MT30_MAN_EXT_EN_V503


ZERA

Instructions for use

# MT30

## Portable reference meter

Keep for reference

9. February 2023

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# 1 General

Contents

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# Declaration of conformity

| | |
|---|---|
| Manufacturer | ZERA GmbH<br>Humboldtstraße 2a<br>D-53639 Königswinter |
| Validity of Declaration of conformity | The company ZERA GmbH hereby declares under sole responsibility that the product described below is in conformity with the fundamental requirements of the Directives listed below:<br>• Product description: Portable reference meter<br>• Model: Moving Test MT30 |
| Declaration of conformity with Directives | The manufacturer declares that the reference meter described above is in conformity with the following directives:<br>• 2014/30/EU (Electromagnetic Compatibility)<br>• 2014/35/EU (Low Voltage Directive) |
| Standards compliance | The reference meter described above complies with the requirements in the following European standards:<br>• DIN EN 61010-1<br>• DIN EN 61000-4-2<br>• DIN EN 61000-4-3<br>• DIN EN 61000-4-4<br>• DIN EN 61000-4-5<br>• DIN EN 61000-4-6<br>• DIN EN 61000-4-8<br>• DIN EN 61000-4-11<br>• DIN EN 55011 |

# About these Instructions for use

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Validity and purpose

These Instructions for use apply to the MT30 reference meter, firmware version 6.25.

The Instructions for use contain the information needed for safe and correct working practices when testing installations and meters.

Target readership

The Instructions for use are intended solely for trained electricians who are **additionally qualified to work with live voltages**.

Conventions used for hazard notices

The hazard notices are categorized according to the following hazard levels:

| Hazard level | Consequence | Likelihood |
|---|---|---|
| DANGER | Death / serious injury (irreversible) | Immediate hazard |
| WARNING | Death / serious injury (irreversible) | Potential hazard |
| CAUTION | Minor injury (reversible) | Potential hazard |
| NOTICE | Damage to property | Potential hazard |

# 2 Safety

Summary

The Safety chapter contains information that is essential to read and follow before using the reference meter.

Contents

# Intended use

Intended use

The MT30 is a portable reference meter. It is used for on-site testing under mains load of various types of electricity meter

- Ferraris meters
- Electronic meters

The reference meter can be used for:

- Testing meter installations in a single-phase two-wire, three-phase three-wire or three-phase four-wire system
- Checking the meter's energy register and power register
- Measuring active, reactive and apparent power
- 4-quandrant measurements
- Measuring frequency, phase angle and power factor
- Analysing voltage and current harmonics up to the 40th harmonic
- Measuring the total harmonic distortion
- Vectorial view of the measured values
- Oscilloscope function for waveform sampling
- Rotating field indication

The reference meter must be used within the limits specified in the Technical Data

Restrictions on use

The reference meter must not be used for measurements that lie outside the ranges specified in the Technical Data.

# Essential safety regulations

Persons who should read these regulations

These regulations are intended for any person who works with the reference meter.

Purpose of these regulations

These regulations are intended to ensure that any person working with the reference meter has a thorough understanding of the associated hazards and safety precautions and heeds the safety instructions given in the Instructions for use. You risk injury and even death if you do not follow these instructions, and you may also cause damage to property.

Using the Instructions for use

Follow the instructions below:

- Read carefully the Safety chapter and those chapters relating to your activity. You must have understood the information contained in these chapters.
- Always keep the Instructions for use available for reference.
- Pass on the Instructions for use with the reference meter.

Using the instrument safely

Follow the instructions below:

- Only those persons who meet the requirements stipulated in these Instructions for use are allowed to use the reference meter.
- Employ the reference meter solely for the intended use. Never use the reference meter under any circumstances for other purposes, even if these may seem perfectly normal.
- Take all the safety precautions specified in these Instructions for use. Use in particular the personal protective equipment specified
- Always ensure your hands and footwear are dry and the floor is dry before using the instrument.
- Do not make any modifications to the reference meter. In particular, you are not allowed to modify or disable any safety devices.

Ensuring the reference meter is in good working order

Follow the rules below:

- Only use the reference meter if the case and all the accessories are in perfect condition.
- Check all cables for breaks or for cracks in the insulation before use. Immediately replace any cables showing signs of damage.
- Make sure that
  - you always use insulated safety voltage pins/cables for more than 40 V.
  - you never use unprotected metal pins or banana plugs.
- Make sure that all connections are plugged in properly. Loose connections can cause arcing, overheating or short-circuits and may damage the equipment and/or associated devices.

Requirements for the environment in which the equipment is used

The *Technical Data* on page 18 contains the specification for the equipment environment.

Restrictions on use:

- The equipment must be operated solely in enclosed spaces and/or with suitable protection against rain and water spray/splash and excessive heat, e. g. from direct sunlight.
- The environment of use must be dry.

# Requirements for personnel and personal protective equipment

| | |
|---|---|
| Requirements for personnel | Measurements using the reference meter must be carried out solely by an electrician who is additionally trained and qualified in working with live voltages. |
| Who is an electrician? | An electrician is someone who, based on his/her technical training, knowledge and experience and familiarity with the relevant regulations, can assess the work assigned to him/her and recognize potential hazards. |
| Personal protective equipment | Personal protective equipment is required when working with live voltages. National regulations relating to safety at work specify the requirements for personal protective equipment. |

# 3 Design and function of the reference meter

Summary

This chapter introduces you to the reference meter.

Contents

## Contents of the case

Details

The reference meter is always supplied in a special case. The contents of the case will vary depending on the purchase order.

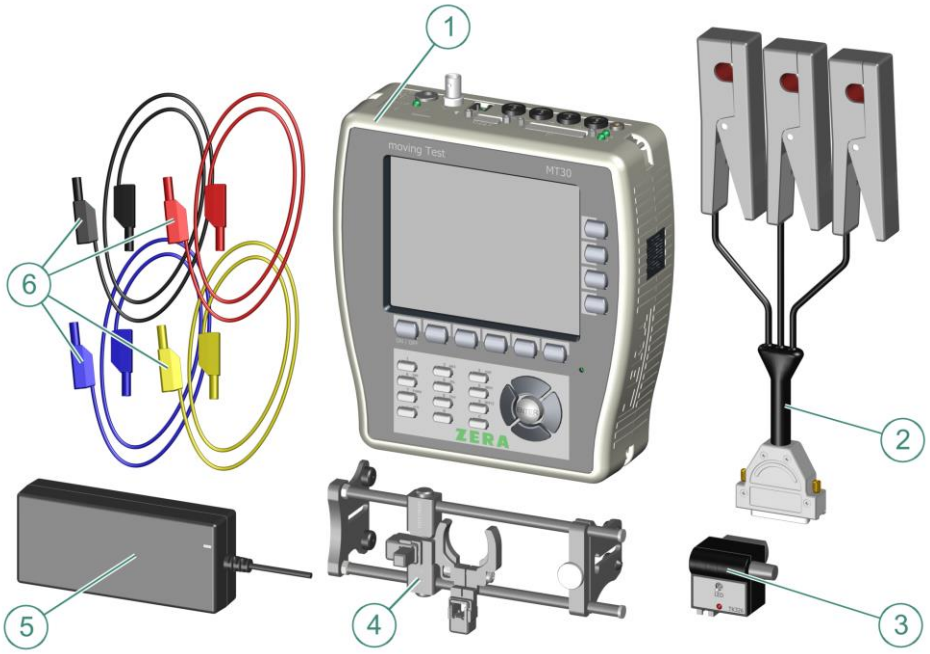
Photo of the case

The reference meter inside the aluminium case alongside typical accessories

Delivery note

A delivery note is included with each case. The delivery note tells you what the case contained when shipped. Check against the delivery note that the case contains all the parts listed.

Basic kit




Elements of the basic kit

| No. | Name |
|---|---|
| 1 | Reference meter |
| 2 | AC current clamps |
| 3 | Scanning head (various types available, with separate Instructions for use) |
| 4 | Scanning-head mount |
| 5 | Power supply unit (mains adapter) |
| 6 | Four coloured laboratory leads |

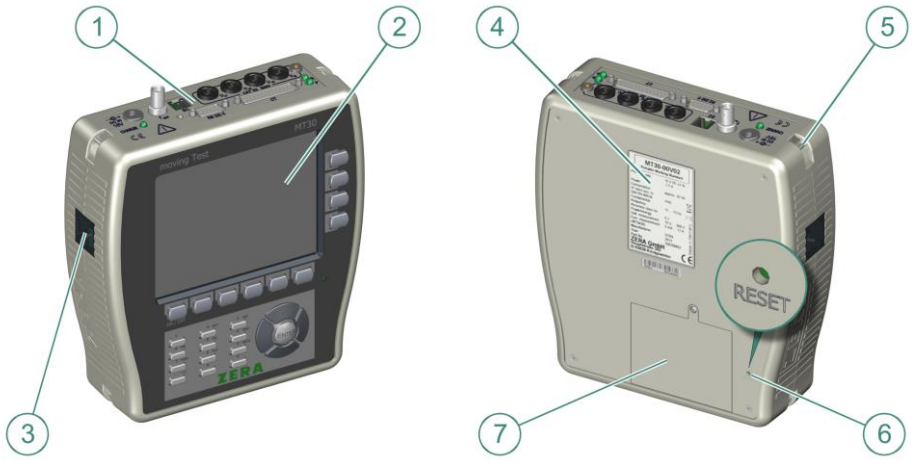
A calibration certificate is always included with every reference meter.

# The MT30 reference meter

The MT30

The MT30 is a reference meter. The reference meter is used to check meter installations (single-phase two-wire, three-phase three-wire and three-phase four-wire systems).

Overview of the reference meter

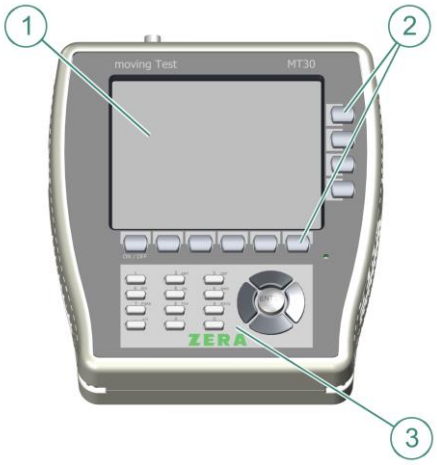



Design of the reference meter

| No. | Details |
|---|---|
| 1 | Connection panel |
| 2 | Operating panel |
| 3 | Ventilation |
| 4 | Type plate |
| 5 | Belt fastening (4x) |
| 6 | Reset button |
| 7 | Battery compartment |

## Controls and indicators

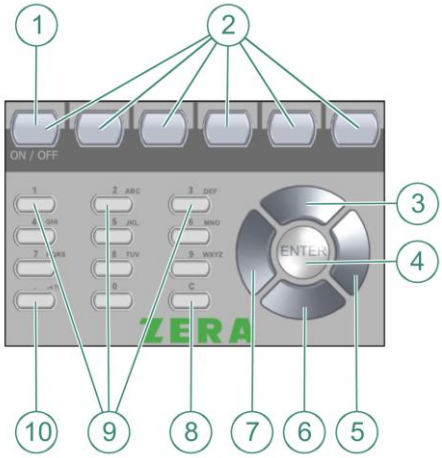
Front view of the reference meter




Controls and indicators

| No. | Name | Function |
|---|---|---|
| 1 | Screen | Displays all the functions and measured values (6.4″ monochrome backlit LCD screen) |
| 2 | Function keys | Used to select the functions displayed on the screen |
| 3 | Keypad and cursor control | • Alphanumeric input<br>• Cursor control<br>• Input confirmation |

The control panel

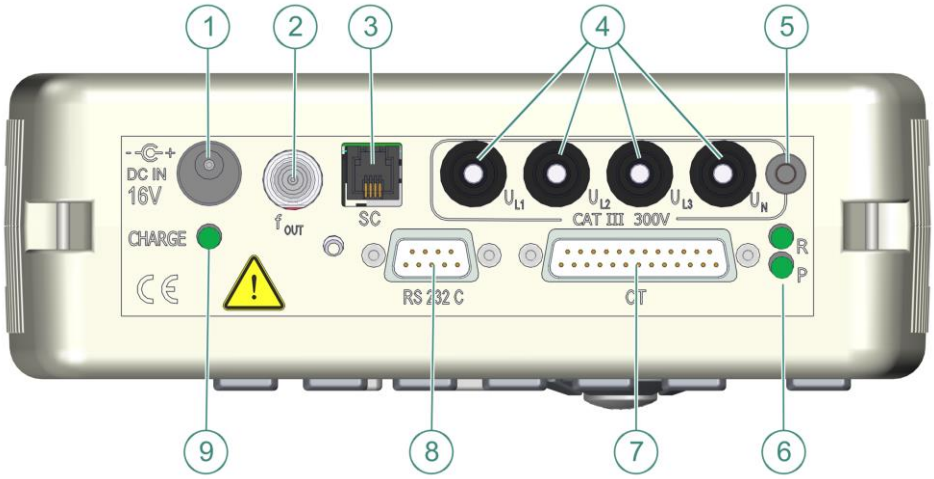



The control buttons

| No. | Name | Function |
|---|---|---|
| 1 | ON/OFF button<br>Function key | • Switch reference meter on or off<br>• Used to select the functions displayed on the screen |
| 2 | Function keys | Used to select the functions displayed on the screen |
| 3 | Cursor up | Move cursor upwards |
| 4 | Enter | Confirm input |
| 5 | Cursor right | Move cursor to the right |
| 6 | Cursor down | Move cursor downwards |
| 7 | Cursor left | Move cursor to the left |
| 8 | Clear | Delete the character currently indicated by the cursor |
| 9 | Numeric keypad | Used for entering numbers and letters<br>(press repeatedly) |
| 10 | Special characters | Used for entering special characters ., +, -, ?, ! |

# Connection panel

Connection panel




Purpose of the connectors and LEDs

| No. | Name | Details |
|---|---|---|
| 1 | DC IN 16V | Connection for mains adapter<br>• Power supply for the reference meter<br>• Charges the built-in battery |
| 2 | f OUT | BNC connector for connecting to a reference meter.<br>The frequency of the signal is proportional to the power. |
| 3 | SC | "RJ10" 4P4C connector for scanning head for pulse acquisition |
| 4 | UL1 | Voltage connection for line phase 1, max. 300 V CAT III |
| | UL2 | Voltage connection for line phase 2, max. 300 V CAT III |
| | UL3 | Voltage connection for line phase 3, max. 300 V CAT III |
| | UN | Voltage connection for neutral, maximum 300 V CAT III |
| 5 | - | Indexing hole for the quick-connect voltage connector to prevent wrong polarity. |
| 6 | LED P (Power) | Power status LED |
| | LED R (Ready) | Ready status LED |
| 7 | CT | 25-pin connector for:<br>• AC current clamps<br>• Temperature sensor |
| 8 | RS-232 | RS-232 interface D-Sub DE-9<br>Port for connecting a PC<br>Port for connecting an external source<br>Port for connecting a serial printer |
| 9 | LED CHARGE | Status LED showing level of battery charge |

Charge status LED

| LED | Details |
|---|---|
| Permanently on | Instrument being powered from the mains adapter<br>Internal battery is fully charged |
| Flashing slowly | Instrument being powered from the mains adapter<br>Internal battery is being charged |
| Flashing rapidly | Instrument being powered from the mains adapter<br>Internal battery is faulty; must be replaced immediately |
| Off | Instrument under battery power |

# Technical data

General

| Date | Value |
|---|---|
| Power supply | 16 V DC ±3 %, 2.5 A |
| Power consumption | ~ 20 VA |
| Rechargeable battery operation : operating time | ~ 1 h |
| Rechargeable battery operation : recharging time<br>At cells with different charge up to max.30 h | ~ 3 h |
| Temperature range, operation | −15 … +50 °C |
| Temperature range, storage | −15 … +65 °C |
| Relative humidity (not condensing) | max. 95 % |
| Dimensions (L×W×H) | 190 × 190 × 80 mm |
| Weight | ~ 1.6 kg |
| Max. height above sea level | 2000 m |
| External power supply unit | Type: Mascot 9921<br>(90 ... 264 V / 47 ... 63 Hz / max 0.9 A) |

Safety

| Date | Value |
|---|---|
| IP class according to DIN EN 60529 | IP40 |
| Declaration of conformity | CE conform |
| Overvoltage category voltage measurement<br>Option CAT IV 300V | CAT III 300 V |
| Overvoltage category, current measurement (MT3430) | CAT III 30 V |

Reference meter

| Date | Value |
|---|---|
| Measuring modes<br>Depending on the selected option | 1-ph 2 WA / WR / WAP<br>3-ph 3 WA / WR / WRCA / WRCB / WAP<br>3-ph 4 WA / WAb / WR / WRb / WRC / WAP / WAPb |
| Fundamental frequency | 15 … 70 Hz |
| Bandwidth | 3000 Hz |
| Sampling | 16 bit 504 samples/period |
| Accuracy class for measuring of power / energy | 0.2 |
| Rotary field indication | yes |
| Angle measurement accuracy<br>From 30 V … 300 V (45 ... 65 Hz)<br>From 500 mA … 120 A (45 ... 65 Hz) | < 0.1° |
| Frequency measurement deviation | ± 0.01 Hz |

Voltage Measurement

| Date | Value |
|---|---|
| Number of voltage channels | 3 |
| Voltage measurement | 10 ... 300 V |
| Voltage range(s) | 250 V |
| Usage of ranges | 10 ... 120 % @ 15 ...70 Hz<br>2 ... 120 % @ 50 Hz |

| Date | Value |
|---|---|
| Input impedance of voltage channels (@ range) | 264.5 kΩ @ 250 V |
| Voltage measurement accuracy<br>From 30 V … 300 V (45 ... 65 Hz)<br>Related to the read value at optimum range selection | < 0.05 % @ 30 ... 300 V |
| Voltage measurement temperature drift<br>From 30 V … 300 V (45 ... 65 Hz) | < 15 × $10^{-6}$ / K |
| Voltage measurement stability<br>Stability over 1 hour (every minute one measurement with ti = 60 s) | < 50 × $10^{-6}$ |
| Voltage measurement long term stability<br>Stability over 1 year (every month one measurement over one hour)<br>From 30 V … 300 V (45 ... 65 Hz) | < 100 × $10^{-6}$ / Year |
| Voltage measurement linearity | < 100 × $10^{-6}$ |

Current measurement using AC current clamps MT3430

| Date | Value |
|---|---|
| Current measurement | 5 mA … 120 A |
| Current range(s) | 100 A, 50 A, 10 A, 5 A, 1 A, 500 mA, 100 mA, 50 mA |
| Usage of ranges | 10 % ... 120 % |
| Current measurement accuracy<br>Related to the read value at optimum range selection | < 0.15 % @ 500 mA … 120 A<br>< 0.3 % @ 100 mA … 500 mA |
| Current measurement temperature drift<br>From 500 mA … 120 A (45 ... 65 Hz) | < 50 × $10^{-6}$ /K |
| Current measurement stability<br>Stability over 1 hour (every minute one measurement with ti = 60 s)<br>From 500 mA … 120 A (45 ... 65 Hz) | < 150 × $10^{-6}$ |
| Current measurement long term stability<br>Stability over 1 year (every month one measurement over one hour)<br>From 500 mA … 120 A (45 ... 65 Hz) | < 600 × $10^{-6}$ / Year |
| Clamp for cables up to ⌀ | 12 mm |

Power measurement (@MT3430)

| Date | Value |
|---|---|
| Power/energy measurement accuracy<br>From 30 V … 300 V (45 ... 65 Hz)<br>From 500 mA … 120 A (45 ... 65 Hz)<br>Related to the read value at optimum range selection<br>Related of apparent power | < 0.2 % |
| Power/energy measurement temperature drift<br>From 30 V … 300 V (45 ... 65 Hz)<br>From 500 mA … 120 A (45 ... 65 Hz) | < 65 × $10^{-6}$ |
| Power/energy measurement stability<br>Stability over 1 hour (every minute one measurement with ti = 60 s) | < 200 × $10^{-6}$ |
| Power/energy measurement long term stability<br>Stability over 1 year (every month one measurement over one hour) | < 700 × $10^{-6}$ / Year |

# 4 Design and operation of the user interface

Summary

This chapter describes the general layout of the user interface. Details of the screens displayed for the various functions are given in the Chapter *Functions provided by the reference meter* on page 57

Contents

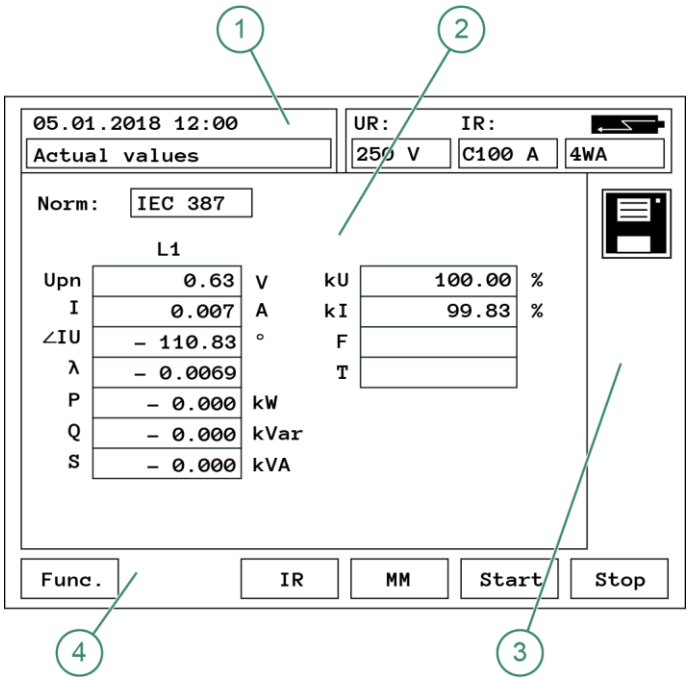
# The software interface

Details

The software interface displays all the data and possible functions. The software is operated using the buttons arranged around the screen edge. Values can be entered using the numeric keys.

Layout of the software interface

The figure shows the essential layout of the software interface. The contents in the different areas of the screen vary depending on the function selected.




Areas of the software interface and their purpose

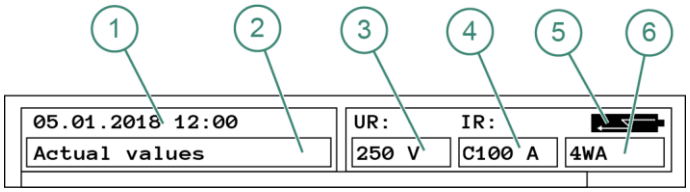
| No. | Details | Function |
|---|---|---|
| 1 | Status bar | • Shows general system information such as system time and battery status<br>• Shows the selected function and the measurement presets |
| 2 | Display area | • Shows the measurement data in various display modes |
| 3 | Vertical function bar | Shows subfunctions for selection using function keys |
| 4 | Horizontal function bar | Shows various functions for selection using function keys |

# The status bar

Details

The status bar shows the currently selected function, the measurement range and the measurement mode.

Layout of the status bar




Areas of the status bar and their purpose

| No. | Details | Function |
|---|---|---|
| 1 | Date and time | Shows the date and time |
| 2 | Function | Shows the selected function |
| 3 | Voltage measuring range UR | Shows the voltage measurement range |
| 4 | Current measurement range IR | Shows the current measurement range |
| 5 | Battery indicator | Shows the power supply status |
| 6 | Mode MM | Shows the selected measurement mode |

What the battery indicator means

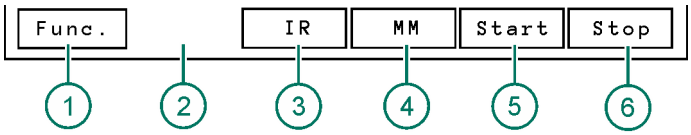
| Display | Details |
|---|---|
|  | Powered from the mains adapter |
|  | Operation under battery power<br>The status bar indicates the battery charge level. |

# The function bars

Purpose of the horizontal function bar

The horizontal function bar is used to select the function, measurement range and mode. It can also be used for actuating core functions of the reference meter such as starting and stopping the measurement.

Layout of the horizontal function bar




Functions of the horizontal function bar

| No. | Name | Details |
|---|---|---|
| 1 | Func. | Select function |
| 2 | – | unassigned |
| 3 | IR | Select current measurement range |
| 4 | MM | Select measurement mode |
| | Print | Print measurement data |
| | Load | Load settings for external source |
| 5 | Start | • Start measurement<br>• Display actual values for the measurement in progress |
| | Save | • Save measurement data<br>• Save settings for external source |
| | Delete | Delete all measurement data |
| | On | Enable external source |
| 6 | Stop | • Stop measurement<br>• Display actual values for the stopped measurement |
| | Back | Back to function |
| | Off | Disable external source |

Purpose of the vertical function bar

The vertical function bar is used to open the subfunctions of the functions ('Func.'). Details of the subfunctions are given with the associated functions.

# 5 Taking test measurements

Summary

The Taking test measurements chapter describes the test procedure for measuring certain values. Measurement results that can be displayed without any specific procedure are described directly in the chapter *The functions provided by the reference meter* on page 57.

Contents

# Switching on the reference meter and preparing for testing

Introduction

Certain preliminary settings must be made in order to perform a test measurement. These presets are retained for all measurements until changed again by the operator.

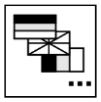
Switching on

| Step | Procedure | |
|---|---|---|
| 1 | Press the ON/OFF button for about 5 seconds.<br>Result: the screen comes on and the Start-up screen is displayed. |  |

Switching off

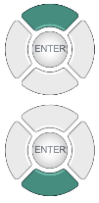
| Step | Procedure | |
|---|---|---|
| 1 | Press the ON/OFF button for about 5 seconds.<br>Result: the screen switches off. |  |

Selecting the system language

| Step | Procedure | |
|---|---|---|
| 1 | Select the 'Settings' function. | |
| 2 | Select the subfunction 'Select the system language' . |  |
| 3 | Select the language you require. |  |
| 4 | Confirm your selection. |  |

Selecting the phase angle calculation under the 'Norm' entry

The 'Select angle calculation' subfunction under the 'Norm' entry defines how phase angles are measured, calculated and displayed in the vector diagram; see *'Settings'* on page 79. The names of the two options derive from past standards. This documentation uses the terms 'IEC 387' and 'DIN 410' to distinguish between the two options. Selecting 'DIN 410' will define U1 as the reference value, while selecting 'IEC 387' defines I1 as the reference value.

| Step | Procedure | |
|---|---|---|
| 1 | Select the 'Settings' function. | |
| 2 | Select the 'Select angle calculation' subfunction. |  |
| 3 | Choose the option you require:<br>• IEC 387<br>or<br>• DIN 410 |  |
| 4 | Confirm your selection. |  |

Measuring under battery power

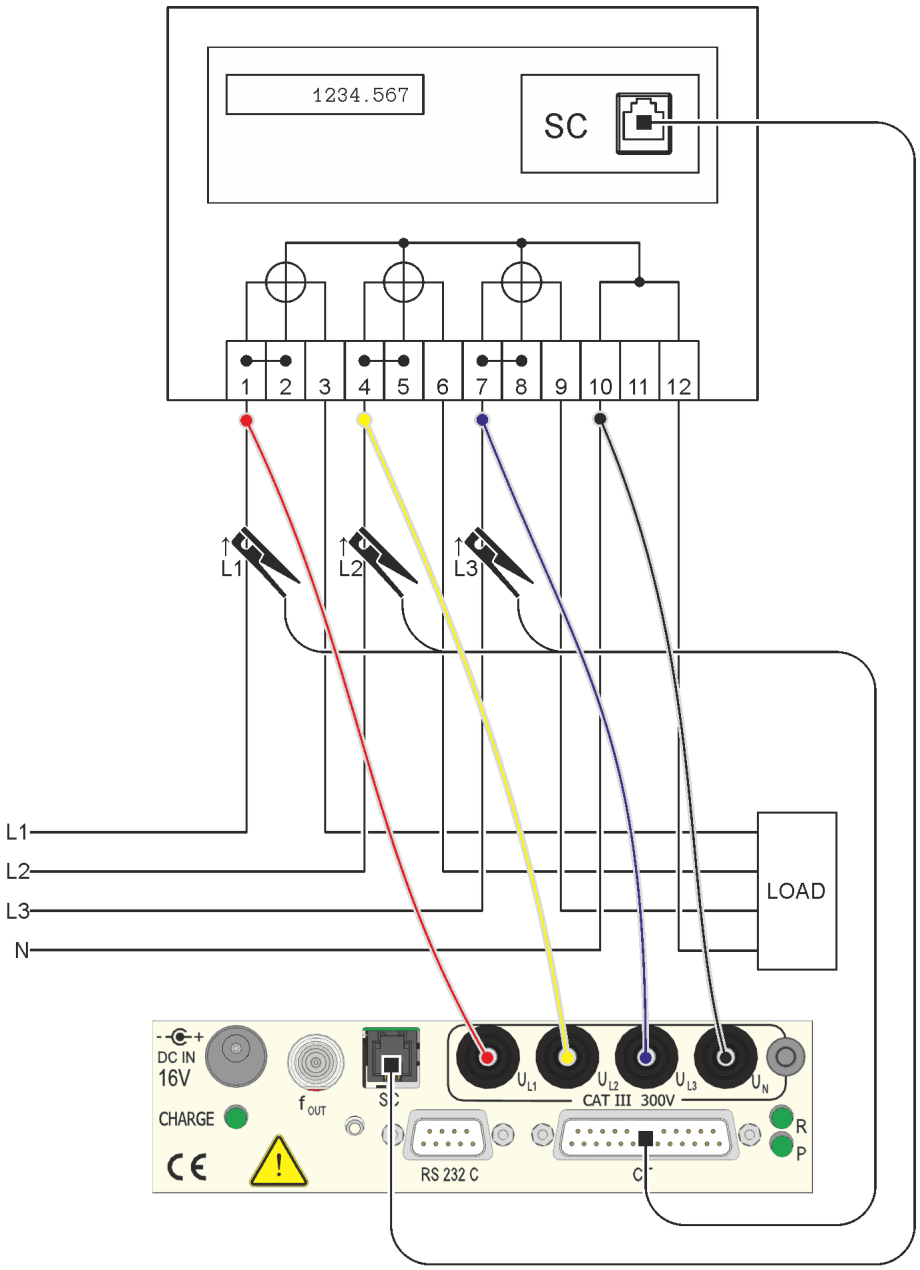
The test instrument can optionally be powered from rechargeable batteries rather than the mains adapter. Battery operation is not suitable for measurements that take a long time, which may be the case for the Error Measurement and Register tests.

# General procedure for a test measurement

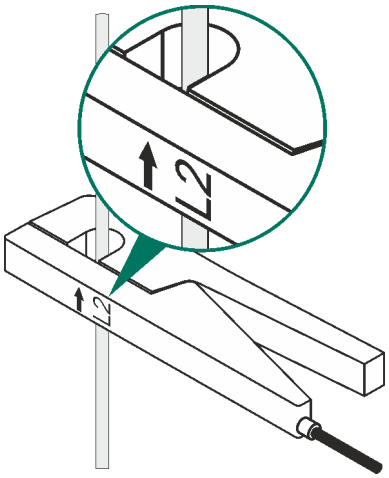
Measuring principle

In a meter test, the energy consumption measured (metered) by a meter is compared with the result from the reference meter. In order to be able to make the comparison, the reference meter must measure the current and voltage in exactly the same way as the meter itself, and compare these readings with the meter result. The meter result from the meter is signalled by pulses from an LED or the number of revolutions of a rotor disc. This signal can be detected by a scanning head and transmitted to the reference meter.

Typical connection diagram



General procedure for connecting the reference meter to a device under test

| Step | Description |
|---|---|
| **1** | Connect the AC current clamps to the CT input of the reference meter. |
| **2** | Connect the voltage cables to the inputs $U_1$, $U_2$, $U_3$, $U_N$ of the reference meter. |
| **3** | Connect the reference meter to the mains supply:<br>• Connect the mains adapter to the mains supply.<br>• Connect the mains adapter to the DC IN 16V input of the reference meter.<br>• Switch on the reference meter.<br>Result: the reference meter powers up.<br>• Wait until the reference meter is ready for use. |
| **4** | Make the following settings at the reference meter:<br>• Select the current measurement range; see *The Measurement ranges* on page 55<br>• Select a suitable measuring mode; see *The measuring modes* on page 56 |
| **5** | Connect the voltage cables to the device under test:<br>• first $U_N$<br>• then $U_1$, $U_2$, $U_3$ |
| **6** | Clamp the AC current clamps around the cables L1, L2 and L3 that supply the current. Make sure that the AC current clamps are fully closed and sit in the correct direction.<br>Measurement results will be incorrect if the AC current clamps are not fully closed (air gap) or if the current is flowing in the wrong direction.<br>  |
| **7** | Attach the scanning head to the meter; see *Attaching the scanning head to the meter* on page 30. |
| **8** | Connect the scanning head cable to the SC input on the reference meter and then to the scanning head.<br>Result: the LED on the scanning head flashes in time with the LED on the meter or the mark on the rotor disc.<br>If this is not the case, realign the scanning head. |
| **9** | Check the settings at the reference meter for the current measurement range, and correct the range if necessary.<br>**Video tutorial:** |
| **10** | Enter the meter constant in the 'Error measurement' function; see *Entering the meter constant* on page 31. |
| **11** | For CT operated meters, enter their associated ratio in the 'Ratio' function; see 'Ratio′ on page 82. |
| **12** | Perform the measurements you require. |
| **13** | Save your test results. |

General procedure for disconnecting the reference meter from the device under test

| Step | Description |
|---|---|
| **1** | Disconnect the scanning head cable from the scanning head and the reference meter. |
| **2** | Remove the scanning head. |
| **3** | Disconnect the voltage cables from the device under test:<br>• $U_1$, $U_2$, $U_3$ first<br>• $U_N$ last |
| **4** | Remove the AC current clamps from the device under test. |
| **5** | Switch off the reference meter and disconnect it from the mains adapter. |
| **6** | Disconnect the voltage cables from the reference meter. |
| **7** | Remove the AC current clamps from the reference meter. |

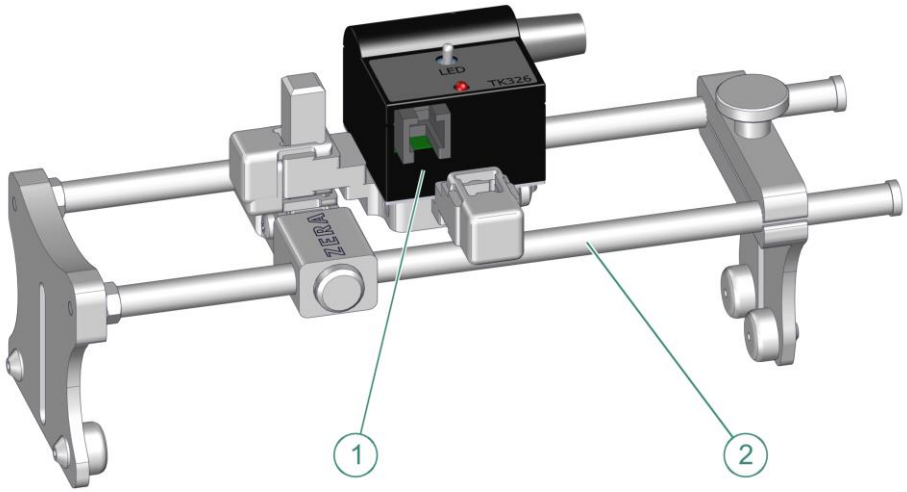
# Attaching the scanning head to the meter

Further details on scanning heads

ZERA offers a range of scanning heads and mounts, each of which has its own Instructions for use. These dedicated Instructions for use contain details of the scanning heads and how they are fitted to the meter.

Illustration as an example

The following picture illustrates a scanning head with mount by way of example:




Design and operation

| No. | Name | Details |
|---|---|---|
| 1 | Scanning head | The scanning head detects the signal from the meter.<br>• Scanning heads come in various designs. They can be attached to the meter using mounts, magnets or suction pads, for instance.<br>• The scanning head is connected to the reference meter via the scanning-head input connector. |
| 2 | Mount | The mount is used to fit the scanning head to the meter.<br>• Mounts come in various designs depending on the scanning head. The mounts can be fastened to the meter using clamps or even belts, e. g. for round-shaped meter enclosures. |

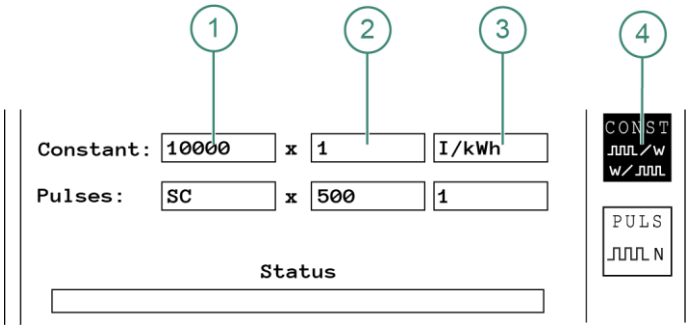
# Entering the meter constant

The meter constant

The meter constant indicates the number of LED pulses given per kWh for an electronic meter, or the number of revolutions made per kWh for a mechanical meter. The meter constant is written on the meter type plate or can be found in the meter documentation. The meter constant must be saved in the reference meter before the actual meter testing starts.

Screenshot of entering the meter constant

The meter constant is entered in the 'Error measurement' function.




Entering the meter constant

| Step | Procedure |
|---|---|
| **1** | Open the subfunction for entering the meter constant (4). |
| **2** | Enter the meter constant in the input field (1). A multiplier (2) is needed for values ≥ 1000000. |
| **3** | Select a multiplier from the list box (2).<br>Exp−5 (0.00001) … 1 … Exp+5 (100000) |
| **4** | Select the units from the list box (3). |

Units for the meter constant

| Func-tion | Details |
|---|---|
| I/kWh | Pulses per kilowatt-hour |
| I/kvarh | Pulses per kilovar-hour for reactive power |
| I/kVAh | Pulses per kiloVolt-Ampere hour for apparent power |
| Wh/I | Watt-hours per pulse |
| varh/I | Var-hours per pulse for reactive power |
| VAh/I | Volt-Ampere hours per pulse for apparent power |

# Error Measurement using a scanning head

Aim

The purpose of the error measurement using a scanning head is to measure the percentage error of the device under test.

Method

The reference meter uses the scanning head to detect the amount of energy (number of pulses) metered by the device under test, and compares this with the amount of energy measured by the reference meter. The percentage error is calculated from the comparison.

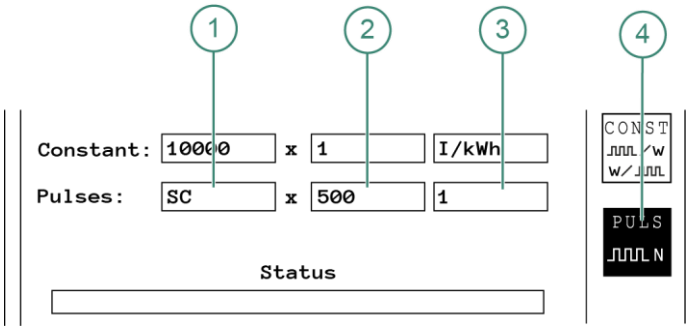
Requirements

The following requirements must be met before performing a test:

- The reference meter has been prepared for the test; see *General procedure for a test measurement* on page 27.
- The meter constant has been entered; see *Entering the meter constant* on page 31.
- The scanning head has been connected; see *Attaching the scanning head to the meter* on page 30
- The 'Error Measurement' function is open; see *Error measurement* on page 67.

Screenshot of entering the pulse source

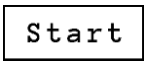
The pulse source is entered in the 'Error measurement' function.




Entering data for the pulse source

| Step | Procedure |
|---|---|
| **1** | Open the subfunction for entering the pulses to be counted (4). |
| **2** | Select the correct pulse source from the list box (1):<br>• SC |
| **3** | Enter the number of pulses (2) to be counted for the measurement (number of revolutions for Ferraris disc meters).<br>• A multiplier (3) is needed for values ≥ 1000000. |
| **4** | Select a suitable multiplier between<br>1 and Exp+5 (100000) from the list box (3).<br>Result:<br>• You have finished entering the data for the pulse source.<br>• The button (4) returns to its normal appearance. |

## Taking measurements

| Step | Procedure | |
|---|---|---|
| **1** | Watch the LED on the scanning head to check it is emitting enough pulses in a suitable time period to avoid the test taking too long. | |
| **2** | Start the test.<br>Result:<br>• The measured energy is displayed.<br>• The progress bar indicates how far the measurement has progressed.<br>• An error value is displayed once the first measurement has finished.<br>• The test continues to take further measurements. The unit displays the error for the most recent measurement. |  |
| **3** | Stop the test.<br>Result:<br>• The reference meter displays the error for the most recent measurement.<br>• Continuous measurements are stopped. |  |
| **4** | Save the measurement. |  |

## Accuracy of the measurement

The accuracy of the measurement depends on fitting the scanning head precisely; for details, refer to the specific instructions for the scanning head used.

# Error Measurement without scanning head

Aim

The error measurement without scanning head is intended for measuring the percentage error of the device under test when a scanning head cannot be used.

Method

The operator counts the amount of energy (pulses) signalled by the device under test. The reference meter simultaneously measures the amount of energy consumed. The operator starts and stops the meter-tester measurement manually.

The reference meter compares the energy values metered by the device under test with the amount measured by the reference meter. The percentage error is calculated from the comparison.

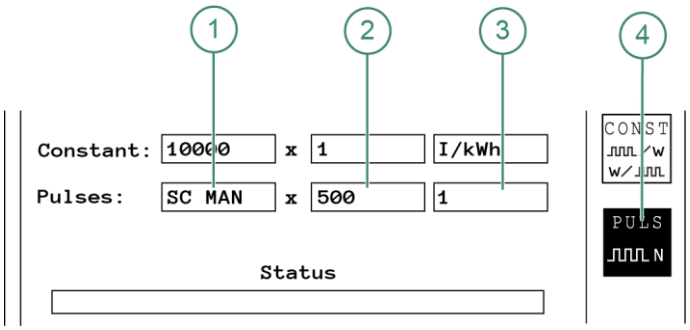
Requirements

The following requirements must be met before performing a test:

- The amount of energy supplied to the meter under test is so small that the operator can easily see and count the rotations of the rotor disc on Ferraris meters or the frequency of the flashing LED pulse.
- The reference meter has been prepared for the test; see *General procedure for a test measurement* on page 31.
- The meter constant has been entered; see *Entering the meter constant* on page 31.
- The 'Error Measurement' function is open; see *Error measurement* on page 67.

Screenshot of entering the pulse source

The pulse source is entered in the 'Error measurement' function.



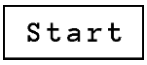

Entering data for the pulse source

| Step | Procedure |
|---|---|
| **1** | Open the subfunction for entering the pulses to be counted (4). |
| **2** | Select the correct pulse source from the list box (1):<br>• SC MAN or St/St |
| **3** | Enter the number of pulses (2) to be counted for the measurement. |
| **4** | Select the multiplier 1 from the list box (3).<br>Result:<br>• You have finished entering the data for the pulse source.<br>• The button (4) returns to its normal appearance. |

## Taking measurements using 'TK MAN' pulse source (manual pushbutton)

For the test using the manual pushbutton, the operator must count the signals until they reach the number entered under Pulses. At precisely this instant, the operator uses the manual pushbutton to confirm that the set number of pulses has been reached.

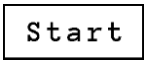
Follow these steps to perform the test:

| Step | Procedure | |
|---|---|---|
| **1** | Watch the LED on the meter or watch the meter disc to check it is emitting enough signals in a suitable time period to avoid the test taking too long. | |
| **2** | Press the 'Start' function key to make ready for the measurement. |  |
| **3** | Start the measurement when there is a pulse (pulse zero) from the LED or meter disc by pressing the manual pushbutton.<br>Result:<br>• The measurement starts running. | |
| **4** | Count the number of pulses **after** the start pulse according to the set number of pulses. Do not touch the manual pushbutton while counting the pulses.<br>Result:<br>• The measured energy is displayed. | |
| **5** | Press the manual pushbutton once you have reached the last pulse to be counted, given by the set number of pulses.<br>Result:<br>• The progress bar flashes.<br>• The error from the measurement is displayed.<br>• The next measurement begins; the measured energy is reset to 0.<br>You can repeat this step as often as you wish. | |
| **6** | Stop the test.<br>Result:<br>• The reference meter displays the error for the performed measurement.<br>• Continuous measurements are stopped. |  |
| **7** | Save the measurement. |  |

## Taking measurements using Start and Stop

For the test using 'Start' / 'Stop', the operator must count the signals until they reach the number entered under Pulses. At this precisely this instant, the operator uses 'Stop' to confirm that the set number of pulses has been reached.

Follow these steps to perform the test:

| Step | Procedure | |
|---|---|---|
| **1** | Watch the LED on the meter or watch the meter disc to check it is emitting enough signals in a suitable time period to avoid the test taking too long. | |
| **2** | Start the measurement when there is a pulse (pulse zero) from the LED or meter disc by pressing the 'Start' function key.<br>Result:<br>• The measured energy is displayed. |  |
| **3** | Count the number of pulses **after** the start pulse according to the set number of pulses. | |
| **4** | Press the 'Stop' function key to stop the measurement once you have reached the last pulse to be counted, given by the set number of pulses.<br>Result:<br>• The unit displays the error for the most recent measurement. |  |
| **5** | If possible, perform more than one test. | |
| **6** | Save the measurement. |  |

## Accuracy of the measurement

The accuracy of the measurement in both measuring methods depends on the user. The user must count the pulses and press the manual pushbutton or 'Stop' at the right moment.

# Performing a W-register test (energy register)

Aim

The W-register test is designed to test the accuracy of a W-register (energy register).

Method

The operator reads the initial value in the W-register from the device under test and enters this reading in the reference meter. The reference meter then measures the energy consumption over a certain period of time. The operator stops the measurement, reads the final value in the W-register from the device under test and also enters this reading in the reference meter.

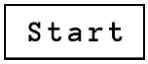
The percentage error is calculated from the comparison of the entered readings with the value measured by the reference meter.

Requirements

- The reference meter has been prepared for the test; see *General procedure for a test measurement* on page 27.
- The required current range has been selected; see *The measurement ranges* on page 55.
- The required mode has been selected; see *The measuring modes* on page 56.
- The 'W-register test' function is open; see *W-register test (energy register)* on page 69.

Taking measurements

Follow these steps to perform the test:

| Step | Procedure | |
|---|---|---|
| **1** | Open the function for entering the initial value from the energy register. |  |
| **2** | Enter the initial value and select the register units. | |
| **3** | Start the test. |  |
| **4** | Stop the test. |  |
| **5** | Open the function for entering the final value from the energy register. |  |
| **6** | Enter the final value and select the register units.<br>Result:<br>The reference meter displays the calculated error. | |

Accuracy of the measurement

The accuracy of the measurement depends on the user. The user must read and enter the values at the start and stop time correctly and precisely.

# Performing a P-register test (power register)

Aim

The P-register test is designed to test the accuracy of a P-register (power register).

Method

The operator reads the initial value in the P-register from the device under test and enters this reading in the reference meter. The reference meter then measures the power over a certain period of time. The operator stops the measurement, reads the final value in the P-register from the device under test and also enters this reading in the reference meter.

The percentage error is calculated from the comparison of the entered readings with the value measured by the reference meter.

Requirements

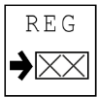
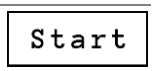
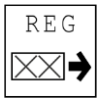
- The reference meter has been prepared for the test; see *General procedure for a test measurement* on page 27.
- The required current range has been selected; see *The measurement ranges* on page 55.
- The required mode has been selected; see *The measuring modes* on page 56.
- The 'P-register test' function is open; see *P-register test (power register)* on page 70.

Entering the time for the P-register test

You have the option to change the settings for the measurement time.

| Step | Procedure | |
|---|---|---|
| 1 | Open the setting for the measurement time. |  |
| 2 | Manual time measurement<br>• Skip the step for entering the measurement time<br>• Select 'Off'.<br>Automatic time measurement<br>• Enter a measurement time<br>• Select 'On'. | |

Performing a P-register test

| Step | Procedure | |
|---|---|---|
| 1 | Open the function for entering the initial value from the power register. |  |
| 2 | Enter the initial value and select the register units. | |
| 3 | Start the test. |  |
| 4 | Stop the test (only if automatic time measurement is 'Off') |  |
| 5 | Open the function for entering the final value from the power register. |  |
| 6 | Enter the final value and select the register units.<br>Result:<br>The reference meter displays the calculated error. | |

Accuracy of the measurement

The accuracy of the measurement depends on the user. The user must read and enter the values at the start and stop time correctly and precisely.

# 6 Connection diagrams

Summary

The connection diagrams show how the reference meter must be connected for different types of meter connection. They state the measuring modes available for each connection type and what settings are needed for the measuring mode.

Contents

# Single-phase 2-wire meter connected directly

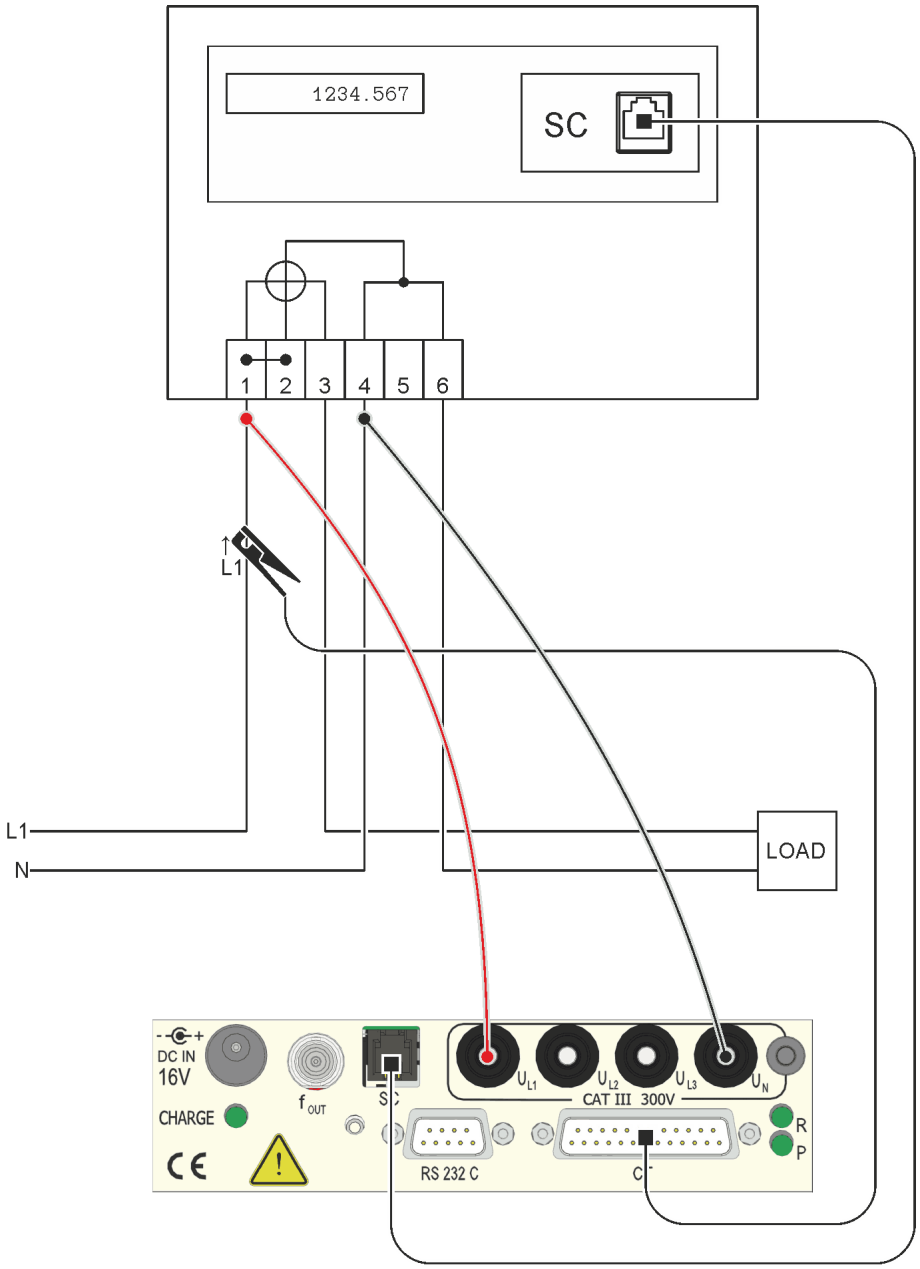
Required data

- Meter constant; see *Entering the meter constant* on page 31

Measuring modes available

2WA, 2WR, 2WAP, see *The measuring modes* on page 56

Connection diagram



Rules

The following rules must be observed when connecting the clamps:

- AC current clamps come in different designs, for insulated lines or for uninsulated lines. The AC current clamps for insulated lines must be used only on insulated lines; see the Instructions for use for the particular AC current clamps.
- The 25-pin connector for the AC current clamps must not be removed from the test instrument while the AC current clamps are still clamped around a line or the test instrument is still on.
- Clamp the AC current clamp around the cable of the line that leads to the current input terminal. The arrow on the current clamp points towards the meter.

Also refer to the *General procedure for a test measurement* on page 27.

# Three-phase 3-wire meter connected directly

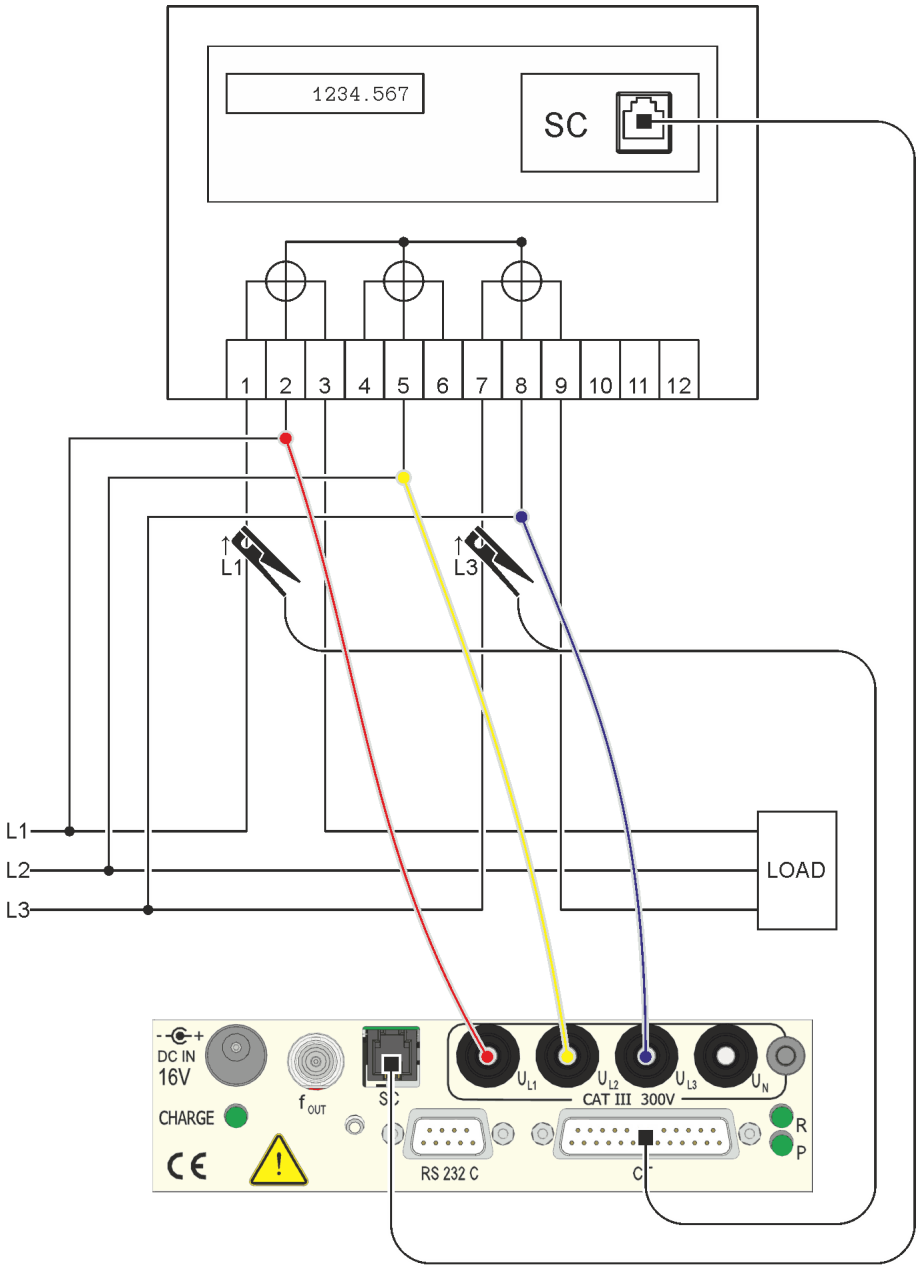
Required data

- Meter constant; see *Entering the meter constant* on page 31
- Enter the ratio 1:1 for the voltage transformer (VT) and current transformer (CT); see *Settings* on page 79

Measuring modes available

3WA, 3WR, 3WAP, see *The measuring modes* on page 56

Connection diagram



Rules

The following rules must be observed when connecting the clamps:

- AC current clamps come in different designs, for insulated lines or for uninsulated lines. The AC current clamps for insulated lines must be used only on insulated lines; see the Instructions for use for the particular AC current clamps.
- The 25-pin connector for the AC current clamps must not be removed from the test instrument while the AC current clamps are still clamped around a line or the test instrument is still on.
- Clamp the AC current clamp around the cable of the line that leads to the current input terminal. The arrow on the current clamp points towards the meter.

Also refer to the *General procedure for a test measurement* on page 27.

Interpreting the measurement results

With this type of connection, the following readings are not shown: current for L2, ∠UI, ∠IU, λ, S for all lines.

# Three-phase 3-wire meter with current and voltage transformer

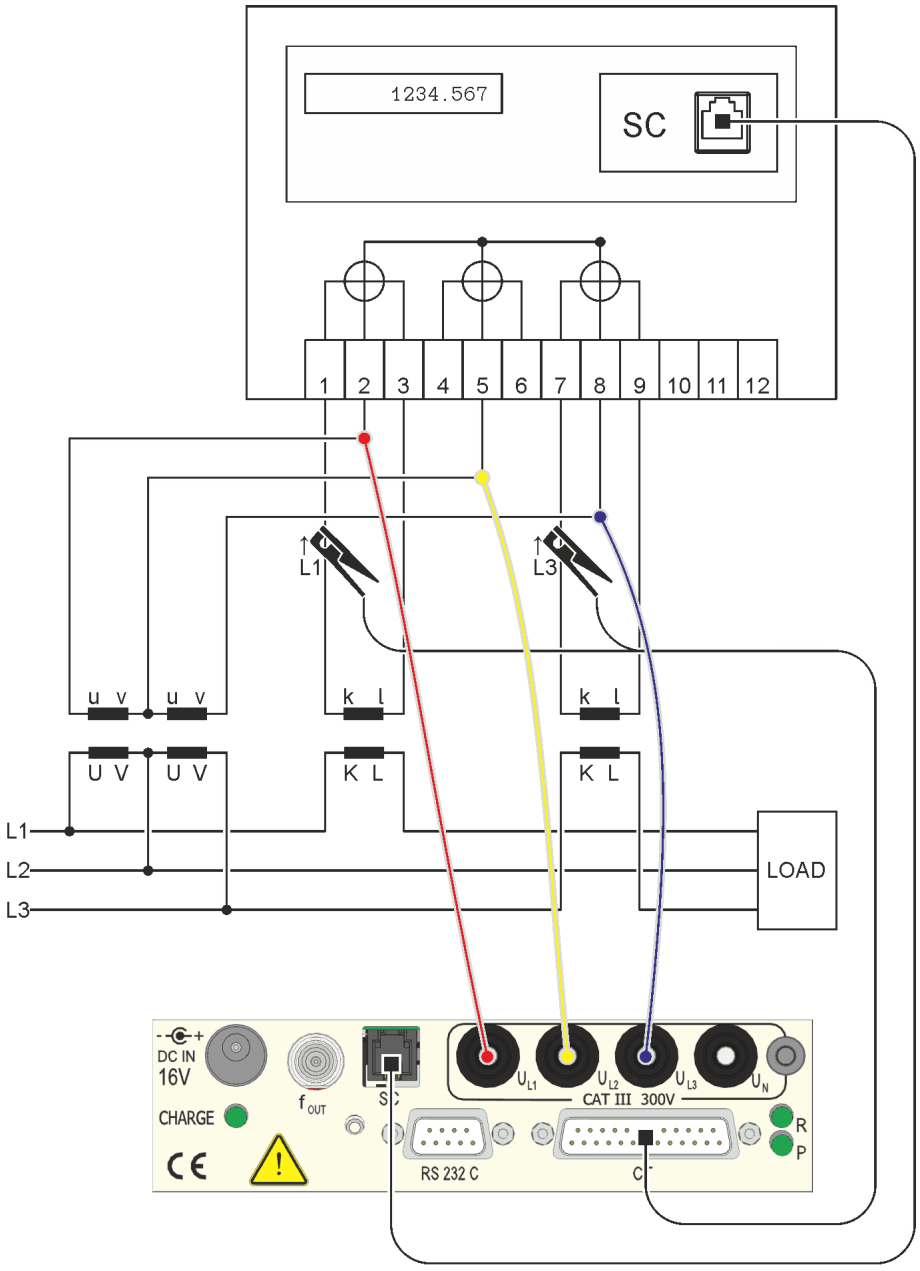
Required data

- Meter constant; see *Entering the meter constant* on page 31
- Ratio for voltage transformer (VT); see *Settings* on page 79
- Ratio for current transformer (CT); see *Settings* on page 79

Measuring modes available

3WA, 3WR, 3WAP, see *The measuring modes* on page 56

Connection diagram




Do not open the secondary side of the current transformer

**DANGER**

**High voltage generated by opening the secondary side of the current transformer while the transformer is still electrically live.**

If the secondary side of the current transformer is opened while current is still flowing in the primary side, i.e. the primary side is still live, a hazardous high voltage may be induced in the secondary side.

- Never under any circumstances open the secondary side of a current transformer while the transformer is electrically live.

Rules

The following rules must be observed when connecting the clamps:

- AC current clamps come in different designs, for insulated lines or for uninsulated lines. The AC current clamps for insulated lines must be used only on insulated lines; see the Instructions for use for the particular AC current clamps.
- The 25-pin connector for the AC current clamps must not be removed from the test instrument while the AC current clamps are still clamped around a line or the test instrument is still on.
- Clamp the AC current clamp around the cable of the line that leads to the current input terminal. The arrow on the current clamp points towards the meter.

Also refer to the *General procedure for a test measurement* on page 27.

Interpreting the measurement results

With this type of connection, the following readings are not shown: current for L2, ∠UI; ∠IU λ, S, for all lines.

# Three-phase 4-wire meter connected directly

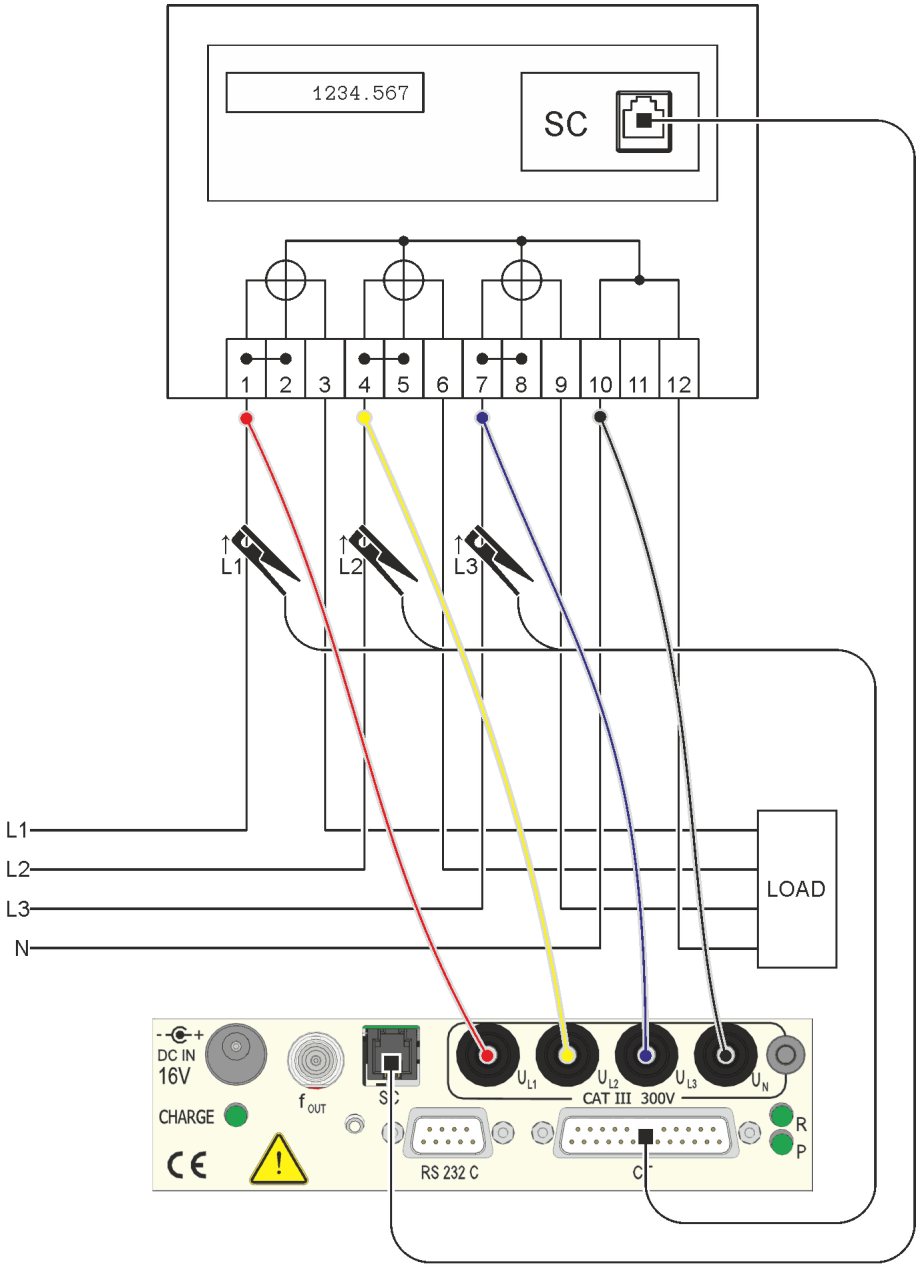
Required data

- Meter constant; see *Entering the meter constant* on page 31
- Enter the ratio 1:1 for the voltage transformer (VT) and current transformer (CT);
  see *Settings* on page 79

Measuring modes available

4WA, 4WAb, 4WR, 4WRb, 4WAP, 4WAPb, see *The measuring modes* on page 56

Connection diagram



Ratio for instrument transformer

Since an instrument transformer is not used in the circuit, set the ratio for instrument transformer to 1 : 1.

- 'Settings': ratio
  - Voltage transformer U: 1 × 1 → 1 × 1
  - Current transformer I: 1 → 1

or

- 'Settings (2)': ratio for the meter constant is disabled for Actual values (and Register test) and Meter constant (error measurement)

Rules

The following rules must be observed when connecting the clamps:

- AC current clamps come in different designs, for insulated lines or for uninsulated lines. The AC current clamps for insulated lines must be used only on insulated lines; see the Instructions for use for the particular AC current clamps.
- The 25-pin connector for the AC current clamps must not be removed from the test instrument while the AC current clamps are still clamped around a line or the test instrument is still on.
- Clamp the AC current clamp around the cable of the line that leads to the current input terminal. The arrow on the current clamp points towards the meter.

Also refer to the *General procedure for a test measurement* on page 27.

# Three-phase 4-wire meter with current transformer

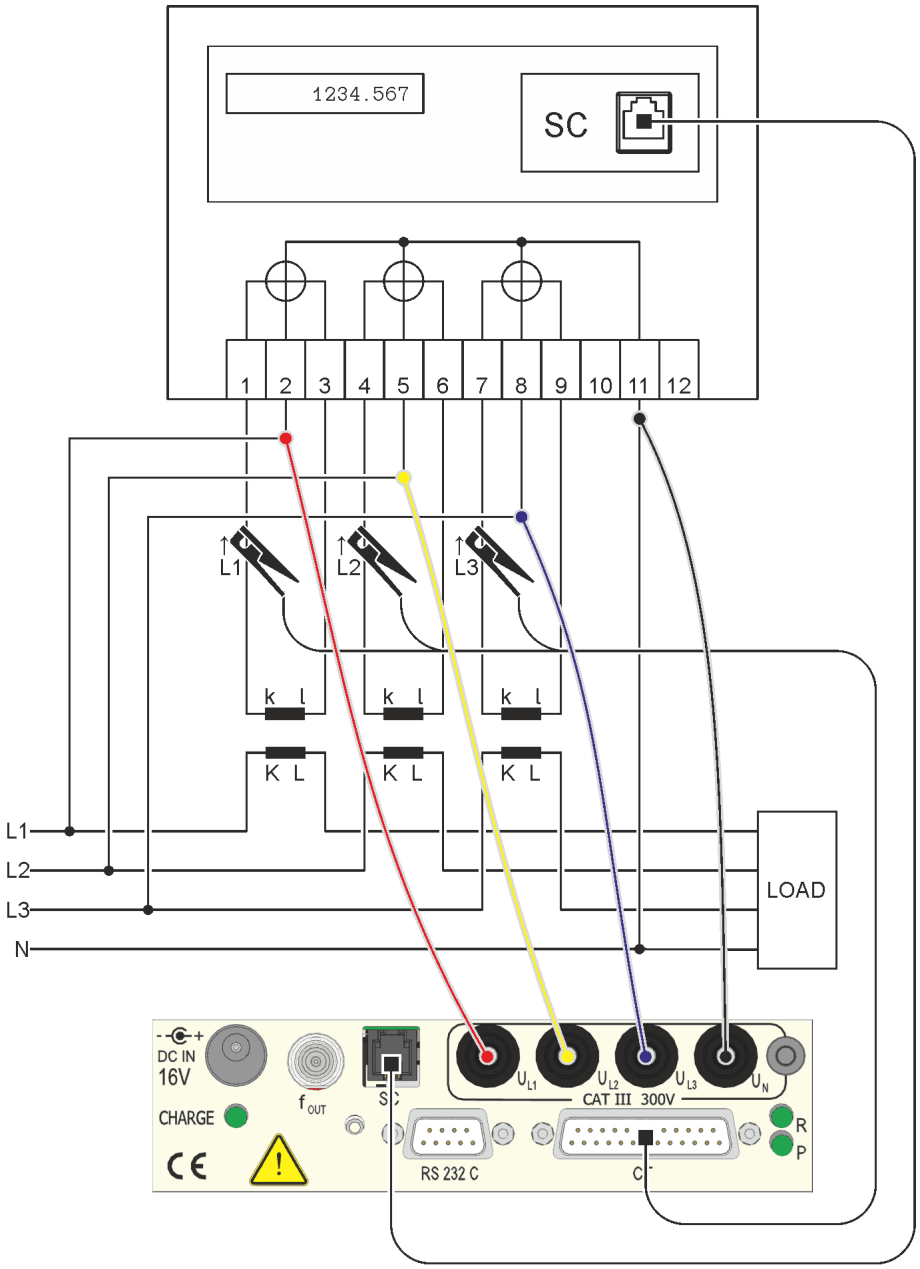
Required data

- Meter constant; see *Entering the meter constant* on page 31
- 1:1 ratio for voltage transformer (VT); see *Settings* on page 79
- Ratio for current transformer (CT); see *Settings* on page 79

Measuring modes available

4WA, 4WAb, 4WR, 4WRb, see *The measuring modes* on page 56

Connection diagram



Do not open the secondary side of the current transformer

**DANGER**

**High voltage generated by opening the secondary side of the current transformer while the transformer is still electrically live.**

If the secondary side of the current transformer is opened while current is still flowing in the primary side, i.e. the primary side is still live, a hazardous high voltage may be induced in the secondary side.

- Never under any circumstances open the secondary side of a current transformer while the transformer is electrically live.

Rules

The following rules must be observed when connecting the clamps:

- AC current clamps come in different designs, for insulated lines or for uninsulated lines. The AC current clamps for insulated lines must be used only on insulated lines; see the Instructions for use for the particular AC current clamps.
- The 25-pin connector for the AC current clamps must not be removed from the test instrument while the AC current clamps are still clamped around a line or the test instrument is still on.
- Clamp the AC current clamp around the cable of the line that leads to the current input terminal. The arrow on the current clamp points towards the meter.

Also refer to the *General procedure for a test measurement* on page 27.

# Three-phase 4-wire meter with current and voltage transformer

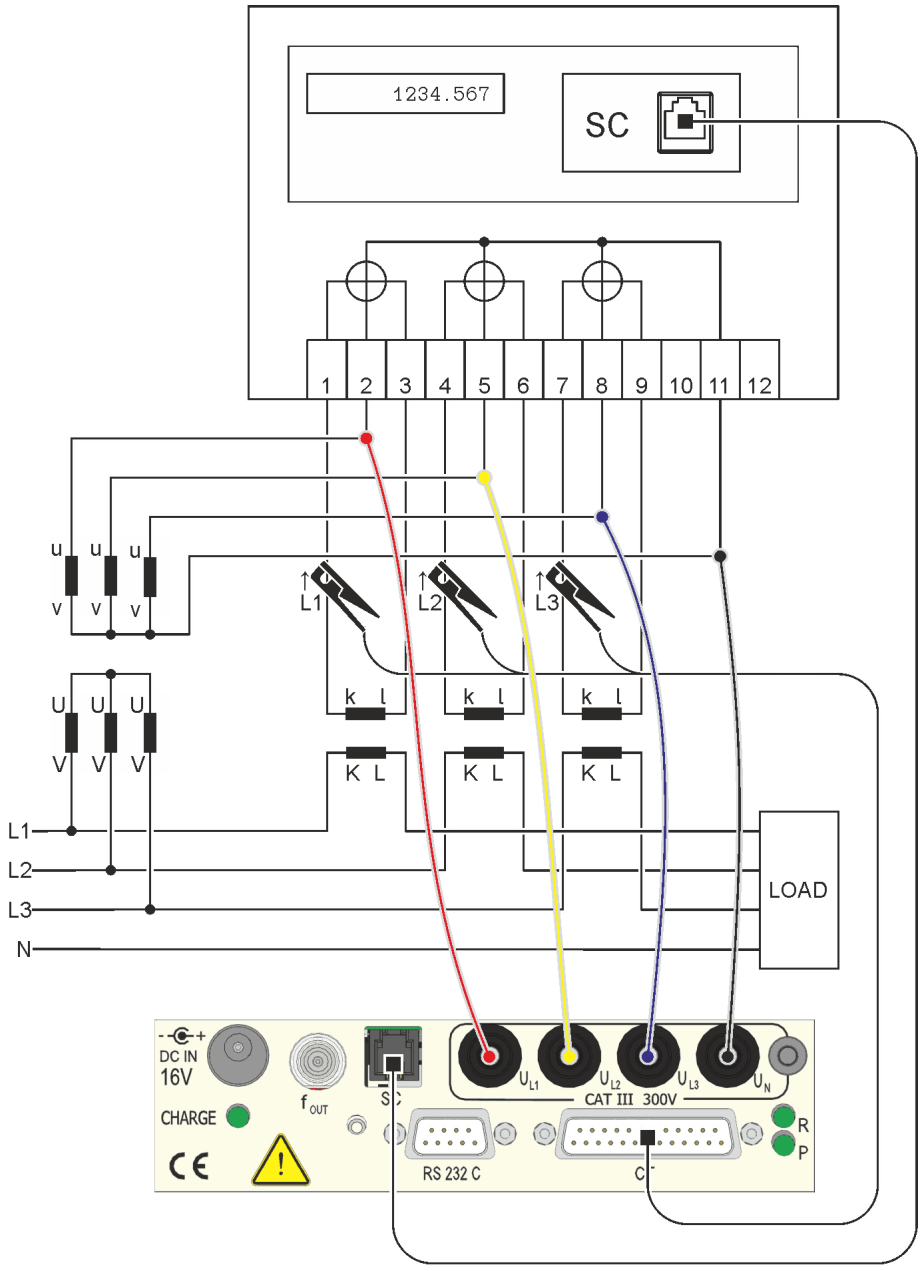
Required data

- Meter constant; see *Entering the meter constant* on page 31
- Ratio for voltage transformer (VT); see *Settings* on page 79
- Ratio for current transformer (CT); see *Settings* on page 79

Measuring modes available

4WA, 4WAb, 4WR, 4WRb, see *The measuring modes* on page 56

Connection diagram




Do not open the secondary side of the current transformer

**DANGER**

**High voltage generated by opening the secondary side of the current transformer while the transformer is still electrically live.**

If the secondary side of the current transformer is opened while current is still flowing in the primary side, i.e. the primary side is still live, a hazardous high voltage may be induced in the secondary side.

- Never under any circumstances open the secondary side of a current transformer while the transformer is electrically live.

Rules

The following rules must be observed when connecting the clamps:

- AC current clamps come in different designs, for insulated lines or for uninsulated lines. The AC current clamps for insulated lines must be used only on insulated lines; see the Instructions for use for the particular AC current clamps.
- The 25-pin connector for the AC current clamps must not be removed from the test instrument while the AC current clamps are still clamped around a line or the test instrument is still on.
- Clamp the AC current clamp around the cable of the line that leads to the current input terminal. The arrow on the current clamp points towards the meter.

Also refer to the *General procedure for a test measurement* on page 27.

# 7 The horizontal function bar of the reference meter in detail

Summary

The horizontal function bar is used to select the function, measurement range and mode. It can also be used for actuating core functions of the reference meter such as starting and stopping the measurement.

Contents

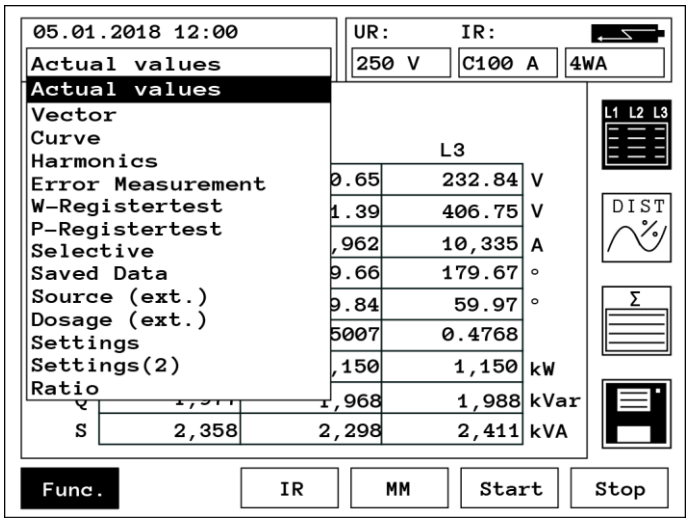
# The functions in outline

Function groups

The functions can be grouped into the following areas:

| Function group | Function |
|---|---|
| Measured values display | • Actual Values<br>• Vector<br>• Curve<br>• Harmonics<br>• Selective - optional |
| Running tests | • Error Measurement<br>• W-Registertest<br>• P-Registertest |
| Settings | • Settings<br>• Settings(2)<br>• Ratio |
| Data management | • Saved Data |
| Controlling an external device | • Source (ext.) - optional<br>• Dosage (ext.) - optional |

The functions




The functions in outline

| Function | Description | Subfunctions |
|---|---|---|
| Actual Values | Displays the actual measured values as a table | • U, I, ∠U, ∠UI; ∠IU, λ, P, Q, S<br>• Distortion factor<br>• Total power values |
| Vector | Displays the actual values as a vector diagram | • Normal<br>• Delta mode<br>• 3-line mode |
| Curve | Displays the actual values as a waveform | • Selection of required UL and IL channels |
| Harmonics | Displays the harmonics of the actual values referred to the fundamental frequency | • As a table up to the 40th harmonic<br>• As a bar graph up to the 40th harmonic |
| Error Measurement | Measures the error of a meter | Entering the<br>• meter constants<br>• pulse source<br>• number of pulses for measurement |
| P-Registertest | Tests the power register of a meter | • Entering register readings |

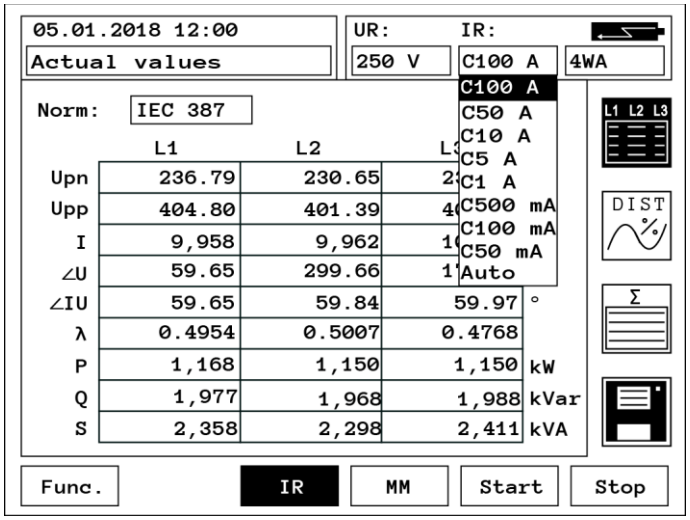
**MT30** – The horizontal function bar of the reference meter in detail

| Function | Description | Subfunctions |
|---|---|---|
| W-Registertest | Tests the energy register of a meter | • Entering register readings |
| Selective | Displays the active, reactive and apparent power components of the first 40 harmonics | • Selection of L1, L2, L3<br>• Selection of harmonics to be displayed |
| Saved Data | Displays the saved data | • Navigation around the saved data |
| Source (ext.) | Controls an external ZERA source | • Selecting the Symmetry/ Frequency<br>• Entering voltage, current and phase angle<br>• Activating individual phases<br>• Saving and managing settings |
| Dosage (ext.) | Controls the "dose" of energy supplied from an external ZERA source | • Actuating dosage mode<br>• Entering the dosage energy |
| Settings | Used for specifying global settings that apply to all the measurements | • System language<br>• Phase angle<br>• Control of the reference meter |
| Settings(2) | Used for specifying additional global settings that apply to all the measurements | • System time<br>• Calculation method for the apparent power<br>• Printer |
| Ratio | Can be used to enter the transformer ratios of input-side current and/or voltage transformers. | • Ratio for input-side voltage and current transformers<br>• Ratio for high-current transformer of AC current clamps<br>• Conversion of actual values |

# The measurement ranges

Measurement ranges

The voltage measurement range 'UR' is always 250 V. The current measurement ranges can be selected. It is essential to choose the correct measurement range to obtain an accurate measurement result.




What the voltage measurement range means (IR:)

| Current measurement range | Details |
|---|---|
| C100 A to C50 mA | Measurement range set manually using AC current clamp |
| Auto | Measurement range set automatically |

Selecting the setting

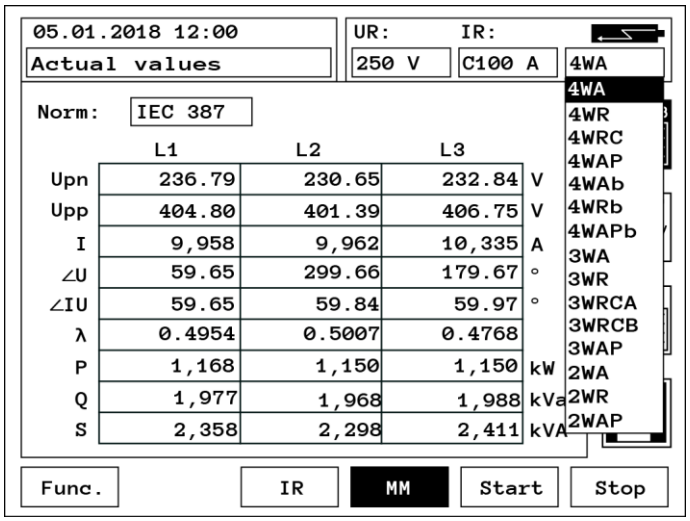
With the 'Auto' setting, the reference meter seeks the appropriate measurement range itself.

If the power consumption varies sharply at the measurement point, we recommend selecting the measurement range manually. Any strong variation in the power consumption when 'Auto' is set will result in incorrect measurement results, e.g. in the error measurement and power measurement.

# The measuring modes

Mode (MM)

The measuring mode required depends on the way the meter under test is connected. Selecting the wrong measuring mode will produce incorrect results.




What the measuring modes mean

| Mode | Details |
|---|---|
| 2WA | 1-phase, 2-Wire, Active power |
| 2WR | 1-phase, 2-Wire, Reactive power |
| 2WAP | 1-phase, 2-Wire, APparent power |
| 4WA | 3-phase, 4-Wire, Active power |
| 4WAb | 3-phase, 4-Wire, Active power of fundamental harmonic |
| 4WR | 3-phase, 4-Wire, Reactive power, true |
| 4WRC | 3-phase, 4-Wire, Reactive power with phase-shift Circuit |
| 4WAP | 3-phase, 4-Wire, APparent power |
| 3WA | 3-phase, 3-Wire, Active power |
| 3WR | 3-phase, 3-Wire, Reactive power, true |
| 3WRCA | 3-phase, 3-Wire, Reactive power with phase-shift Circuit A |
| 3WRCB | 3-phase, 3-Wire, Reactive power with phase-shift Circuit B |
| 3WAP | 3-phase, 3-Wire, APparent power |

Optional measuring modes

| Mode | Details |
|---|---|
| 4WRb | 3-phase, 4-Wire, Reactive power of fundamental harmonic |
| 4WAPb | 3-phase, 4-Wire, APparent power of fundamental harmonic |

Special features of the 3-phase, 3-wire measurements

For this measuring mode, the total apparent power (ΣS) is always geometric.

$$S_\Sigma = \sqrt{P_\Sigma^2 + Q_\Sigma^2}$$

# 8 The functions of the reference meter

Summary

The reference meter provides many different functions and measurement ranges, each available for a choice of measuring modes.

Contents

# Actual values

Description

The 'Actual Values' function displays the currently measured values as a table.

Application

The table view of the actual values provides a rapid overview for error analysis. The actual values measurement helps to assess the condition of the mains supply and the meter installation, for instance no voltage, no current, incorrect current polarity, symmetry and asymmetry, etc.

Subfunctions

The 'Actual Values' function contains the following subfunctions:

| Function | Details |
|---|---|
|  | • Main measured values displayed in table form<br>• Selecting the phase angle calculation under the 'Norm' entry: IEC 387 or DIN 410 |
|  | Harmonic distortion factor displayed in table form |
|  | Total values for power displayed in table form |
|  | See *Save Data subfunction* on page 84 |

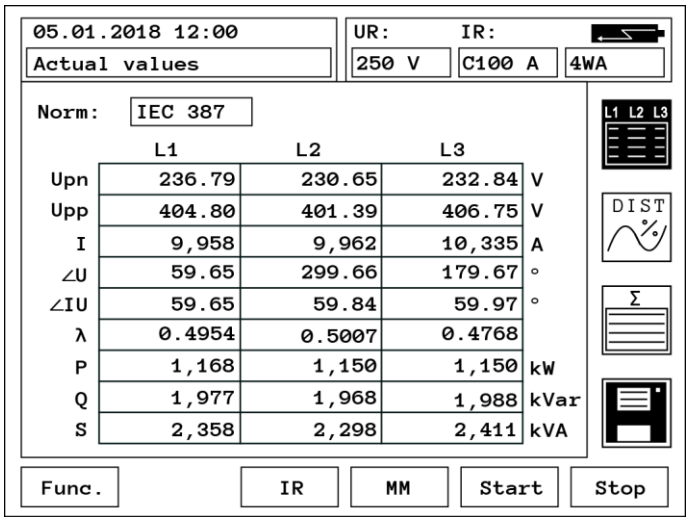
Meaning of the 'Norm' selection for the phase angle display

The choice made under the 'Norm' entry affects how values are displayed:

| Options | Details |
|---|---|
| IEC 387 | • Current vectors are fixed, voltage vectors are variable<br>• Reference value I1, displayed horizontally<br>• φ($I_1$) is always 0 (in 3 O'clock position)<br>• Positive angle is anticlockwise |
| DIN 410 | • Voltage vectors are fixed, current vectors are variable<br>• Reference value U1, displayed vertically<br>• φ($U_1$) is always 0 (in 12 O'clock position)<br>• Positive angle is clockwise |

Measured values displayed as a table

The standard for the phase-angle representation must be defined first when opening this view.

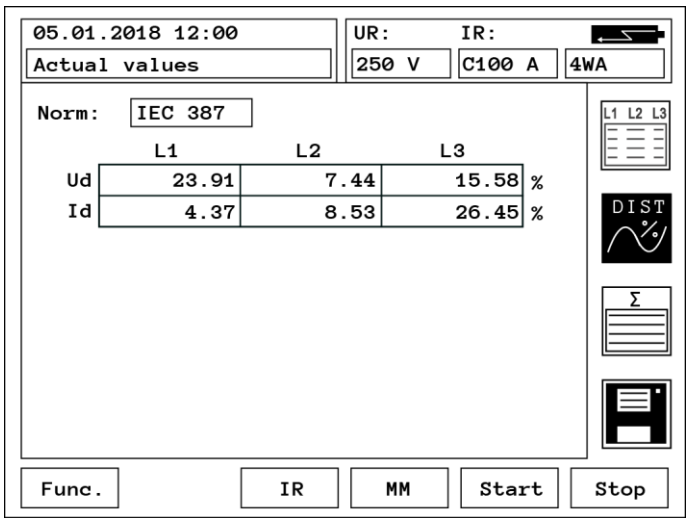


## What the values in the table mean

Some of the measured values displayed are calculated values; see *Calculation of derived values* on page 86.

| Measured value | Details | Source | Resolution |
|---|---|---|---|
| Upn | Effective value of the voltage between phase and neutral for each phase | measured | 0.01 V |
| Upp | Effective value of the voltage between the phases 1–2, 2–3, 3–1 | calculated | 0.01 V |
| I | Effective value of the current for each phase | measured | 100, 50 A: 0.001 A<br>10, 5, 1 A:<br>0.0001 A<br>500 mA: 0.01 mA |
| ∠U | Phase angle φ of the voltage, with zero phase given by the chosen standard | measured | 0.01° |
| ∠UI; ∠IU | Phase angle between voltage and current (DIN 410) or current and voltage (IEC 387). The values are the same in both standards. | measured | 0.01° |
| λ | Power factor<br>• Active power measurement: $\lambda = P/S = \cos(\angle UI)$<br>• Reactive power measurement: $\lambda = Q/S = \sin(\angle UI)$ | calculated | 0.0001 |
| P | Active power | calculated | 0.01 W<br>0.001 kW |
| Q | Reactive power | calculated | 0.01 var<br>0.001 kvar |
| S | Apparent power | calculated | 0.01 VA<br>0.001 kVA |

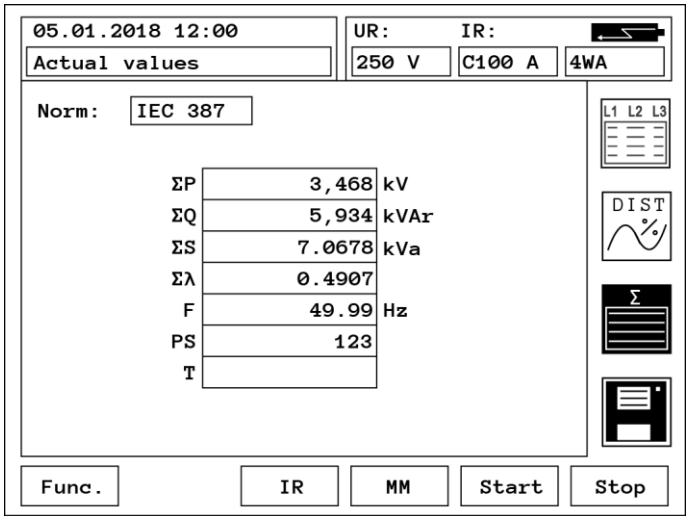
## Harmonic distortion factor displayed in table form




## What the measured distortion factors mean

| Measured value | Details | Source | Resolution |
|---|---|---|---|
| Ud | Distortion factor for the voltage of one phase | calculated | 0.01 % |
| Id | Distortion factor for the current in one phase | calculated | 0.01 % |

Total values in table form




What the total values in the table mean

| Measured value | Details | Source | Resolution |
|---|---|---|---|
| ΣP | Sum of the active powers for all the phases | calculated | 0.01 W<br>0.001 kW |
| ΣQ | Sum of the reactive powers for all the phases | calculated | 0.01 var<br>0.001 kvar |
| ΣS | Sum of the apparent powers for all the phases<br>Setting for the calculation method: *Settings (2)* on page 81 | calculated | 0.01 VA<br>0.001 kVA |
| Σλ | Total power factor | calculated | 0.0001 |
| F | Frequency | measured | 0.01 Hz |
| PS | Direction of rotating field<br>• 123: ↻ clockwise rotation<br>• 132: ↻ anticlockwise rotation | calculated | |
| T | Temperature<br>The temperature display is only possible when a temperature sensor is connected.<br>The screen displays "???" if a sensor is not connected. | measured | 0.01 °C |

# Vector

Description

The 'Vector' function displays the actual values as a vector diagram. Certain representations are only relevant to certain measuring modes.

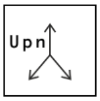
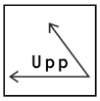
Application

Die vector diagram helps to locate circuit faults:

- Incorrect connections
  - Wrong terminal and incorrect rotating field
  - Polarity (e.g. K-L swapped over)
- Short-circuits
  - Inside the meter (e.g. transport damage)
  - At the current transformer (e.g. jumper not removed)
  - Damage to insulation (e.g. through overheating / overloading)
- Open-circuits
  - In the instrumentation of the meter (e.g. transport damage)
  - Voltage tab not closed
  - Broken wire
  - Contact fault

Subfunctions

The 'Vector' function contains the following subfunctions:

| Function | Details |
|---|---|
|  | • Measured values displayed in vector form<br>• Selecting the phase angle calculation under the 'Norm' entry: IEC 387 or DIN 410<br>• Shows voltage between line and neutral (Star)<br>• Useful for the following measuring modes:<br>  • 4WA |
|  | • Measured values displayed in vector diagram in Delta mode<br>• Voltage between two lines<br>• Useful for the following measuring modes:<br>  • 4WA |
|  | Measured values displayed in vector form in 3-wire mode<br>• Useful for the following measuring modes:<br>  • 3WA |
|  | See *Save Data subfunction* on page 84 |

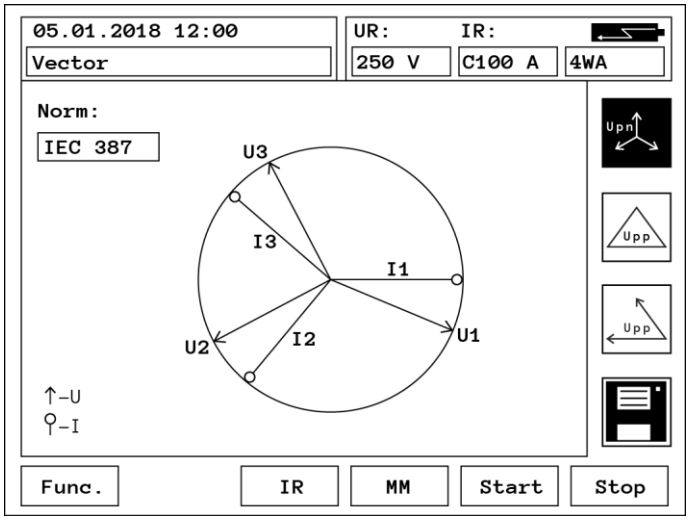
Meaning of the 'Norm' selection for the vector diagram

The choice made under the 'Norm' entry affects how values are displayed:

| Options | Details |
|---|---|
| IEC 387 | • Current vectors are fixed, voltage vectors are variable<br>• Reference value I1, displayed horizontally<br>• φ($I_1$) is always 0 (in 3 O'clock position)<br>• Positive angle is anticlockwise |
| DIN 410 | • Voltage vectors are fixed, current vectors are variable<br>• Reference value U1, displayed vertically<br>• φ($U_1$) is always 0 (in 12 O'clock position)<br>• Positive angle is clockwise |

Measured values displayed in vector form in 4WA mode

Options 'IEC 387': I1 to the right is defined as φ = 0.

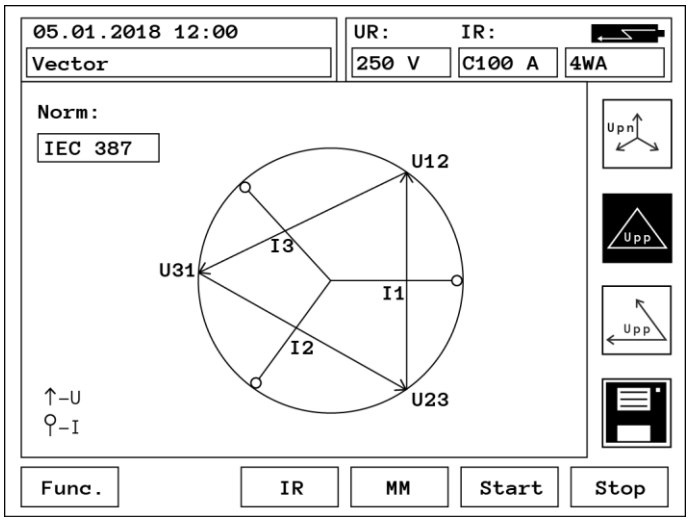



Options 'DIN 410': U1 vertically upwards is defined as φ = 0.

What the values in the vector diagram mean

| Parameter | Details |
|---|---|
| U1, U2, U3 | Voltage between neutral and line 1, 2, 3 |
| I1, I2, I3 | Current in phase 1, 2, 3 |

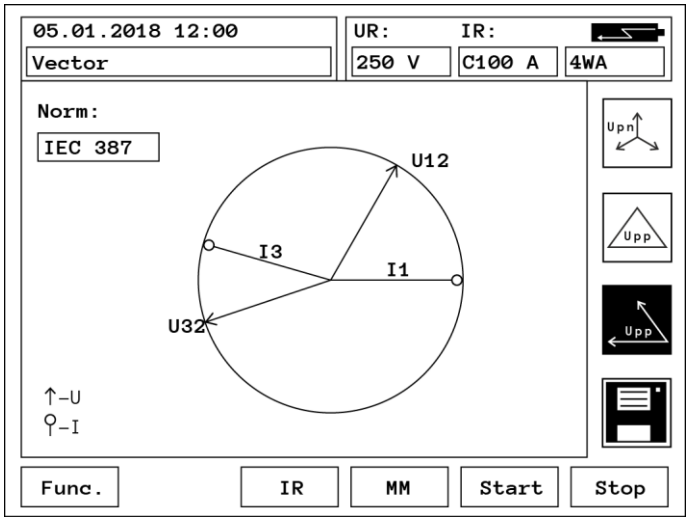
Measured values displayed in vector diagram in Delta mode




What the values in the vector diagram mean in Delta mode

| Parameter | Details |
|---|---|
| U12 | U1 − U2 as a vector |
| U23 | U2 − U3 as a vector |
| U31 | U3 − U1 as a vector |
| I1, I2, I3 | Current in phase 1, 2, 3 |

Measured values displayed in vector diagram in 3-wire mode




What the values in the vector diagram mean in 3-wire mode

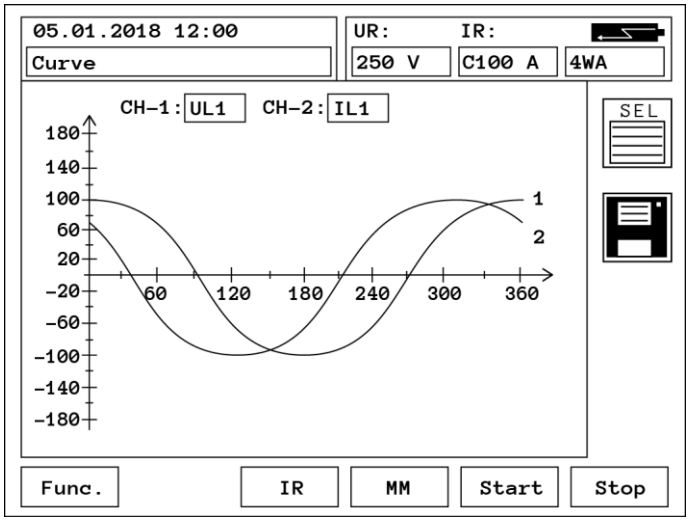
| Parameter | Details |
|---|---|
| U12 | U1 − U2 as a vector |
| U32 | U3 − U2 as a vector |
| I1 | Current in phase 1 |
| I3 | Current in phase 3 |

# Curve

Description

The 'Curve' function displays the actual values as a waveform.

Display




Description of parameters

| Parameter | Details |
|---|---|
| CH-1 | Measured value from channel 1 |
| CH-2 | Measured value from channel 2 |
| Vertical | Measured value in % of measurement range |
| Horizontal | Phase angle in ° |

Subfunctions

The 'Curve' function contains the following subfunctions:

| Function | Details |
|---|---|
|   | • Select the measured value for channel CH-1: UL1, UL2, UL3, IL1, IL2, IL3<br>• Select the measured value for channel CH-2: UL1, UL2, UL3, IL1, IL2, IL3 |
|  | See *Save Data subfunction* on page 84 |

# Harmonics

Description

The 'Harmonics' function displays the actual values of the harmonics referred to the fundamental harmonic.

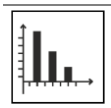
Application

The 'Harmonics' function indicates whether there are harmonic distortions in the current or voltage.

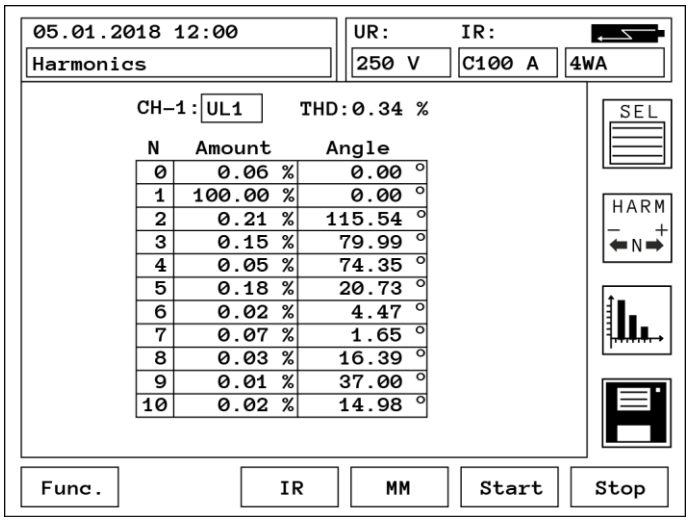
Measurements on currents of less than 50 mA give inaccurate results. This is because the AC current clamps inherently produce high harmonic components when I ≤ 50 mA.

Subfunctions

The 'Harmonics' function contains the following subfunctions:

| Function | Details |
|---|---|
|  | Select the measured value for CH:<br>• UL1, UL2, UL3, IL1, IL2, IL3<br>Measured value and angle displayed in table form |
|  | Switch display to the next 10 harmonics:<br>0…10→10…20→20…30→30…40→0…10→… |
|  | • Open the bar graph view<br>• Close the bar graph view |
|  | See *Save Data subfunction* on page 84 |

Displayed as a table

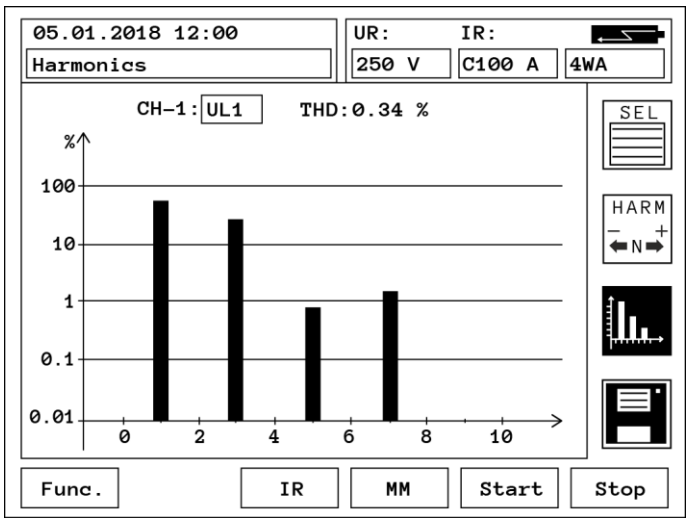



| N | Amount | Angle |
|---|---|---|
| 0 | 0.06 % | 0.00 ° |
| 1 | 100.00 % | 0.00 ° |
| 2 | 0.21 % | 115.54 ° |
| 3 | 0.15 % | 79.99 ° |
| 4 | 0.05 % | 74.35 ° |
| 5 | 0.18 % | 20.73 ° |
| 6 | 0.02 % | 4.47 ° |
| 7 | 0.07 % | 1.65 ° |
| 8 | 0.03 % | 16.39 ° |
| 9 | 0.01 % | 37.00 ° |
| 10 | 0.02 % | 14.98 ° |

What the values in the table mean

| Parameter | Details |
|---|---|
| CH | Selected channel; default setting: UL1 |
| THD | Total harmonic distortion up to the 40th harmonic in % |
| N | Number of the harmonic. 11 harmonics are displayed at once. |
| Amount | The ratio of the amplitudes of the Nth harmonic and fundamental in % |
| Angle | Magnitude of the phase angle between the Nth harmonic and the fundamental in ° |
| 0.. | DC component |
| 1 | Fundamental: mains frequency $f$ |
| 2. | 2 × $f$ |
| 3 | 3 × $f$ |
| etc. | etc. |

Displayed as a bar graph




What the values in the bar graph mean

| Parameter | Details |
|---|---|
| CH | Selected channel |
| THD | Total harmonic distortion in % |
| Vertical | The ratio of the amplitudes of the Nth harmonic and fundamental in % on logarithmic scale |
| Horizontal | Number of the harmonic |

# Error measurement

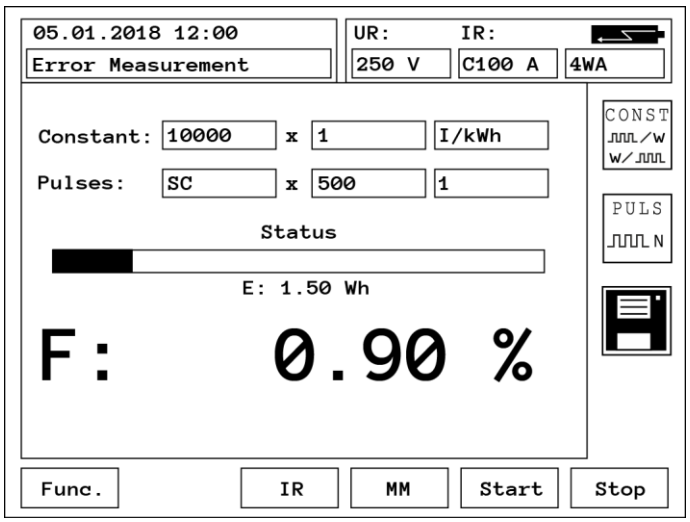
Description

The 'Error measurement' function measures the error of a meter. The error measurement compares the energy measured by the reference meter with the energy measured by the meter. The energy measured by the meter is transferred to the reference meter by a pulse sensor or by the user counting the pulses. When the measurement has finished, the error of the device under test is displayed as a %.

The following sections explain how to perform the error measurement:

- *Settings* on page 79
- *Error measurement under manual control* on page 34

Display

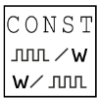



Description of the display

| Parameter | Details |
|---|---|
| Constant: | Meter constant, multiplier and units |
| Pulses: | • Pulse source<br>• Number of pulses to be counted<br>• Multiplier |
| Status | • The bar shows how far the measurement has progressed<br>• E: states the energy measured by the reference meter during the measurement<br>If the device under test is reading accurately, the amount of energy given by the pulse count will equal the amount of energy measured. For the case given in the example above, this would be:<br>$E = \frac{500 \times 1\,\mathrm{I}}{10000 \times 1\,\frac{\mathrm{I}}{\mathrm{kWh}}} = 0.05\,\mathrm{kWh}$ |
| F: | Error for the last measurement in % |

Subfunctions

The 'Error measurement' function contains the following subfunctions:

| Function | Details |
|---|---|
|  | • Enter the meter constant<br>• Select the multiplier<br>• Select the units |
|  | • Select the pulse source<br>• Enter the number of pulses to be counted<br>• Multiplier selection: 1, EXP+1, EXP,+2, … Exp+5 (100000) |
|  | See *Save Data subfunction* on page 84 |

Units for the meter constant

| Function | Details |
|---|---|
| I/kWh | Pulses per kilowatt-hour |
| I/kvarh | Pulses per kilovar-hour for reactive power |
| I/kVAh | Pulses per kiloVolt-Ampere hour for apparent power |
| Wh/I | Watt-hours per pulse |
| varh/I | Var-hours per pulse for reactive power |
| VAh/I | Volt-Ampere hours per pulse for apparent power |

Pulse source

It is possible to select from four different types of pulse sources and operating procedure:

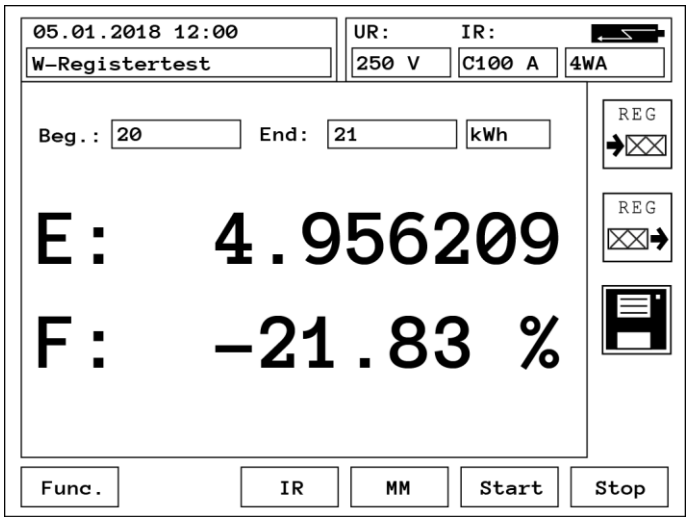
| Type | Details |
|---|---|
| SC | With scanning head<br>The pulses from the scanning head are transferred 1:1 to the reference meter. |
| SC MAN | Without scanning head<br>An external manual pushbutton is used to trigger the start and stop signals for the measurement.<br>In this method, the user counts the pulses/revolutions and presses the external pushbutton according to the count. |
| SC1000 | F OUT from another reference meter<br>Additional 1000:1 pulse step-down ratio. The pulses from another pulse source are transferred in the ratio 1000:1 to the reference meter.<br>The divisor (1000) is used by the internal software, i.e. the constant can be entered directly and the number of pulses must be divisible by 1000 and have a minimum value of 1000. |
| St/St | Without scanning head<br>In this method, the user counts the pulses/revolutions and presses the following function keys on the reference meter to start and stop the measurement:<br>• Start (to start)<br>• Stop (to stop) |

# W-register test (energy register)

Description

The 'W-Registertest' function tests the energy register of a meter. The energy register contains the total amount of energy consumed over time. This test finds the difference between the initial value in the energy register at the start time and the final value at the stop time. The difference equals the energy metered by the device under test. The percentage error is calculated by comparing this energy with the energy measured by the reference meter.

Display

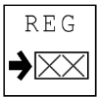
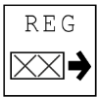



Description of parameters

| Parameter | Details |
|---|---|
| Beg.: | Value entered as the initial value from the energy register |
| End: | • Value entered as the final value from the energy register<br>• Selected units (µWh … MWh) |
| E: | Measured energy in selected units |
| F: | Energy register error in % |

Subfunctions

The 'W-Registertest' function contains the following subfunctions:

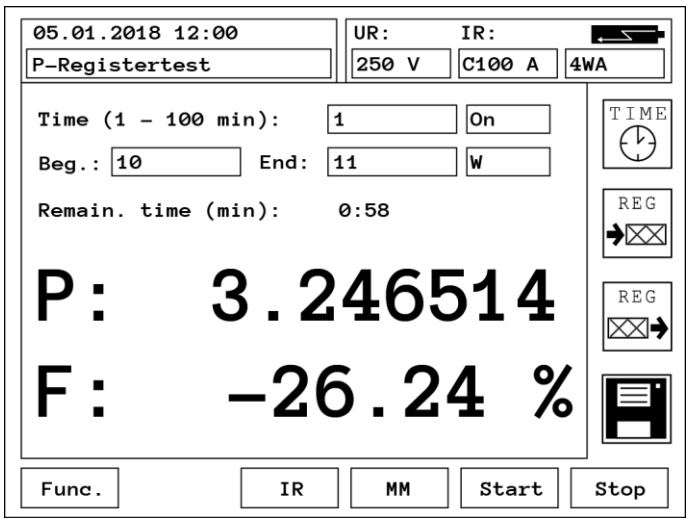
| Function | Details |
|---|---|
|  | • Input the initial value from the energy register<br>• Select the units (µWh … MWh) |
|  | • Input the final value from the energy register<br>• Select the units (µWh … MWh) |
|  | See *Save Data subfunction* on page 84 |

# P-register test (power register)

Description

The 'P-Registertest' function tests the power register of a meter. A power register contains the peak value of the power that occurred in a measured time period. The P-register test compares the value metered by the device under test (final value) with the value measured independently by the reference meter, and calculates the error from the difference.

Display

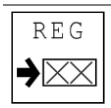
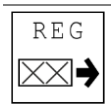



Description of parameters

| Parameter | Details |
|---|---|
| Time: | Selected measurement period in minutes, and status of the automatic timer |
| Beg.: | Value entered as the initial value from the power register<br>The initial value is needed in order to identify whether a peak value (final value) of power was retrieved during the measurement that was higher than the initial value. |
| End: | • Value entered as the final value from the power register<br>The final value must be greater than the initial value for the reference meter to obtain a relevant comparison value.<br>• Selected units (µW … MW) |
| Remain. time (min): | Time remaining for the measurement in minutes |
| P | Measured power in selected units |
| F | Power register error in % |

Subfunctions

The 'P-Registertest' function contains the following subfunctions:

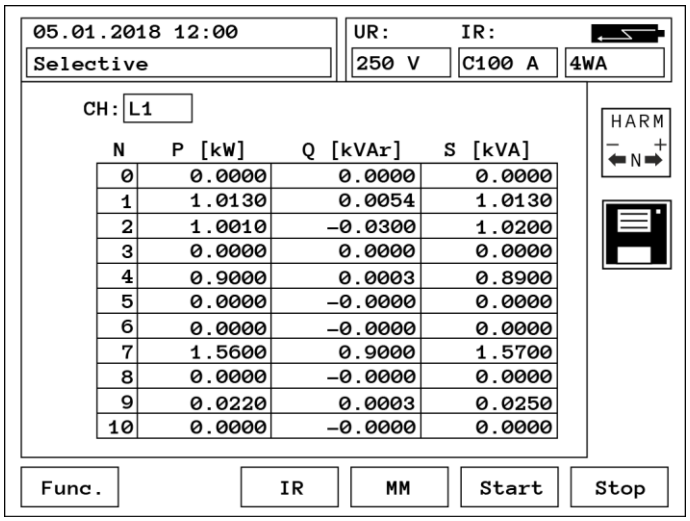
| Function | Details |
|---|---|
|  | • Input the measurement period<br>• Actuate the automatic timer |
|  | • Input the initial value from the power register<br>• Select the units (µW … MW) |
|  | • Input the final value from the power register<br>• Select the units (µW … MW) |
|  | See *Save Data subfunction* on page 84 |

# Selective – optional

Description

The 'Selective' function displays the active, reactive and apparent power for the first 40 harmonics of a selected phase. The sign in front of a measured value indicates whether the power is being drawn from the mains or fed into the mains.

Display




Description of parameters

| Parameter | Details |
|---|---|
| CH | Selected line |
| N | Display shows the measurements for the first 10 harmonics |
| P [(k)W] | Active power [units] |
| Q [(k)var] | Reactive power [units] |
| S [(k)VA] | Apparent power [units] |

Subfunctions

The 'Selective' function contains the following subfunctions:

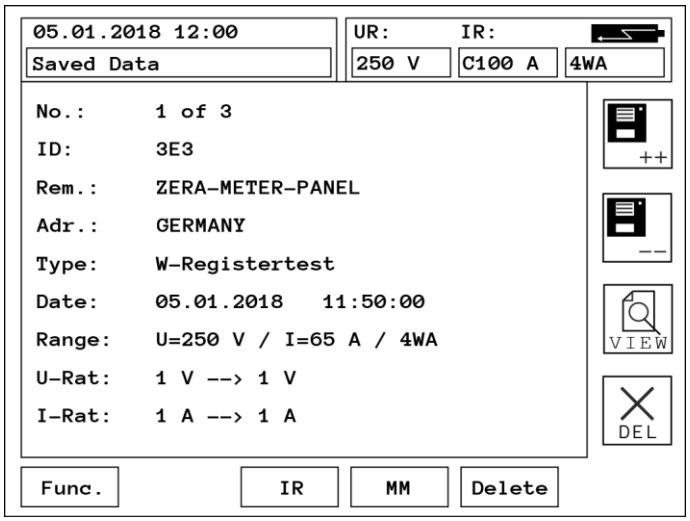
| Function | Details |
|---|---|
|   | Phase selection: L1, L2, L3 |
|   | Show the next 10 harmonics:<br>0…10→10…20→20…30→30…40→0…10→… |
|  | See *Save Data subfunction* on page 84 |

# Saved Data

Description

The 'Saved Data' subfunction displays in the reference meter the saved measurement data and the relevant settings in the reference meter associated with this data.

Display




Description of the display

| Parameter | Details |
|---|---|
| No.: | Data record number |
| ID: | Customer ID |
| Rem.: | Comment |
| Adr.: | Address |
| Type: | Function used to perform the test, e.g. error measurement |
| Date: | Date of the measurement |
| Range: | Measurement ranges and mode |
| U-Rat: | Voltage transformer ratio |
| I-Rat: | Current transformer ratio |

Subfunctions

The 'Saved Data' function contains the following subfunctions:

| Function | Details |
|---|---|
|  | Display the next data record |
|  | Display the previous data record |
|  | View details of the selected data record |
|  | Delete the currently viewed data record |

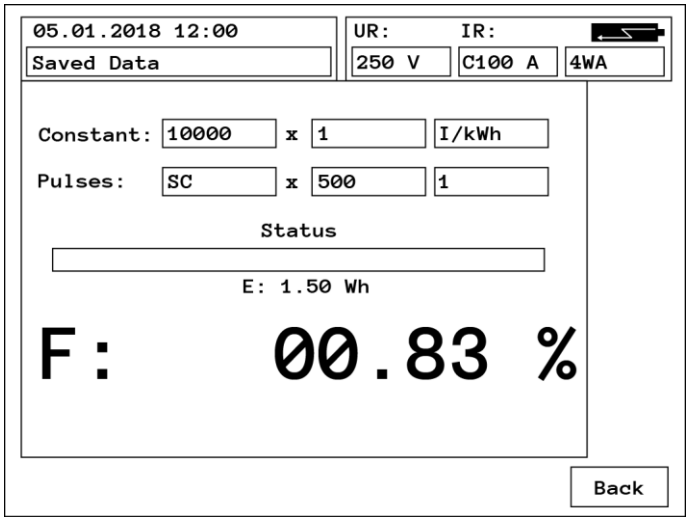
The horizontal function bar

The horizontal function bar differs from the standard function key layout by including the following function key:

| Function | Details |
|---|---|
| Delete | Delete all the data records |

Detailed view

The Detailed view for a measurement corresponds to the view for the function in which the data was saved. The data in the screenshot below was saved in the 'Error measurement' function.



# Source (ext.) - optional

Description

The 'Source (ext.)' function controls an external ZERA source. When an external source is connected, the 'Source (ext.)' function can be used to define and actuate the load point required for the device under test. The operator can set the value for the current and phase angle or power factor for each phase.

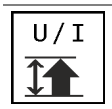
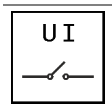
Requirement

The following requirements must be met:

- An external ZERA source is connected to the reference meter.
- The source and reference meter are connected by an RS232 cable.

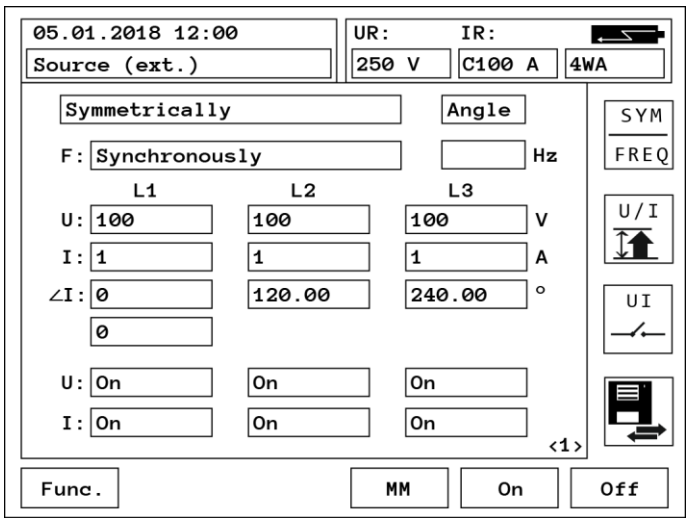
Subfunctions

The 'Source (ext.)' function contains the following subfunctions:

| Function | Details |
|---|---|
|  | Options: Sym or Freq<br>Symmetrically or Frequency is selected under cursor control.<br>Additional selections/entries are then made.<br>Sym:<br>• Symmetrically<br>  • Angle<br>  • PF (Power factor)<br>• Not symmetrically<br>  • Angle<br>Freq:<br>• Synchronously<br>• Variable<br>  • Enter the frequency |
|  | Enter voltage and current of the source |
|  | Activate individual phases of the source |
|  | Open the subfunction for loading or saving the load point |

Display showing the set load point

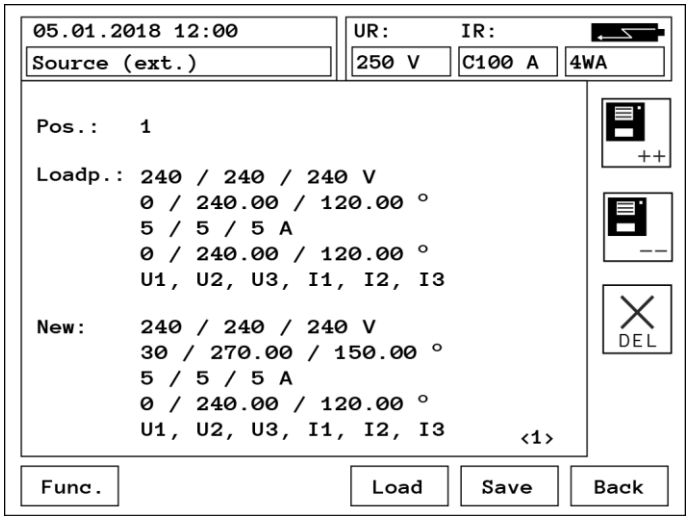
The screen contents will vary depending on the settings for the symmetry of the mains supply.



Description of input data

| Parameter | Details |
|---|---|
| Symmetrically / Not symmetrically | Symmetrically:<br>Voltage and current can be set for L1 and then are adopted automatically for L2 and L3.<br>The following phase angles apply depending on the standard:<br>• IEC 387: φ(IL1) = 0°, φ(IL2) = 120°, φ(IL3) = 240°<br>• DIN 410: φ(UL1) = 0°, φ(UL2) = 240°, φ(UL3) = 120°<br>Not symmetrically:<br>• Voltage, current and phase angle for the voltage and current can be set as required for each phase. |
| Angle / PF | Choice of 'Angle' or 'PF' (power factor)<br>Angle:<br>• The phase angle for the voltage (IEC 387) or for the current (DIN 410) can be set for L1 and adopted automatically for L2 and L3.<br>PF:<br>• The same power factor can be set for L1 - L3. The power factor defines the phase angle. |
| F: | Select the frequency:<br>• Synchronously: the frequency cannot be entered<br>• Variable: a frequency can be entered: 45–65 Hz |
| U: | Enter the voltage for each phase |
| I: | Enter the current for each phase |
| ∠I ∠U: / P/Q: | • Enter the phase angle<br>  • ∠I for IEC 387<br>  • ∠U for DIN 410<br>• P/Q: Input and settings for the power factor and the quadrant |
| U: | Activation status of the voltage for each phase |
| I: | Activation status of the current for each phase |
| <#> (bottom right) | Number for the loaded load point |

Display for the subfunction for loading or saving the load point



Description of the display

| Parameter | Details |
|---|---|
| Pos.: | No. of the saved load point |
| Loadp.: | Data for the selected load point<br>(empty if a load point has not been saved) |
| New: | Currently set data for the load point |
| <#> | No. of the saved load point |

Subfunctions for loading or saving the load point

The 'Save data' subfunction contains the following subfunctions:

| Function | Details |
|---|---|
|  | Display the next saved load point |
|  | Display the previous saved load point |
|  | Delete the saved load point displayed for 'Loadp.:' |

Horizontal function bar

The horizontal function bar differs from the standard function key layout by including the following function keys:

| Function | Details |
|---|---|
| Load | The load point displayed for 'Loadp.:' is set<br>Back to the 'Source (ext.)' function |
| Save | The load point displayed for 'New:' is saved as the load point |
| Back | Back to the 'Source (ext.)' function without loading or saving |

# Dosage (ext.) – optional

Description

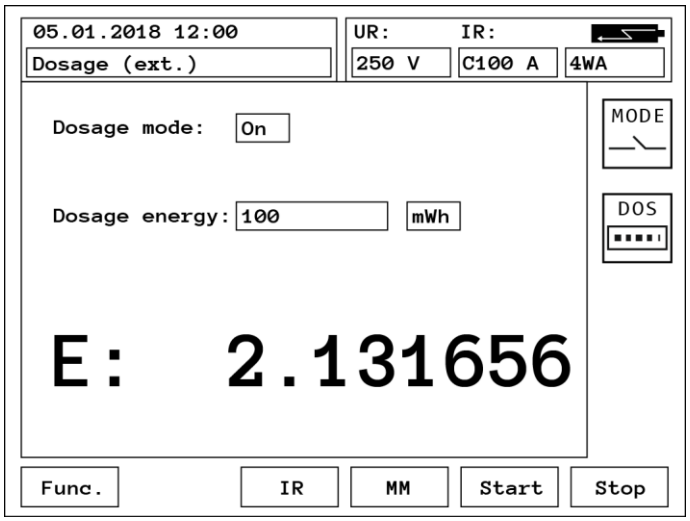
The 'Dosage (ext.)' function controls the amount (or "dose") of energy supplied from an external ZERA source. The 'Dosage (ext.)' function can be used with a ZERA MT400/500 source to supply a specified amount of energy to the device under test.

Requirement

The following requirements must be met:

- An external ZERA source is connected to the reference meter.
- The source and reference meter are connected by an RS232 cable.
- The source and reference meter are connected by a BNC cable.

Display




What data is entered and displayed

| Parameter | Details |
|---|---|
| Dosage mode: | Status of dosage mode |
| Dosage energy: | Value and units of the dosage energy |
| E: | Shows the amount of energy still to be supplied after starting the dosage function. |

Subfunctions

The 'Dosage (ext.)' function contains the following subfunctions:

| Function | Details |
|---|---|
| MODE | Disable/Enable dosage mode:<br>• 'On': enables dosage mode<br>• 'Off': disables dosage mode |
| DOS | Enter the dosage energy: amount and units. |

Dosage procedure

The dosage process is performed in the following stages:

| Stage | Procedure |
|---|---|
| **1** | On dosage mode being enabled, the external source cuts off the supply of current. |
| **2** | When the dosage function is started, the external source switches on the current. |
| **3** | The external source supplies current until the specified amount of dosage energy is reached. |
| **4** | Once the specified amount of dosage energy is reached, the external source cuts off the supply of current again. |

Closing dosage mode

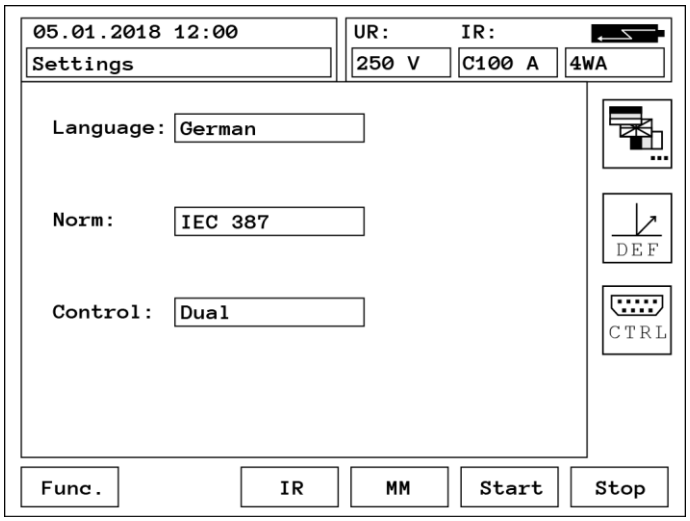
Dosage mode must be set to 'Off' again at the end of the dosage function. If dosage mode is left enabled, this can cause malfunctions.

# Settings

Description

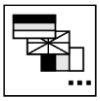
The 'Settings' function is used for specifying global settings that apply to all the measurements. The settings must always be made before the actual measurement.

Display




Subfunctions

The 'Settings' function contains the following subfunctions:

| Function | Details |
|---|---|
|  | Select the system language<br>Languages available: German, English, Italian, French, Czech, Spanish, Turkish, Serbian, Hungarian |
|  | Select the phase angle calculation under the 'Norm' entry<br>Choice of IEC 387 or DIN 410 |
|  | Select the mode for controlling the source and dosage of the reference meter<br>• Device<br>• Dual<br>• External |

Meaning of the 'Norm' selection for the phase angle calculation

The choice made under the 'Norm' entry affects how values are displayed:

| Options | Details |
|---|---|
| IEC 387 | • Current vectors are fixed, voltage vectors are variable<br>• Reference value I1, displayed horizontally<br>• φ($I_1$) is always 0 (in 3 O'clock position)<br>• Positive angle is anticlockwise |
| DIN 410 | • Voltage vectors are fixed, current vectors are variable<br>• Reference value U1, displayed vertically<br>• φ($U_1$) is always 0 (in 12 O'clock position)<br>• Positive angle is clockwise |

What the input data means for the Control function

An external instrument connected to the reference meter via the RS232 port can be used to control the reference meter. The list box contains the following options:

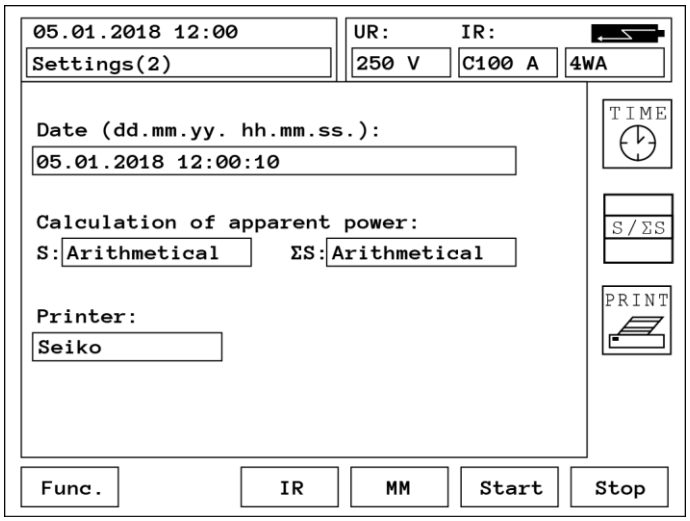
| Input | Details |
|---|---|
| Device | • Control is via the reference meter's built-in keypad<br>• The external instrument is not used for control purposes |
| Dual | • Control is via the reference meter's built-in keypad<br>• The external instrument is also used for control |
| External | • Control is not possible via the reference meter's built-in keypad<br>• Only the external instrument is used for control |

# Settings (2)

Description

The 'Settings (2)' function is used for specifying additional global settings that apply to all the measurements. The settings must always be made before the actual measurement.

Display




Subfunctions

The 'Settings (2)' function contains the following subfunctions:

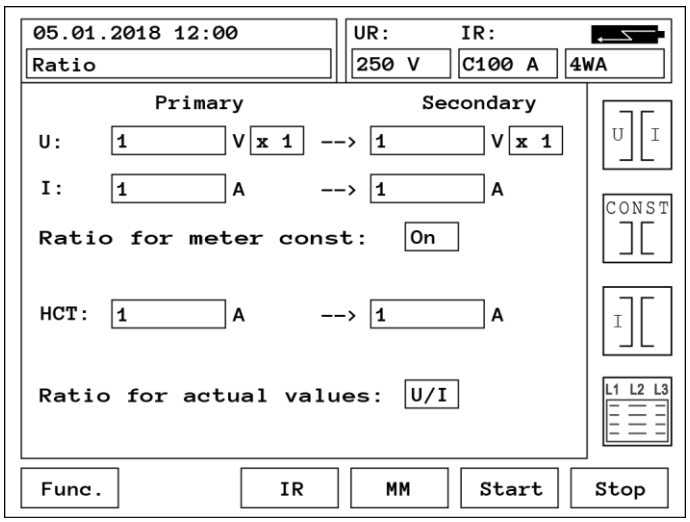
| Function | Details |
|---|---|
| TIME | Enter the system time in the format<br>dd.mm.yyyy hh:mm:ss |
| S/ΣS | Select the method for calculating the apparent power for each separate phase (S) and as a total value (ΣS)<br>• Arithmetical<br>$S_\Sigma = U_1 \cdot I_1 + U_2 \cdot I_2 + U_3 \cdot I_3$<br>• Geometrical<br>$S_\Sigma = \sqrt{P_\Sigma^2 + Q_\Sigma^2}$ |
| PRINT | Optional function: Select a connected thermal printer:<br>• Seiko<br>• Mobile Pro |

# Ratio

Description

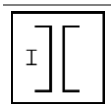
The 'Ratio' function is used for entering the transformer ratios of any current and voltage transformers that may be connected on the input side of the meter. These ratios can then be taken into account to provide the correct measured values. The values for the transformer ratios must always be entered before the actual measurement.

Display




Subfunctions

The 'Ratio' function contains the following subfunctions:

| Function | Details |
|---|---|
|  | Enable the input of all the rated voltages and currents, starting with the rated primary voltage (pressing the Enter key takes you to the next input option) |
|  | Disable/Enable the ratio for the meter constant:<br>• 'On': enable<br>• 'Off': disable |
|  | Enter the rated-current ratio for external high-current transformers (HCT) in AC current clamps (the ratio is obtained by dividing the value entered for the primary rated current by the value entered for the secondary rated current of the HCT)<br>**NOTICE!** Because no other external current clamps can be connected to this device, the operator must ensure that the values set here are always set 1:1. |
|  | Select the conversion for the actual values.<br>• U/I: Select this option for measurement using current or voltage transformers<br>• Off: Select this option for a measurement without current or voltage transformers (measurement directly at the meter)<br>• HCT: This function is not supported by the MT30. |

Ratio for voltage and current transformer

In many meter installations, transformers are used to step down the large voltage and current values. The measurement must take into account the ratios for the transformers depending on the position of the taps.

For voltage transformers it is also necessary to enter a factor for the primary and secondary sides of the transformer. There is a choice of two values:

| Factor | Usage |
|---|---|
| x1 | for two-pole voltage transformers in a three-phase, 3-wire meter installation, where the voltage value represents the voltage from phase to phase e.g. 11 kV |
| 1/√3 | for single-pole voltage transformers in a three-phase, 4-wire meter installation, where the voltage value represents the voltage from phase to phase e.g. 11 kV/√3 |

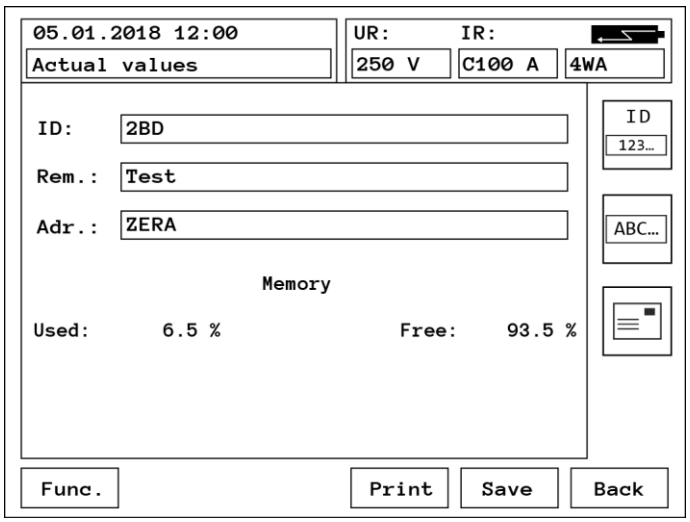
# The Save Data subfunction

Description

The 'Save Data' subfunction can be used to save the currently measured data for the selected function. The 'Save Data' subfunction is available in most functions.

If the Print function is available (optional), the currently measured data for the selected function can be printed.

Display

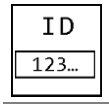
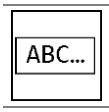



Description of the display

| Parameter | Details |
|---|---|
| ID: | Customer ID |
| Rem.: | Comment |
| Adr.: | Address |
| Used: | Percentage of memory space used |
| Free: | Percentage of memory space available |

Subfunctions

The 'Save data' subfunction contains the following subfunctions:

| Function | Details |
|---|---|
|  | Enter customer ID<br>• 25 characters maximum |
|  | Enter comment<br>• 25 characters maximum |
|  | Enter address<br>• 25 characters maximum |

Horizontal function bar

The horizontal function bar differs from the standard function key layout by including the following function keys:

| Function | Details |
|---|---|
| Print (optional) | Print the currently measured data including the customer information |
| Save | Save the data record<br>• Updates the percentages for used and available memory space |
| Back | Return to the function without saving the data record |

Information on printing

The data that is printed is always the data for the function from which 'Save data' was opened.

Requirements:

- The 'Print' option is available.
- A suitable printer is connected to the RS-232 port.
- The printer is configured; see *Settings(2)* on page 81

Information on saving

- If several sets of data need to be saved under the same customer ID, there is no need to re-enter the address and comments.
- A PC running the relevant software can be used to access the data held in the memory. It is also possible, for instance, to reprint a vector diagram from the saved values.

Memory usage

- Total memory space: 250 kB
- Approximate memory usage per save operation for one data record for the functions:
  - Actual Values, Vector, Harmonics, Error Measurement, P-Registertest, W-Registertest: 0.2 % of the total memory space
  - Waveforms: 1.6 % of the total memory space

# 9 Calculation of derived values

Voltage, current and measurement periods are measured, but all other variables are calculated and are therefore derived values. In all formulae, an L as subscript stands for the line, where L is a member of the set {L1; L2; L3}. If the turns ratio for voltage or current is not 1:1, the given formulae must be corrected accordingly.

Contents

**In this Chapter** **Page**

## Calculating the voltage

Effective value of the voltage

$$U_L = \sqrt{\frac{1}{N}\sum_{n=1}^{N} U_{L;n}^2}$$

$U_L$ Effective value of the voltage between line L and neutral
$U_{L;n}$ Sampled value of the voltage between line L and neutral
$N$ Number of samples

Voltage harmonic

$$U_k = \sqrt{a_{U_k}^2 + b_{U_k}^2}$$

$$U_k\% = \frac{U_k}{U_1} \cdot 100\%$$

where

$$a_{U_k} = \frac{2}{N}\sum_{n=0}^{N-1} U_n \cos\left(k\frac{2\pi n}{N}\right)$$

$$b_{U_k} = \frac{2}{N}\sum_{n=0}^{N-1} U_n \sin\left(k\frac{2\pi n}{N}\right)$$

$k$ Number of the harmonic
$U_k$ Effective value of the kth voltage harmonic
$U_k\%$ Ratio of $U_k$ to $U_1$ in %
$U_1$ Effective value of the voltage fundamental
$a_{Uk}$ Real part of $U_k$
$b_{Uk}$ Imaginary part of $U_k$

Total harmonic distortion (THD) of the voltage

$$\mathrm{THD}(U_L)\% = \frac{\sqrt{\sum_{k=2}^{40} U_{L;k}^2}}{U_{L;1}}$$

$\mathrm{THD}(U_L)\%$ Total harmonic distortion (THD) of the voltage in %

Distortion factor ($\mathrm{THD_R}$) of the voltage

$$\mathrm{THD_R}(U_L)\% = \frac{\sqrt{\sum_{k=2}^{40} U_{L;k}^2}}{U_L}$$

$\mathrm{THD_R}(U_L)\%$ Distortion factor ($\mathrm{THD_R}$) of the voltage in %

## Calculating the current

Effective value of the current

$$I_L = \sqrt{\frac{1}{N}\sum_{n=1}^{N} I_{L;n}^2}$$

$I_L$ Effective value of the current in line L
$I_{L;n}$ Sampled value of the current in line L
$N$ Number of samples

Current harmonic

$$I_k = \sqrt{a_{I_k}^2 + b_{I_k}^2}$$

$$I_k\% = \frac{I_k}{I_1} \cdot 100\%$$

where

$$a_{I_k} = \frac{2}{N}\sum_{n=0}^{N-1} I_n \cos\left(k\frac{2\pi n}{N}\right)$$

$$b_{I_k} = \frac{2}{N}\sum_{n=0}^{N-1} I_n \sin\left(k\frac{2\pi n}{N}\right)$$

$k$ Number of the harmonic
$I_k$ Effective value of the kth current harmonic
$I_k$% Ratio of $I_k$ to $I_1$ in %
$I_1$ Effective value of the fundamental of the current
$a_{Ik}$ Real part of $I_k$
$b_{Ik}$ Imaginary part of $I_k$

Total harmonic distortion (THD) of the current

$$\mathrm{THD}(I_L)\% = \frac{\sqrt{\sum_{k=2}^{40} I_{L;k}^2}}{I_{L;1}}$$

THD($I_L$)% Total harmonic distortion (THD) of the current in %

Distortion factor ($THD_R$) of the current

$$\mathrm{THD_R}(I_L)\% = \frac{\sqrt{\sum_{k=2}^{40} I_{L;k}^2}}{I_L}$$

$THD_R(I_L)$% Distortion factor ($THD_R$) of the current in %

## Power for the 4-wire measurement

Active power

$$P_L = \sqrt{\frac{1}{N}\sum_{n=1}^{N} u_{L;n}^2 \cdot i_{L;n}^2}$$

- $P_L$ Active power for line L
- $u_{L;n}$ Sampled value of the line-neutral voltage for line L
- $i_{L;n}$ Sampled value of the current in line L
- $N$ Number of samples in a period ($1/f$)

Reactive power

$$Q_L = \frac{1}{N}\sum_{n=1}^{N} u_{L;n}^2 \cdot i_{L;n-N/4}^2$$

- $Q_L$ Reactive power for line L
- $u_{L;n}$ Sampled value of the phase-neutral voltage for the line L
- $i_{L;n-N/4}$ Sampled value of the current in line L, ¼ period ahead of the voltage
- $N$ Number of samples in a period ($1/f$)

Apparent power

In geometric mode:

$$S_L = \sqrt{P_L^2 + Q_L^2}$$

In arithmetic mode:

$$S_L = U_L \cdot I_L$$

- $S_L$ Apparent power for line L

Power factor λ

$$\lambda_L = \frac{P_L}{Q_L}$$

- $\lambda_L$ Power factor for phase L; for sinusoidal variables, equals the active power factor cos φ

Active power factor cos φ

Only applies to function tests in the 4-wire active mode (4WA)

Only applicable with sinusoidal variables: $THD_R(I_L)$; $THD_R(I_L) \approx 1$

Total powers $P_\Sigma$, $Q_\Sigma$, $S_\Sigma$

$$P_\Sigma = P_{L1} + P_{L2} + P_{L3}$$

$$Q_\Sigma = Q_{L1} + Q_{L2} + Q_{L3}$$

In geometric mode:

$$S_\Sigma = \sqrt{P_\Sigma^2 + Q_\Sigma^2}$$

In arithmetic mode:

$$S_\Sigma = U_1 \cdot I_1 + U_2 \cdot I_2 + U_3 \cdot I_3$$

- $P_\Sigma$ Total active power
- $Q_\Sigma$ Total reactive power
- $S_\Sigma$ Total apparent power

# Power for the three-phase 3-wire measurement

Active power

$$P_2 = U_{L32} \cdot I_{L3} \cdot \cos(\angle U_{L32} - \angle I_{L3})$$

$$P_1 = U_{L12} \cdot I_{L1} \cdot \cos(\angle U_{L12} - \angle I_{L1})$$

$P_1$; $P_2$ Active powers
$U_{L32}$ Effective value of the voltage between lines L3 and L2
$U_{L12}$ … L1 and L2
$I_{L1}$; $I_{L3}$ Effective value of the currents in the outside lines L1 and L3 respectively

Reactive power (true)

$$Q_1 = U_{L12} \cdot I_{L1} \cdot \sin(\angle U_{L12} - \angle I_{L1})$$

$$Q_2 = U_{L32} \cdot I_{L3} \cdot \sin(\angle U_{L32} - \angle I_{L3})$$

$Q_1$; $Q_2$ reactive powers
$U_{L32}$ Effective value of the voltage between lines L3 and L2
$U_{L12}$ … L1 and L2
$I_{L1}$; $I_{L3}$ Effective value of the currents in the outside lines L1 and L3 respectively

Total powers $P_\Sigma$, $Q_\Sigma$, $S_\Sigma$

$P_\Sigma = P_1 + P_2$
$Q_\Sigma = Q_1 + Q_2$
In geometric mode:

$$S_\Sigma = \sqrt{P_\Sigma^2 + Q_\Sigma^2}$$

$P_\Sigma$ Total active power
$Q_\Sigma$ Total reactive power
$S_\Sigma$ Total apparent power (always geometric)

## Phase angles

Phase angle of the voltage

$$\angle U_L = \arctan\left(\frac{b_{U_{1;L}}}{a_{U_{1;L}}}\right) - \varphi_{Ref}$$

- $\angle U_L$ Phase angle of the fundamental voltage harmonic in line L referred to the reference channel
- $\varphi_{Ref}$ Phase angle of the reference channel (DIN410: U1; IEC387: I1)
- $a_{U\_1;L}$ Real part (active component) of the 1st voltage harmonic in line L
- $b_{U\_1;L}$ Imaginary part (reactive component) of the 1st voltage harmonic in line L

Phase angle of the current

$$\angle I_L = \arctan\left(\frac{b_{I_{1;L}}}{a_{I_{1;L}}}\right) - \varphi_{Ref}$$

- $\angle I_L$ Phase angle of the fundamental current harmonic in line L referred to the reference channel
- $\varphi_{Ref}$ Phase angle of the reference channel (DIN410: U1; IEC387: I1)
- $a_{I\_1;L}$ Real part (active component) of the 1st current harmonic in line L
- $b_{I\_1;L}$ Imaginary part (reactive component) of the 1st current harmonic in line L

# Accuracy test

Accuracy test

$$F\,\% = \frac{N_{must} - N_{actual}}{N_{actual}} \cdot 100\,\%$$

where

$$N_{must} = \frac{3600\frac{s}{h} \cdot 1000\frac{W}{kW} \cdot n \cdot C_{PZ}}{U_B \cdot I_B \cdot C}$$

| | |
|---|---|
| $F\%$ | Error (measurement deviation) in % |
| $N_{must}$ | Number of pulses calculated by the reference meter that must be received from the DUT |
| $N_{actual}$ | Actual number of pulses received from the DUT |
| $n$ | Number of cycles ($n$ + 1 = number of measurement cycles) |
| $U_B$ | Voltage measurement range |
| $I_B$ | Current measurement range |
| $C_{PZ}$ | Reference frequency at 100% P (Q) in Hz |
| $C$ | Meter constant or pulse constant [$kWh^{-1}$ / $kvarh^{-1}$] |

Meter constant

The reference meter has a power-proportional output frequency of 60000 Hz in each nominal voltage and current measurement range.

Formula for converting the output frequency into pulses per kilowatt-hour.

$$C\left[\frac{Imp}{kWh}\right] = \frac{1000 \cdot 3600 \cdot 60000\frac{Imp}{s}}{n \cdot U_B \cdot I_B}$$

| | |
|---|---|
| $n$ | Number of lines ($n \in \{1; 3\}$) |
| $U_B$ | Voltage measurement range |
| $I_B$ | Current measurement range |

Value table for $C$ for n = 3 and $U_B$ = 250 V:

| $I_B$ [A] | $C$ [Imp/kWh] |
|---|---|
| 100 | 2880000 |
| 50 | 5760000 |
| 10 | 28800000 |
| 5 | 57600000 |
| 1 | 288000000 |
| 0.5 | 576000000 |

# 10 Troubleshooting and routine maintenance

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## Cleaning and routine maintenance

| | |
|---|---|
| Frequency of cleaning and maintenance | There are no set intervals for cleaning and maintenance. The usage determines how often cleaning and maintenance is carried out. |
| Cleaning the reference meter | Use a soft, slightly damp cloth to clean the instrument.<br>Never use abrasive cleaners, solvents or alcohol for cleaning. These may damage the equipment or remove its labelling. |
| Cleaning the cables | The cables must be cleaned regularly because dirt can affect or reduce the insulating properties/insulation. This may cause electric shock or a short-circuit in wet or damp environments.<br>Always inspect the cables for signs of damage. Damaged cables must be replaced. |
| Cleaning and maintaining the AC current clamps | The clamps of the AC current clamps must be cleaned regularly with a soft cotton cloth using a corrosion inhibitor spray such as CRC 2-26<br>Check that the clamp jaws meet up. The clamp jaws may get twisted out of shape if the clamps are not handled carefully. This will result in inaccurate measurements. Twisted clamp jaws must be replaced. |

# Battery use

The batteries

If batteries are fitted, the reference meter can be used temporarily without the mains adapter. The power is then supplied by the batteries (3 in all). The batteries are rechargeable lithium-ion batteries (3.7 V / 2200 mAh).

Battery use

**⚠ WARNING**

**Fire and explosion hazard arising from mechanical damage or overheating of the batteries**

Mechanical damage can cause short-circuits inside the battery. The resultant current flow can produce heat, which in turn can cause a fire or explosion, which may not even occur until hours after the damage. The same applies to operation above the approved operating temperature.

- Protect the batteries from mechanical damage.
- Do not use the batteries in an environment that is warmer than 60 °C.

Battery lifetime

Batteries only have a limited lifespan. If the reference meter works for less than 30 minutes from a fully charged battery then the batteries are faulty. A faulty battery is also indicated by rapid flashing of the 'Charge' LED.

New batteries can be purchased from ZERA. For ordering information, please see the MT30 product catalogue.

Battery charging

The batteries are charged while the mains adapter is connected. The charge level is indicated by the 'Charge' LED.

| LED | Details |
|---|---|
| Permanently on | Instrument being powered from the mains adapter<br>Internal battery is fully charged |
| Flashing slowly | Instrument being powered from the mains adapter<br>Internal battery is being charged |
| Flashing rapidly | Instrument being powered from the mains adapter<br>Internal battery is faulty; must be replaced immediately |
| Off | Instrument under battery power |

Storage

The charge level of lithium ion batteries needs to be checked regularly if they are stored for prolonged periods. The optimum charge level is between 50 % and 80 %. Although the self-discharge rate of 1 % per month is extremely low, it is highly dependent on temperature. Lithium-ion batteries should be recharged every 3 to 4 months to prevent deep discharge. If a cell gets to less than 2 Volts it may be irreparably damaged. Lithium-ion batteries should be stored in as cool a place as possible because of the sharp drop in lifetime associated with an increase in storage temperature.

# Potential problems arising from the hardware

Instrument will not run

| Cause | Suggested remedy |
|---|---|
| Instrument has "frozen" | Press the Reset button: the reference meter starts running |
| No power supply | Check whether the adapter is supplying 16 V.<br>• If not, replace the mains adapter. |
| Batteries flat or faulty | Connect a power supply<br>• Battery indicator flashing rapidly: batteries faulty<br>• Battery indicator flashing slowly: batteries being charged |
| Current measurement ranges not displayed | Insert plugs from AC current clamps correctly.<br>• If the current measurement ranges are still not displayed, replace the AC current clamps |

No response to the ON/OFF button

| Cause | Suggested remedy |
|---|---|
| ON/OFF button pressed too briefly | Press ON/OFF button for at least 5 secs |
| Instrument has "frozen" | Press the Reset button: the reference meter starts running |

Current measurement ranges not displayed

| Cause | Suggested remedy |
|---|---|
| AC current clamps not plugged in correctly | Screw in place the 25-pin plug for the AC current clamps. |
| AC current clamps are faulty | Replace the AC current clamps |

Incorrect voltage and current measurements

| Cause | Suggested remedy |
|---|---|
| Instrument is no longer calibrated correctly | Run functional test; seePower check |

No light on scanning head

| Cause | Suggested remedy |
|---|---|
| Lead is loose or faulty | • Check lead is connected properly<br>• Replace lead |
| Scanning head is faulty | • Replace scanning head |

# Potential problems arising from use

Actual values are incorrect or too high

| Cause | Suggested remedy |
|---|---|
| Wrong ratio for voltage/current transformer | • Enter the correct values in 'Settings'<br>• Enable/Disable the ratio for voltage/current transformer in 'Settings 2' |

Error measurement reads 99.99 % or HH.HH %

| Cause | Suggested remedy |
|---|---|
| Ratio for voltage/current transformer | • Enter the correct values in 'Settings'<br>• Enable/Disable the ratio for voltage/current transformer in 'Settings 2' |
| Incorrect meter constant | • Correct the meter constant under 'Error measurement'<br>• Enable/Disable the meter constant in 'Settings 2' |
| Incorrect measuring mode | • Set correct mode |
| Scanning head not adjusted correctly | • Correct the scanning head |

Error measurement taking too long or does not start

| Cause | Suggested remedy |
|---|---|
| Incorrect current measurement range | Set the correct current measurement range |
| Number of pulses to be counted is too high | Check/correct pulse number and factor |
| Scanning head not adjusted correctly | Reposition the scanning head correctly |

The percentage error is 67 % or 33 %

| Cause | Suggested remedy |
|---|---|
| AC current clamps connected in wrong order | Check test setup<br>• AC current clamp L1 to L1, L2 to L2, L3 to L3, check direction of current for the AC current clamp |
| Voltage connection UL1, UL2, UL3, UN mixed up | • Check test setup |
| Scanning head not adjusted correctly | • Check the scanning head |

Accuracy for cos φ = 1 is OK but not for cos φ = 0.5 ind

| Cause | Suggested remedy |
|---|---|
| AC current clamps corroded | • Clean them |
| AC current clamps do not close completely | • Replace the AC current clamps |

High error (e.g. 2000 %) in the P-/W-register test

| Cause | Suggested remedy |
|---|---|
| Wrong ratio for voltage/current transformer | • Enter the correct values in 'Settings'<br>• Enable/Disable the ratio for voltage/current transformer in 'Settings 2' |

Unable to perform Save operation

| Cause | Suggested remedy |
|---|---|
| Cursor in wrong field | • Press Enter then press Save |
| Memory full | • Clear the memory<br>• Back up the data first on a PC if necessary |

Data download to the PC will not run

| Cause | Suggested remedy |
|---|---|
| RS232 cable not connected properly | • Check connection |
| Wrong interface port selected | • Select the correct interface in MTVis software |

Data download was stopped

| Cause | Suggested remedy |
|---|---|
| Timeout time in MTVis software is too short | • Select a larger value |

Data download taking too long

| Cause | Suggested remedy |
|---|---|
| Other entries being made in parallel with the data download | • Do not press any buttons during the download |

The power from an external source cannot be switched off

| Cause | Suggested remedy |
|---|---|
| Dosage mode is enabled in the Dosage function (ext.). | Set Dosage mode to 'Off' |

# Warranty, Service, Disposal

Warranty

ZERA guarantees to the customer that any product from ZERA GmbH, Germany is free from defects in materials and/or workmanship for the duration of the warranty period. ZERA GmbH will repair or replace damaged parts that are returned post-paid during the warranty period. Replacement or repair of damaged parts will be free of charge provided there are no signs of misuse or usage other than for its intended purpose. ZERA GmbH does not extend this warranty to damage caused by incorrect or inadequate maintenance or operation by unqualified persons. ZERA GmbH does not extend this warranty to cover costs for routine maintenance or for calibration required by local laws and regulations. ZERA GmbH does not extend this warranty to consumable parts such as rechargeable batteries or other parts subject to wear from frequent use.

ZERA GmbH does not accept liability for any special, direct, indirect, incidental or consequential damages or losses (including loss of data) whether as a result of infringements of the warranty and contractual terms and conditions or on any theory of liability.

This warranty runs for a period of 12 months from the date of installation or for a period of 15 months from the date of dispatch, whichever is earlier.

The ZERA Service

If you need spare parts or have any technical questions, please contact our Service department, making sure you have the following information to hand:

- Equipment serial number
- Equipment order number
- Detailed description of the problem/fault

To contact our Service department:

Tel +49 2244 9277-169
Email service@zera.de

Returns

Should it be necessary to return the instrument to ZERA for servicing or repair work, pack the unit carefully and firmly with suitable packaging and ship it in a well-padded cardboard box to avoid damage. Never return the reference meter in an unsealed or flexible pack. ZERA does not accept liability for any damage arising from improper packing.

Procedure for a Service request

ZERA's website (www.zera.de) includes a Service/Repair area giving precise instructions on how to place a Service request. A special CALL form is provided for this purpose, which you need to download from the website. Then simply follow the guidance on the CALL form.

Disposal – WEEE

During their entire lifetime, the products from ZERA GmbH do not pose a potential hazard to human health or the environment if the following conditions are met:

- product used properly in accordance with intended use
- product disposed of in accordance with WEEE regulations.

ZERA GmbH is registered under WEEE reg. no. DE 53879641. This is required according to EU law for the disposal of waste electrical and electronic equipment.

According to EU law, it is the responsibility of the user to dispose of the product in accordance with WEEE regulations.

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