Megger

INGVAR

Primary Current Injection Test System

User guide

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Contents

1 Safety

1.1 General

- Always follow the local safety regulations that apply to work with high-voltage equipment.
- Make certain that all personnel who work with INGVAR have been trained in its use and that all applicable safety precautions are taken.
- Read and comply with the following instructions as well as the warnings and instructions on the INGVAR control panel.

Symbols on the instrument

Caution, refer to accompanying documents.

Caution, risk of electric shock.

Protective conductor terminal.

WEEE, Waste Electrical and Electronic Equipment. Please utilize your local WEEE collection facilities in the disposition of this product and otherwise observe all applicable requirements.

Precaution levels

The manual uses two precaution levels, **WARNING** and **Important**. The messages will be in the following formats:

WARNING
Means you may risk possible bodily harm and damage to the test object and/or test equipment.

Important
Means you risk damage to the test object and/or the test equipment.

1.2 Safety instructions

You must also read and follow the additional safety precautions in each appropriate section of the manual.

1. Read / Follow / Retain all instructions

- All safety and operating instructions must be read before using INGVAR.
- All safety and operating instructions for INGVAR must be followed.
- All safety and operating instructions must be retained for future reference.

2. Connecting

- Always ground INGVAR
- Before connecting INGVAR, turn off its master ON/OFF switch.
- When changing the connections make sure that current not can be generated accidently. Disconnect the mains supply or switch the miniature breaker F1 to the 0-position.
- Do not use within measurement categories II, III and IV.
- Use caution when working near bare conductors or bus bars. Accidental contact with a conductor may cause electrical shock. At dry locations use caution when working with voltages that exceed 33 V AC and 46 V peak or 70 V DC, such signals pose a shock hazard. At wet locations, use caution when working with voltages that exceed 16 V AC and 22 V peak or 35 V DC. Follow the local safety regulations.
- Before connecting INGVAR to a circuit breaker, make certain that the circuit breaker is closed and grounded on one side.
- When testing current transformer. Dangerous voltages can appear in the secondary circuits if they are open.
- Unplug INGVAR from the mains supply when it is left unattended or not in use.

3. Grounding (Earthing)

- INGVAR can be used only in electrical systems with single ground. User must verify before connecting this unit to power, that High Voltage Ground and Low Voltage Protective Ground create a single protective ground with no measurable voltage potential existing between these ground systems. If a voltage potential is found between the ground systems please consult local safety regulations.
- Always use a grounded mains cable to connect the Control Unit to the mains. Always ground INGVAR using a separate ground cable.

4. Mains cord protective conductor

- INGVAR is equipped with a power cord with integral safety ground pin.
- The equipment must be connected to a grounded mains outlet.
- Do not defeat the safety ground in any manner.

5. Separate ground wire

- The INGVAR case must also be grounded by the separate protective ground wire with connection to the Protective Conductor Terminal on top of the INGVAR. Check the continuity of the protective ground wire before each use. Make sure the connector is fastened properly to the INGVAR Protective Conductor Terminal. Make sure the connection point at the ground system is fastened properly. Route the wire so that it is unlikely to be walked on or that it may loosen accidentally by someone or something moving near it.
- The protective ground wire must not be loosened while any input connector is attached to the contacts of a high voltage circuit breaker or another device being subject to inductive or capacitive coupled interference from surrounding high voltage wires.

6. Placement

- INGVAR must be situated away from any heat sources such as radiators, heat registers, stoves, or other products that produce heat.
  Do not place the INGVAR in areas with excessive dust, mechanical vibration or shock
- Do not use INGVAR near water.
- Do not expose the INGVAR to rain or moisture.
- Do not touch the plug with wet hands. Doing so may result in electrical shock.

7. Use

- Do not use the instrument for any purpose other than indicated by the manufacturer.
- Do not use any accessories/cables not recommended by the INGVAR manufacturer as they may cause hazards.

8. EMC Warning

- INGVAR can generate radio frequency energy. If not installed and used in accordance with this manual it may cause interference to radio communications. INGVAR has been tested and found to comply with the limits for measurement equipment designed to provide reasonable protection against such interference when used in an industrial environment. Operation of INGVAR in a commercial or residential area is likely to cause interference, at which case, the user, at his own expense, will be required to take whatever measures that may be required to correct the interference.

9. Cables

- Use only approved mains detachable cable set with INGVAR. Main supply cables shall be rated for the maximum current for the equipment and the cable shall meet the requirements of IEC 60227 or IEC 60245. Mains supply cables certified or approved by a recognized testing authority are regarded as meeting this requirement.
- To conform to the CE requirements for high frequency radiation, shielded cables or cables with added ferrite filters must be used for connection to the inputs/outputs.
- Connecting cables must be routed so that they are not likely to be walked on nor pinched by items placed upon or against them. Do not pull on or tie them. Pay particular attention to the connectors.
- To disconnect a cable, unlock the retainer (in case of an XLR connector), grasp the connector firmly and pull.
- If an input- or output cable becomes damaged, stop using it. Use of a damaged cable may result in fire or electric shock.

10. Power sources

- Only connect INGVAR to an outlet protected with at least 16 A overcurrent protection.
- Make certain that mains outlet and its fuses and all cables/wiring have sufficient current-carrying capacity, i.e. suitable ratings.
- Use an easily accessible power outlet. This will ensure that you can disconnect the power quickly in case of a problem.
- Never connect INGVAR to a mains voltage other than that specified on the data plates (nameplate) on the Control Unit and the Current Unit.
- The plug to the mains inlet is not to be used as disconnecting device.
- The mains connector or the mains switch are to be used as disconnecting device.

11. Inputs and outputs

- Do not apply voltage to the outputs.
- Do not connect the "AMMETER 2" and VOLTMETER inputs at the same time.
- The voltages and currents that are generated by INGVAR can cause serious injury.
- Dangerous voltages can develop at exposed connectors if the equipment malfunctions.
- The current output terminals and connecting points can be hot after generation of high current.

12. Ventilation

- Slots and openings in the instrument are provided for ventilation. They ensure reliable operations, keeping it from overheating. These openings must not be blocked nor covered during operation.

13. Lightning

- For added protection for INGVAR during a lightning storm unplug it from the AC outlet and from all cables connected to the inputs. This will prevent damage to the INGVAR due to lightning and power supply surges.
- Never touch the plug and power cord if it begins to thunder. Touching them may result in electric shock

14. Cleaning

- Unplug INGVAR before cleaning
- Do not use liquid cleaners or aerosol cleaners.
- Use only a damp cloth for cleaning.
- Stubborn stains may be removed with a cloth lightly dampened with a mild detergent solution.

15. Damage

- Do not use INGVAR if the test leads appear to be damaged.
- Do not continue using a damaged INGVAR. Using a damaged INGVAR may result in fire or electric shock.
- Do not touch a damaged LCD panel directly with bare hands. The liquid crystal, which leaks from the panel, is poisonous if it enters the eyes or mouth. If any part of the skin or body comes in direct contact with the panel, please wash thoroughly. If some physical symptoms result, please consult your doctor.

16. Damage requiring service

- Unplug INGVAR from all connections and refer servicing to qualified service personnel under the following conditions:
  - When any connector is damaged, including mains plug.
  - If liquid has been spilled into INGVAR.
  - If INGVAR has been exposed to rain or moisture.
  - If the INGVAR does not operate normally (following the operating instructions).
  - If the INGVAR has been dropped or damaged in any way.
  - When INGVAR exhibits a distinct change in performance.
  - If INGVAR begins to emit smoke, smells like something is burning or makes strange noise.

17. Servicing

- Do not attempt to service INGVAR yourself; opening or removing covers can expose you to dangerous voltage and other hazards.
- Please refer all servicing to qualified service personnel.
- If you attempt to service INGVAR yourself the warranty is no longer valid.

18. Returning

- If, for some reason, you need to return INGVAR, please use either the original transport box or one of equivalent strength

2 Introduction

2.1 General

INGVAR is intended for use in high-voltage substations and industrial environments, for laboratories and testing purposes. INGVAR consists of a Control Unit equipped with a control panel and a Current Unit. The units are portable and easy to connect.

INGVAR is designed to generate short-duration current, and is protected from overheating. Under special circumstances, INGVAR can generate up to 5,000 amperes.

The Control Unit controls the current output (generation) from the Current Unit and is equipped with sophisticated measurement facilities. The Control Unit can sense the phase angle and adapt subsequent generation operations so that they all start at the current's zero-cross-over points. This ensures minimized DC offset in connection with starting.

Current generation

Current can be generated in many ways:

- Continuously.
- During a preset maximum time.
- As long as you press a button.
- Until an external signal activates the stop input.
- At a lower current (I/30) to avoid unnecessary heating of the object being tested while the current is being adjusted.
- In pulses (both pulse duration and between-pulse pause are user-definable).

The measurement section contains/provides

- Timer.
- Digital ammeter (true RMS).
- An additional channel for measuring a voltage or a second current.
- Direct display of the turns ratio of a current transformer.
- Provisions for measuring phase angle Z, P, R, X, S, Q and power factor (cos φ).
- Currents and voltages expressed (if so desired) as percentages of nominal values.
- Fast-acting hold function. Measured values can be frozen in response to a signal arriving at the stop input and/or when the current is interrupted.

In addition to its normal working mode, there are special INGVAR settings supporting the following types of testing:

- Testing of direct acting automatic reclosers.
- Testing of sectionalizers.

Even though INGVAR features outstanding versatility, it is very easy to use because:

- You can start generation whenever desired.
- You can repeat a measurement by simply pressing a button. It is not necessary to clear the display first.
- You can save different settings for INGVAR in ten different memories.

2.2 Fields of application

INGVAR is primarily intended for:

- Testing of protective relay equipment (primary injection testing).
- Testing of breakers with overcurrent tripping.
- Conducting ratio tests on current transformers.
- Conducting polarity tests on current transformers.

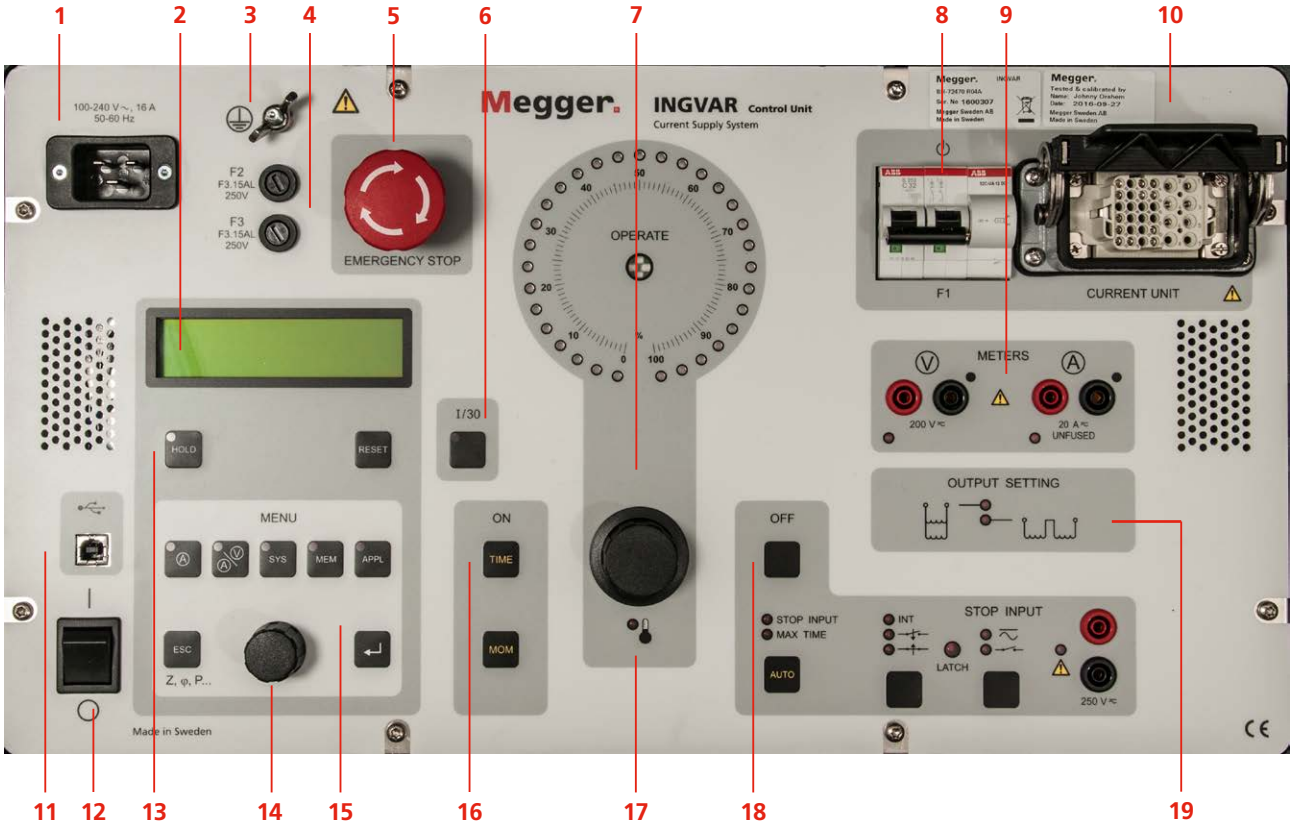
Other fields of application include:

- Tests requiring high currents.
- Testing direct-acting automatic reclosers.
- Testing sectionalizers.
- Testing ground grids.

2.3 Reservations

When set at maximum current, INGVAR is designed only for temporary (short-duration) current generation. Do not use INGVAR for long-term generation at full current. See the product specifications in chapter 11.

3 Panels



3.1 Control Unit panel

More detailed descriptions of the display and the menu options appear in chapter 4 "Display" and chapter 5 "Menu options".

1.	■ **Mains inlet**, 3 pin CEE connector (16 A)
2.	■ **Display**, This block contains the display which presents times, currents or voltages as well as messages and menus. Chapter 4 "Display" describes the display and its functions in greater detail.
3.	■ **Grounding** (earth) terminal
4.	■ **F2 and F3**, fuses (T3.15AL 250V).
5.	■ **EMERGENCY STOP**
6.	■ **I/30**, enables to make the settings at a reduced current, only 1/30 of the real test current. The settings are approximate and work best for linear loads.
7.	■ **Current adjust knob** to set (adjust) the generated current. Adjustment is sensitive to the turning speed. ■ OPERATE lamp indicates current generation ■ Green, yellow and red LEDs indicate percentage of current generated for a specific load.
8.	■ **Miniature circuit breaker (F1)** connected to the current generation circuitry. It can be operated manually and used as a disconnector to prevent unintentional generation

9.	■ **METERS** Ⓥ Voltmeter Ⓐ Ammeter 2 For making the connections needed to measure a voltage or a second current. This is useful when (for example) you want to measure phase angles, polarity or the turns ratio of a current transformer. You can make your settings using the "V/A METER" menu option in the **MENU** block. An indicator lamp lights up to indicate whether you have activated the Voltmeter or the A-meter 2. **WARNING** Do not connect the Ⓐ AMMETER 2 and Ⓥ VOLTMETER inputs at the same time. ■ Indicator lamps. Indicate whether ammeter 2 or the voltmeter is enabled.
10.	CURRENT UNIT, Multiconnector for interconnection of current and control units.
11.	■ **USB** type B
12.	■ **ON/OFF** switch
13.	■ HOLD Press button to freeze (hold) the measured values. When the lamp in the button glows steadily it indicates that the Hold-function is active. Freezing takes place: a) when the stop condition is met or b) when generation is shut off, whereupon the lamp in the button starts to flash. The frozen value disappears as soon as you start a new generation or press the RESET button. ■ RESET Press to clear (reset) the values shown on the display.
14.	■ **Select/set knob** Turn knob to make settings in the display.

15.	**MENU**, select special functions and change the settings for the measuring instruments. Press the button to get the desired menu option. Use the **Select/set knob** to select a function or alter a value. Change generation range, 0 to 66% or 33 to 100%, by turning left / right. ■ Ⓐ Select the range for "A-METER 1", measuring the generated current), and specify whether the measured values are to be expressed: a) in amperes b) as percentages of nominal current c) as ratios. ■ ⒶⓋ Choose between using the voltmeter or the ammeter 2 (A-METER 2, measures a second current), select their ranges and how the values should be expressed. You can also set the system to measure the turns ratio of a current transformer. ■ SYS Here you specify: a) the time unit to be used by the timer b) the amount of delay for the automatic shutoff in accordance with the preset stop condition. In addition you can select the language that will be used in the display and make the desired entries for calibration. ■ MEM Recall or save settings for INGVAR in 10 memories. ■ APPL Here you set INGVAR for the following applications: a) Normal use. b) Testing of a direct acting automatic recloser. c) Testing of a sectionalizer. d) Generation of a pulse train. ESC Press to cancel and/or go back to the previous level. Also used to activate R, Z, X, φ (phase angle), P, S, Q and power factor (cos φ) measurements or to read the maximum current during an operation. ■ ↵ Press to confirm your choice and/or proceed to the next level.
16.	**ON** ■ TIME Starts current generation. When generation starts the timer is instantaneously reset and restarted. ■ MOM Current generation starts and continues as long as you press the button.
17.	■ Temperature alarm, is lit if the temperature rises too high and INGVAR risks becoming overheated

18. ■ **OFF**, stops current generation

STOP INPUT, here you enter the stop condition. When this condition is met, the current generation and timer stops. The measured value can be frozen (held).

AUTO, activates the automatic shutoff-function. INGVAR will automatically stop generating current after a specified period of time. Press the button until the **MAX TIME** lamp lights up, and enter the maximum generation time using the **Select/set knob** in the **MENU** block
This button can also be used to activate the automatic shutoff when a stop condition is met. Press the button until the **STOP INPUT** lamp lights up, and enter the desired stop condition in the **STOP INPUT** block.

INT	Internal detection. Hold/Stop takes place when the current is interrupted by the object being tested.		
Voltage mode	The input responds to application or interruption of voltage	The input responds to application of voltage	The input responds to interruption of voltage.
Contact mode	The input responds to the opening or closing of a contact	The input responds to closing of a contact.	The input responds to opening of a contact.

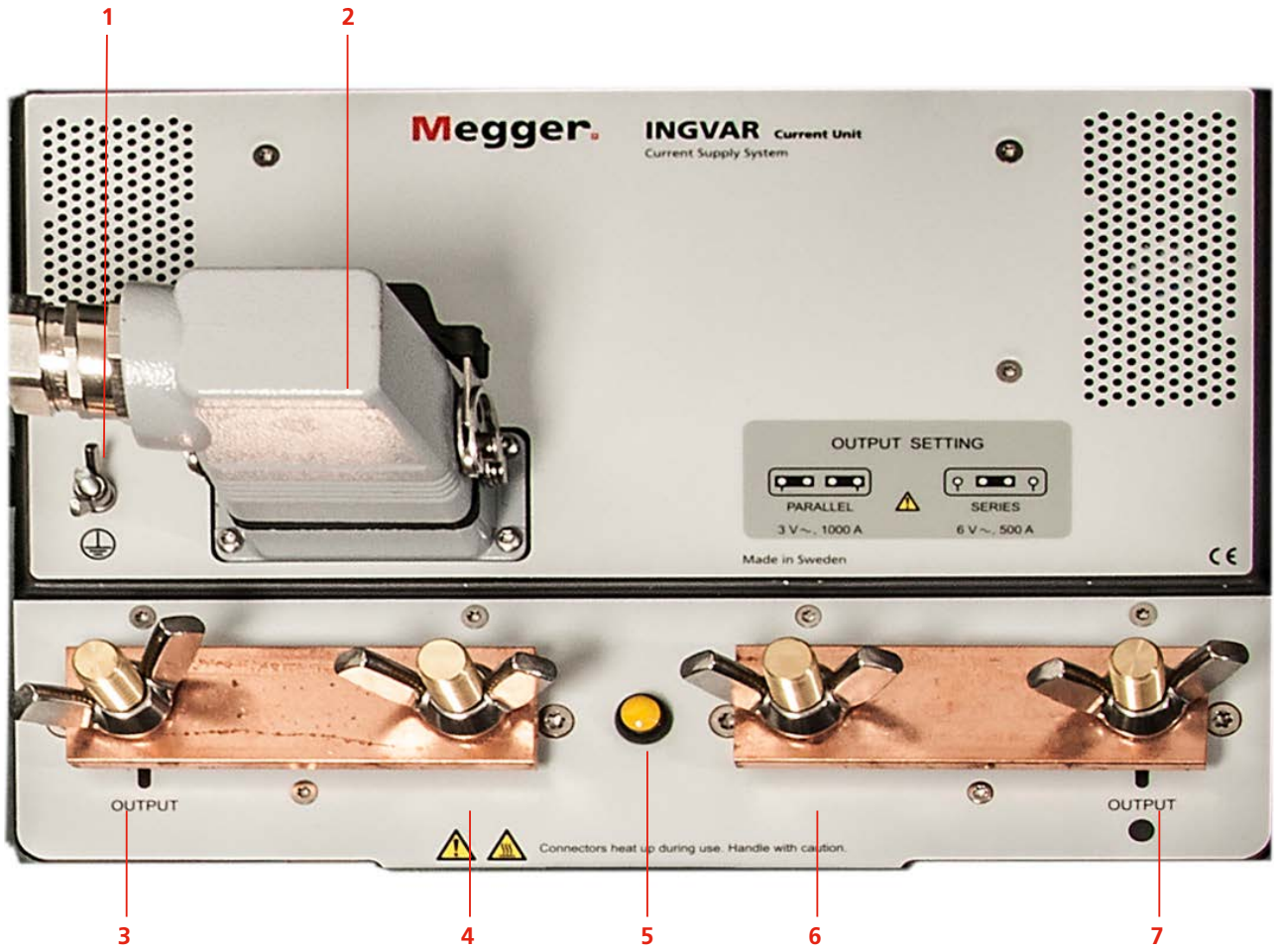
Note *The stop condition for INT is depending of the configuration of current unit and settings of A-meter 1 and setting of the INT-function. See section 5.2*

The status lamp adjacent to the connection sockets is lit:
In the voltage mode — if voltage is present.
In the contact mode — if the contact is closed.

When the preset stop condition is met the **LATCH** lamp is lit. Resetting takes place automatically when you start a new generation or when you press the RESET button.
See chapter 7 for stop condition settings.

19. **OUTPUT SETTING**, indicates how the Current Unit output is configured – parallel or serial.

3.2 Current Unit panel



1	■ **Grounding** (earth) terminal
2	■ **CONTROL UNIT**, input terminal for connection to INGVAR Control Unit
3 4	■ **OUTPUT**, current output Terminals for parallel or serial configuration
5	■ Sensor for the output configuration (parallel/serial)
6 7	■ **OUTPUT**, current output Terminals for parallel or serial configuration

3.3 Cables

Standard cables

Interconnection cable

Cable, 3 m (10 ft) for connection of the Control Unit to the Current Unit.

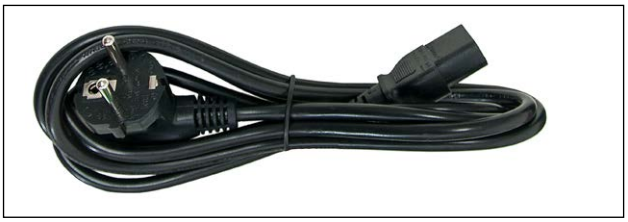
Current cables

Standard current cable set, 2 x 2 m (6.5 ft), 120 mm^2 *and 100 mm clamp jaw width.*

Grounding cable

Cable for protective grounding, 5 m (16 ft), 16 mm^2

Mains cable



Mains cable, 2.5 m (8 ft), 240 V / 16 A

Optional cables

Interconnection cable, 5 m (16 ft)	GA-12705
Interconnection cable, 10 m (33 ft)	GA-12710
Current cable set 2 x 0.5 m (1.6 ft) 3 x 120 mm^2 with end-bars. 	GA-12305

4 Display

4.1 The display

- Presents measured values.
- Presents INGVAR´s settings.
- Guides you by providing helpful messages, warnings and prompts.
- Helps you scroll through menu options by displaying directional indicators.

The display is divided into 4 areas. Normal use:

TIMER	
Ammeter 1	**Ammeter 2 / Voltmeter**

Example:

1.234 s	
750 A	**3.123 V**

By pressing the ESC button; Z, ϕ (phase angle) & Z, P, R, X, S, Q, power factor (cos ϕ) or max I[1)] will appear in the upper area of the display.

[1)] Max I is the highest current value that was generated (minimum time 100 ms) during the injection.

Example:

	4.164 mΩ Z
750 A	**3.123 V**

"**O.F**." (Overflow) in an area means that the value is too high.

"**- - -** " in a field means that it is impossible to present a value. The reason can be too low measurement signal or that it is impossible to calculate a value.

If you press ↵ the measured values will be dumped via the USB port, see appendix 1 for details.

Directional indicators

The directional indicators that appear on the display show which direction you can scroll using the **Select/ set knob**.

- You can scroll upwards
- You can scroll downwards
- You can scroll both up and down

When special applications are activated

When a special application is activated this is indicated in the upper right corner.

Example:

Application **"TEST RECLOSER**

1.234 s	**TEST RECLOSER**
750 A	

See further the descriptions of the application modes, chapter 8 "Application examples".

5 Menu options

5.1 General

This chapter explains the menu options available in the **MENU** block on the control panel and the settings that you can make there. All settings appear on the display.

You can only select a menu option while INGVAR is in the OFF state (i.e. not generating).

There are three ways to exit from a menu option:

A] Press the button of the most recently selected menu option a second time.

B] Press TIME

C] Press RESET

5.2 AMMETER, V/A METER and SYSTEM menu options

You can set INGVAR's first ammeter ("A-METER 1") in the Ⓐ menu option. In the Ⓐ/Ⓥ menu option you can set INGVAR's second ammeter ("A-METER 2") and INGVAR's voltmeter. In the SYS menu option you can set the timer, select the desired language for use on the display, and make certain other settings. The menu options are described in detail below.

How to set values

An example of how the display can appear for the Ⓐ menu option appears below. The top line (the menu heading) shows what is to be set. The second line (right-justified) shows the actual setting. You can use the **Select/set knob** to scroll through the different menu headings. The directional indicators show the direction or directions in which you can scroll.

Example:

You can scroll upwards.

Select the desired menu heading ("RANGE" for example) and press ↵. The value will appear between flashing arrow-heads < >:

You can now change the setting (to the low ampere range for example) using the **Select/set knob**.

Press ↵ to confirm your choice.

You can press the ESC button to leave the field without changing it or to return to the previous level.

A-METER 1

In this menu option Ⓐ you can make settings for INGVAR's intern ammeter ("A-METER 1"). You can select the range and the unit in which the reading is to be expressed (amperes, percentage of nominal current

or as a ratio). In addition, you can specify the nominal current itself.

The available settings are listed below.

A-meter 1 Ⓐ		
Menu	**Settings**	**Description**
Range	Auto	Range is selected automatically To get the best result possible when using short measuring time, you should not use the Auto mode.
	Low	Low range is selected[1)]
	High	High range is selected[1)]
Unit	Ampere	Current reading in Ampere
	% of In	Current reading as percentage of nominal current
	I1/I2	Current reading as the ratio of generated current (I1) to current measured by "AMMETER 2" (I2)
Nominal Current	Value in A	Here you can set the value of the nominal current
1) The value for range Low or High depends on the output configuration, see "Specifications"		

V/A METER

In this menu option Ⓐ Ⓥ you can select to use the voltmeter or the second ammeter ("A-METER 2"). You can also modify the settings for the instruments. You can select the range and the unit in which the reading is to be expressed (volts/amperes or percentage of nominal voltage/current). In addition, you can specify the nominal current/voltage itself and have the turns ratio for a current transformer displayed.

First in the menu you have to select between "A-METER 2" or "VOLTMETER". Select the desired instrument by pressing ↵. The instrument will be activated and you can now modify its settings.

The available settings are listed in the table below.

V/A Meter Ⓐ Ⓥ		
Menu	**Settings**	**Description**
A-Meter 2, Range	Auto	Range is selected automatically. To get the best result possible when using short measuring time, you should not use the Auto mode.
	0 – 2 A	0 – 2 A range is selected.
	0 – 20 A	0 – 20 A range is selected.
A-Meter 2, Unit	Ampere	Current reading in Ampere.
	% of In	Current reading as percentage of nominal current
	CT ratio	Ratio for a current transformer is presented as primary current / secondary current (Nom I)
A-Meter 2, Nom I	Value in A	Here you can set the value of the nominal current
V-Meter, Range	Auto	Range is selected automatically
	0 – 0.2 V	0 – 0.2 V range is selected
	0 – 2 V	0 – 2 V range is selected
	0 – 20 V	0 – 20 V range is selected
	0 – 200 V	0 – 200 V range is selected
V-Meter, Unit	Volt	Voltage reading in Volts
	% of Vn	Voltage reading as percentage of nominal voltage (Vn)
V-Meter, Nom V	Value in V	Nominal voltage (Vn). Enter the nom V value on which percentage will be based.

SYSTEM

In this menu option SYS you can:

- Select the unit in which the timer results will be expressed.
- Activate DC-measurement function.
- Specify the delay time for the automatic shutoff (AUTO OFF) function.
- Activate the Auto-Dump function and select the language that will be used on the display.
- Set the INT level and the threshold for detection that the generated current is interrupted.

The available settings are listed in the table below.

System SYS		
Menu	**Settings**	**Description**
Timer	Seconds	Time displayed in seconds.
	Cycles	Time displayed in number of mains voltage cycles.
	hh:mm	Time displayed in hours, minutes and seconds. Seconds are displayed up to 1 min.
DC- Measurement	On/Off	INGVAR can be set to measure DC-current (A-meter 1 and 2) and DC-voltage (V-meter). See note.
OFF Delay	Cycles	Specify the number of mains voltage cycles which the automatic shut-off is to be delayed (in accordance with the preset stop condition).
Auto-Dump	On/Off	INGVAR can be set to automatically dump test data to a PC when the generation is stopped. See Appendix 1.

System SYS		
Menu	Settings	Description
Language	English French German Russian Spanish Swedish	Language used on the display.
INT-level	Value in approx. 0.5 or 2% of range	The threshold for detecting that the generation has been interrupted can be changed. See Measurement section, Ammeter 1 in Chapter "11 Specifications" on page 60.

Tip

Try higher INT-level if trip-time is unexpectedly long and try lower INT-level if trip time is unexpectedly short.

5.3 MEMORY and APPLICATION menu options

In the MEM menu option, you can store present settings in one of INGVAR's 10 memories, or recall previously stored settings. In the APPL menu option, you can change INGVAR's mode of operation to support certain applications, like testing direct acting automatic reclosers or generate pulse trains (pulse-pause-pulse-pause etc.). These menu options are described in the table below.

Setting values

You make all selections and settings using the **Select/set knob**. You confirm your entries by pressing ↵ whereupon you advance further into the menu. The directional indicators show you the direction (or directions) in which you can scroll. You can return to the previous level by pressing the ESC button.

You select the item you want to change with the **Select/set knob**. Check to see that it is bracketed by arrow-heads (< >) and then press ↵. The arrow-head brackets will start to flash to indicate that you can change the item using the **Select/set knob**. When you are finished, press ↵ to confirm your entry.

MEMORY

You can save your regular INGVAR settings in this menu option. Moreover you can, for example, prepare settings in advance and save them so that they can be recalled whenever desired. INGVAR has ten memories numbered 0-9 where you can save settings. The memories retain their contents even when power to the INGVAR is turned off.

When you start INGVAR, the settings saved in memory number 0 are loaded automatically. This means that if you want a specific set of settings to be used the next time you turn INGVAR on, you can save them in memory 0 before turning INGVAR off. There is one additional memory called the standard memory in which the factory settings are kept, these factory settings cannot be changed.

The available settings are listed in the table below.

Memory MEM		
Menu	Settings	Description
RECALL	RECALL 0 - 9	Recalls settings from a specific memory.
RECALL	RECALL Standard	Recalls factory settings.
SAVE	SAVE 0 - 9	Saves settings in specified memory.

Recalling settings from a memory

1] Press the MEM button

2] Turn the **Select/set knob** until "RECALL" appears on the display.

3] Press ↵.

4] Turn the **Select/set knob** until the number of the desired memory appears.

5] Press ↵.

APPLICATION

In this menu option you can change INGVAR's mode of operation for different types of tests.

The available settings are listed in the table below.

Application APPL	
Menu	Description
NORMAL USE	Configures INGVAR for normal use.
TEST RECLOSER	Sets INGVAR to test a direct-acting automatic recloser.
PULSES	Sets INGVAR to generate a pulse train.
SECTIONALIZER	Sets INGVAR to test a sectionalizer.

6 How to install INGVAR

6.1 Safety

WARNING

When you are changing the connections make sure that current not can be generated accidentally. Disconnect the mains supply or switch the miniature breaker F1 to the 0-position.

The current output terminals and connecting points can be hot after generation of high current.

Do not connect two or more INGVAR systems in parallel or series. This can damage INGVAR or bodily harm

6.2 Connecting the test object and the Current Unit to each other

When you connect INGVAR to the object being tested, you should check that the contacts on the connectors are clean and that the cable clamps are placed as close together as possible on the object being tested. You must also remember that different types of cables have different capacities for carrying high currents.

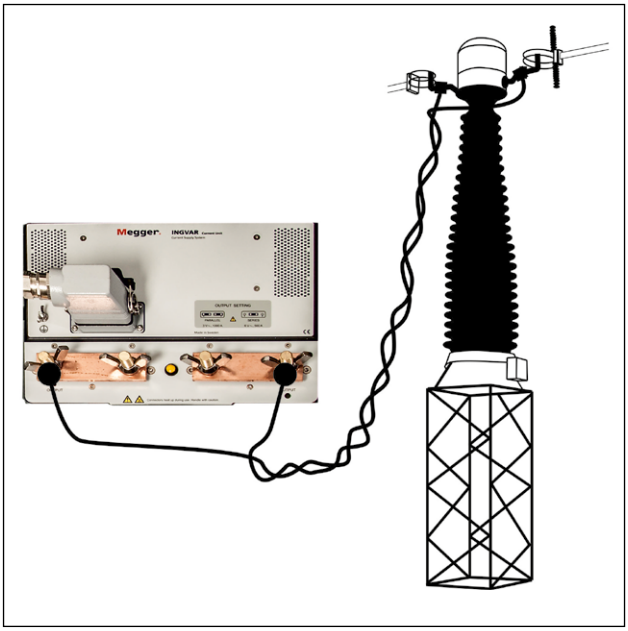
To minimize the voltage drop in the cables from INGVAR to the object under test you can:

A] Use two or more cables in parallel.

B] Use as short cables as possible.

C] Use cables with heavier gauge (thicker) conductors.

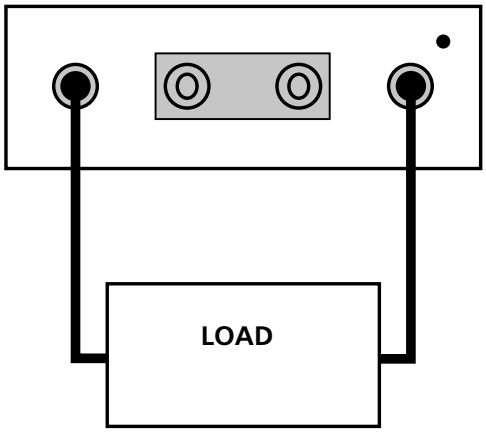
D] Twist cable pairs.



Example of how cables can be run

6.3 Series connection

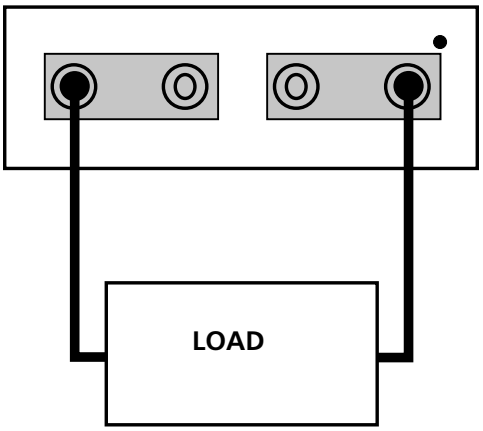
Use series connection when you want a high voltage at a high load impedance.



Output in serial configuration

6.4 Parallel connection

Use parallel connection when you need a low internal impedance in order to be able go generate high current.



Output in parallel configuration

6.5 Connecting the Current Unit to the Control Unit

The Current unit is connected to the Control Unit via a cable with multi-pin connectors.

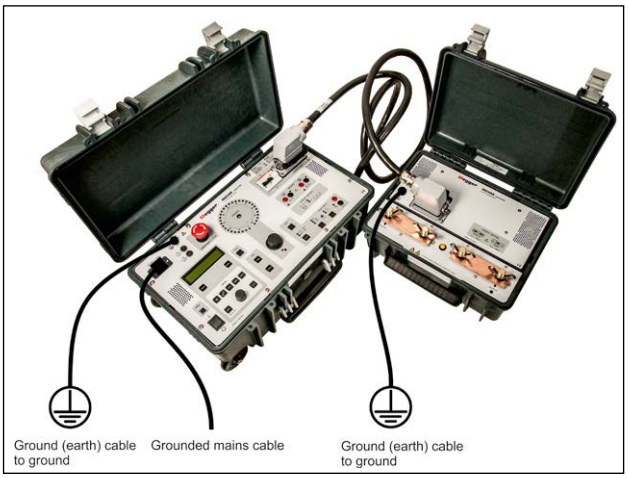
Current unit connected to Control Unit

6.6 Grounding INGVAR

WARNING

This equipment can be used only in electrical systems with single Ground. User must verify before connecting this unit to power, that High Voltage Ground and Low Voltage Protective Ground create a single protective ground with no measurable voltage potential existing between these ground systems. If a voltage potential is found between the ground systems please consult local safety regulations.

Always use a grounded mains cable to connect the Control Unit to the mains, and in addition you must connect separate ground cables. Connect the Control Unit and the Current Unit to ground as shown in the figure below.



INGVAR connected to ground

6.7 Connecting INGVAR to the mains

Important
Make sure that the mains voltage corresponds to that specified on the data plates on the Control Unit and the Current Unit.

Make certain that mains outlet and its fuses and all cables/wiring have sufficient current-carrying capacity, i.e. suitable ratings.

Make sure that the fans in the Current Unit are functioning when INGVAR is turned on.

Mains voltage

INGVAR is designed for 100 – 240 V.

The mains supply fuse normally is rated 10 A or 16. This will limit the highest output current but it is still possible to get several kA for a short time with a slow 16 A fuse.

Note *INGVAR's power consumption will depend on the magnitude of the output generated and also on the mains voltage for which it is intended.*
Power consumption for different operating situations are set forth in chapter 11 "Specifications".

Input current

The input current is directly dependent on the output current and the ratio is stated for different configurations in chapter 11 "Specifications". It can also be calculated as:
Output current x open circuit voltage [1]/ input voltage
1) Open circuit voltage: Output voltage with current setting on maximum and no load connected.

6.8 Current cables and conductors

Available cable sets

Please note how important it is to twist the cables if possible. Values stated for twisted cables presuppose that each cable is twisted over the entire length. See section "How to arrange the cable sets".

Standard multi-cable sets

Cable sets consist of up to three pairs of 120 mm² cables in parallel. At each end there is an end-bar interconnecting the cables. The bar also enables single bolt connection to INGVAR and the test object. See figure below.

Impedance of the cable set is very dependent on how cables are arranged. See section How to arrange the cable sets

Length 2 x 0.5 m (distance to test object 0.5 m)								
Number of cables	***Total cross section area***	***Impedance cables twisted (mΩ)***	***Impedance cables not twisted (mΩ)***	***Impedance cables 1 m apart (mΩ)***	***Max. current in 20 sec. (A)***	***Max. cont. current (A)***	***Weight (total set) (kg)***	***Article number***
1 pair	120 mm² (1 x 120)		<0.6		1600	350		
2 pairs	240 mm² (2 x 120)	0.21	< 0.53	-	3200	700	4.6	GA-12205
3 pairs	360 mm² (3 x 120)	0.18	< 0.46	-	4800	1050	6.0	GA-12305

Length 2 x 1.0 m (distance to test object 1.0 m)								
Number of cables	***Total cross section area***	***Impedance cables twisted (mΩ)***	***Impedance cables not twisted (mΩ)***	***Impedance cables 1 m apart (mΩ)***	***Max. current in 20 sec. (A)***	***Max. cont. current (A)***	***Weight (total set) (kg)***	***Article number***
1 pair	120 mm² (1 x 120)				1600	350		
2 pairs	240 mm² (2 x 120)	0.32	< 0.80	-	3200	700	7.3	GA-12210
3 pairs	360 mm² (3 x 120)	0.25	< 0.63	-	4800	1050	10.0 k	GA-12310

Length 2 x 1.5 m (distance to test object 1.5 m)								
Number of cables	***Total cross section area***	***Impedance cables twisted (mΩ)***	***Impedance cables not twisted (mΩ)***	***Impedance cables 1 m apart (mΩ)***	***Max. current in 20 sec. (A)***	***Max. cont. current (A)***	***Weight (total set) (kg)***	***Article number***
1 pair	120 mm² (1 x 120)				1600	350		
2 pairs	240 mm² (2 x 120)	0.42	< 1.10	< 1.70	3200	700	10.0	GA-12215
3 pairs	360 mm² (3 x 120)	0.32	< 0.80	< 1.30	4800	1050	14.1	GA-12315

Length 2 x 2.0 m (distance to test object 2.0 m)								
Number of cables	***Total cross section area***	***Impedance cables twisted (mΩ)***	***Impedance cables not twisted (mΩ)***	***Impedance cables 1 m apart (mΩ)***	***Max. current in 20 sec. (A)***	***Max. cont. current (A)***	***Weight (total set) (kg)***	***Article number***
1 pair	120 mm² (1 x 120)				1600	350		
2 pairs	240 mm² (2 x 120)	0.53	< 1.30	< 2.10	3200	700	12.7	GA-12220
3 pairs	360 mm² (3 x 120)	0.39	< 1.00	< 1.60	4800	1050	18.1	GA-12320

Multi-cable sets with customised length

Megger can supply the Multi-cable Sets with other lengths than specified above.
"L" refers to length of the set (maximum distance to the test object).

Calculate the impedance

Number of cables	*Total cross section area*	*Impedance, cables twisted [1)] (mΩ)*	*Max. current in 20 sec.*	*Max. continuous current*	*Weight (total set)*
1 pair	120 mm² (1 x 120)	(L x 0.43) + 0.1	1 600 A	350 A	(L x 2.7) + 1.9 kg
2 pairs	240 mm² (2 x 120)	(L x 0.22) + 0.1	3 200 A	700 A	(L x 5.4) + 1.9 kg
3 pairs	360 mm² (3 x 120)	(L x 0.14) + 0.1	4 800 A	1 050 A	(L x 8.1) + 1.9 kg
1) Impedance can be up to 2.5 times higher if the cables are running close together but not twisted and up to 4 times higher if they are 1 meter apart.					

Example, customised Multi-cable sets, length 2 x 5.0 m

Number of cables	*Cross section area*	*Impedance cables twisted (mΩ)*	*Impedance cables not twisted (mΩ)*	*Impedance cables 1 m apart (mΩ)*	*Max. current in 20 sec.*	*Max. continuous current*	*Weight (total set)*
1 pair	120 mm² (1 x 120)	2.2	< 5.5	< 8.8	1600 A	350 A	15.4 kg
2 pairs	240 mm² (2 x 120)	1.2	< 3.0	< 4.8	3200 A	700 A	28.9 kg
3 pairs	360 mm² (3 x 120)	0.8	< 2.0	< 3.2	4800 A	1050 A	42.4 kg

Standard 2 X 5 m (single pair) cable set with clamps)

Cross section area	*Impedance cables twisted (mΩ)*	*Impedance cables not twisted (mΩ)*	*Impedance cables 1 m apart (mΩ)*	*Max. current in 20 sec.*	*Max. continuous current*	*Weight (total set)*	*Article number*
120 mm² (1 x 120)	2.2	< 5.5	< 8.8	1600 A	350 A	15.2 kg	GA-12052

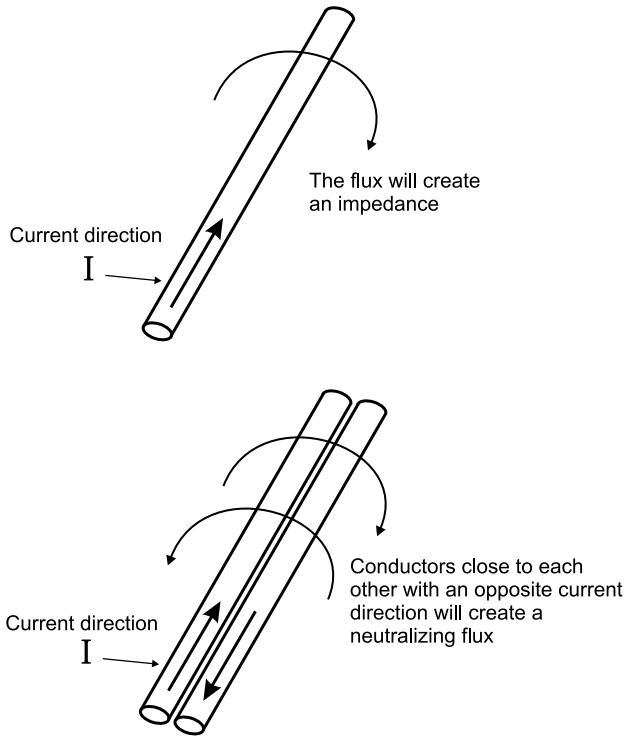
6.9 How to arrange the cable sets

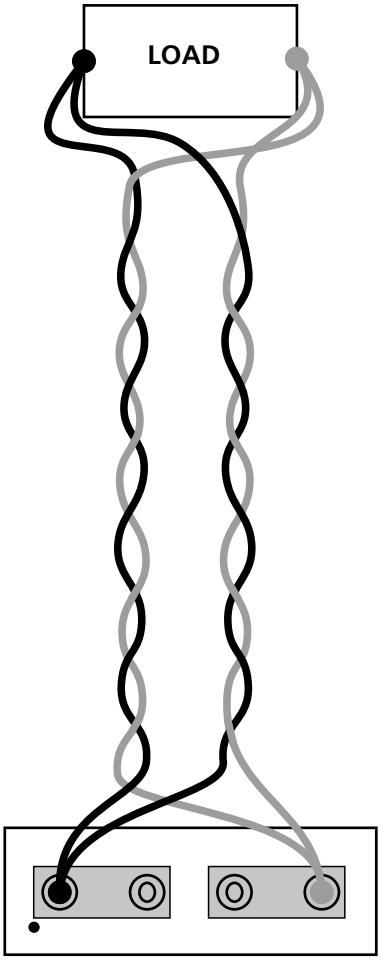
Minimising impedance in cables

Just increasing cross-section area helps only to a certain extent. When resistance is low, the major part of the impedance is caused by the reactance. Minimising the magnetic flux will reduce the reactance:

A] If cables not can be twisted, keep cables with same current direction away from each other as much as possible

B] Avoid loops or "windows".

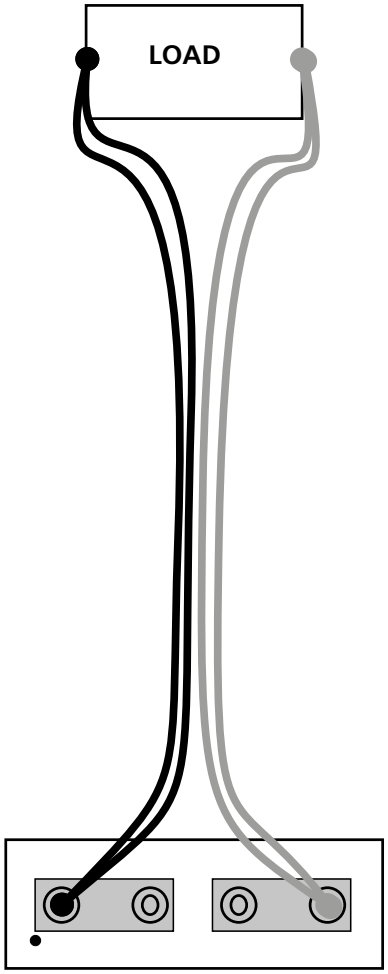




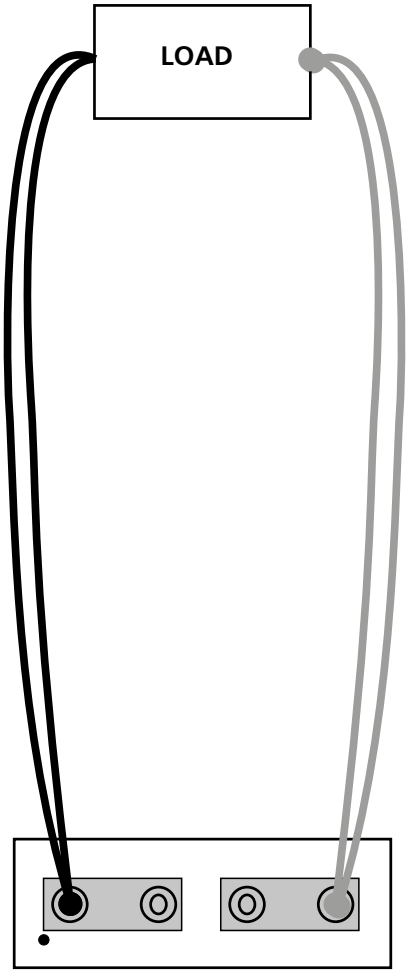
Cables pair-twisted over their entire length.

It is sometimes not possible or practical to twist the cables. However any action to keep cables with opposite current direction close together and to minimise loops helps. If the distances to the test object terminals are different it is better to use cables with different lengths in order to avoid loops.

Current Unit with twisted 2 pairs Multi-cable Set



Cables close together but not twisted. Impedance is 1.5 to 2.5 times higher than with twisted cables.



Cables with opposite current direction 1 meter apart. Impedance is 2 to 4 times higher than with twisted cables

6.10 How to arrange bars

Copper-bars are in many cases a better solution than cables at high currents and short distances and at long load times. Bars must be specially designed for the actual test objects and in general this work must be the users responsibility. Here are some guidelines:

- Proper cross section area. Not less than 500 mm^2 - 1000 mm^2 (depends on the actual current). Take eventual heating into consideration.
- As close to the bar as possible (preferably maximum 1 mm) there should be another bar carrying the same amount of current in the opposite direction. This will neutralise the magnetic flux. Even if this arrangement slightly increases the length, it still is a gain because impedance due to magnetic flux is a bigger problem than the resistance.
- Do not use bars thicker than 10 mm and arrange the bars with their flat sides close together. The reason is that the magnetic flux (and the reactance) will be more effective neutralised if the current is forced to flow close to the current with opposite direction.
- Loops (windows) that allow magnetic flux must be avoided).
- Joints must have low resistance

Example:

Two copper bars have the cross section 10 mm x 50 mm and they are mounted 5 mm from each other (the flat sides close together). Per meter of this arrangement the impedance is:

90 mΩ at 50 Hz (R = 73 mΩ and X = 54 mΩ)
98 mΩ at 60 Hz (R = 73 mΩ and X = 65 mΩ)

6.11 FAQ

Q	Is it possible to connect INGVAR systems in parallel or series.
A	No. There is risk for damage since one system can feed the other backwards.
Q	Can INGVAR supply 3-phase current.
A	No. INGVAR can only supply single phase current.

7 How to use INGVAR

This chapter describes the functions that you can perform using INGVAR. Complete test procedures are described in chapter 8 ”Application examples”.

7.1 How to generate current

1] Connect INGVAR to the object under test as described in chapter 6.

2] Turn on INGVAR using the mains switch on the Control Unit.
All the LEDs lights up in sequence. After a few seconds the blue LED turns on at 66% and the display will show briefly

CURRENT RANGE
0 – 66%

1] In this mode, you can generate power in the range 0 - 66% of max.
In order to generate higher power you turn the "Select / Set knob" to the right, the LEDs 0-33% are lit and the display show briefly:

CURRENT RANGE
33 – 100%

1] In this mode, you can generate power in the range 33-100% of max.
To switch back to the range 0-66%, turn the "Select / Set knob" to the left until all LEDs turn off.

Note *You can not change range during generation*

2] Specify the desired settings using the **MENU** on the control panel.

3] Set the circuit breaker F1 in the upper position.

4] Press TIME. The value of the output current will appear on the display.

5] Adjust (set) the current using the **Current adjust knob**.

6] If time test is included, press the **OFF** button to shut off the current.

7] Press TIME to start a new generation with the correct current.

7.2 Rules of thumb when generating current

When you generate current there are rules which can be useful to follow.

A] To reduce voltage drop, the current cables running to the object being tested should be as short as possible and have sufficient heavy-gauge (thick) cross-area. You can reduce the voltage drop further by twisting cables of different polarity together (see 6.9 "How to arrange the cable sets"), thereby making it possible to inject higher currents.

B] If the object being tested has a low impedance connect the Current Unit in parallel. Connect it in series if the object has high impedance.

C] To avoid unnecessary heating of objects being tested, current can be generated in brief intervals. It might be best to use manually-controlled (momentary) injection or time-limited injection. With INGVAR, it is also possible to make a coarse adjustment of the current using the I/30 function (which uses only 1/30th of the real test current).

D] When operating time is measured, the value of the injected current or applied voltage must exceed the lowest operating limit by an ample margin (1.2 - 2 times is the rule of thumb here).

7.3 Setting the desired current

Low currents

1] Connect the object being tested to INGVAR Current Unit output.

2] Press TIME.

3] Adjust the current using the **Current adjust knob**. The value of the current will be presented on the display.

High currents

High currents can generate a great deal of heat in both INGVAR and the object being tested. To avoid unnecessary heating, you can:

A] Generate current only for brief intervals.

B] Use the I/30 function .

Generating briefly

There are two easy ways to generate current for brief intervals:

A] Using the MOM button

B] Using the limited-time generation function. These are described in this chapter in section 7.14 “Measuring operating limits”.

Using I/30 function

1] Connect INGVAR properly to the object being tested.

2] Press **I/30** button to activate the I/30 function.

3] Press TIME. The current is displayed as ”XXXX/30”. XXXX represents the value the current will have when the I/30-function is released.

4] Adjust the current using the **Current adjust knob**. The value of the current will be presented on the display.

5] Press **OFF** button to shut off the current.

6] Press **I/30** button to turn off the I/30 function.

7] Press HOLD to activate the hold function.

8] Press the MOM button briefly.

9] Read the current presented on the display.

Note *The I/30-function is less accurate on none linear test objects.*

7.4 Setting times for limited-time generation (MAX TIME)

If you want to generate current throughout a limited time using the MAX TIME function, proceed as follows:

1] Press AUTO
The **MAX TIME** lamp is lit. The preset maximum generation time will appear on the display.

2] Set the desired generation time by turning the **Select/set knob**.
To get the time expressed in another unit than the preset, select unit in the SYS menu option"TIMER".

3] Press TIME to start generation.

7.5 Continuous current generation

If you want to generate current for an unlimited time, i.e. until you shut generation off manually, proceed as follows:

1] Press AUTO to turn off the **STOP INPUT** and **MAX TIME** lamps.

2] Press TIME to start generation.

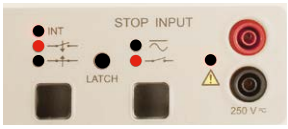
3] Set the desired current using the **Current adjust knob**.

7.6 Setting stop conditions

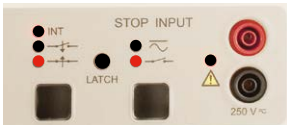
The status lamp adjacent to the connection sockets is lit:
In the voltage mode — if voltage is present.
In the contact mode — if the contact is closed.

When the preset stop condition is met the **LATCH** lamp is lit. Resetting takes place automatically when you start a new generation or when you press the RESET button.

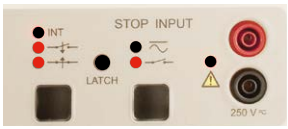
You can set the stop condition in a number of different ways. You can use the following combinations:



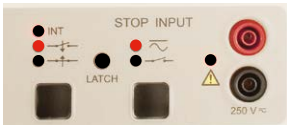
Closing of an external contact.



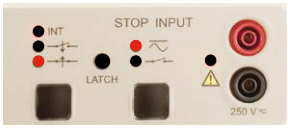
Opening of an external contact.



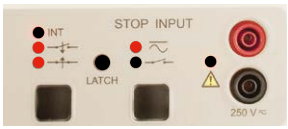
Opening or closing of an external contact.



Application of a voltage.



Interruption of a voltage.



Application or interruption of a voltage.

Note *See Chapter 11 "Extended specification" for treshold values.*

7.7 Getting maximum current from INGVAR

Maximum output current is limited by the following:

- Impedance of the object being tested.
- Impedance of the current cables.
- Mains supply.
- Voltage drop in mains cables and other cables.
- INGVAR's internal impedance

To obtain maximum current from INGVAR proceed as follows:

A] If the object being tested has high impedance, connect the Current Unit in series.

B] If the object being tested has low impedance, connect the Current unit in parallel.

C] Use short, heavy-gauge (thick) cables and twisted cables, see section 6.2.

D] Make certain that the object being tested is connected properly (all connectors must be clean, connected at the right places etc.).

7.8 Generating low currents

If you want to improve the accuracy of current settings, you can:

- Use a voltage that is as low as possible by (for example):
  a) not connecting the Current Unit in series
  b) Increase the impedance in the circuit, for instance use longer, lighter-gauge (thinner) current cables.

7.9 Generating pulse trains

You can set INGVAR to generate a pulse-train (intermittent current generation at regular intervals, i.e. pulse-pause-pulse-pause etc.). This will continue until you shut off generation, until a preset maximum time (MAX TIME) is reached or until the condition at the **STOP INPUT** is met.

1] Basic settings:

OPERATE:	OFF

2] Set the desired current. See section 7.3 "Setting the desired current".

3] Press the APPL menu option.

4] Turn the **Select/set knob** until "PULSES" appears on the display.

5] Press ↵.

6] Set the pulse duration "TIME ON" by turning the **Select/set knob**.

7] Press ↵.

8] Set the desired between-pulse pause "TIME OFF" by turning the **Select/set knob.**

9] Press ↵.

Note *You can select the unit in which time is to be expressed in the SYS menu, option "TIMER".*

10] Press TIME or MOM to start the test.
The word "OPERATE" appears on the display indicating that INGVAR is generating.

Note *The counter on the display (":OP") is intended mainly for use when testing sectionalizers. Each time the current is interrupted the counter value increases by one. The counter can count up to 127 pulses.*

11] Generation stops:
You press **OFF** ■
or
You release the MOM button
or
when the **AUTO OFF** conditions are met

7.10 Holding (freezing) measured values

The function freezes a measured value when a signal arrives at the **STOP INPUT** or when the current is interrupted.

1] Press the HOLD button to activate the holding (freeze) function.
When the hold function is activated the lamp in the HOLD button glows steadily.
As soon as the stop condition is met, the lamp in the HOLD button starts to flash.

2] The frozen values disappears when you start a new current generation operation or press RESET.

7.11 Measuring phase angle and polarity

INGVAR can display the phase angle between the current from INGVAR (A-METER) and:

A] the current (I2) passing through INGVAR's second ammeter "A-METER 2"
or

B] the voltage (V) at the voltmeter input.

1] Press the ESC button until the sign for degrees "°" appears in the upper-left corner of the display.

Measuring current

Current direction is defined as illustrated in fig 7.1.

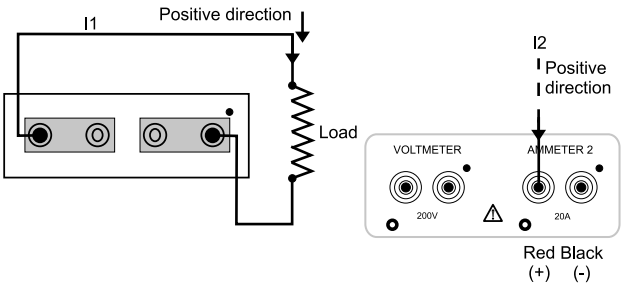


Fig 7.1

I1 is the reference current and the range is 0-360°.

The number of degrees that I2 is displaced **ahead** of I1 appears on the display.

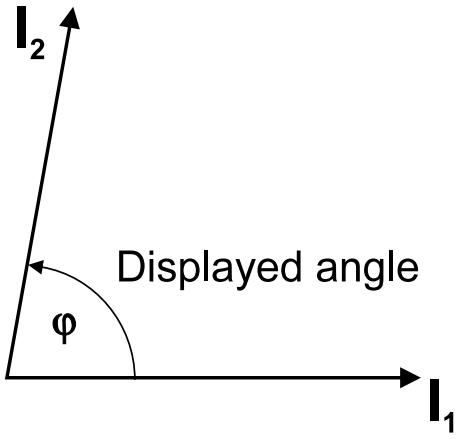
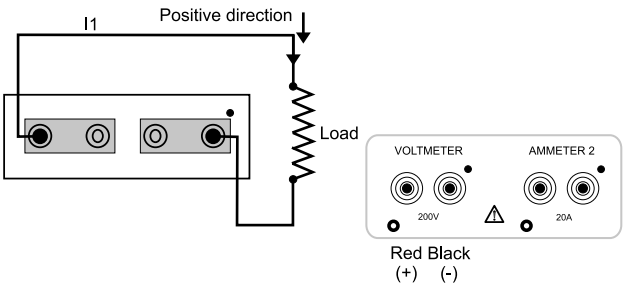


Fig 7.2

Measuring voltage

Current direction is defined as illustrated in fig 7.3:



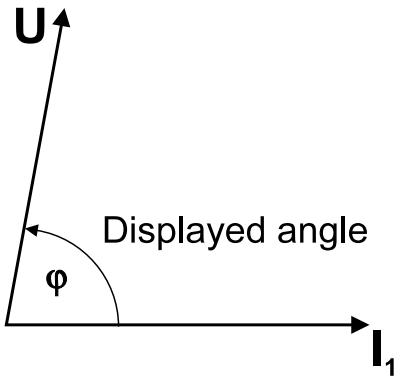


Fig 7.3

I1 is the reference and the range is 0-360°. The number of degrees that voltage (V) is displaced ahead of I1 appears on the display.

Example

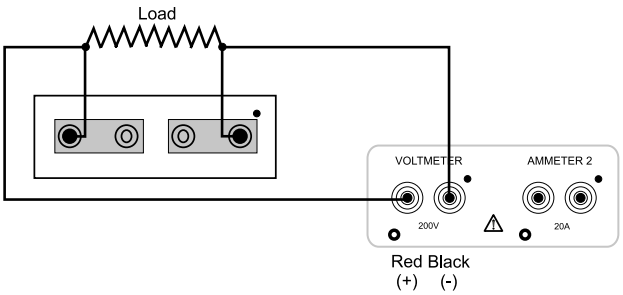


Fig 7.4

Phase displacement caused by an inductive load. Voltage lies 60° ahead of current. 60° appears on the display.

7.12 Measuring Z, P, R, X, S, Q and power factor (cos φ)

When INGVAR's voltmeter is activated you can measure impedance (Z), active power (P), resistance (R), reactance (X), virtual power (S), reactive power (Q) and power factor (cos φ).
Scroll through these quantities by pressing the ESC button several times. Scrolling is possible even if the measurement is frozen.

300ms	
800A	**0.558V**

Standard: Time displayed on upper row.

Pressing the ESC button once provides:

	1.434Ω Z
800A	**0.558V**

Continue scrolling by pressing the ESC button to view the desired quantities.

	0.866cos φ
800A	**0.558V**

7.13 Reading maximum current at an operation

The highest current value showed on the display at an operation is stored.

1] Press ESC repeatedly until a current value and the text "max" appears.
The maximum current value is updated every 1/3 second.

7.14 Measuring operating limits

There are three ways to measure operating limits:

- Normal generation. Used when there is little risk for undesirable heating in the object under test.
- Manually-controlled momentary injection.
- Limited-time generation. Used when you do not want to expose the object under test to needless heating.

Method 1: Normal injection – gradually increase in current.

In this method current is sent out continuously. The current is gradually increased until the object being tested operates. When this happens:
a) the **LATCH** lamp lights up
b) the current value is frozen on the display
c) the current to the object is interrupted

When you are testing protective relay equipment you can, as a next step, reduce the current and freeze the displayed value to obtain information about the drop-out function.

1] Basic settings:

OPERATE	OFF.
CURRENT ADJUST	Lower than the tripping/operating limit.
HOLD function	ON.
AUTO OFF	STOP INPUT.

2] • For protective relay equipment:
Set the stop condition to (for example):

• For breakers:
Set the stop condition to **INT**.

3] Press TIME to start generation.

4] Increase the current until operation occurs. The value frozen when operation occurred is now presented on the display.

Note *If the impedance of the object under test changes during operation, you should use the maximum current value during the operation as pick-up value. Press the* ESC *button to get the maximum value.*

The following steps apply only when testing protective relay equipment:

5] In order to measure the **drop-out** function, change the stop condition to (for example):

6] Press TIME to start generation and turn up the current until the protective relay equipment operates (pick-up).

7] Turn down the current until drop-out occurs. The value frozen when drop-out occurred is now presented on the display.

For protective relay equipment you can simplify the procedure by testing both the pick-up and drop-out functions with a single current generation operation. This can be accomplished as follows:

1] Basic settings:

OPERATE	OFF
CURRENT ADJUST	Lower than the tripping/operating limit
HOLD function	ON
AUTO OFF	Turn off the AUTO OFF function (neither the STOP INPUT nor the MAX TIME lamp will be lit)

2] Select the stop condition:

3] Start current generation.

4] Increase the current until the protective relay equipment operates (pick-up).

5] Read the pick-up function value from the display.

6] Press RESET.

7] Turn down the current until the protective relay equipment drops out. You can now on the display read the value that was frozen when drop-out occurred.

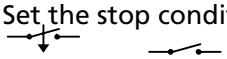
Method 2: Manually controlled momentary injection

Here, current is sent out as long as you hold down the **MOM** button. This method is useful when you do not want to expose the object being tested to unnecessary heat.

1] Basic settings:

OPERATE	OFF
CURRENT ADJUST	Close to the operating limit
HOLD function	ON
AUTO OFF	STOP INPUT

2] • For protective relay equipment:
Set the stop condition to (for example):



• For breakers:
Set the stop condition to **INT**

3] Press MOM briefly.
Note, however, that current must be sent out for a period longer than the operating time.

4] Read the current from the display.

5] Change the current setting somewhat.

6] Repeat, starting at step 3 above, until you find the lowest current that provides operation.

Method 3: Limited-time generation

Here, current is sent out for a limited period of time and interrupted when a present maximum time (**MAX TIME**) is reached. This method is useful when you do not want to expose the object being tested to unnecessary heat. Section 7.4 "Setting times for limited-time generation (**MAX TIME**)" explains how to set **MAX TIME**.

1] Basic settings:

OPERATE	OFF
CURRENT ADJUST	Close to the tripping/operating limit
HOLD function	ON
AUTO OFF	Specify MAX TIME (choose a generation time that is longer than the operating time) and also specify STOP INPUT

2] • For protective relay equipment:
Set the stop condition to (for example):

• For breakers:
Set the stop condition to **INT**

3] Press TIME to start generation.

4] Read the current on the display after generation has stopped.

5] Change the current setting somewhat.

6] Repeat, starting at step 3 above, until you find the lowest current that provides operation.

7.15 Measuring tripping/ operation times

Here, generation continues until the protective relay equipment operates or the breaker trips. To avoid unnecessary heating or operation of the object being tested, the I/30-function can be used (see section 7.3 "Setting the desired current" in this chapter) while the current is being adjusted.

1] Basic settings:

OPERATE	OFF
CURRENT ADJUST	Lower than the operating limit
HOLD function	ON
AUTO OFF	STOP INPUT

2] Set the stop condition to (for example):

3] Press TIME to start generation.

4] Set the current at which the operating time is to be measured. The current must exceed the operating limit by an ample margin.

5] Press **OFF** button to turn off the current.

6] Press TIME and wait until the stop condition is met.

7] Read the time and the current from the display.

7.16 Instantaneous trip unit measurement

You can test the instantaneous trip for breakers and for protective relay equipment as follows:

- When you test the **instantaneous pick-up** you can generate current by using the MOM button. This permits you to find the instantaneous pick-up without operating the overcurrent stage.
- You can also use limited-time generation (**MAX TIME**) to obtain the desired generation time.

Manually-controlled momentary injection is described below:

1] Basic settings:

OPERATE	OFF
CURRENT ADJUST	Close to the operating limit
HOLD function	ON

2] • For protective relay equipment:
Set the stop condition to (for example):

• For breakers:
Set the stop condition to **INT**

3] Select a suitable current setting.

4] Press MOM briefly. The interval throughout which current is sent out must be shorter than the overcurrent stage's tripping/operating time.

5] Change the current setting somewhat and repeat, starting at step 4 above, until you find the lowest current that provides instantaneous pick-up.

When you test the **instantaneous trip time** make the following settings. Use the I/30 function (described in section 7.3 "Setting the desired current" in this chapter) while making current adjustments to avoid undesired operation of the object being tested.

1] Basic settings:

OPERATE	OFF
CURRENT ADJUST	Instantaneous operating limit
HOLD function	ON
AUTO OFF	STOP INPUT

2] • For protective relay equipment:
Set the stop condition to (for example):

• For breakers:
Set the stop condition to **INT**

3] Press MOM briefly.

4] If necessary readjust the current and inject again. Repeat this until you have achieved the desired current value. Deactivate the I/30 function.

5] Inject until the test object operates and the operating time is presented on the display.

7.17 Test circuit impedance

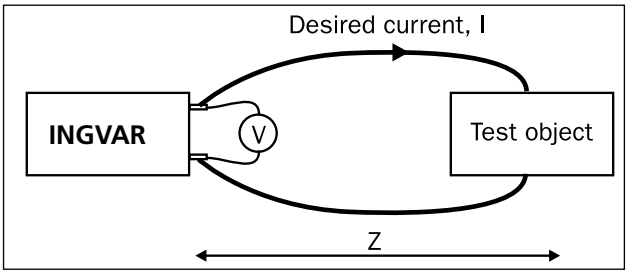
Introduction

Different applications have various requirements on current and load time and the test objects have different impedance.

Examples of different applications:

- Up to 5 kA through 0.5 m current cables. Applications: Test of MCCB.
- Continuous current generation.
  Up to 900 A through 5 meters current cables.

Test circuit impedance limits the current



The test circuit impedance Z consists of current cable impedance and impedance of the test object. According to Ohms law I x Z volt is required to push current I through the impedance. If voltage at INGVAR terminals is less, current will be lower than desired.

Note *Voltage is required to get current through the impedance and you need to know the impedance of the test circuit.*

The current capability is dependent on the load time. You must also check in the load time.

Impedance of the test object

Knowledge saves you from surprises

- Test object impedance has most impact at higher currents and when current cables are short.
- Test object impedance is less important when cable set is 5 meters or longer and only consists of one or two cables each side. Then cable set impedance is the major part of the test circuit impedance.
- Test object impedance can be measured. Inject an AC current, measure voltage drop directly across the object. Divide voltage by the current to get the impedance (mΩ = V/kA).
  If possible, current magnitude should be the same as when testing the object. Some test objects saturate at high currents and measurement at low currents will give a too high impedance value.

Test object impedance can be estimated from experience, some examples:

- Low Voltage air breaker rated 4 kA:
  0.09 - 0.2 mΩ
- Low Voltage circuit breaker rated 630 A:
  0.3 - 1mΩ
- Outdoor breaker pole or disconnector:
  0.2 - 0.5 mΩ

In general test objects rated for higher currents have lower impedance.

Regarding current transformers, the impedance in the secondary circuit has a direct impact on the impedance. Shunting secondary circuits not included in the test reduces but some users dislike to do that. For outdoor current transformers current cable impedance is usually the problem, not impedance of the CT.

7.18 Selecting output configuration and cables / conductors

Current output – Series or Parallel

You can choose to connect the Current Unit output in serial or parallel. Using serial connection reduces current but delivers higher voltage. This is useful when you cannot use short cables and it will do with lower current

1. Load time - Current & Output Voltage

See Specifications chapter for data.

2. Calculate maximum allowed test circuit impedance

Test circuit impedance = Output voltage / Current
(mΩ = V / kA)

3. Calculate maximum allowed cable set impedance

Subtract test object impedance from test circuit impedance.
(Simplification. Both cable set and test object are inductive)

4. Select current cables / conductors

You know the length. Select from tables in chapter 6.8, "Current cables and conductors".

- Impedance may not exceed maximum allowed value. It should be as low as possible but cable set should not be unnecessarily clumsy or heavy.
- Impedance can be reduced by:
  a) twisting cables is important since it reduces the reactance.
  b) using sets with more cables
  c) using several cable sets in parallel. This is especially useful when Current Unit is in parallel.
- At continuous or long term load:
  Check that the current per cable not will be too high (a 120 mm2 cable can withstand 350 A continuously). If so, use a set with more cables in parallel.
- Weight. Overhead test object must be able to carry the weight of the cable set. Divide weight by 2 to get load at one side of the test object or check if the cables can be supported by other method.
- Solid bars can be a better solution than cables at high currents and short distances.
- If distances to test object terminals are different, using a set with different cable lengths can reduce impedance. This also makes twisting easier

Rules of thumb

A] Distance max. 0.5 m, current 5 kA
(For example Low Voltage Circuit Breaker testing)
Minimise cable impedance. Weight is a minor problem. Use cable set with many cables in parallel or bars.

B] Distance 5 meters or more, current max 3 kA and time max. 10 seconds:
(For instance at outdoors Current Transformer testing)
Since current is moderate and load time is short, it is possible to use a cable set that is not too clumsy. One or two cables in parallel each side is sufficient in many cases, especially if it is possible to twist the cables.

C] Distance 5 meters or more and current >3 kA:
(for instance outdoor Current Transformer testing)
Low impedance must be given highest priority in order to get the desired current. This means many cables in parallel. Unfortunately it is unavoidable that the cable set will become rather heavy.

D] Continuous or long injection time.
(for instance at heat run)
First you must check that cable set has sufficient number of cables that current through a single cable does not become too high.

8 Application examples

8.1 Testing a low-voltage circuit breaker

The following sections explain how to test a low-voltagecircuit breaker.

1] Start by measuring the overcurrent stage's tripping limit and the tripping time.

2] Then measure the tripping limit and tripping time for the instantaneous unit.

Measuring the tripping limit (normal generation)

Current is generated continuously and gradually increased until the breaker trips. When the breaker trips the current shown on the display is frozen and the current is interrupted. When current first is generated for a load (while the current is being set), INGVAR adapts itself so that all subsequent generation operations start at the current's zero-cross-over points. This ensures minimized transient DC offset when the injection is initiated.

1] Basic settings:

OPERATE	OFF
CURRENT ADJUST	Lower than the tripping limit
HOLD function	ON
AUTO OFF	STOP INPUT

2] Set the stop condition to **INT.**

3] Press TIME to start generation.

4] Increase the current until tripping occurs (the **LATCH** lamp lights up).

5] The current value frozen when tripping occurred can now be read from the display.

Note *You can read out the highest current value during an operation by pressing ESC repeatedly until "max" appears after a current value. This value should be used for test objects whose impedance changes during the operation.*

Measuring the tripping time

1] Set the current to an ample margin above the tripping limit. The procedure is described in section 7.3. Use the I/30 function (step 2 to 6 in section 7.3) if you want to set the current without operating the breaker.
Note: Disable the **INT**-function when you are using I/30.

2] Settings:

HOLD	ON
AUTO OFF	STOP INPUT
STOP INPUT	INT

3] Press TIME or MOM to start generation.

4] Read the time and the current presented on the display.

Instantaneous trip unit measurement

When you test the instantaneous pick-up you can provide a manually-controlled momentary current injection by pressing the MOM button. This permits you to find the instantaneous trip unit's lowest operating current without tripping the overcurrent stage.

1] Basic settings:

OPERATE	OFF
CURRENT ADJUST	Close to the tripping limit
HOLD function	ON

2] Set the stop condition to **INT.**

3] Select a suitable current setting.

4] Press MOM briefly. The time throughout which current is generated must be shorter than the overcurrent stage's tripping time. You can also use limited-time current generation (**MAX TIME**). See section 7.14 "Measuring operating limits".

5] Change the current setting somewhat and repeat from step 3 above until you find the lowest current that provides tripping of the instantaneous trip unit.

Measure the instantaneous trip time

1] Increase the current to an ample margin above the tripping level.

2] Start an injection and read the time on the display.

8.2 Testing the ratio of a current transformer

This test determines whether or not a current transformer has the correct ratio. During the test, current is injected into the primary side of the current transformer, and the current in each secondary winding is measured using INGVAR's second ammeter ("A-METER 2").

WARNING
Make certain that you observe all applicable safety regulations and precautions associated with dielectric strength on the secondary side. The secondary side of the transformer must be closed during the injection!

1] Basic setting:

OPERATE	OFF
AMMETER1, UNIT	AMPERE

2] Connect the INGVAR output to the primary terminals on the current transformer.

3] Connect INGVAR's second ammeter ("A-METER 2") input to the current transformer winding that is to be tested. Make certain that this winding is not connected to any other circuit.

4] Activate "A-METER 2" in the "V/A METER" menu option under the "A-METER 2" menu heading.

5] Select "A-METER 2 NOM I" and set the nominal secondary current for the current transformer. You might, for example, set it to 5 A.

6] Select "A-METER 2 UNIT", and then select "CT ratio".

7] Press TIME .

8] Set the desired primary current, whereupon both the primary current and the actual ratio will appear on the display.

Example

1000 A injected into a transformer with a ratio of 5000/5.

Note *Another method to measure the ratio between primary and secondary current is to set the unit for ammeter 1 to "I1/I2". Do not however try to combine the two methods!*

8.3 Measuring the polarity of a current transformer

You can conduct a polarity test to determine whether or not the current direction in a current transformer is correct.

In this test it is to be verified that the terminal S1 (X1) on the secondary side is positive relative to terminal S2 (X2) when terminal P1 (H1) on the primary side is positive relative to terminal P2 (H2).

1] Basic setting:

OPERATE	OFF

2] Connect the one of the output terminals on INGVAR's which is marked with a dot (·) to P2 (H2) on the primary side of the CT.

3] Connect the other output terminal to P1 (H1).

4] Connect the one of A-METER 2:s Ⓐ terminals which is marked with a dot (·) to S2 (X2) on the secondary side of the CT.

5] Connect the other terminal of A-METER 2 Ⓐ to S1 (X1).

6] Activate INGVAR's second ammeter (A-METER 2) Ⓐ under the "A-METER 2" menu heading in the "V/A METER" menu option.

7] Press the ESC button (normally twice) until the sign for degrees ("°") appears in the upper-left corner of the display.

8] Press TIME.

9] Turn the current up until the a stable phase-angle appears on the display.

10] If the phase angle is close to 0° or 359° the polarity is correct. If the phase angle is 180°, the polarity is incorrect.

11] Press **OFF** .

12] Move the cables used for A-METER 2 Ⓐ to the other secondary windings and check them in the same way.

A sample hookup is shown in fig 8.3.1.

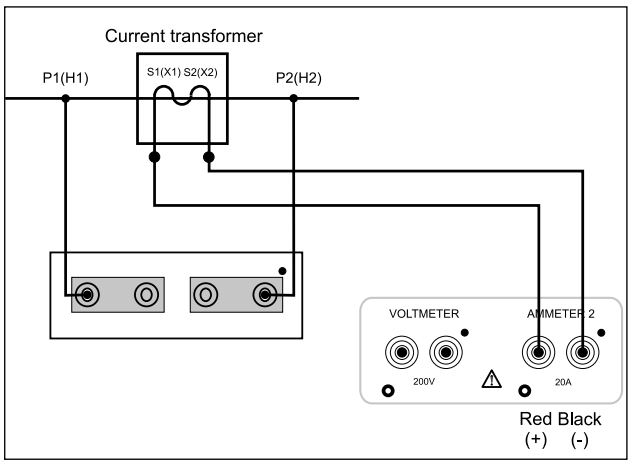


Fig 8.3.1

WARNING
Never ever make this hook-up while current is being generated. If you do, you may be exposed to dangerously high voltages.

8.4 Testing a direct acting automatic recloser

Setting the currrent and testing the pick-up level is done in the same way as when testing low voltage circuit breakers, see section 8.1.

1] Press ESC to obtain the maximum current during a test for reclosers that change their impedance.

At time tests INGVAR will generate current until:

the **OFF** button is pressed
or
a preset maximum generation time is reached.

After the cycle is completed the following measurements are stored and displayed:

A] Number of operations (number of times the current is interrupted).

B] The total accumulated time taken by the reclosing cycle (i.e. from the recloser's first trip to its last trip).

C] The trip and reclosing times.

D] The current at the first four trip operations.

The showed value is the average of the current at the beginning and the end of the operation.

Time test

1] Press the APPL button.

2] Turn the **Select/set knob** until "NORMAL" appears on the display.

3] Use the **Current adjust knob** to set the current.

4] Press the APPL button.

5] Turn the **Select/set knob** until "TEST RECLOSER" appears on the display and then press ↵ INGVAR will now work as a recloser test equipment.

Note *Range for "A-METER 1" will automatically be changed to "LOW".*
The Hold-feature is not active in "TEST RECLOSER".

6] To get a limited-time measurement, activate "**MAX TIME**" and set the desired maximum generation time.

7] Press TIME or MOM to start the test.
INGVAR now generates current continuously while the direct acting automatic recloser trips and closes alternately. For each time the current is interrupted, the number of opera-

tions ("OP" on the display) is increased by one on the display. INGVAR stores the trip (opening) times and reclosing times and the currents that prevailed when each trip and reclosing took place.

8] Generation stops when you press the **OFF** button ■ or when the preset limited-time generation period ("MAX TIME") is reached. Display shows:

Total time to OFF	**10.00s**	**RECLOSER**	
Actual current	**0A**	**3:OP**	Number of operations

9] Press ↵ to dump the test results via the USB-port, see appendix 1.

10] Press ESC to get more information on the display:

Total recl. time [1]	**9.015sTot**	**3:OP**	
First trip pulse	**985ms T1**	**39A**	Current at T1

1) Displayed provided generation continued until lock-out

11] Turn the **Select/set knob** to get more information displayed.

12] Press TIME to start a new test.

13] Press the APPL button to reset INGVAR to normal use.

14] Turn the **Select/set knob** until "NORMAL USE" appears on the display.

15] Press ↵ and INGVAR will be reset for normal use.

8.5 Testing a sectionalizer

You can test a sectionalizer by making appropriate changes in INGVAR's settings. Here INGVAR sends out a preset sequence of current pulses corresponding to those that would be obtained from a direct-acting automatic recloser. After the cycle is completed, the following are stored and displayed:

The number of current pulses until lockout (number of times the current is interrupted).

The total accumulated time (i.e. from the recloser's first trip until its last trip).

The trip times and the reclosing times.

The current at the first four trip occations.

Prior to the test 4 different puls-duration times (T1 - T4) and the reclosing time (R1 - R4) can be set.

Note *After pulse T4 and R4 a pulse T5 and a pulse R5 will be generated. T5 and R5 are identical to T1 and R1. Use the "MAX TIME" function to limit no. of pulses.*

1] Set the desired current, see section 7.3 "Setting the desired current" for details.

2] Press the APPL button.

3] Turn the **Select/set knob** until "SECTIONALIZER" appears in the display window.

4] Press ↵.

5] Set the time for T1 using the **Select/set knob**.

6] Press ↵.

7] Set the times for R1, T2, R2 etc.using the **Select/set knob**.

8] Press APPL.

9] If you want to use limited-time generation, activate **MAX TIME** and set the desired maximum generation time.

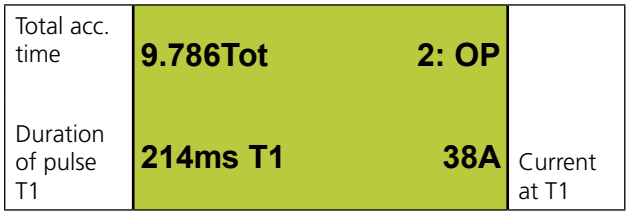
10] Press TIME or MOM to start the test.

11] Generation stops when you press **OFF**button ■, release the **MOM** button or when the preset **MAX TIME** has been reached.
The display shows:

Total time to OFF	**10.00s**	**SECTIONALIZER**	
Actual current	**0A**	**2:OP**	Pulses until lockout

12] Press ↵ to dump the results via the USB-port, see appendix 1.

13] Press ESC to get more information.



14] Scroll using the **Select/set knob** to get the times for R1, T2, R2 etc.

15] Press TIME to start a new test .

16] Press the APPL button to reset INGVAR to normal use.

17] Turn the **Select/set knob** until "NORMAL USE" appears on the display.

18] Press ↵ and INGVAR will be reset for normal use.

19]

9 Troubleshooting

General

Problem	Possible cause	Remedy
No current is sent out from INGVAR	Check miniature circuit breaker F1.	
	Overheating may have triggered the thermal protection.	The thermal protection resets itself automatically after INGVAR cools down.
	Interupted circuit	Check the connections to the object being tested. If a breaker is being tested, check to see that it is closed.
		Check the connection between Control Unit and Current Unit.
Not possible to switch on INGVAR. The display is dark	The fuse F2 / F3 has blown	Check the fuses.
	No mains	Check that the mains cable is plugged in properly and that mains voltage is present.
Generation stops immediately or after half a cycle	Stop condition is set to INT and F1 is off	Close F1
	Stop condition is set to INT and the output circuit is open.	Change stop condition or close output circuit.
		Stop condition is set to INT and the output current is just a few percentage of the measurement range of ammeter 1, see 11.8.
		Increase the current, decrease INT-level or use range or output with lower current rating. **Note**: Connecting Current Unit in series will decrease the measurement ranges.
Generation does not stop when the breaker opens	Zero offset need to be calibrated, see section 10.2 "Calibration of offset"	
Unexpected value on Ammeter 1		
	INGVAR is set for DC-Measurement while AC is generated or vice versa. (Fault will be approx. 10%)	Select proper setting for DC-Measurement (submenu system)
	The test object has higher impedance than expected	Increase the voltage applied from INGVAR by connected the Current Unit in series.

Measurement errors

Problem	Possible cause	Remedy
No reading on voltmeter and ammeter 2	The instrument is not activated	Activate the instrument in the "V/A-METER" menu option if its indicator lamp is not lit.
Time "**0.000s**" is displayed but generation continues	The stop condition is met but AUTO is not activated	Press RESET if you want the generation time displayed
" **——- A or ——-V**" is displayed	The measurement time was too short, the HOLD function cannot present any frozen readings or there was not enough time for a range to be selected automatically.	Increase the measurement time or select a fixed range
"**——- OFA or OFV**" is displayed	The magnitudes of the input signals are too great for the fixed preset range or the "AUTO" range does not have time to function properly for high-speed cycles. ("OF" = Overflow)	Carry out a new measurement or select a fixed range
"**AMP2=0A AMP1=0A**"is displayed	Because the measurement current is 0, no ratio can be calculated.	Generate current
"****** A**"is displayed	Ammeter cannot present measured values for the generated current because: Current Unit unknown because it is uncalibrated.	Calibrate the Current Unit
Unexpectively long trip-time while testing instantaneous trip on a circuit breaker		Increase INT-level or use range or output with higher current rating.

10 Calibration

10.1 General

You can calibrate the zero levels (offset) for A-meter 1, A-meter 2 and the Voltmeter. The timer in INGVAR is crystal controlled and requires no calibration, but can be checked against an external timer.

The instruments used for calibration should have a verified high accuracy.

The Control Unit and the Current Unit must be calibrated together. It is recommended that you calibrate your INGVAR system once a year or if the system has been exposed to extreme variations in ambient temperature.

Regarding calibration of the scale factors we recommend that it is done at 2/3 of the measurement range or at 2/3 of the highest rated current for your INGVAR-system (see output specifications in chapter 11).

You can however calibrate at other values. If accuracy at a certain value is important you can calibrate at this value instead.

For reference to words in this chapter.

Quotation marks are used to refer to words in the display. For reference to button symbols, capital letters are used.

10.2 Calibration of the DC-offset

The zero-offset for Ammeter 1, Ammeter 2 and the Voltmeter is calibrated.

1] Disconnect the Current Unit from the Control Unit.

2] The input for ammeter 2 should be open.

3] Short circuit the voltmeter input (i.e. the voltage should be 0V).

4] Press the SYS button.

5] Press and hold the ENTER button and then the ESC button simultaneously. Turn the select/set knob until you see “CALIBRATION”, then release ESC and ENTER. .

6] Pres ENTER to confirm calibration.

7] Choose 0 DC OFFSET and press ENTER twice..

8] Calibration of zero-offset is done automatically. Wait until the calibration type selection comes back in the display.

9] Press the button ESC twice to exit the calibration menu.

10.3 Calibration of scale factor, ammeter 1

The calibration process of ammeter 1 involves taking one reading for each of the two measurement ranges: "LOW" and "HIGH".

1] Set up the current unit for parallel configuration.

2] Short circuit the outputs using a third bus bar 53-13304 or at least a 120mm² cable. Connect external reference ammeter consisting of a precision DMM and precision shunt in the short loop cable between the current unit output terminals.

3] Connect mains power to the control unit and power on. Verify parallel configuration on the output setting indicators.

4] Press the A button to enter metering settings. Select "RANGE" (first choice) and manually select measurement range "LOW" with the select/set knob. Press Enter and then ESC.

5] Set the current range to "0-66%".

6] Activate the HOLD function, which must be done before entering calibration functions.

7] Press the MOM button and adjust the current until the calibration value (about 2/3 of maximal current, see chapter 11 Specifications) appears on the reference ammeter.

8] Make a note of the reference value from the ammeter instrument.

9] Release the MOM button once the desired adjustment has been made to the current value. Note: The lamp on the HOLD button should flash.

10] Press the SYS button.

11] Press and hold the buttons ENTER and ESC simultaneously. Turn the select/set knob until you see "CALIBRATION", then release ESC and ENTER. Press ENTER to confirm calibration.

12] Choose "AMPERMETER-1" and press ENTER. Calibration values will only be set for the "LOW" range, as prior selected.

13] Turn the select/set knob until the reading on INGVAR matches the value from the reference ammeter and press ENTER. Leave the calibration menu by pressing ESC twice.

14] Check that the reading conforms to the reading on the reference ammeter.

15] Press the A button to enter metering settings. Select "RANGE" (first choice) and manually select measurement range "HIGH" with the select/set knob. Press ENTER and then ESC.

16] Set the current range to "33-100 %"

17] Activate the HOLD function, which must be done before entering calibration functions.

18] Press the MOM button and adjust the current until the calibration value (about 2/3 of maximal current, see chapter 11 Specifications) appears on the reference ammeter.

19] Make a note of the reference value from the ammeter instrument.

20] 20] Release the MOM button when the current value has been adjusted. Note: The lamp on the HOLD button should flash.

21] Press the SYS button.

22] Press and hold the ENTER button and then the button ESC. Turn the select/set knob until you see "CALIBRATION", then release ESC and ENTER. Press ENTER to confirm calibration.

23] Choose "AMPERMETER-1" and press ENTER. Calibration values will only be set for the high range, as prior selected.

24] Turn the select/set knob until the reading on INGVAR matches the value from the reference ammeter and press ENTER. Press ESC twice to leave the calibration menu.

25] Check that the reading conforms to the reading on the reference ammeter.

10.4 Scale factor for the I/30-function

The I/30 function is intended only for use at coarse adjustment of high currents. It gives only an approximate indication with a target to achieve a normal (not I/30) current with no more than 5 % deviation from wanted value. Please note that the linearity of the load and the mains capacity will influence the result greatly.

1] Calibration is performed in two steps. First at approx 1 kA using 0-66 % settings, second step at approx 2 kA using 33-100 % settings. Set up the current unit for parallel configuration.

2] Short circuit the outputs using a third bus bar 53-13304 or at least a 120 mm² cable. Connect external reference ammeter consisting of a precision DMM and precision shunt in the short loop cable between the current unit output terminals.

3] Select 0-66 % setting on the control unit. And set the ammeter to low range.

4] Switch on the I/30 function.

5] Adjust the current output to approximately 1 kA

6] Activate the HOLD function.

7] Switch off the I/30 function.

8] Press and hold the MOM button for approx 1 second and make a note of the current measured with the reference ammeter. Release the MOM button.

9] **NOTE**: The LED on the HOLD button should flash.

10] Switch on the I/30-function.

11] Press and release the MOM button shortly. Press the SYS button.

12] Press and hold the button ENTER and then the button ESC simultaneously. Thereafter turn the select/set knob until you see “CALIBRATION”, then release ESC and press ENTER. Press ENTER to confirm calibration.

13] Choose the “AMPERMETER-1” and press ENTER.

14] Adjust the displayed calibration value to the value read earlier during normal mode and press ENTER.

15] Leave the calibration mode to check the accuracy of the value presented during I/30 and the real current. If necessary, redo the calibration until you get an acceptable result.

16] Change setting to 33-100 % duty time. And set the ammeter to high range.

17] Switch on the I/30-function.

18] Adjust the current output to approximately 2 kA.

19] Repeat calibration in the same way as was done at 1 kA.

10.5 Calibration of scale factor, ammeter 2

1] Press A/V , select " AMMETER 2 " and press ENTER.

2] Select the "0-2 A" range and press ENTER. Press A/V to leave the menu.

3] Connect an DC current source and a reference DC-ammeter to the "AMMETER-2 (A)" input.

4] Adjust the current from the DC current source to about 1.30 A (2/3 of full range).

5] Activate the HOLD function.

6] Press the MOM and hold it down for a second. The LED in the HOLD-button should start flash. Release the MOM button.

7] Press the SYS button.

8] Press and hold the button ENTER and then the button ESC. Turn the select/set knob until you see "CALIBRATION", then release ESC and ENTER. Press ENTER to confirm calibration.

9] Choose "AMMETER-2" and press ENTER.

10] Turn the select/se knob until the current value on the display matches the value from the reference ammeter and press ENTER.

11] Check that the ampere reading in the display matches the reference ammeter by pressing MOM. If not, redo from step 5.

12] Repeat the calibration process for the range 0-20 A at 13.0 A (at 2/3 of the full scale).

13] Leave the calibration menu by pressing ESC twice.

10.6 Calibration of scale factor, voltmeter

Scale factor, range 0 – 0.2 V

1] Press A/V, select "VOLTMETER" and press ENTER.

2] Select the "0-0.2 V" range and press ENTER.

3] Press A/V to leave the menu.

4] Connect a DC voltage source and a reference DC voltmeter input.

5] Adjust the voltage from the DC voltage source to about 0.133 V (2/3 of the full range).

6] Press HOLD to activate the hold function.

7] Press the MOM and hold it down for a second. The LED in the HOLD-button should start flash. Release the MOM button.

8] Press the SYS button.

9] Press and hold the button ENTER and then the button ESC. Turn the select/set knob until you see " CALIBRATION ", then release ESC and ENTER. Press ENTER to confirm calibration.

10] Choose " VOLTMETER " and press ENTER.

11] Turn the CHANGE knob until the voltage value on the display matches the value from the reference voltmeter and press ENTER.

12] Without leaving calibration functions, press the MOM(ON) button again to generate a new voltage and get a new hold-value. Select " VOLTMETER " and press ENTER. Check that the reading conforms to the reading on the reference voltmeter. If not, correct and store the new value and repeat until no more adjustment is needed. Then press ESC twice.

13] Repeat the calibration process for the ranges 0-2 V, 0-20 V, and 0-200 V at 2/3 of full scale *a reset is performed.*

10.7 Resetting to preset (standardized) calibration values

Instead of regular calibration a resetting function can be activated that will set the calibration values to a set of preset and standardized values. This will give an accuracy of about 1%. Resetting can never replace a regular calibration where accurate and traceable reference instrument are used, but is a quick and simple method of solving the problem of having no calibration values at all. Resetting must always be followed by a calibration of the zero-offset, which is a part of the regular calibration procedure.

It is possible to combine resetting and calibration; first perform a reset and then calibrate the ranges for which required instruments and sources are available. The ranges that can not be calibrated will then use the standard calibration values.

Note: *When a reset is performed, ALL settings, values and parameters will be set to preset default values. This also implies the settings stored in INGVAR's memories, which will be lost if a reset is performed.*

Performing a reset

1] Press and hold down the RESET button while INGVAR is switched on.

11 Specifications

SPECIFICATIONS INGVAR

Specifications are valid for an ambient temperature of +25°C and nominal input voltage. The specifications are subject to change without notice.

System designation

An INGVAR-system consists of a Control Unit and one Current Unit.

Environment

Application field	The instrument is intended for use in medium-voltage substations and industrial environments.
Temperature	
Operating	0°C to +50°C (+32°F to +122°F)
Storage & transport	-25°C to +55°C (-13°F to +127°F)
Humidity	5% – 95% RH, Non-condensing
Altitude (operational)	<2000 m
Pollution degree	2

CE-marking

EMC	2014/30/EU
LVD	2014/35/EU
ROHS	2011/65/EU

General

Measurement category	CAT I Rated transient overvoltage: 2200 V
Mains voltage	100 – 240 V AC, 50/60 Hz
Mains inlet	IEC 60309-1, -2. 16 A

Power consumption

Input voltage	*Output current*	*Input current*
240 V	2 kA	20 A
240 V	3.8 kA	45 A
120 V	2.5 kA	30 A
120 V	1 kA	12 A

Input current	Output current x open circuit voltage /input voltage
Protection	The output transformer has a built-in thermal cut-out, and the primary side is protected by a miniature circuit breaker
Dimensions	
Control Unit	546 x 347 x 247 mm (21.5" x 13.7" x 9.7")
Current Unit	410 x 340 x 205 mm (16.1" x 13.4" x 8")
Weight	
Control Unit	20 kg (44 lbs)
Current Unit	21 kg (46.3 lbs)
Data transfer	USB Type B Female

Display

Type	LCD
Available languages	English, German, French, Spanish, Swedish.

Outputs

Outputs in parallel, 240 mains voltage

Maximal current	*Maximum generation time*	*Minimum rest time*[1)]	*Load voltage*
0A	continuously	–	3V [2)]
700 A	continuously	–	2.6 V
1000 A	30 min	5 min	2.5 V
2000 A	3 min	10 min	2.1 V
3000 A	1 min	12 min	1.8 V
5000 A	2 sec	3 min	1.2 V
Outputs in series, 240 mains voltage			
350 A	continuously	–	5.3 V
500 A	20 min	15 min	5.1 V
1500 A	2 min	12 min	3.5 V

1) Time to reset the thermal protection.

2) No load voltage

Measurement section

Ammeters

Measurement method	AC 50/60 Hz, DC RMS
Inaccuracy	1% of range ±1 digit

Ammeter 1

Ranges	
Serial Low	0 – 2.15 kA
Serial High	0 – 3.30 kA
Parallel Low	0 – 4.00 kA
Parallel High	0 – 6.50 kA
Resolution	
0-999 A	1 A
1.00 – 6.50 kA	10 A

Ammeter 2

Ranges	0 – 2 A / 0 – 20 A

Voltmeter

Measurement method	AC 50/60 Hz, DC RMS
Ranges	0 – 0.2 V, 0 – 2 V, 0 – 20 V, 0 – 200 V, AUTO
Inaccuracy	1% of range ±1 digit
Input resistance (Rin)	240 kΩ (range 0 – 200 V) 24 kΩ (other ranges)
Dielectric withstand	2.5 kV

Timer

Presentation	In seconds, mains frequency cycles or hours and minutes
Ranges	0.000 – 99999.9 s 0 – 9999 cycles
Inaccuracy	±(1 digit + 0.01% of value) For the stop condition in INT-mode 1 ms shall be added to the specified measurement error.

Stop input

Max. input voltage	250 V AC / 275 V DC
Phase angle	
Range	0 – 359°
Resolution	1°
Inaccuracy	±2° (For voltage and current readings higher than 10% of the selected range)

Z, P, R, X, S, Q and power factor (cosφ)

The result is calculated using U, I and j

Imax

Stores highest current value that exists ≥100 ms

INT-level

Threshold indicating that current is interrupted, can be set to approx. 0.5 or 2% of range for Ammeter 1

A1 Appendix 1

A1.1 Transferring test data to a PC or a printer

Test data from INGVAR can be transferred to a PC for further processing or to a printer.

The transfer to a PC is made between the USB port on INGVAR and the USB port on the PC, using a cable and a communications program, such as the terminal program featured in Windows (or something similar to this). The transfer of test data is initiated each time the <ENTER> key is pressed.

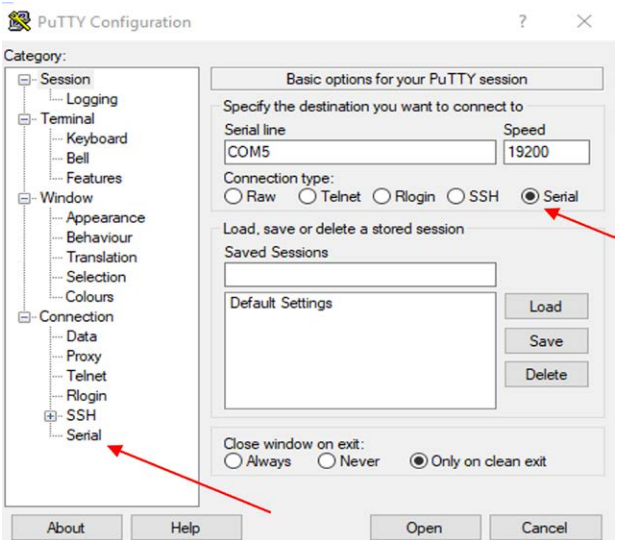
See also “Auto-Dump” functionality in system settings "SYSTEM" on page 21.

A1.2 Setting up the PC connection

When retrieving test data from the INGVAR test instrument, a terminal software program has to be used. Such as the PuTTY terminal software, which can be downloaded from the internet.

Connect the test instrument with a USB A/B cable to the PC. Check the comm port used on your PC. The driver for the communication port is “Silicon Labs CP210x USB to UART Bridge”. Which can be downloaded from the internet.

Start the test instrument and the PuTTY terminal software.

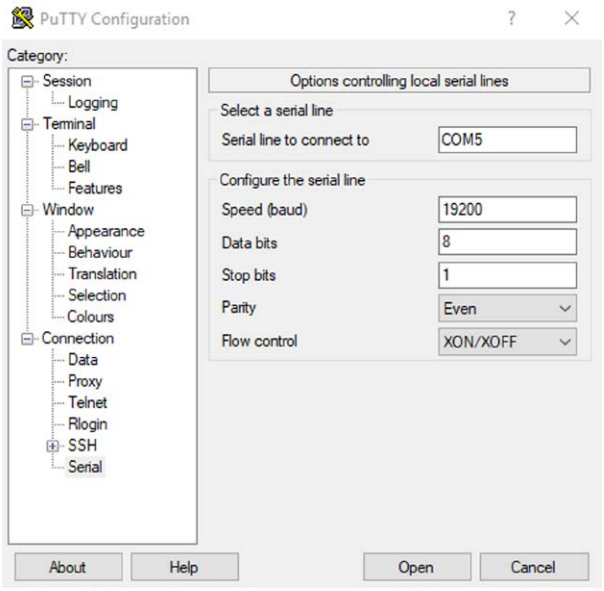


Set the COM port number that is used on the computer, and the speed 19200.

Select “Serial” by clicking the tick/checkbox.

Click on “serial acc to arrow

This menu will appear.



Type in and select the parameters for the communication.

Click on "Open" The menu COM5 puTTY appears.

Do a short current trip test from the test instrument, INGVAR.

The test results are transferred from the test instrument by pressing the **Enter button** on the test instrument, INGVAR.

In this case, current has been injected 4 separate times.

Test data can also be retrieved by setting the INGVAR to the "Auto-Dump" function.

Test data will be dumped to PC when the test on INGVAR has stopped.

A1.3 Transfers in "NORMAL USE"

Data measured by INGVAR will be dumped to the PC (or printer) each time you press <ENTER>. The downloaded data contains this:

- Current measured by Ammeter 1 (amperes)
- Time (seconds)
- Current measured by Ammeter 2 (amperes)
- Voltage (volts)
- Phase angle (degrees)
- Imax (amperes)

Example of transferred data:

288;A; 6.538;s; 0.290;A;---;V; 182;Deg; 290;A; Imax

908;A; 1.697;s; 0.917;A;---;V; 182;Deg; 910;A; Imax

951;A; 3.339;s; ---;A;0.099;V; 2;Deg; 960;A; Imax

A1.4 Transfers in applications "TEST RECLOSER" and "SECTIONALIZER"

Measured data from a test in the "**TEST RECLOSER**" and "**SECTIONALIZER**"applications will be dumped to the PC (or printer) each time you press <ENTER>. The downloaded data contains this:

- Number of operations
- Total accumulated time (seconds)
- Trip times and current (seconds, amperes)
- Reclosing times and current (seconds, amperes)

Example of transferred data:

2;OP

TAT; 0.673;s

T01;0.397;s; 47;A

R01;0.254;s; 0;A

T02;0.419;s; 47;A

R02;0.000;s; 0;A

T03;0.000;s; 0;A

R03;0.000;s; 0;A

T04;0.000;s; 0;A

R04;0.000;s; 0;A

T05;0.000;s; 0;A

R05;0.000;s; 0;A

Index

P

Q

R

S

T

V

W

X

Z

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