disappearing temporarily like, for example, during zero crossing. This means, if you do a time measurement using "Overload" triggers, add to or deduct from the result 200 ms, accordingly.

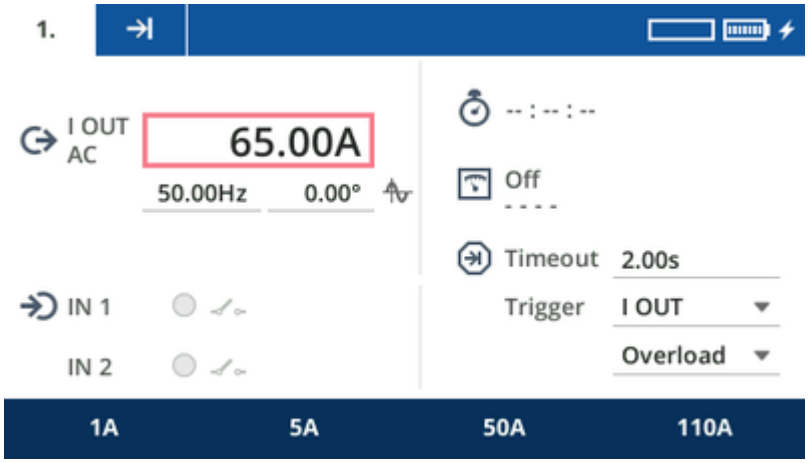
26.2 Automated MCB testing with FLEX

This example shows how to automate the measurement of three interesting points. Use the FLEX application module to program a sequence that detects the overload of the output once the breaker trips. Such a semi-automatic test makes sense if the number of breakers to test is higher.

Three test points are tested:

- first, the current for the magnetic trip (in our example five times nominal current)
- the final point where the thermal overcurrent detection will trip and the magnetic one should not (in our example three times nominal current)
- and a longer time period of nominal current for a stability test (when the breaker is still warm from the thermal trip before).

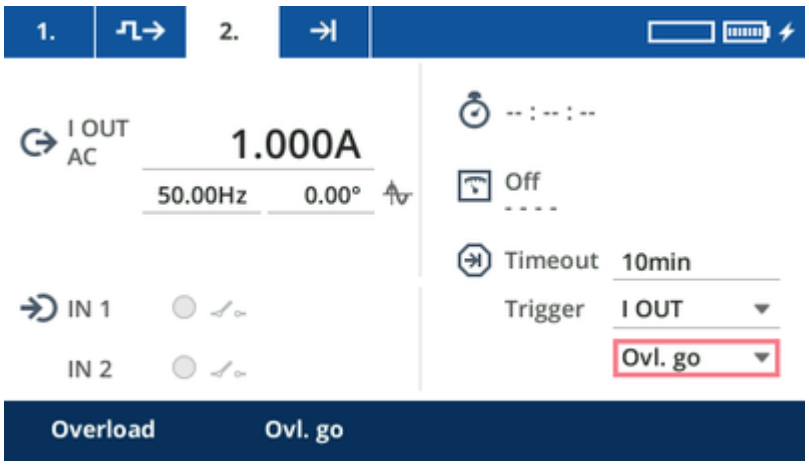
1. The first step of such a FLEX sequence is a step issuing five times the nominal current, with a trigger **I OUT Overload**, and a timeout of 2 seconds to protect the circuit and the cables in case something goes wrong.



Example screenshot

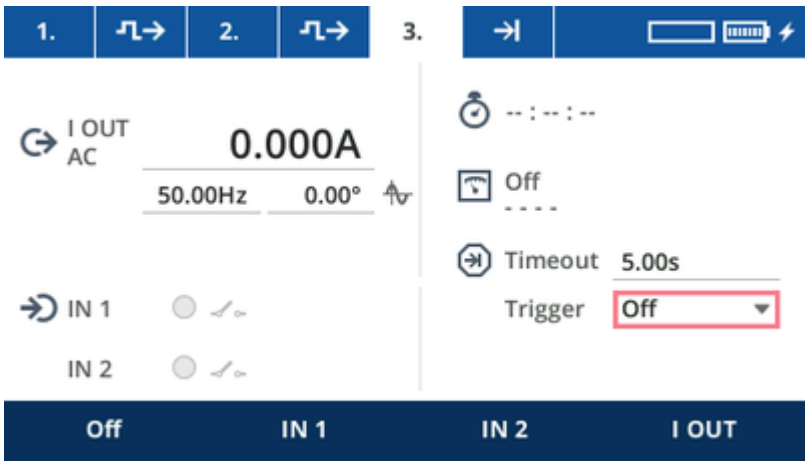
When the breaker trips, the operating time is recorded.

2. In the next step, the MCB needs to be manually closed again. To detect the closing, add a sequence step 2, and set an output current of **I OUT** = 1 A, a timeout of 10 minutes, and a trigger **I OUT Overload Go**. That way you have sufficient time to close the breaker.



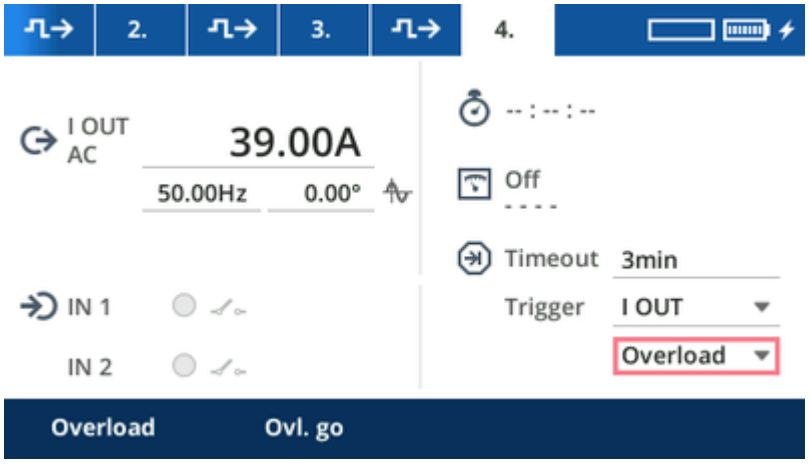
Example screenshot

3. To avoid having to hold the MCB in your hands while it trips, set an additional sequence step 3 with 0 A for 5 seconds.



Example screenshot

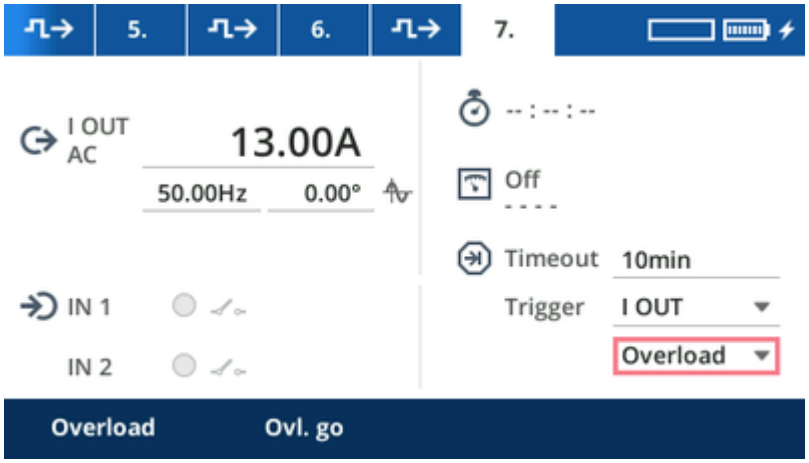
4. Add a sequence step 4 with an output current of three times the nominal current. In that sequence step the MCB's thermal mechanism should react at some point between 6 seconds and slightly below 3 minutes.



Example screenshot

5. Add two more sequence steps with values as before: sequence step 5 with an output current of 1 A, a timeout of 10 minutes, and a trigger **Overload go**; and a sequence step 6 with 0 A for 5 seconds.

6. As a last sequence step, sequence step 7, add a stability test with an output current of 13 A for 10 minutes. The MCB should not trip in that time, nevertheless set **I OUT Overload**, this time expecting that the overload will not occur.



Example screenshot

For a 13 A MCB, for example, with the above shown overcurrent-time characteristics, in a tabular form the sequence looks as follows:

Step	I OUT	f	Timeout	Trigger	Transition
1	65 A	50 Hz	2 s	I OUT Overload	Step
2	1 A	50 Hz	10 min	I OUT Ovl. Go	Step
3	0 A	50 Hz	5 s	Off	Step
4	39 A	50 Hz	3 min	I OUT Overload	Step
5	1 A	50 Hz	10 min	I OUT Ovl. Go	Step
6	0 A	50 Hz	5 s	Off	Step
7	13 A	50 Hz	10 min	I OUT Overload	Step

- Prior to starting the test, make sure the MCB is closed.
- Press the **Start/Stop** key. The MCB should trip immediately.
- Close the circuit breaker within the next 10 minutes. About 5 seconds later, you will hear the MCB humming loudly as the magnetic trip is working but not strong enough for the trip.
- Finally after a while — within 3 minutes — the circuit breaker will trip again.
- Close the circuit breaker within the next 10 minutes. The MCB should not trip again at its nominal current of 13 A.

To see the results of the individual sequence steps, press the **Previous** or **Next** soft keys. The results can be seen in the following sequence steps:

- sequence step 1: magnetic trip time at 5 times overcurrent
- sequence step 4: thermal trip at 3 times overcurrent
- sequence step 7: (hopefully) timed-out.

Most breakers with a nominal current of 13 A and 16 A trip long before the internal limit of the test set is reached, that is, before a thermal overload of the *COMPANO 100* occurs. However, if you had a breaker with a very long trip time but an overcurrent-time characteristic still within the tolerance, *COMPANO 100* may not trip that breaker.
Therefore note: *COMPANO 100* can well be used to prove that an MCB works properly by initiating the MCB's trip. However, it cannot reliably verify in ***all*** cases that the breaker is ***not*** working properly, in particular when a thermal overload stops the test set's current output ***before*** the MCB trips.

The overload indicator is delayed by 200 ms in either direction, coming and going. This is necessary to suppress short spikes of the detection, on one hand, and, on the other hand, to reliably evaluate that the overload has finally cleared instead of just disappearing temporarily like, for example, during zero crossing. This means, if you do a time measurement using "Overload" triggers, add to or deduct from the result 200 ms, accordingly.

27 Software License Information

Parts of the embedded *COMPANO* software are under OMICRON license, other parts are under open source software licenses.

You can find all required software license information and notifications at **Setup ► Service ► Legal notes**.

Both the open source license texts and the necessary source code are provided in the OMICRON Open Source Download Area at https://www.omicronenergy.com/opensource/.

COMPANO 100 software update:
About information on how to install a new software version, refer to Software Update on page 92 in chapter **Setup**.

28 Troubleshooting

Results seem to be wrong

Check your input filter configuration:

The accurate filter needs about 500 ms to 1 second to return an updated value.

The fast filter needs at least one full cycle to return the updated value. If the time since the last value change was shorter, the result still does not reflect the new value.

Check your measurement range:

Always select the smallest suitable input range of **IN 1** and **IN 2**.

Furthermore, check your current clamp ranges.

Example: If you are measuring say the secondary side of a 1000:1 CT with 100 A primary injection, you will see 100 mA on the secondary side. Using a current clamp in the 10 mV/A range will result in a voltage of 1 mV on the analog input. If a high input range is selected, this small value could not be measured correctly.

Check the response time of your relay:

Especially digital relays need some time for their internal calculations. For example, some frequency relays need 100 ms or more to react to a frequency change. If you want to test such relays with frequency ramps, check the data sheet of the relay, and set the step time of the ramp to a sufficiently large value.

Check your sensor:

Some smart sensors, like Rogowski coils, have integrated power-saving or power-off functions, which may switch off the measurement after a few minutes. In case of power-saving functions, it might take a few seconds until the sensor provides correct values again. Refer the user documentation of your sensor on how to use this function and how to disable it for the measurement.

Check your grounding:

COMPANO 100 is of protection class II. Therefore, grounding is not as critical as with devices that are grounded via a power cord. Nevertheless, due to internal capacities there is a certain coupling between the mains, housing and outputs, which might lead to wrong results, depending on the input circuit of the used relay. Grounding is therefore recommended.

Check the DC offset calibration of your clamp or sensor:

Current clamps like the OMICRON *C-PROBE 1* or the Chauvin Arnoux *E25* allow you to adjust the DC offset of the clamp.

Please make sure that the DC offset is set to 0 A before using the clamp for the actual measurement. You can, for example, connect the clamp to **IN1** of *COMPANO 100*, configure **IN1** for the current clamp, start the output of 0 A in **QUICK**, and then adjust the offset until the current reading of **IN1** is (almost) zero. Alternatively, use the auto offset calibration function of the current clamp, if available.

Check the batteries of your clamp or sensor:

Some current clamps or sensors need batteries for operation. Weak batteries can interfere with the output signal.

Results seem to be wrong

Check the user documentation of your clamp or sensor for details.

When testing a self-supplied relay:

Some self-supplied (CT-supplied) relays use a switched-mode power supply that heavily distorts the voltage in the current path and may interfere with the controller algorithms in *COMPANO 100*.

In most cases such relays can be tested using the *CBF1* accessory for *COMPANO 100* (→ Accessories on page 117).

Test set does not power up, or it switches off immediately

Temperature too high:

If the battery temperature exceeds an upper limit, the test set cannot be powered up, or it switches off immediately in order to protect the battery. Let the test set and the battery cool down, then try again to power it up.

Temperature too low

If the battery temperature falls below a lower limit, the test set cannot be powered up, or it switches off immediately in order to protect the battery. Slowly warm up the test set and the battery, then try again to power it up.

Test set switches off immediately after starting the signal output

Maximum power limitation:

The maximum output power is limited to about 1 kVA. If the output power is higher, for example when putting out 100 A to 200 mΩ, the test set will switch off the current immediately. In this case, reduce the current in order to reduce the output power.

The resistance of the used cables may be at fault for the largest part of the resistance. Try to use dedicated high-current cables, like the optional 6 m (19.5 ft) high-current cable set (P0006213) or contact OMICRON Support (→ Support on page 175) for a custom cable set.

Temperature too low:

The internal resistance of the battery depends on its temperature. If it is very cold (≤ 0 °C/14 °F), the battery may not be able to deliver the full output power, and the test set will switch off the current immediately. In such a case, either reduce the output current or warm up the test set.

State of charge too low:

If the state of charge is very low, a high output power will generate very high currents in the test set. To protect both the test set and the battery, the test set will switch off the current immediately. In such a case, either reduce the output current or recharge the battery.

Grounding system test aborts

Message “Invalid measurement possibly due to large interferences. Please try again.“:

The application module uses the auto-ranging mode of the measurement input. If there are no large interferences (for example, at mains frequency), a smaller and more accurate input range will be selected automatically. In the rare case of a large, non-constant interference after the start of the measurement, the input range will be exceeded and the measurement will be invalid. In this case, please repeat this specific measurement by pressing the start button again. If the interference continues, it may be necessary to try it several times for the measurement to become valid.

This can happen, for example, next to an electrical railway track, when a train is passing by, or nearby an industrial plant if there is a sudden change in the load-flow.

Battery State of Health is low

State of health update:

The system needs a full charging cycle to update the state of health.

More information about the state of health (SOH) of the battery on page 22.

Battery cannot be charged to 100 %

State of health update:

If the battery is used for a long time without a full charge cycle, the displayed charge level can be inaccurate even if the battery is fully charged.

The battery needs a full charging cycle to update the state of health and reset the charge level calculation.

More information about the state of health (SOH) of the battery on page 22.

Update does not work

Before starting the update, *COMPANO 100* needs to be charged to at least 70 %. If this is the case, disconnect the charger and make sure *COMPANO 100* is powered down before starting the update process (→ Software update on page 92).

The polarity checker does not detect the signal correctly

Signal amplitude too small:

CPOL, *CPOL2* and *CPOL3* need to detect a voltage between two measurement points. In some cases, for example, when measuring on two sides of a closed switch, this voltage might be too small. In this case you can try to increase the measurement current, if possible, or to use *CPOL2* or *CPOL3*, which provide a higher sensitivity than *CPOL*.

Signal distorted:

Some self-supplied relays (CT-supplied) use a switched-mode power supply that heavily distorts the measured voltage. *CPOL*, *CPOL2* and *CPOL3* are not able to detect such a distorted sawtooth signal. In such a case, use a current clamp together with *CPOL2* or *CPOL3* to test the polarity (→ Polarity check on page 48).

The polarity checker does not detect the signal correctly

High sensitivity:

When performing wiring checks, it is possible for you to inject, for example, into phase A and also measure a signal on phase B. This can be caused by capacitive or inductive coupling between the phases.

In such a case, use a current clamp together with *CPOL2*or *CPOL3* to test the polarity (→ Polarity check on page 48). *CPOL3* is less sensitive to coupled signals.

Output voltage is only available during a running test

If you want to supply, for example, a relay, to configure it before and read the results after the test, you can use the **AUX DC** mode (→ AUX DC mode on page 34).

In the **AUX DC** mode, only the current output can be used for the test.

Granularity of the output value is not fine enough

Current granularity is not fine enough:

The 20 A output range of the current output provides a higher granularity for small currents. This can, for example, be used to test ground fault relays.

29 Support

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

OMICRON Support – get in touch

omicronenergy.com/support

At our support hotline, you can reach well-educated technicians for all of your questions.

Make use of our 24/7 hotlines:

Americas:	+1 713 830-4660 or +1 800-OMICRON
Asia-Pacific:	+852 3767 5500
Europe / Middle East / Africa:	+43 59495 4444

Additionally, you can find the service center or sales partner closest to you at omicronenergy.com

OMICRON Customer Portal – stay informed

my.omicronenergy.com

Browse through the knowledge library and find manuals, application notes, conference papers, and much more.

Download the latest software updates and learn about upcoming events.

OMICRON Academy – learn more

omicronenergy.com/academy

Learn more about your product in one of the training courses offered by the OMICRON Academy.

UK importer: OMICRON electronics UK Limited, Staples Close, Redhill Business Park, Stafford, ST16 1WQ, United Kingdom
Manufacturer: OMICRON electronics GmbH, Oberes Ried 1, 6833 Klaus, Austria

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