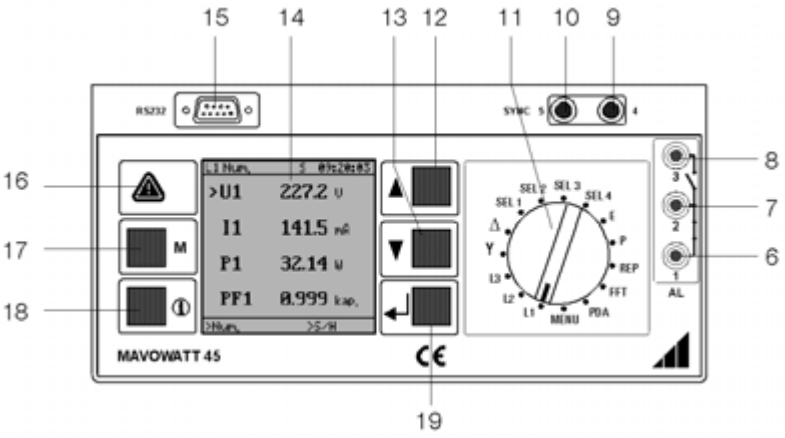
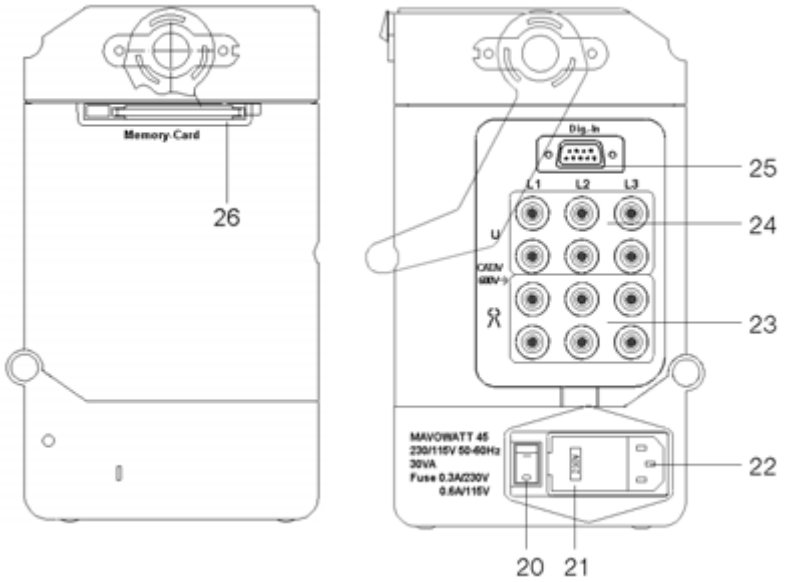
MAVOWATT 45

Energy and Power Disturbance Analyzer

3-348-745-03
6/3.02

Controls, Displays and Connectors





[1] Buttons (left and right) for releasing carrying handle detents

[2] Buttons (left and right) for releasing housing top detents

[3] Housing top

[4] Compartment with SECUTEST PSI printer (optional) and storage space, e.g. for recording chart rolls

[5] Handle and tilting stand

[6] Jack 1: alarm output for limit value monitoring (normally open contact)

[7] Jack 2: alarm output for limit value monitoring (contact root)

[8] Jack 3: alarm output for limit value monitoring (normally closed contact)

[9] Jack 4: synchronizing input (minus pole)

[10] Jack 5: synchronizing input (plus pole)

[11] Function selector switch

[12] Scroll key ▲ (up in increments)

[13] Scroll key ▼ (down in increments)

[14] LCD

[15] RS232 port for PSI printer or PC

[16] Warning symbol "Read Operating Instructions"

[17] Menu key M

[18] Info key for querying online help

[19] Enter key ↵ for the acknowledgement of entries

[20] Mains switch

[21] Mains voltage selector and fuse holder

[22] Supply input socket for recessed plug

[23] Connector jacks for current measurement inputs (for clip-on current transformers with voltage output or shunt)

[24] Connector jacks for voltage measurement inputs

[25] Connector plug for digital counter inputs

[26] Slot opening for memory card (PC-Card)

Contents

I Receiving Inspection

Immediately after receipt of the instrument and included accessories, unpack and inspect for completeness and any possible damage:

Unpacking

Other than the usual care required for the unpacking and handling of electronic instruments, no special precautions are necessary.

The transport packaging is made from recyclable material and provides for ample protection under normal transport conditions. Use equivalent material if the instrument needs to be repacked.

Visual Inspection

Compare the order number and type designation shown on the instrument and/or its packaging with those in the shipping documents.

Make sure that all accessories have been included (→1.4.1 Included Accessories)

Inspect the packaging and the mechanical components of the instrument and accessories for transport damage.

Complaints

If damage has occurred, a complaint should be filed immediately with the freight forwarder (save the packaging!). If other defects are discovered, or if repair of the instrument is required, please inform your local representative, or contact us directly at the address shown on the last page of these instructions.

II Safety Precautions

The MAVOWATT 45 Energy Analyzer has been manufactured and tested as a protection class I instrument in accordance with safety regulations IEC 1010-1/EN 61010-1/VDE 0411. If used for its intended purpose, the safety of the operator, as well as that of the instrument, is assured. However, safety cannot be guaranteed if the instrument is operated incorrectly or handled improperly.

In order to maintain flawless technical safety conditions and to assure hazard-free operation, the user must observe all warnings and safety precautions which are included in these instructions. These have been identified with the following terminology and visual highlights:

WARNING!

Instructions, concerning instrument operation or applications, which must absolutely be observed in order to assure safe operation of the instrument and to prevent bodily injury.

ATTENTION!

Instructions, concerning instrument operation or applications, which must absolutely be observed in order to avoid damage to the instrument and to assure correct operation.

The most important general safety precautions are summarized below. Reference is made to these warnings at the appropriate points within the operating instructions.

WARNING 1

The instrument may only be operated if the protective conductor has been connected. Interruption of the protective conductor, either inside or outside of the instrument, may result in hazardous operating conditions. Intentional interruption is prohibited.

The instrument is connected to the mains by means of a 3 conductor power cable with an earthing contact plug. This plug may only be inserted into an appropriate outlet socket with an earthing contact. Do not disable the protective function through the use of an extension cable without protective conductor.

WARNING 2

The instrument may only be operated by personnel who are capable of recognizing contact hazards and implementing appropriate safety precautions.

Contact hazards are present anywhere where voltages of greater than 50 V exist.

WARNING 3

Do not work alone when performing measurements which involve contact hazards. In such cases, a second person must always be present.

WARNING 4

The maximum allowable potential between current or voltage measurement inputs and ground is:

– 600 V for connection to overvoltage category IV circuits

– 1000 V for connection to overvoltage category III circuits

ATTENTION!

It is absolutely essential that the measurement inputs are not overloaded beyond allowable capacities. Maximum allowable voltage is:

– 1200 V each at the voltage measurement inputs designated "U"

– 250 V each at the current measurement inputs designated "I"

– 48 V DC each at the meter inputs designated "Dig. In" and the synchronizing inputs designated "SYNC"

WARNING 5

No measurements may be performed within circuits with corona discharge (high-voltage).

WARNING 6

Special care must be taken when measurements are performed within HF circuits. Dangerous oscillating voltages may be present.

WARNING 7

It must be assumed that unexpected voltages may occur at devices under test (e.g. defective instruments). Capacitors, for example, may be dangerously charged.

WARNING 8

Measurements under damp ambient conditions are prohibited.

WARNING 9

The measurement cables must be kept in flawless conditions, e.g. no damage to insulation, no interruptions at cables and plugs etc.

WARNING 10

If it may be assumed that the instrument can no longer be safely operated, it must be removed from service and secured against unintentional use.

Safe operation can no longer be assumed:

– If the instrument demonstrates visible damage

– If the instrument no longer functions

– After lengthy periods of storage under unfavorable conditions

– After exposure to unusual transport stresses

WARNING 11

As long as the instrument is connected, voltage conducting parts may be exposed if the instrument's cover panels are opened.

Maintenance and repair work, as well as internal device balancing, may only be performed by trained personnel who are familiar with the dangers involved.

In as far as is possible, the instrument must be disconnected from all external power sources before the performance of this type of work. A waiting period of 5 minutes must be observed after the instrument has been disconnected, in order to allow for the discharging of internal capacitors to a safe voltage level.

WARNING 12

Only designated fuse types with the indicated current ratings may be used for the replacement of blown fuses (see Technical Data and information printed on the instrument next to the fuse switch.

Tampering with fuses or the fuse holder ("repairing" fuses or short-circuiting the fuse holder etc.) is prohibited.

1 Technical Description

1.1 Use and Applications

The portable MAVOWATT 45 Energy and Power Disturbance Analyzer has been designed for the measurement of electrical quantities in DC systems, as well as single and 3-phase AC systems with balanced or unbalanced loads with frequencies of up to 400 Hz. Measurements at frequency converter outputs (motor controls) are also possible with the TCM option.

Applications range from acquisition, display and recording of mains quantities through the recognition and analysis of fluctuations and other interferences within the power supply (options FFT, PDA and FSA), right on up to analysis and recording of energy consumption.

The MAVOWATT 45 can also be used for a wide variety of industrial applications. For example, it functions as a precision recorder and measuring instrument for the determination of characteristic quantities for electrical load components or generators either under static conditions or during dynamic operation. Or it functions as a test instrument and compares harmonic current or voltage fluctuations generated by load components with predefined limit values (options FFT and FSA).

Thanks to its compact and rugged design, the MAVOWATT 45 can be implemented as a portable instrument, as well as for use in stationary applications.

1.2 Included Functions

- Measuring
  – Simultaneous acquisition of three analog voltage and three analog current signals with simultaneous sampling at 50 kHz
  – Simultaneous acquisition of three digital pulse signals.
- Calculation
  Calculation of derived electrical quantities for single and 3-phase systems as RMS values, extreme values and mean values, as well as consumed power and energy.
- Displays
  – Numeric and graphic display of measured and calculated quantities in predefined combinations (selector switch positions L1, L2, L3, Y, Δ, E and P), or in freely selectable combinations (SEL1, SEL2, SEL3, SEL4) with up to 20 possibilities
  – Display of setup menus in various languages
  – Display of operating and hookup instructions
- Monitoring
  Acquisition and recording of violated limit values (user adjustable) for 4 different measured quantities. Limit value violation is indicated with a group interrupt by switching a floating relay contact.
- Memory
  – FIFO register (operating memory) for approx. 900 measurement values for quantities included in the selected rotary switch position, including time stamp. The contents of the register can be displayed in tabular form or as a Y-t graph, and serve as the basis for statistical analyses.
  – Non-volatile image memory for up to 15 images (hardcopies) from the LCD which have been stored by pressing a key, can be replayed with the REP Hardcopy function.
  – Non-volatile storage of measurement values to a plug-in PCMCIA flash memory card (accessory PC-Card)

1.3 Options

The instrument can be equipped with the following optional functions.

Hardware option: SECUTEST PSI Printer Module

Firmware options:
MAVO-FFT Harmonic Analysis,
MAVO-PDA Power Disturbance Analysis,
MAVO-TCM Transient and ConverterMeasurements,
MAVO-FSA Flicker Analysis.

The firmware options are installed by the user except on model MAVOWATT 45S which already includes all firmware options. This is performed with the help of a PC by uploading and enabling the specific device software via the included RS232 interface. Subsequent uploading of optional functions can be performed at any time.

The model MAVOWATT 45S already includes all optional functions ex works!

- Printer
  The following printing options are made possible with the SECUTEST PSI report printer, which can be integrated into the instrument's housing cover:
  – Manually controlled print-out the current LCD display together with 2 headers and two footers
  – Time controlled print-out (interval printing) of respective measured values at the end of a selected time period
  – Measurement value driven print-out (alarm printing) of measurement values for up to four selectable measured quantities dependent upon individually adjustable limit values
- MAVO-FFT: Harmonic Analysis
  DC components, fundamental components and harmonics for current and voltage up to the 50th harmonic are continuously and uninterruptedly acquired and calculated in relation to a fundamental frequency of 15 to 400 Hz at all three phases by means of a 16 period rectangular window in real-time, and are displayed as numeric values or as a bar graph for the selected phase.

  Alternatively, THD (total harmonic distortion) measurement values from all three phases for voltage and current can be displayed numerically, or can be statistically classified.

  Furthermore, the FFT option provides for two test functions:
  – Uninterrupted comparison of calculated values for harmonic voltage with limits defined in EN 50160 (Voltage Characteristics for Public Power Supply Networks), and the recording of limit value violations at an adjustable interval

– Uninterrupted comparison of calculated values for harmonic current with limits defined in EN 61000-3-2 (Harmonic Current Limit Values for Devices with Conductors < 16 A), and the recording of limit value violations within an adjustable interval period.

- MAVO-PDA: Power Disturbance Analysis
  The MAVOWATT 45 makes use of power disturbance analysis methods which allow for uninterrupted monitoring and classification of disturbances within electrical power supply networks.

  The measured quantities (RMS values for voltage and current, as well as frequency and THD), which have been calculated during 2, 4, 8 or 16 signal periods for all, or only selected phases, are continuously compared with the respective, individually selected trigger criteria (*upper limit for U/I/ THD_U/THD_I/f, lower limit for U/I//f, fluctuation for U/I*). Individually or simultaneously occurring events are continuously recorded and are summarized for display in three different tables:
  – *Number and type of voltage and frequency events which occurred* within an adjustable interval period
  – *Number and type of current events which occurred* within an adjustable interval period
  – Events list with indication of *point in time*, *cause* and *measurement value*
  If continuous acquisition is not required, *voltage and current signal characteristics* can be displayed with high time resolution when an event occurs.

  This allows, on the one hand, for documentation of mains voltage characteristics as required by EN 50160, and, for example, the analysis of making operations for load components.

- MAVO-FSA: Flicker Analysis
  Flicker is defined as the subjective impression made by brightness fluctuations at light fixtures caused by supply voltage fluctuations. Fluctuations of this type can be measured and analyzed with the help of a flicker meter. EN 61000-4-15 (former EN 60868) defines the basic functional principle of the flicker meter, which takes the entire chain of events into consideration, i.e. light bulb - eye - brain, and compares measurement results to an experimentally determined limit value curve (perceptibility limit).

  The MAVO-FSA option expands the MAVOWATT 45 to include a flicker meter function. The values for the resulting measured quantities P_{st} (*short-term flicker strength* for a period or 10 min) and P_{lt} (*long-term flicker strength* for a period of 2 hours) are simultaneously calculated for all three phases on an individual basis. An evaluation of mains voltage quality in accordance with EN 50160 can be performed on the basis of these measurement values.

  Additionally, this function also allows for the acquisition of the *largest relative change in voltage* d_{max}, *relative constant voltage deviation* d_c and the *maximum duration of deviation dt>3%* for voltage changes of greater than 3% within the short-term measuring interval. These measured quantities are required for type testing for electrical devices in accordance with EN 61000-3-3. The observance of the limit values set forth in this standard will be absolutely essential for branding with the CE mark as of 1 January 2001.

- MAVO-TCM: Transient and Converter Measurements
  This option makes the instrument suitable for the performance of measurements at frequency converters, as well as for the acquisition of transients within the electrical system.

  – Frequency converters which are used to control motor speed are usually equipped with a high-frequency, square-wave output voltage which is pulse modulated by means of the motor frequency. Signals of this type necessitate a special measuring process which filters out the converter's switching frequency, and determines the motor's fundamental frequency. The MAVOWATT 45 is capable of deriving *all measurement quantities required for power and energy analysis* with signals processed in this fashion, as long as the following conditions have been fulfilled: The switching frequency must be greater than 1200 Hz and the fundamental frequency must lie within a range of 10 to 100 Hz. Acquisition of motor current must be electrically isolated, e.g. through the use of a clip-on ammeter.

  – As opposed to the RMS trigger criteria for the PDA option, and as an alternative thereto, the trigger conditions for the TCM function for the recording of power disturbances are derived from a comparison between the absolute level of a sampled value and the selected *level limit value Up* or *Ip*. The *adjustable steepness trigger dU/dt* or *dI/dt* is also active, and trigger conditions are based upon a comparison of the rising or falling edge of two consecutively sampled values. The time difference between the two samples, which corresponds to the minimum duration for recognizable events, can be selected in 6 steps ranging from 20 µs to 640 µs. After an event has been recognized, approximately 3800 current and voltage values (corresponds to a recording period ranging from 76 ms to 4.43 s) from the relevant phase are sampled and stored to memory under consideration of the percentage value which has been selected for the pre-trigger, and are displayed at the LCD as a *characteristic curve* with indication of the *cause of triggering*. This display remains until memory content is overwritten by the next event.

1.4 Accessories

1.4.1 Included Accessories

Depending upon model, the following are included with the MAVOWATT 45:

- MAVOWATT 45L - M815C

1 MAVOWATT 45 Energy Analyzer (without options, without SECUTEST PSI printer)

1 cable set for the voltage measurement inputs consisting of 3 pairs of measurement cables (approx. 1.2 m long) with test probe and 6 plug-on alligator clips

4 short measurement cables with 4 mm safety plugs (stackable) for bridging the measuring inputs

1 power cable with earthing contact and recessed plug

1 RS232 interface cable

1 carrying pouch for instrument and accessories

1 floppy disc with software for the installation of online help in various languages

1 set of operating instructions for MAVOWATT 45

- MAVOWATT 45S - M815E

Same as MAVOWATT 45L, except with the following options already installed: FFT, PDA, FSA and TCM

3 passive 1000 A clip-on current-voltage converters, item number Z823B

1 set of operating instructions for the Z823B, as well as for each of the installed options

1 K45 plastic case (instead of carrying pouch)

1.4.2 Available Accessories

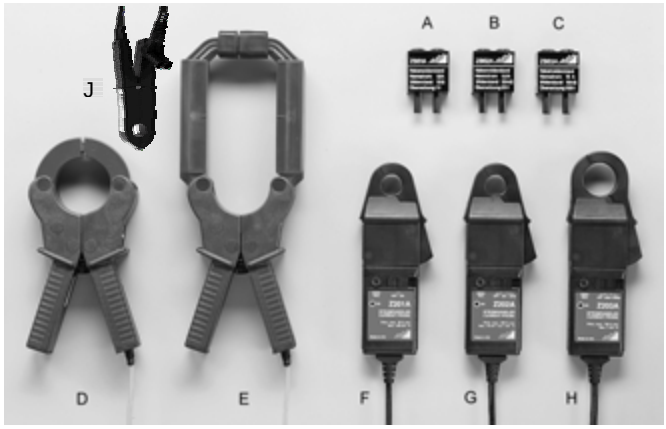
- MAVO-RC8 (→5.7)
  8 MB PCMCIA flash RAM memory card (PC card) for long term recording of measurement data
- METRAwin 45 (→ 6.4)
  PC software for expanded measurement data analysis
- Printer Module SECUTEST PSI (→3.6)
  The SECUTEST PSI report printer can be integrated into the instrument's housing cover and allows for on-site documentation

- PS-10P
  Pack of 10 rolls of recording chart paper for the SECUTEST PSI printer
- Z3210
  Pack of 10 ink ribbon cartridges for the SECUTEST PSI report printer
- K45
  Plastic case with foam inserts for MAVOWATT 45 and accessories

- UPS Pulsar EL2
  The Uninterruptable Power Supply Pulsar EL2 provides instantanuous power for mains supplied equipment at unstable line voltage.Uninterruptable power supply 120W/220VA
  Devices such as PC, fax, modem, measuring instruments with 220 VA max. power consumption can be connected.
  With a fully charged Pulsar EL2 one MAVOWATT 45 can be operated for at least 30 minutes.

Current Sensors (→8 Techn. Data)

- Z860A (Fig. A)
  50 Ω plug-in shunt resistor, 0.2%, 1.5 W,
  50 mV/mA (0 to 20 mA → 0 to 1 V)
- Z861A (Fig. A)
  1Ω plug-in shunt resistor, 0.2%, 1.5 W,
  1 mV/mA (0 to 1 A→ 0 to 1 V)
- Z862A (Fig. B)
  0.05 Ω plug-in shunt resistor, 0.2%, 1.5 W,
  50 mV/A (0 to 5 A → 0 to 0.25 V)
- Z863A (Fig. C)
  0.01 Ω plug-in shunt resistor, 0.2%, 1.5 W,
  10 mV/A (0 to 16 A → 0 to 0.16 V)
- Z201A (Fig. F)
  Active clip-on current-voltage converter with 9 V battery (service life approx. 30 hours),
  0 to 30 A DC, 0 to 20 A AC, 100 mV/A, DC to 20 kHz
- Z202A (Fig. G)
  Active clip-on current-voltage converter with 9 V battery (service life approx. 50 hors), 0 to 30/300 A DC,
  0 to 20/200 A AC, 10/1 mV/A, DC to 10 kHz
- Z203A (Fig. H)
  Active clip-on current-voltage converter with 9 V battery (service life approx. 50 hours), 0 to 300/1000 A DC, 0 to 200/1000 A AC, 1 mV/A, DC to 10 kHz
- WZ12F (Fig. J)
  Passive clip-on current-voltage converter,
  0.02 to 15 A AC, 100 mV/A, 30 Hz to 500 Hz
- WZ12E (Fig. J)
  Passive clip-on current-voltage converter,
  0.2 to150 A AC, 10 mV/A, 30 Hz to 500 Hz
- Z823B (Fig. D)
  Passive clip-on current-voltage converter,
  0 to 1000 A AC, 1 mV/A, 45 Hz to 10 kHz
- Z821B (Fig. E)
  Passive clip-on current-voltage converter,
  0 to 3000 A AC, 0,333 mV/A, 30 Hz to 5 kHz



- AF11A
  Flexible "Amp*FLEX*" current-voltage converter,
  with 9 V battery (service life approx. 150 hours),
  (0.5...) 5 to 1000 A AC, 1 mV/A, 10Hz to 20kHz,
  45 cm loop
- AF033A
  Flexible "Amp*FLEX*" current-voltage converter,
  with 9 V battery (service life approx. 150 hours),
  (0.5...)5 to 30/300 A AC, 100/10 mV/A, 10Hz to 20kH,
  60 cm loop
- AF33A
  Flexible "Amp*FLEX*" current-voltage converter,
  with 9 V battery (service life approx. 150 hours),
  (0.5...)5 to 300/3000 A AC, 10/1 mV/A, 10Hz to 20kHz
  90 cm loop
- AF101A
  Flexible "Amp*FLEX*" current-voltage converter,
  with 9 V battery (service life approx. 150 hours),
  (5...)50A to 1/10 kA AC, 1/0.1 mV/A, 10Hz to 20kHz;
  120 cm loop

2 Initial Start-Up

2.1 Mains Connection

A supply voltage of either 115 or 230 VAC is required for operation of the instrument. The instrument is connected to the mains via the combination unit which is integrated into the housing base and the recessed plug [22]. The combination unit also includes the mains switch [20], the fuse holder for the mains fuse and a mains voltage selector [21].

ATTENTION!

Make certain that the correct mains voltage has been selected, and that the correct mains fuse (see ratings next to mains connection) has been installed before initial start-up.

Observe **WARNING 1**!

Note

The MAVOWATT 45 has a mains failure buffering time of at least 30 ms. If the instrument is to be used for power disturbance analysis of its own power supply, and if lengthy power failures are expected to occur, a commercially available uninterruptible power supply (UPS) can be utilized. UPSs with a "square wave" output waveshape are also suitable.

2.1.1 Selecting Mains Voltage / Replacing Mains Fuses

Observe **WARNING 12**!

WARNING!

Disconnect the instrument at all poles from the measuring circuit before opening the fuse holder.

Disconnect the instrument from the mains by pulling the mains plug from the outlet.

☞ Open the fuse link cover [21] with an appropriate tool (e.g. screwdriver) by prying the cover up with protruding tab.

☞ Plug the mains voltage selector unit into the fuse holder such that the desired voltage can be read from the outside through the cover.

☞ Remove the fuse holder (see arrow).

☞ Replace the fuse with the correct fuse for the selected voltage (see serial plate next to the mains switch for values and refer to chapter 10, Maintenance and Repair).

☞ Close the cover.

2.1.2 Switching the Instrument On

The instrument is switched on and off with the mains switch [20] at the right-hand side of the instrument. An integrated lamp indicates that the instrument has been switched on. The controls start an initialization sequence after the instrument has been switched on. The following information is displayed at the LCD [14] underneath the company logo during this sequence:

- Instrument name
- Revision level of the integrated software, e.g. *REV. 2.05*
- The instrument's serial number
- Memory capacity of the memory card, if one has been installed, e.g. *2097152 byte*.

The instrument is then switched to the function which has been selected with the rotary switch in the "numeric" display format (= default display format), and is ready for operation. If the instrument was in the Hold or Memory mode when it was last switched off, it returns to the corresponding operating mode when it is switched back on again.

2.2 Updating / Upgrading MAVOWATT 45 Software

2.2.1 General

MAVOWATT 45 measuring functions are, to a great extent, in compliance with existing standards. Regulations change, and new regulations are introduced. Thanks to modern design including flash memory, the processor-controlled instrument functions can be easily updated and upgraded. New device software (firmware) can be uploaded to the instrument from a PC via the included RS232 interface. This feature is specifically designed to allow for:

- Installation (unlocking) of optional instrument functions FFT, PDA, FSA and TCM
- Changing language for setup menus and online help
- Installation of new device software which has resulted from on-going technical developments.

The firmware being installed in the MAVOWATT 45 consists of two independent parts:

- The operational software

  This controls the measurements and functions and displays the setup menus in one of two languages (selectable in *MENU – general*).
- The info menu software

  It contains in one language the help informations which can be displayed at the MAVOWATT 45 when pressing the info key.

Available languages:

Setup menus:	German/English *) French/English Italian/English Spanish/English
Info menus:	German *) English French Italian Spanish

*) = Language(s) installed at factory

By installation of other firmware versions it is possible to
– update or change language of the operational firmware,
– update or change language of the info menu firmware.

This is performed by transmission of the corresponding data from a DOS PC to the MAVOWATT 45 via serial interface.

The diskette being delivered with the device or its options contains the software required for this purpose.

All files are packed into a self-extracting archive named "mw45firm.exe". Executing this file will extract the archive into a directory of your PC. Default path is C:\MWATT45\FIRMWARE.

You are requested to enter a different path if desired.

The latest firmware version can also be downloaded via internet from the address given at last page of this manual.

2.2.2 Preparations for Program Uploading

A PC with DOS is required for uploading firmware to the instrument.

☞ Close all background programs and enter DOS in order to prevent interrupts during data transfer.

☞ Switch the MAVOWATT 45 off, disconnect the printer module (SECUTEST PSI) and remove the Memory Card from the instrument if one has been installed.

☞ Connect the interface at the MAVOWATT 45 with the designation RS232 to the serial port at your PC (e.g. COM1) with the included cable (= extension cable, 9-pin socket to 9-pin plug, do not use a zero modem cable!).

☞ Insert the respective MAVOWATT program floppy disc into the floppy disc drive at the PC.

☞ Enter the designation for the floppy disc drive at the DOS entry prompt (e.g. *A:*).

☞ The floppy disc may include a text file (e.g. *README.TXT*) with additional information. Read this text with the help of a text editor.

☞ Connect the MAVOWATT 45 to mains power and switch the instrument on.

Note

Make sure that printer function has been disabled for the RS232 interface at the MAVOWATT 45 before communications with a PC are established:

Select: *printer off*
– In the *limits* setup menu in selector switch position MENU (alarm printing)
– And in the *setup* menu, for example in selector switch position L1 (interval printing)

2.2.3 Enabling Optional Functions: FFT, PDA, FSA, TCM

A serial number specific password is required for unlocking each of these functions. The password is sent to you via mail or fax after you have returned (by fax) the registration card(s) being delivered with the installation diskette for the optional function.

Enabling and correct functioning of the options are only possible if the following firmware versions have been installed to the instrument:
– Version 2.00 or higher for the FFT and PDA options
– Version 3.00 or higher for the TCM option
– Version 4.00 or higher for the FSA option
The current version of the device firmware is displayed underneath the company logo after the instrument has been switched on during the initialization sequence, for example: *Rel. 2.05*

If the device contains an older firmware than required then you first have to update the operational firmware as described in chapter 2.2.4a before you can proceed with the following steps.

☞ Turn the function selector switch at the MAVOWATT to:
  – FFT, in order to unlock the MAVO-FFT option
  – PDA, in order to unlock the MAVO-PDA option
  – MENU, in order to unlock the MAVO-FSA option
  – MENU, in order to unlock the MAVO-TCM option

☞ Start the enabling sequence at the PC with the command *FFTKEY <Enter>* or
PDAKEY <Enter> or
FSAKEY <Enter> or
TCMKEY <Enter>

⇒ You will then be requested to enter your password. The password is a several digit number.

☞ Enter the password and press *<Enter>.*

⇒ After the enabling process has been completed, »*FFT unlocked*« or »*PDA unlocked*« or »*FSA unlocked*« or »*TCM unlocked*« appears at the PC monitor.

☞ Switch the MAVOWATT 45 off.

⇒ When the MAVOWATT 45 is switched back on, the newly installed function is ready for use.

Notes

- Installed options remain enabled even after a firmware update has been performed.

2.2.4 Updating or Changing Language of the Instrument

ATTENTION!

Pay attention to not overwrite the firmware being installed in the MAVOWATT by a possibly older version from the diskette.

The installed firmware release is briefly shown on the MAVOWATT display after power-on: e.g. REV. 3.20.

The version and release of the firmware files can be recognized at their file names: MAVOx###.S19
x stands for the language version,
stands for the firmware release number.

☞ Set the function switch on the MAVOWATT to the L1 position.

☞ At the DOS prompt enter the command to change to directory containing the firmware files (e.g. CD C:\MAVOWATT\FIRMWARE).

a) Updating or Changing Language of Operational Firmware

Uploading of the operational firmware is started by executing the file: *LOAD[language].BAT*.

[language] = Designation for the desired language:

	using COM1	using COM2
German / English:	*LOAD.BAT*	*LOAD_2.BAT*
French / English:	*LOADF.BAT*	*LOADF_2.BAT*
Italian / English:	*LOADI.BAT*	*LOADI_2.BAT*
Spanish / English:	*LOADS.BAT*	*LOADS_2.BAT*

⇒ The initialization sequence is displayed at the PC monitor as a series of semicolons (**; ; ; ; ; ;**). Uploading of the firmware is represented by a series of points (**. . . . .**) which extend over several lines at the PC monitor. Uploading takes several minutes and may not be interrupted. If problems appear during transmission, this procedure must be repeated, perhaps using a different PC.

⇒ The cursor reappears at the DOS entry prompt after uploading has been successfully completed. The MAVOWATT 45 is rebooted automatically, after which it is ready for operation with the new software.

Note

After transmission check the measuring and device parameters (language, time, date, mains type, tariff times etc). These may have been changed during uploading!

The display contrast setting may also have been reset, so that the display is illegible. If this is the case, proceed as follows:

☞ Switch the instrument off.

☞ Set the function switch to MENU.

☞ Switch the instrument on.

⇒ A signal sounds after initializing and the cursor blinks at the first contrast setting position.

☞ Contrast can now be adjusted with the scroll keys, even if nothing is visible at the display.

b) Updating or Changing Language of Info Menu Firmware

The installation of the info menu firmware is done in the same way as the above described operational firmware installation by executing the file: *INFO[language].BAT*.

[language] = Designation for the desired language:

	using COM1	using COM2
German:	*INFOD.BAT*	*INFOD_2.BAT*
English:	*INFOE.BAT*	*INFO_2E.BAT*
French:	*INFOF.BAT*	*INFOF_2.BAT*
Italian:	*INFOI.BAT*	*INFOI_2.BAT*
Spanish:	*INFOS.BAT*	*INFOS_2.BAT*

2.3 Measurement Inputs

Observe WARNINGS 3 through 9!

The MAVOWATT 45 includes the following measurement inputs:

- Three analog voltage measurement inputs - U_{L1}, U_{L2}, U_{L3} - for direct or alternating voltages of up to 600 V (for overvoltage category CAT IV) or 1000 V (CAT III). Measurements in medium-voltage systems must generally be performed via voltage transformers at the system side! The corresponding transformation ratio, *Uratio,* can be selected individually for each input in the *setup* menu for selector switch positions L1, L2 and L3.

  The 2-pole, floating inputs are electrically isolated from one another, although they feature high impedance connections (approx. 2 MΩ) to the appropriate current measurement input. Input impedance is approx. 4 MΩ.

  Connector jacks [24]: 1 pair each 4 mm safety jacks, black (high level) and blue (low level) at the right-hand side of the instrument. Voltage is normally connected to the device under test with the included measurement cables with 4 mm safety plug, and test probes with plug-on alligator clips.

  See chapter 7 for connection examples.

- Three analog current inputs, I_{L1}, I_{L2}, I_{L3}, set up as voltage inputs (see technical data for measuring ranges) for the connection of shunts or (clip-on) current transformers with voltage output, or burdened current transformers. The corresponding transformation ratio, *Iratio,* can be selected individually for each input in the *setup* menu for selector switch positions L1, L2 and L3.

  The 2-pole, floating inputs are electrically isolated from one another, although they feature high impedance connections (approx. 2 MΩ) to the appropriate voltage measurement input. Input impedance is approx. 11 kΩ.

  Connector jacks [23]: 1 pair each 4 mm safety jacks, red (high level) and black (low level) at the right-hand side of the instrument.

  See chapter 7 for connection examples.

- Three digital counter inputs, Dig.-In P4, P5 and P6 for the determination of energy quantities and periodic power through the use of interconnected pulse generators (usually impulsing meters). The corresponding counter constant, *cconst*, can be selected individually for each input in the *setup* menu for selector switch positions E or P.

  the 2-pole, floating inputs (optocoupler) are functionally isolated from one another. They are S_0 compatible and require a binary signal which is generated from an external, auxiliary voltage source (Safety Extra-Low Voltage!).

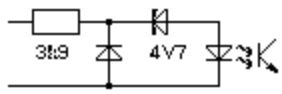
  → chapter 7.3.

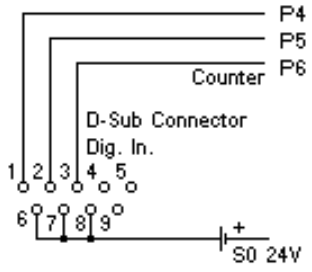
Signal Level

Level	Signal Voltage	Signal Current
Low	< +4 V (max. –48 V)	0 mA @ 0...+4 V
High	> +12 V (max. +48 V) nominal +24 V	approx. 2,6 mA @ +12 V approx. 6 mA @ +24 V

Connector plug [25]: 9-pin D-Sub plug, Dig.-In at the right-hand side of the instrument, and a specially fabricated, applications-specific signal cable.

Connector Pin Assignments

Input	P4	P5	P6	Internal Circuit
+	1	2	3	
–	6	7	8	



ATTENTION!

The application of a voltage of greater than 48 V to the Dig-In counter inputs, the synchronizing inputs (SYNC) or the alarm output may cause damage to the instrument.

☝ Important Note

The instrument must continuously monitor the frequency of the measuring signal for correct calculation of AC quantities. AC measured quantities are only acquired via voltage measurement input L1. Voltage U1 must therefore always be connected for voltage and/or current measurement at any given phase.

3 Operating and Display Elements

3.1 General

The control panel at the top of the instrument includes a function selector switch with 15 detent positions and 5 pushbuttons. These are used to select the desired measurement types, functions and parameters. All of the measurement values, measured quantities and other information required for the performance of measurements and settings are displayed at the integrated LCD.

3.2 Function Selector Switch

Measured quantities and functions are selected with the function selector switch.

Switch positions with preprogrammed measured quantities are available for measurements within individual phases (L1, L2, L3) and within the overall system (wye or delta), as well as for energy and periodic power analysis (E, P).

Up to 20 measured quantities, as well as the respective measurement types, can be selected for display in the four selector switch positions SEL1 through SEL4. This user-specific measured quantity summary is set up in each of the respective selector switch positions and remains intact, even after the instrument has been switched off. In addition to free selection of measured quantities, additional functions including an alarm function and storage to a PC card are available in selector switch position SEL4.

General instrument parameters, tariff *zones*, *limit* values for the alarm function and *printer* top lines/bottom lines are selected in the MENU position.

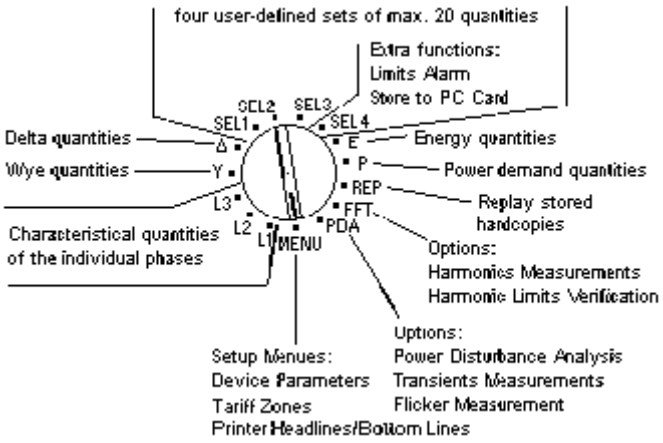
Read-out of up to 15 stored display images is accomplished in the REP position (replay hardcopy).

The optional instrument functions, harmonic analysis and power disturbance analysis, are made available with the FFT and PDA selector switch positions.

The TCM and FSA options do not have their own selector switch position, since these functions only change or expand the characteristics of the basic measuring functions and power disturbance analysis.

Measuring and instrument parameter settings remain intact, even after the instrument has been switched off.

Measured quantities and measuring sequences are displayed in different formats at the LCD, and make use of several pages if necessary.



Position	Function	Measured Quantities
MENU	Configuration of instrument parameters	General setup parameters, tariff zones, limit values for alarm function, printer top lines/bottom lines
L1	Primary measured quantities for phase L1 (instantaneous r.m.s. values)	U1, I1, P1, PF1, cap./ind.
L2	Primary measured quantities for phase L2 (instantaneous r.m.s. values)	U2, I2, P2, PF2, cap./ind.
L3	Primary measured quantities for phase L3 (instantaneous r.m.s. values)	U3, I3, P3, PF3, cap./ind.
Y	Measured quantities with reference to the neutral point (instantaneous r.m.s. values)	UΣ, IΣ, PΣ, PFΣ, SΣ, Rot. (phase sequence)
Δ	Phase-to-phase quantities (instantaneous r.m.s. values), system crest factors, frequency	U12, U23, U31, cuΣ, ciΣ, f
SEL1	Selection 1 from the list of measured quantities and measurement types	max. 20 measured quantities
SEL2	Selection 2 from the list of measured quantities and measurement types	max. 20 measured quantities
SEL3	Selection 3 from the list of measured quantities and measurement types	max. 20 measured quantities
SEL4	Selection 4 from the list of measured quantities and measurement types	max. 20 measured quantities, alarm function, store to PC-Card
E	Total energy accumulated as of a defined point in time	Analog inp.: WP1, WP2, WP3, WΣ Counter inp.: W4, W5, W6
P	Periodic power during current period 0	Analog inp.: 0P1, 0P2, 0P3, 0PΣ Counter inp.: 0P4, 0P5, 0P6
REP	Read-out of stored display images (replay hardcopy). Up to 15 display images can be stored in accordance with the FIFO principle (first in first out).	
FFT	Harmonic analysis for voltage and current by means of the FFT process (Fast Fourier Transformation)	Option MAVO-FFT
PDA	• Power disturbance analysis with definable trigger conditions (r.m.s. values) • Transient measurements with definable trigger conditions (sampled values) • Flicker measurements according to EN 61000-4-15	Option MAVO-PDA Option MAVO-TCM Option MAVO-FSA

3.3 Key Functions

The four keys at the front panel, **M**, ▲, ▼ and ↵, are used for the selection and configuration of displays, operating modes, parameters and functions. Configuration is performed by briefly pressing one of the four keys in the prescribed order. Simultaneous activation of more than one key has no effect on key functions.

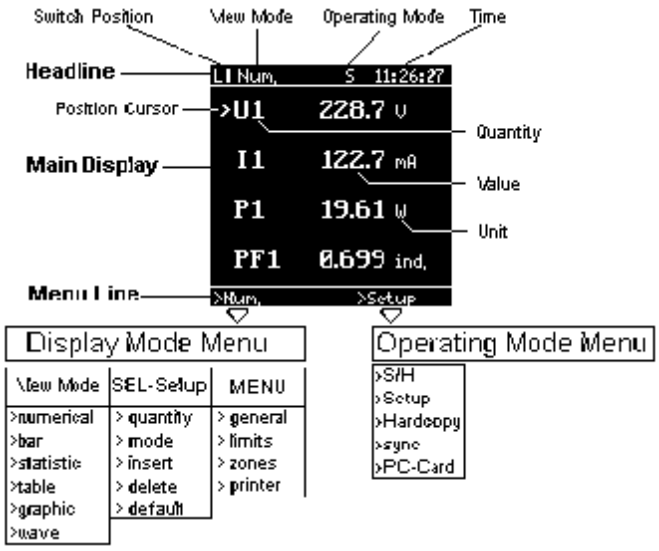
The fifth key, **i**, is used to query a directory which contains information concerning the current selector switch position.

Key	Designation	Function
M	Menu Key	• From within the main display: Move cursor ▮ from main display to the display mode menu in the menu line (left) • From within the menu line: Move cursor ▮ back and forth between display mode menu (left) and operating mode menu (right).
▲▼	Scroll up/down	• In the "*numeric*" display format: Selection of the first of a series of consecutive measured quantities, which are to be displayed in the other display formats • In the "*table*" display format: (also for read-out from the PC-Card): Browse through measurement sequences, select the time range – press key briefly = go to next line – press and hold key = go to next page • Menu line, left (display mode menu): Select a display format (*numeric*, *table*, *graphic* etc.) • Menu line, right (operating mode menu): Select an operating mode (*S/H*, *setup*, *hardcopy*, *sync*, *PC-Card*) • In the operating mode menu *setup*: Select the operating parameter to be configured Selection of possible configuration alternatives for the individual operating parameters, or increasing / decreasing the selected value, as well as decimal point shifting for numeric parameters • Online Help Function **i**: Browse through the display pages
↵	Enter	• Acknowledgement of a selection (display format, operating parameter etc.) • Acknowledge and save new settings
i	Help	• Enter or exit the help menus Operating and connection instructions are displayed for the currently selected measuring function.

3.4 LCD

The display unit consists of a dot matrix LCD with adjustable contrast (in the *general* MENU). It is functionally subdivided into three fields:

- Measurement values and measuring sequences are displayed at the LCD's main display, and are refreshed at a selectable interval (*cycle time*). Either the alphanumeric or the graphic display format can be selected.
- Selector switch position (*L1*, *L2*, ...), display format (*numeric*, *wave*, ...) and the current operating mode (see table below) are displayed in the headline.
- The footer (menu line) is used to select the display format and operating mode. The operating mode *setup* menu is also entered from the menu line.



Meanings of Operating Mode Displays

Display	Designation	Meaning	See Chapter
S	Sample	The instrument measures and updates displayed measurement values at the interval selected for *cycle time.*	5.3.1
H	Hold	The measuring operation has been temporarily interrupted.	5.3.2
M	Memory	Data are being stored to the PC card. The current selector switch position cannot be exited until after storage to the PC card has been deactivated in the *PC-Card* menu.	5.7.5
E	Enabled	Measurement value storage has been initialized, although it is not active because, for example, the selected starting time has not yet been reached. For PDA and TCM function with *single mode display*: Triggering is enable but has not yet occurred.	5.7.4 MAVO-PDA MAVO-TCM operating instructions
R	Read	Indicates read-in of measuring sequences stored to the PC card.	5.7.6
W	Wait	Waiting for the synchronization pulse	5.6.2
T	Triggered	Only for PDA / TCM function: Triggering has occurred, an event has occurred.	MAVO-PDA MAVO-TCM

3.5 Menu-Driven Operation

The following optical displays and acoustic signals guide the user during operation of the instrument:

- A cursor ▮ marks the active data entry field in the LCD. After the instrument has been switched on, the cursor blinks at the first entry field within the main display. No cursor appears within displays which do not allow for the selection of settings from the main menu.

  If the M key is activated, the active field, as well as the cursor, is moved to the menu line. Submenus can be activated from the menu line, within which the desired instrument configurations can be selected.
- An arrow **>** in the main display marks:
  - The first (uppermost) measured quantity to be displayed in display formats other than the numeric format, in which not all of the current measured quantities can be displayed simultaneously
  - The operating parameter which has been selected for configuration in the configuration menus (*setup*, *PC-Card* etc.)
- An acoustic signal: Each key operation is acknowledged with a brief acoustic signal. If a given operation is rejected (e.g. selected option not installed), a long acoustic signal ensues.
- The help menu: The help menu can be activated with the **i** key from any window. Operating instructions are then displayed for the currently selected function. The help menu is exited by pressing the **i** key a second time, or by changing the selector switch position.

3.6 SECUTEST PSI Printer Module (Option)

The PSI printer module which can optionally be installed to the lid of the MAVOWATT 45 is used in a variety of instruments from our product spectrum. If necessary, it can be removed by loosening the knurled screws and disconnecting the plug, and can be installed to the SECUTEST 0701/0702S, SECUTEST 0751/601S or PROFITEST 204 test instrument.

Only the printer function from the PSI module is taken advantage of in combination with the MAVOWATT 45. The following print-outs can be generated:

- Manually Activated Print-Out
  The current display image together with two top lines and two bottom lines can be printed by pressing and holding the PRINT key at the PSI module for approx. 1 second. → chapter 5.5.1
- Time Controlled Print Out (interval printing)
  If *printer on* is selected in one of the setup menus, the respective measurement values are printed out periodically at the end of the selected *interval*. → chapter 5.5.2
- Measurement Value Controlled Print-Out (alarm printing)
  Measurement values for up to four selectable measured quantities are printed out in tabular form when adjustable upper and lower limit values are violated. → chapter 5.5.3

Key Functions

Key	Designation	Function
PRINT	Print	Starts manually activated print-out
FF	Fast Forward	Rapid paper advance takes place for as long as the FF key is depressed
A ... Z, 0 ... 9, <Space> ⇑	Letters, Numbers	Only active in MENU > printer > top line 1/2, bottom line 1/2: Alphanumeric key pad for entry of text for two top lines and two bottom lines; hold the ⇑ key depressed for entry of upper-case letters
←	Backspace	During text entry mode: Deletes character left of cursor position
STORE		No function with MAVOWATT 45
ENTER	Enter	Accept entered text

Other functions described in the operating instructions for the SECUTEST PSI are not relevant for operation with the MAVOWATT 45.

The 9-pin socket at the PSI module is also inactive.

Due to the fact that power is supplied to the printer via the RS232 port at the MAVOWATT, and since no data are stored to the PSI module, the batteries need not be installed.

For maintenance instructions and information concerning consumable materials (recording charts and ink ribbon cartridges) → chapter 10.

4 Configuring the Operating Parameters

4.1 Menu Structure

The operating parameters setup menu encompasses several pages. Functionally related parameters are listed together in a single page. The subdivision of the setup menu into several selector switch positions allows for unambiguous allocation of the current selector switch position to the corresponding parameters.

The settings are entered to a parameters list and are valid for all applicable selector switch positions.
Exception: *printer on/off* settings in the *limits* menu (alarm printing) and in the *setup* menus are dependent upon one another.

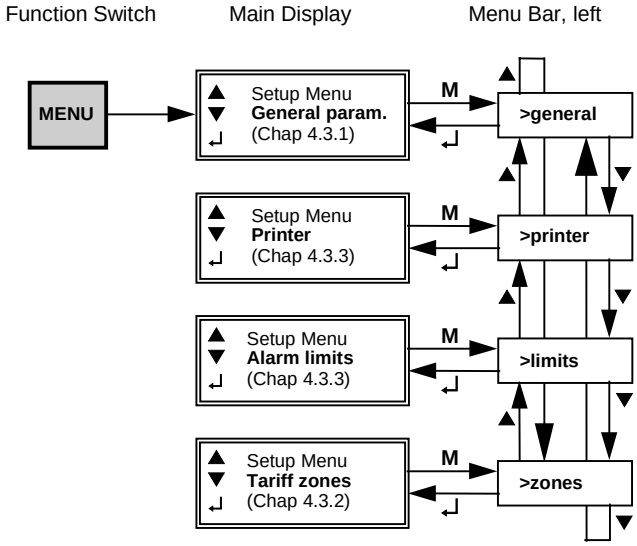
No parameter settings can be made in the wye and delta connection selector switch positions.

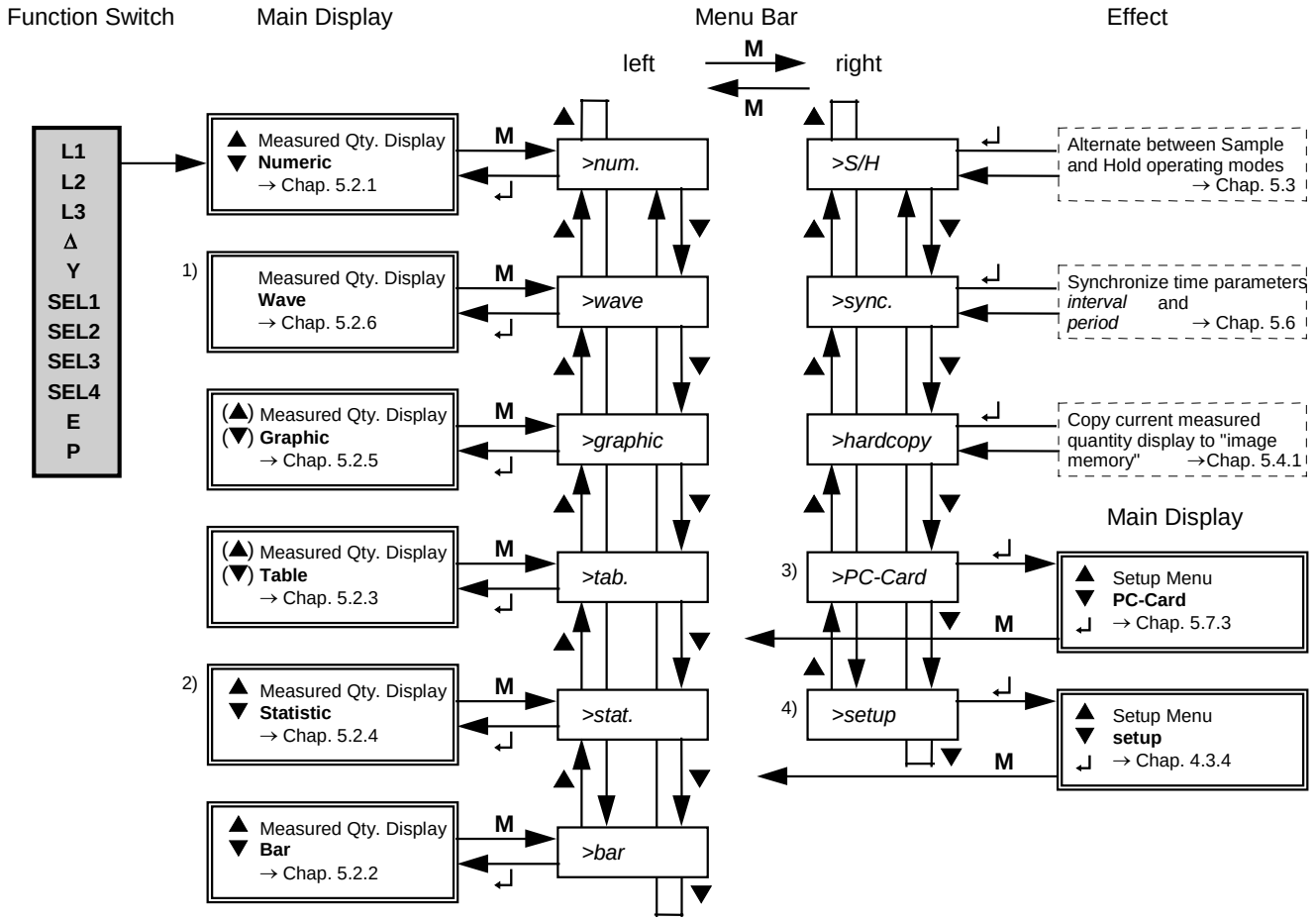
A separate *setup* menu page is assigned to each of the selector switch positions L1, L2, L3, E and P.

The MENU selector switch position has four mutually independent menu pages: *general, limits,* tariff *zones* and *printer*.

A setup menu which has been distributed over several pages is provided for the definition of quantities to be measured, as well as the appropriate measuring type, for selector switch positions SEL1, SEL2, SEL3 and SEL4.

A single-page parameters menu is also provided for selector switch position SEL4 (as well as FFT and PDA if enabled) for the operation of the PC-Card.





[1] Wave display only available for directly measured quantities U1, U2, U3, I1, I2 and I3.

[2] Statistical display not available for selector switch position E (not sensible for energy quantities).

[3] PC card setup menu only available for selector switch positions SEL4, PDA and FFT if memory card is installed.

[2] *Setup* menu not available for selector switch positions Y and Δ.

4.2 Operating Parameters Configuration Procedure

This section describes the basic procedure for the configuration of operating parameters in the setup menus *setup* (positions L1, L2, L3, P, E, FFT, PDA) and *PC-Card* (positions SEL4, FFT, PDA), as well as *general*, *printer*, *zones* and *limits* (MENU position).

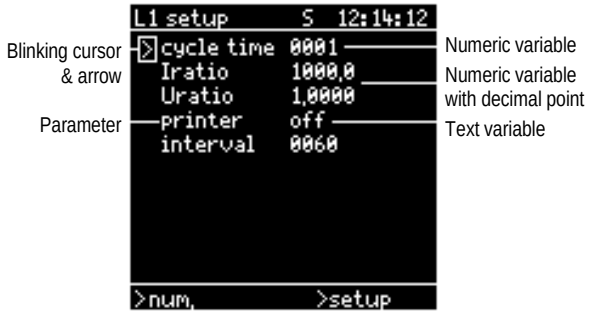
4.2.1 Entering the Setup Menu

Select the switch position which includes the page with the desired setup menu.

2x**M** Press the M key twice.
⇒ The cursor moves to the Operating Mode menu (right-hand field of the menu line).

▼▲ Select the *setup* operating mode with the scroll keys.

↵ Acknowledge your selection with Enter.
The *setup* menu appears at the display:
⇒ The current selector switch position and the name of the current submenu is displayed at the left-hand side of the headline.
⇒ The adjustable operating parameters are displayed along with their current settings in the main display.
⇒ The cursor blinks at the arrow **>** in the first (uppermost) field.



4.2.2 Adjusting Parameters with Text Variables

▼▲ Move the arrow **>** to the desired parameter with the scroll keys.

↵ Acknowledge the menu item (parameter) with Enter.
⇒ The cursor blinks at the first field of the text variable.

▼▲ The various alternative settings can be selected by repeatedly activating the scroll keys.

↵ Acknowledge the desired setting with Enter or press the M key if no change is to be made to the previous setting.
⇒ The cursor jumps back to its previous position (to the left of the selected parameter).

4.2.3 Adjusting Parameters with Numeric Variables

▼▲ Move the arrow **>** to the desired parameter with the scroll keys.

↵ Acknowledge the menu item (parameter) with Enter.
⇒ The cursor blinks at the first field of the numeric variable (digit or plus or minus sign).

▼▲ The selected values can be increased or decreased, and the sign can be changed from plus to minus and vice versa by repeatedly activating the scroll keys.

↵ Acknowledge the desired setting with Enter.
⇒ The cursor moves to the next decimal place.

▼▲ ↵ Settings are selected for each decimal place in the same way.

If a decimal point is allowed at any given location, the cursor blinks at the current decimal point position after the last digit has been selected.

▼▲ Move the decimal point to the desired position with the scroll keys.

↵ Acknowledge the desired setting with Enter or press the M key if no change is to be made to the previous setting.
⇒ The cursor moves to the left-hand field of the menu line.

4.2.4 Return to the Measurement Value Display Mode

M Press the M key if no change is to be made to the previous setting.
⇒ The cursor moves to the left-hand field of the menu line

▼▲ Select the desired display format.

↵ Acknowledge your selection with Enter.
⇒ The instrument returns to measurement value display with the selected display format.

4.3 Operating Parameters Description

4.3.1 Operating Parameters in General MENU

Selecting the *general* setup menu:

MENU

Parameter	Description	Settings Range	U/M Format	Notes
contrast	Adjust LCD contrast to ambient light conditions and viewing angle	00 … 99		If the instrument is switched on with the selector switch in the MENU position, contrast can be directly adjusted with the scroll keys.
language	Select language for operating menus	German / English		Does not apply to help texts in info menu **i** → chapter 2.2.1
time	Set time for integrated real-time clock	00:00:00 … 23:59:59	hh:mm:ss 24 hr. mode	The point in time at which the setup menu was opened is displayed here.
date	Set date for integrated real-time clock	01.01.1980… 01.01.2100	DD.MM.YY YY	
mains type	Define mains type for measurements in 3-phase systems 2/4-Wire For measurements – in DC and single phase AC systems – in 3-phase AC systems with neutral conductor – with artificial neutral point in 3-phase AC systems with unbalanced load and no neutral conductor 3-Wire For measurements – in 3-phase AC systems without neutral conductor and without greatly unbalanced load	2/4-Wire / 3-Wire		No measurement occurs at current measurement input L2 if 3-wire system has been selected. The measurement value displayed for L2, as well as the measured quantities derived therefrom, are calculated based upon the two-wattmeter method from the other measured values. → chapter 7.2.1 … 7.2.3
Optional: TCM Flicker	Measurements with options PDA, TCM and FSA are performed in switch position PDA. If several of these options are installed, the function to be used is selected here	on / off		Simultanuous measurements in two or all optional functions are not possible.

4.3.2 Operating Parameters in the Tariff Zones MENU

In the SEL1 through SEL4 switch positions, energy quantities can be displayed, based upon which energy consumption in various tariff zones can be determined (e.g. WPT1 = cumulative active energy in tariff zone 1). If measured quantities of this type have been selected for display, the corresponding tariff zone periods must be defined within the tariff *zones* MENU.

Opening the tariff *zones* setup menu:

MENU → **M** → ▼▲ *zones* → ↵

2 Tariff Zones

3 Tariff Zones

3 Tariff Zones

Two time periods can be selected for three tariff zones for a period of one day (24 hours). For example, consumption for two tariff zone periods (i.e. two starting times per day for a single tariff zone) can be recorded for the usual tariff types (on-peak tariff I, on-peak tariff II and off-peak tariff).

Two tariff zones are common for many applications (day and night time tariffs). In this case, the starting times for identical tariffs must be set to the same time. The starting times for the third tariff must be identical to the time of the first or second tariff. The third tariff is thus void.

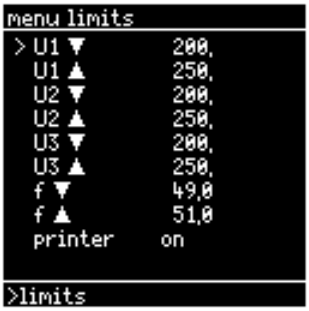
Tariffs established by the power utilities include a wide variety of tariff types with different tariff zones. Tariffs for special clients (i.e. large customers) further broaden the range of tariff types. The basic characteristics of energy consumption can be recorded at daily intervals with the MAVOWATT 45, and times of day can be assigned as well. Tariff types which are valid for periods of longer than one day are no longer differentiated (e.g. weekend and holiday tariffs, summer and winter tariffs etc.).

4.3.3 Operating Parameters in the Limits MENU

Limit values for the limit monitoring function (→ chapter 5.5.3) can be selected in this setup menu, and the alarm printing function can be activated or deactivated. The limit values apply to the measured quantities which are defined in the first four fields for the SEL4 selector switch position. The designations for these measured quantities are displayed automatically.

Opening the *limits MENU*:

MENU → **M** → ▼▲ *limits* → ↵



The following settings must be made for each displayed quantity with a three place decimal number:
– Lower limit value (identified with ▼)
– Upper limit value (identified with ▲)

Numeric values may include a minus sign (the plus sign is not displayed) and a designation of magnitude (*µ, m, k, M* etc.).

The value *0.00* can also be used as a valid parameter setting.

The *printer on* / *off* parameter allows for activation or deactivation of interrupt-driven measurement value print-outs. This parameter selection is independent of the parameter selection *printer on / of* in the *setup* menus for interval controlled measurement value print-out.

Notes

- No plausibility check is undertaken for selected limit values. For example, the upper limit value for power factor in L1 can be set to PF1▲ = 10, although this value could never be attained. It may nevertheless be sensible if only the lower limit value needs to be monitored.
- Negative limit values (with a minus sign) are necessary for, amongst other quantities, power factor and active power (overcompensation or energy recovery). However, they cannot be used for polarity monitoring for direct voltage because the displayed effective value for a direct voltage of random polarity is always positive.

4.3.4 Operating Parameters in the Setup Menu (L1, L2, L3, E, P)

Opening the *setup* menu:

L1/L2/L3/E/P → **M** 2x → ▼▲ *setup* → ↵

Setup menu for Selector Switch Positions L1, L2 and L3

Setup menu for Selector Switch Positions E and P

Interval and Period Parameters

Measurements for chargeable demand, which must be performed by the electric utilities specifically for billing purposes, are fundamentally different than measurements used for systems measurement technology. For this reason, a second measurement interval (observation period) has been made available for power and energy quantities. The two measurement intervals, *interval* and *period*, allow for simultaneous measurement with different measurement types. For example, the greatest instantaneous power during the interval, as well as periodic power for a given period, can be measured simultaneously.

Cumulative energy for an entire *period* is stored to memory as periodic power, and is reset at the end of the period. The load curve results from continuous measurement. The (three) highest periodic power values are used by the electric utilities as a basis for the determination of billed power (chargeable demand).

At the same time, the highest instantaneous power value can be registered for the *interval*. This value provides information concerning the highest, short-term system load and thus the required system capacity.

Note

If measured quantities relative to both interval and period are to be displayed and recorded (only possible in selector switch positions SEL1 through SEL4), the following must be observed:

- The selected value for the parameter *period* must be a whole-number multiple of the selected value for the parameter *Interval* (e.g. interval = 60 s and period = 900 s)
- The starting times for the interval and the period must be synchronized (→ chapter 5.6)

See the following table for additional parameter description.

Table of Setup Parameters for L1 / L2 / L3 / E / P

Parameter	Description	Setting Range	U/M	Comment
cycle time	Time interval for refreshing the values for the basic measured quantities Each time cycle time has expired, a new measuring cycle is started: ⇒ Sampling of all analog measurement inputs at 50 kHz ⇒ Integration of the respective sampled values over a duration of 20 periods with reference to the voltage measuring signal U_{L1} ⇒ Calculation of all required measurement values ⇒ Updating of the display	0001 … 3600	s (seconds)	Is set to 1 s as a rule (= highest measurement value refresh rate). A setting where ***cycle time*** > ***interval*** is not sensible. Does not apply to FFT and PDA.
Iratio (L1) Iratio (L2) Iratio (L3)	Evaluation factors for the analog current measurement inputs = current-voltage transformation ratio of the interconnected I-U converter (clip-on current transformer, burdened current transformer, shunt). Iratio must be individually set for each measurement input in the corresponding selector switch position L1, L2, L3.	.10000… 99999	A/V	Setting is valid for all measuring functions incl. options. See chapter. 7.2 for configuration examples.
Uratio (L1) Uratio (L2) Uratio (L3)	Evaluation factors for the analog voltage measurement inputs = voltage transformation ratio of the interconnected voltage transformer for measurements in medium-voltage systems. Iratio must be individually set for each measurement input in the corresponding selector switch position L1, L2, L3.	.10000… 99999	V/V	Setting is valid for all measuring functions incl. options. See chapter. 7.2 for configuration examples.
printer	Activation / deactivation of time controlled measurement value print-out (interval printing) If the printer function is activated, the measurement values defined for the current selector switch position are printed out periodically at the end of the selected interval. Basic Functions: Print-out in tabular form Optional Functions: Print-out in the currently selected display format	off / on		Setting is valid for all measuring functions, but is independent of the setting ***printer on / off*** in the ***limits*** MENU (alarm printing) → chapters 5.5.2 and 5.5.3
interval	• Observation Period – For the acquisition of min. and max. RMS values and the calculation of average values for measured quantities in selector switch positions SEL1 through SEL4 with correspondingly selected measurement type – For the analysis of statistical display formats • Interval – For saving data to the PC-Card and periodic measurement value print-out. The measurement values which are available at the end of each interval are stored to memory or printed. – For entering the current measurement value for a given measured quantity to the-FIFO register, and thus to measurement value table (for display format: Tab.) or to the Y-t graph (for display format: Graphic)	0002 … 1800	s (seconds)	Setting is valid for all measuring functions incl. options. If ***printer on*** has been selected, set the ***interval*** to greater than 30 s due to time required for printing. Important! When saving data to the PC-Card under SEL4 the interval must be set greater than 1s; otherwise the saved time information might be wrong.
period	Observation Period (integration time) for the determination of the measured quantities periodic power and energy, which are significant for the electrical utilities. Selected duration is valid for all measured quantities in selector switch positions P, and SEL1 through SEL4 for energy and power quantities for which meas. types ***Period 0*** or ***Period 1*** have been selected.	0060 … 3600	s (seconds)	→ chapter 5.6
cconst-4 cconst-5 cconst-6	Counter Constants (weighting factors) for digital counter inputs 4, 5, 6 The factor selected for a counter input is valid for all applicable measured quantities (for E and P, as well as SEL1 through SEL4)	.10000… 99999	Pulses per kWh	→ chapter 7.3 → Glossary
sync.	Defines the source of the start pulse for the (first) period for the previously named periodic measured quantities: Time: (= based on internal time) manual synchronization: period and interval are started simultaneously if ***sync***. is acknowledged in the operating mode menu in the menu line. Extern: Synchronization with external clock (utilities sync pulse): After ***sync. extern*** has been selected, the instrument waits for the first pulse at the SYNC input before starting with the recording of a measurement series, or simultaneous starting of period and interval (*W* appears in the headline).	time / extern		Synchronization of period and interval is required if interval and period related measured quantities are to be displayed or recorded simultaneously. Furthermore, ***period*** should be set to a whole number multiple of ***interval***. → chapter. 5.6
PFnom	Predetermined power factor (cos φ) for the calculation of compensating reactive power (quantities DQ1, DQ2, DQ3, DQΣ for SEL1 ... SEL4)	.200… 1.00	W/VA (cos φ)	
reset	By acknowledging ***reset yes***, cumulative, non-volatile measurement values (meter readings) for all energy quantities (except for periodic energy quantities 0W.. and 1W..) are reset to 0.000.	no / yes		→ chapter 4.4.2, footnote 2)

4.4 Assigning Measured Quantities to SEL1 ... SEL4

4.4.1 Selection Procedure

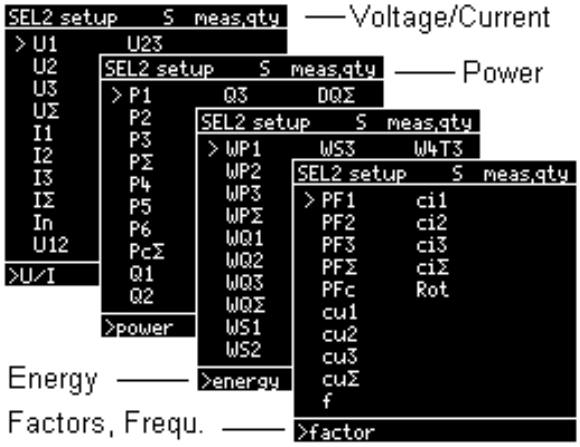
Up to 20 measured quantities can be assigned to each of the selector switch positions SEL1 through SEL4 in any desired order and can, for example, be numerically displayed in two display pages with ten items each. Four steps are involved in the selection of each measured quantity:

- Current measured quantity selections are displayed after entering *setup* (1st display mode menu, position). The arrow **>** is used to select a position, for which a change is to be made.

- If the marked position is acknowledged with the **M** key, the blinking cursor is moved to the menu line with which the type of change to be made to the marked position is selected (2nd display mode menu). The following selections are possible:

– *meas. qty*, for the selection of a different measured quantity
– *measurement type*, for the assignment of a different measurement type to the measured quantity
– *insert*, for the insertion of an additional measured quantity above the marked position (always U1)
– *delete*, for deletion of the marked position
– *default*, for the deletion of all measured quantities except for one (always U1)

If *meas. qty* is acknowledged, the Index of Measured Quantities appears at the main display (3rd display mode menu). This menu consists of four pages with a list of all available measured quantities by type (*U/I*, *power*, *energy*, *factor*).



The page which contains the desired measured quantity is selected in the menu line. The page is selected and acknowledged with the cursor. The display then returns to the position menu and the changed measured quantity is marked with the cursor.

- Finally, the *measurement type* is selected (*effective* RMS value, *maximum* value etc.) for the selected position.

The Measurement Type menu (4th display mode menu) is accessed via the menu line.

The instrument is returned to the measuring mode from the position menu. The new measured quantity configuration is activated when setup is exited via the *end* field at the right-hand side of the menu line.

The measuring function is placed on hold during and after setup has been exited. The measuring function must be activated by acknowledging with *S/H* in the right-hand field of the menu line.

Setup Notes

- If a completely new measured quantities list is to be generated, or if several positions need to be changed, it is recommended that you clear the list completely (*default*) in order to assure clarity, and the desired number of measured quantities are entered as a first step. A measured quantity and a measurement type can then be assigned to each position (see 4.4.4 for example).
- If an attempt is made to assign a non-allowable measurement type to a measured quantity or vice versa, the entry is rejected and the corresponding position is reset to U1.
- The following should be observed when measured quantities are selected for long-term recording to a PC card: It is usually more advantageous to record maximum and minimum values for a given measured quantity at relatively large intervals, instead of recording instantaneous RMS values at short intervals. This reduces the amount of recorded data and lengthens maximum recording time, although only a minimal amount of data is lost: The measurement value fluctuation range for the measured quantity which occurs during the interval is still apparent. High time resolution is only required for the determination of the point in time at which the recorded extreme values occurred.

4.4.2 Index of Available Measured Quantities

Formula Char.	Quantity	Applied Calculation Formula	U/M	Designation	Assignable Meas. Type				
U1	L1 phase to neutral voltage: voltage at L1, RMS value measured over 20 signal periods	$U1 = \sqrt{\frac{1}{20T_{U1}} \int_0^{20T} u_1^2 dt} = \sqrt{\frac{1}{N} \sum_{k=0}^{N-1} u_1^2(t_k)}$	V	Volt	▲	▼	■		
U2	L2 phase to neutral voltage: voltage at L2, RMS value measured over 20 signal periods for U1	$U2 = \sqrt{\frac{1}{20T_{U1}} \int_0^{20T} u_2^2 dt} = \sqrt{\frac{1}{N} \sum_{k=0}^{N-1} u_2^2(t_k)}$	V	Volt	▲	▼	■		
U3	L3 phase to neutral voltage: voltage at L3, RMS value measured over 20 signal periods for U1	$U3 = \sqrt{\frac{1}{20T_{U1}} \int_0^{20T} u_3^2 dt} = \sqrt{\frac{1}{N} \sum_{k=0}^{N-1} u_3^2(t_k)}$	V	Volt	▲	▼	■		
UΣ	Equivalent 3-phase wye voltage: calculated RMS value	$U\Sigma = (U1 + U2 + U3) / 3$	V	Volt	▲	▼	■		
I1	L1 phase current: current at L1, RMS value measured over 20 signal periods for U1	$I1 = \sqrt{\frac{1}{20T_{U1}} \int_0^{20T} i_1^2 dt} = \sqrt{\frac{1}{N} \sum_{k=0}^{N-1} i_1^2(t_k)}$	A	Ampere	▲	▼	■		
I2	L2 phase current: current at L2, *For 4-wire connection:* RMS value measured over 20 signal periods for U1 *For 3-wire connection:* RMS value calculated based upon the two-wattmeter principle	$I2_{4L} = \sqrt{\frac{1}{20T_{U1}} \int_0^{20T} i_2^2 dt} = \sqrt{\frac{1}{N} \sum_{k=0}^{N-1} i_2^2(t_k)}$ $I2_{3L} = \sqrt{I1^2 + I3^2 - I1 \cdot I3 \cdot \cos(\varphi_{I1} - \varphi_{I3})}$	A	Ampere	▲	▼	■		
I3	L3 phase current: current at L3 RMS value measured over 20 signal periods for U1	$I3 = \sqrt{\frac{1}{20T_{U1}} \int_0^{20T} i_3^2 dt} = \sqrt{\frac{1}{N} \sum_{k=0}^{N-1} i_3^2(t_k)}$	A	Ampere	▲	▼	■		
IΣ	3-phase total current: calculated RMS value	$I\Sigma = I1 + I2 + I3$	A	Ampere	▲	▼	■		
In	Neutral conductor current: current at the neutral conductor calculated RMS value	$In = \sqrt{\left(I1 + I2 \cdot \cos(\varphi_{I1} - \varphi_{I2}) + I3 \cdot \cos(\varphi_{I1} - \varphi_{I3})\right)^2 + \left(I2 \cdot \sin(\varphi_{I1} - \varphi_{I2}) + I3 \cdot \sin(\varphi_{I1} - \varphi_{I3})\right)^2}$	A	Ampere	▲	▼	■		
U12	L1-2 delta voltage: voltage between phase conductors L1 and L2, calculated RMS value	$U12 = \sqrt{U1^2 + U2^2 - 2 \cdot U1 \cdot U2 \cdot \cos(\varphi_{U1} - \varphi_{U2})}$	V	Volt	▲	▼	■		
U23	L2-3 delta voltage: voltage between phase conductors L2 and L3, calculated RMS value	$U23 = \sqrt{U2^2 + U3^2 - 2 \cdot U2 \cdot U3 \cdot \cos(\varphi_{U2} - \varphi_{U3})}$	V	Volt	▲	▼	■		
U31	L3-1 delta voltage: voltage between phase conductors L3 and L1, calculated RMS value	$U31 = \sqrt{U1^2 + U3^2 - 2 \cdot U1 \cdot U3 \cdot \cos(\varphi_{U3} - \varphi_{U1})}$	V	Volt	▲	▼	■		
P1	L1 active power	$P1 = \sqrt{\frac{1}{20T_{U1}} \int_0^{20T} u_1 \cdot i_1 dt}$	W	Watt	▲	▼	■	0	1
P2	L2- active power	$P2 = \sqrt{\frac{1}{20T_{U1}} \int_0^{20T} u_2 \cdot i_2 dt}$	W	Watt	▲	▼	■	0	1
P3	L3- active power	$P3 = \sqrt{\frac{1}{20T_{U1}} \int_0^{20T} u_3 \cdot i_3 dt}$	W	Watt	▲	▼	■	0	1
PΣ	3-phase total active power	$P\Sigma = P1 + P2 + P3$	W	Watt	▲	▼	■	0	1
P4	Active power at digital counter input 4 with interconnected impulsing meter for active energy	$P4 = \frac{\Sigma W4 \text{ since begin of period}}{\Sigma t \text{ since begin of period}}$	W	Watt	▲	▼	■	0	1
P5	Active power at digital counter input 5 with interconnected impulsing meter for active energy	$P5 = \frac{\Sigma W5 \text{ since begin of period}}{\Sigma t \text{ since begin of period}}$	W	Watt	▲	▼	■	0	1
P6	Active power at digital counter input 6 with interconnected impulsing meter for active energy	$P6 = \frac{\Sigma W6 \text{ since begin of period}}{\Sigma t \text{ since begin of period}}$	W	Watt	▲	▼	■	0	1
PcΣ	Total active power at digital counter inputs 4+5+6	$Pc\Sigma = P4 + P5 + P6$	W	Watt	▲	▼	■	0	1
Q1	L1 reactive power	$Q1 = \sqrt{S1^2 - P1^2}$	var	Var[1])	▲	▼	■	0	1
Q2	L2 reactive power	$Q2 = \sqrt{S2^2 - P2^2}$	var	Var[1])	▲	▼	■	0	1
Q3	L3 reactive power	$Q3 = \sqrt{S3^2 - P3^2}$	var	Var[1])	▲	▼	■	0	1
QΣ	3-phase total reactive power	$Q\Sigma = Q1 + Q2 + Q3$	var	Var[1])	▲	▼	■	0	1
Qc	Reactive power at digital counter input 4 with interconnected impulsing meter for reactive energy	$Qc = \frac{\Sigma W4 \text{ since begin of period}}{\Sigma t \text{ since begin of period}}$	var	Var[1])	▲	▼	■	0	1
S1	Apparent power at L1	$S1 = U1 \bullet I1$	VA	Volt-ampere	▲	▼	■	0	1
S2	Apparent power at L2	$S2 = U2 \bullet I2$	VA	Volt-ampere	▲	▼	■	0	1
S3	Apparent power at L3	$S3 = U3 \bullet I3$	VA	Volt-ampere	▲	▼	■	0	1
SΣ	3-phase total apparent power	$S\Sigma = S1 + S2 + S3$	VA	Volt-ampere	▲	▼	■	0	1

DQ1	Required compensating reactive power at L1 for the attainment of predefined power factor *PFnom*	$DQ1 = Q1 - \sqrt{\left(\frac{P1}{PF_{soll}}\right)^2 - P1^2}$	var	Var[1])	▲	▼	■	0	1
DQ2	Required compensating reactive power at L2 for the attainment of predefined power factor *PFnom*	$DQ2 = Q2 - \sqrt{\left(\frac{P2}{PF_{soll}}\right)^2 - P2^2}$	var	Var[1])	▲	▼	■	0	1
DQ3	Required compensating reactive power at L3 for the attainment of predefined power factor *PFnom*	$DQ3 = Q3 - \sqrt{\left(\frac{P3}{PF_{soll}}\right)^2 - P3^2}$	var	Var[1])	▲	▼	■	0	1
DQΣ	Required total compensating reactive power for the attainment of predefined power factor *PFnom*	$DQ\Sigma = Q\Sigma - \sqrt{\left(\frac{P\Sigma}{PF_{soll}}\right)^2 - P\Sigma^2}$	var	Var[1])	▲	▼	■	0	1
WP1	Active energy at L1 [2])	$WP1 = \int_{t0}^{t1} P1\ dt$	Wh	Watt-hours				0	1
WP2	Active energy at L2 [2])	$WP2 = \int_{t0}^{t1} P2\ dt$	Wh	Watt-hours				0	1
WP3	Active energy at L3 [2])	$WP3 = \int_{t0}^{t1} P3\ dt$	Wh	Watt-hours				0	1
WPΣ	Total active energy in 3-phase system [2])	$WP\Sigma = \int_{t0}^{t1} P\Sigma\ dt$	Wh	Watt-hours				0	1
WQ1	Reactive energy at L1 [2])	$WQ1 = \int_{t0}^{t1} Q1\ dt$	varh	Var-hours				0	1
WQ2	Reactive energy at L2 [2])	$WQ2 = \int_{t0}^{t1} Q2\ dt$	varh	Var-hours				0	1
WQ3	Reactive energy at L3 [2])	$WQ3 = \int_{t0}^{t1} Q3\ dt$	varh	Var-hours				0	1
WQΣ	Total reactive energy in 3-phase system [2])	$WQ\Sigma = \int_{t0}^{t1} Q\Sigma\ dt$	varh	Var-hours				0	1
WS1	Apparent energy at L1 [2])	$WS1 = \int_{t0}^{t1} S1\ dt$	VAh	Volt-ampere-hours				0	1
WS2	Apparent energy at L2 [2])	$WS2 = \int_{t0}^{t1} S2\ dt$	VAh	Volt-ampere-hours				0	1
WS3	Apparent energy at L3 [2])	$WS3 = \int_{t0}^{t1} S3\ dt$	VAh	Volt-ampere-hours				0	1
WSΣ	Total apparent energy in 3-phase system [2])	$WS\Sigma = \int_{t0}^{t1} S\Sigma\ dt$	VAh	Volt-ampere-hours				0	1
W4	Active, apparent or reactive energy at counter input 4 (depending upon type of interconnected impulsing meter) [2])	$W4[\mathrm{kVAh}] = \frac{\text{no. of pulses}[\mathrm{Imp}]}{\text{cconst4}[\mathrm{Imp/kVAh}]}$	VAh	Volt-ampere-hours				0	1
W5	Active, apparent or reactive energy at counter input 5 (depending upon type of interconnected impulsing meter) [2])	$W5[\mathrm{kVAh}] = \frac{\text{no. of pulses}[\mathrm{Imp}]}{\text{cconst5}[\mathrm{Imp/kVAh}]}$	VAh	Volt-ampere-hours				0	1
W6	Active, apparent or reactive energy at counter input 6 (depending upon type of interconnected impulsing meter) [2])	$W6[\mathrm{kVAh}] = \frac{\text{no. of pulses}[\mathrm{Imp}]}{\text{cconst6}[\mathrm{Imp/kVAh}]}$	VAh	Volt-ampere-hours				0	1
WPT1	Total active energy in 3-phase system, cumulative for tariff zone 1 [2])	$WPT1 = \int_{t0}^{t1} P\Sigma\ dt \mid t \in T1$	Wh	Watt-hours				0	1
WPT2	Total active energy in 3-phase system, cumulative for tariff zone 2 [2])	$WPT2 = \int_{t0}^{t1} P\Sigma\ dt \mid t \in T2$	Wh	Watt-hours				0	1
WPT3	Total active energy in 3-phase system, cumulative for tariff zone 3 [2])	$WPT3 = \int_{t0}^{t1} P\Sigma\ dt \mid t \in T3$	Wh	Watt-hours				0	1
W4T1	Active, apparent or reactive energy at counter input 4, cumulative for tariff zone 1 [2])	$W4T1 = \int_{t0}^{t1} P4\ dt \mid t \in T1$	VAh	Volt-ampere-hours				0	1

W4T2	Active, apparent or reactive energy at counter input 4, measured for tariff zone 2 [2])	$W4T2 = \int_{t0}^{t1} P4\ dt \quad \mid t \in T2$	VAh	Volt-ampere-hours				0	1
W4T3	Active, apparent or reactive energy at counter input 4, measured for tariff zone 3 [2])	$W4T3 = \int_{t0}^{t1} P4\ dt \quad \mid t \in T3$	VAh	Volt-ampere-hours				0	1
W5T1	Active, apparent or reactive energy at counter input 5 measured for tariff zone 1 [2])	$W5T1 = \int_{t0}^{t1} P5\ dt \quad \mid t \in T1$	VAh	Volt-ampere-hours				0	1
W5T2	Active, apparent or reactive energy at counter input 5 measured for tariff zone 2 [2])	$W5T2 = \int_{t0}^{t1} P5\ dt \quad \mid t \in T2$	VAh	Volt-ampere-hours				0	1
W5T3	Active, apparent or reactive energy at counter input 5 measured for tariff zone 3 [2])	$W5T3 = \int_{t0}^{t1} P5\ dt \quad \mid t \in T3$	VAh	Volt-ampere-hours				0	1
W6T1	Active, apparent or reactive energy at counter input 6 measured for tariff zone 1 [2])	$W6T1 = \int_{t0}^{t1} P6\ dt \quad \mid t \in T1$	VAh	Volt-ampere-hours				0	1
W6T2	Active, apparent or reactive energy at counter input 6 measured for tariff zone 2 [2])	$W6T2 = \int_{t0}^{t1} P6\ dt \quad \mid t \in T2$	VAh	Volt-ampere-hours				0	1
W6T3	Active, apparent or reactive energy at counter input 6 measured for tariff zone 3 [2])	$W6T3 = \int_{t0}^{t1} P6\ dt \quad \mid t \in T3$	VAh	Volt-ampere-hours				0	1
PF1	Power factor at L1 (= cosφ for sinusoidal signals)	$PF1 = \frac{P1}{S1}$	cap./ind.	–	▲	▼	■		
PF2	Power factor at L2 (= cosφ for sinusoidal signals)	$PF2 = \frac{P2}{S2}$	cap./ind.	–	▲	▼	■		
PF3	Power factor at L3 (= cosφ for sinusoidal signals)	$PF3 = \frac{P3}{S3}$	cap./ind.	–	▲	▼	■		
PFΣ	Power factor for the 3-phase system	$PF\Sigma = \frac{P\Sigma}{S\Sigma}$	cap./ind.	–	▲	▼	■		
PFc	Power factor for the counter inputs Condition: An impulsing meter for reactive energy must be connected to P4, and an impulsing meter for active energy must be connected to P5.	$PFc = \frac{P4}{\sqrt{P4^2 + P5^2}}$	cap./ind.	–	▲	▼	■		
cu1	Crest factor for voltage at L1 (= relationship between peak value and RMS value)	$cu1 = \frac{\lvert\hat{u}1\rvert}{U1}$	–	–	▲	▼	■		
cu2	Crest factor for voltage at L2 (= relationship between peak value and RMS value)	$cu2 = \frac{\lvert\hat{u}2\rvert}{U2}$	–	–	▲	▼	■		
cu3	Crest factor for voltage at L3 (= relationship between peak value and RMS value)	$cu3 = \frac{\lvert\hat{u}3\rvert}{U3}$	–	–	▲	▼	■		
cuΣ	Mean crest factor for all voltages in the 3-phase system (= arithmetic mean derived from cu1, cu2 and cu3)	$cu\Sigma = (cu1 + cu2 + cu3) / 3$	–	–	▲	▼	■		
f	Frequency of voltage at L1 (derived from time period for 40 zero crossings for the U1 signal)	$f = \frac{20}{20 \cdot T_{U1}}$	Hz	Hertz	▲	▼	■		
ci1	Crest factor for current at L1 (= relationship between peak value and RMS value)	$ci1 = \frac{\lvert\hat{i}1\rvert}{I1}$	–	–	▲	▼	■		
ci2	Crest factor for current at L2 (= relationship between peak value and RMS value)	$ci2 = \frac{\lvert\hat{i}2\rvert}{I2}$	–	–	▲	▼	■		
ci3	Crest factor for current at L3 (= relationship between peak value and RMS value)	$ci3 = \frac{\lvert\hat{i}3\rvert}{I3}$	–	–	▲	▼	■		
ciΣ	Mean crest factor for all current in the 3-phase system (= arithmetic mean derived from ci1, ci2 and ci3)	$ci\Sigma = (ci1 + ci2 + ci3) / 3$	–	–	▲	▼	■		
Rot	Phase sequence (rotation sense) for all voltages in the 3-phase system	$(\varphi_{U2} - \varphi_{U1}) > 0 \Rightarrow$ ">" $(\varphi_{U2} - \varphi_{U1}) < 0 \Rightarrow$ "<"	> <	+ sequence - sequence					

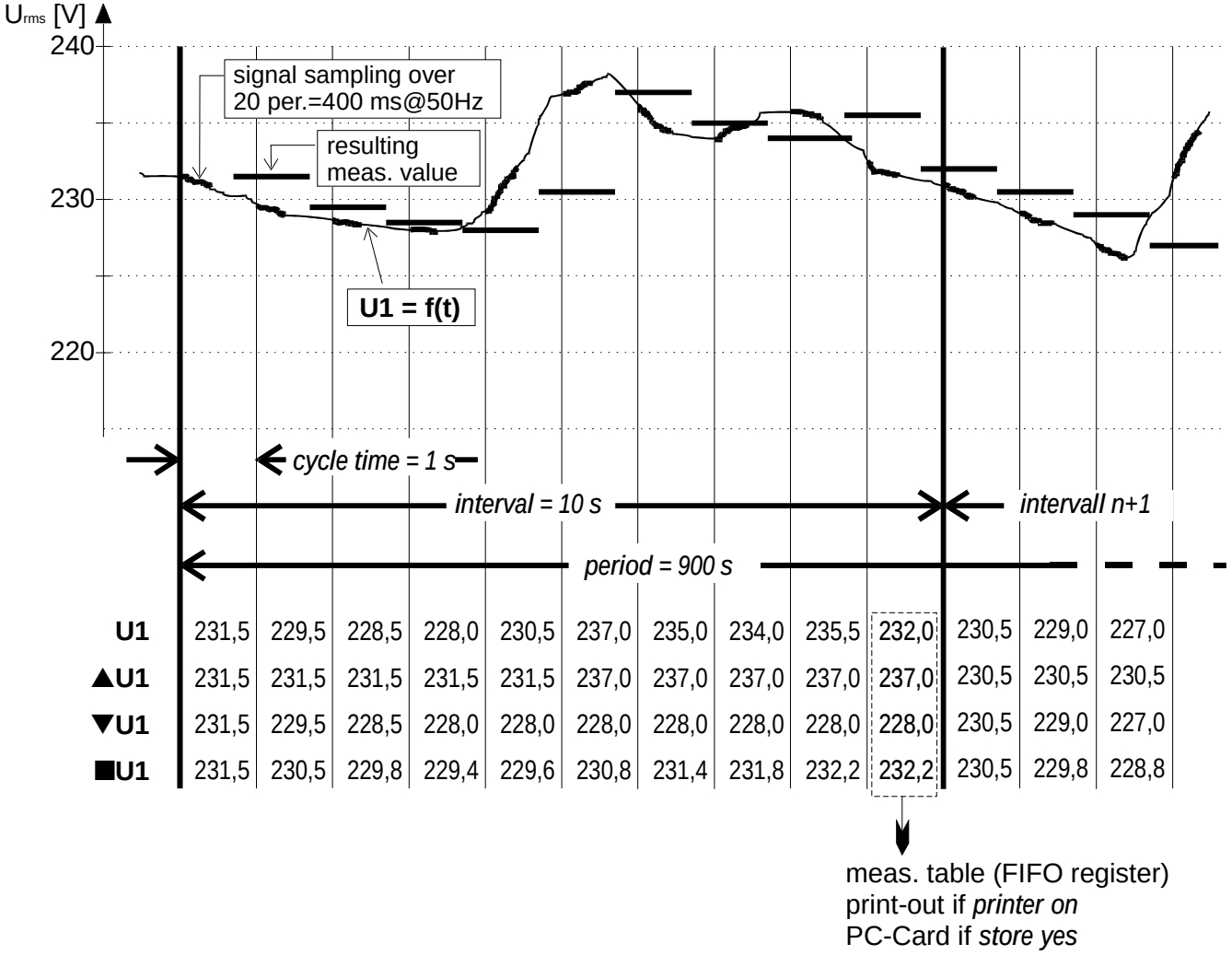
[1]) Var = artificial word for volt-ampere reactive
[2]) Energy (consumption), cumulative since last *reset* (in E/P setup),
for *Measurement Type 0/1*: cumulative for respective time period.

4.4.3 Index and Descriptions of Available Measurement Types

Symbol	Meas.Type	Description
none	effective	"Instantaneous" (RMS) value acquired once per cycle (as a rule cycle time is 1 s) *For measured quantities at the analog measurement inputs:* derived from sampled values at the respective inputs over a duration of 20 signal periods of U1 (for AC) or 0.5 s (for DC) *For measured quantities at the digital counter inputs:* derived from the number of incoming meter pulses
▲	maximum	Highest instantaneous measurement value which has occurred since the beginning of the interval. Is refreshed once per cycle and is stored FIFO register at the end of the interval, is printed if required (interval printing) and/or stored to the PC card and subsequently reset.
▼	minimum	Lowest instantaneous measurement values which has occurred since the beginning of the interval. Is refreshed once per cycle and is stored to FIFO register at the end of the interval, is printed if required (interval printing) and/or stored to the PC card and subsequently reset.
■	average	Arithmetic mean value derived from all measurement values which have occurred since the beginning of the interval. Is refreshed after each cycle (= time averaged mean value generation) and is stored to FIFO register at the end of the interval, is printed if required (interval printing) and/or stored to the PC-Card and subsequently reset.
0	period 0	= Current (active) measuring period Power trend is determined based upon energy consumed since the beginning of the period up to the point in time of the current measurement. Only applicable for power and energy quantities!
1	period 1	= Last completed measuring period, which immediately preceded the current period (Period 0). The measurement quantities at the end of the current period result in new values for quantities with Period1 measurement type. Only applicable for power and energy quantities!

Example of Measured Quantity with Various Measurement Types

Assumed Settings: cycle time: 1 s; interval: 10 s; period: 900 s



U1	231,5	229,5	228,5	228,0	230,5	237,0	235,0	234,0	235,5	232,0	230,5	229,0	227,0
▲U1	231,5	231,5	231,5	231,5	231,5	237,0	237,0	237,0	237,0	237,0	230,5	230,5	230,5
▼U1	231,5	229,5	228,5	228,0	228,0	228,0	228,0	228,0	228,0	228,0	230,5	229,0	227,0
■U1	231,5	230,5	229,8	229,4	229,6	230,8	231,4	231,8	232,2	232,2	230,5	229,8	228,8

meas. table (FIFO register)
print-out if *printer on*
PC-Card if *store yes*

4.4.4 Configuration Example for SEL Measured Quantity Selection

This configuration example is based upon the following application:

The following measured quantities are to be recorded over a lengthy period of time to a PC card for the analysis of power and energy for a user system with a 3-phase power supply:

1 minute mean value for apparent power at L1:	■S1
1 minute mean value for apparent power at L2:	■S2
1 minute mean value for apparent power at L3:	■S3
15 minute periodic active power at L1+L2+L3:	1PΣ
Peak value for total active power during 1 min. interval	▲PΣ
Total active energy consumption since beginning of recording	WPΣ

Enter measured quantity setup:

SEL4 → **M** 2x → ▼▲ *setup* → ↵

Reset previous measured quantity selection:

M → ▼▲ *default* → ↵

Define desired number of measured quantities (6):

M → ▼▲ *insert* → ↵ (2)
M → ↵ (3)
M → ↵ (4)
M → ↵ (5)
M → ↵ (6)

Assign measurement type to first (top) measured quantity:

▼▲ > *1st Position* → **M**
▼▲ *meas.qty.* → ↵
M → ▼▲ *power* → ↵
▼▲ *S1* → ↵
M → ▼▲ *meas. type* → ↵
▼▲ *average* → ↵

Assign measurement type to second measured quantity:

▼▲ > *2nd Position* → **M** → ▼▲ *meas.qty.* → ↵
M → ▼▲ *power* → ↵ → ▼▲ *S2* → ↵
M → ▼▲ *meas. type* → ↵ → ▼▲ *average* → ↵

Assign measurement type to third measured quantity:

▼▲ > *3rd Position* → **M** → ▼▲ *meas.qty.* → ↵
M → ▼▲ *power* → ↵ → ▼▲ *S3* → ↵
M → ▼▲ *meas. type* → ↵ → ▼▲ *average* → ↵

Assign measurement type to fourth measured quantity:

▼▲ > *4th Position* → **M** → ▼▲ *meas.qty.* → ↵
M → ▼▲ *power* → ↵ → ▼▲ *PΣ* → ↵
M → ▼▲ *meas. type* → ↵ → ▼▲ *period 1* → ↵

Assign measurement type to fifth measured quantity:

▼▲ > *5th Position* → **M** → ▼▲ *meas.qty.* → ↵
M → ▼▲ *power* → ↵ → ▼▲ *PΣ* → ↵
M → ▼▲ *meas. type* → ↵ → ▼▲ *maximum* → ↵

Assign measurement type to sixth measured quantity:

▼▲ > *6th Position* → **M**
▼▲ *meas. qty* → ↵
M → ▼▲ *energy*→ ↵
▼▲ *WPΣ* → ↵

Exit setup and save new measured value selections:

M 2 x → *end* ↵

5 Operation

For the purpose of the following description it is assumed that the MAVOWATT 45 is in the measuring mode (operating mode: Sample), and that the blinking cursor is in the main display.

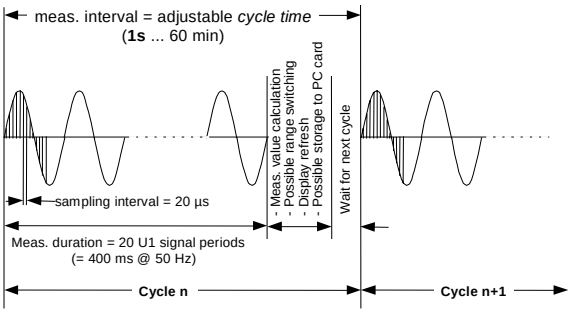
5.1 General Notes

5.1.1 Measuring Sequence Description

All six analog measurement inputs are sampled simultaneously at 50 kHz. A measuring cycle begins (for AC - signal) after a change in polarity has been detected (zero crossing) at voltage measurement input U1. As of this point in time, and up through the 40th zero crossing, sampled values for a given signal are used to determine the respective (RMS) measurement value for all required measured quantities – synchronously at all inputs. The formulas used to this end are listed in chapter 4.4.2.

If no change of polarity is detected at U1 within a period of approx. 0.5 s (e.g. DC signal), the measured quantities are derived from all sampled values recorded during this time.

The effective measuring period within a given measuring cycle (defined through selection of *cycle time*) is thus equal to (valid for all six measurement inputs):
– 20 x T_{U1} for AC signals at U1
– Approx. 0.5 s for DC signals at U1



In the "Sample" operating mode, a measurement value is determined for each of the measured quantities defined for the respective selector switch position cyclically with the selected *cycle time*, and is read out to the display in the selected display format.

The current measurement values for these measured quantities, as well as time of day, are stored to the FIFO register at the end of each *interval* period. The memory has enough capacity for approx. 900 values and is always empty immediately after a measuring function has been selected with the rotary switch. The maximum number of data records the memory can hold is thus dependent upon the number of available measured quantities for the respective selector switch position.

Example for L1:
1 data record consists of
4 (measurement) values
+ 1.5 values (= required memory space for time)
⇒ Max. number of data records = 900/5.5 = approx. 163

When the memory is full, the oldest measurement value record is overwritten by the current record (first-in first-out). Stored measurements are thus continuously updated.

Measurement series taken over lengthy periods of time are stored to the PC-Card (accessory). These can be displayed alphanumerically at the LCD, or can be uploaded to, and analyzed at a PC with METRAwin 45 software which is available as an accessory.

5.2 Selecting a Display Format

Various display formats are available for the representation of measurement values, series measurements and analyses at the LCD. The display formats for the basic measurement functions (power and energy analysis) are described in the following. Additional display formats are included with the optional instrument functions, and are described in the respective operating instructions.

The instrument itself cannot differentiate between correct and unsuitable display formats. It is up to the user to select a suitable display format.

The wave format is only available for the basic measured quantities: current and voltage. All other display formats are available for derived quantities as well.

The selection of a display format remains valid for all selector switch positions, L1, L2, … P, until it has been changed. However, the actual displayed quantities vary from one selector switch position to the next. If the display format is not compatible with one of the selected quantities, an appropriate error message appears at the display, e.g. "NO WAVE". Passing through the REP selector switch position causes resetting to the "*numeric*" display format.

Operating Procedure:

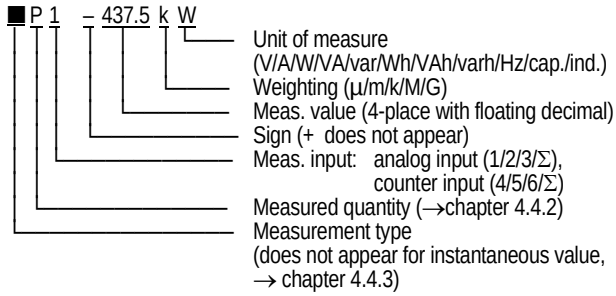
↻	Select the switch position which includes the desired measured quantities (→ chapter 3.2).
M	Press the M -key. ⇒ The cursor moves to the Display Mode Menu (left field of the menu line).
▼▲	Select the desired display format with the scroll keys.
↵	Acknowledge your selection with Enter. ⇒ Data appears at display in the selected display format.

5.2.1 Numeric Display / Selection of Quantities to be Displayed

Available for: L1 / L2 / L3 / Y / Δ / SEL1...4 / E / P.

Current measurement values for measured quantities available in the selected switch position are displayed numerically.

Layout for Numeric Measurement Value Display:



The character height for numeric measurement value display is varied automatically depending upon the number of measured quantities to be displayed.

Measurement values are updated at the selected *cycle time* interval in the "Sample" operating mode.

Measurement is stopped after changing to the "Hold" operating mode, and the last determined measurement values are displayed continuously.

Measurement values for up to 10 measured quantities can be displayed in each display page. If more than 10 quantities have been defined for SEL1 ... SEL4, the additional values can be viewed with the next page by advancing the arrow **>** beyond the upper or lowermost position with the scroll keys ▼ ▲.

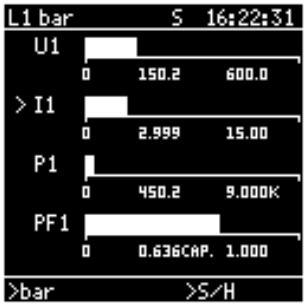
Selecting the Measured Quantities to be Displayed

Due to the fact that only two measured quantities can be displayed simultaneously with the other display formats (e.g. *tabular* display), the quantities to be displayed in these formats must be selected by the user. The quantity which appears at the top or at the left-hand side of the display for the other formats is selected by marking the desired quantity with the arrow **>** with the help of the scroll keys ▼ or ▲. The second display quantity is the next quantity in the order in which the quantities are arranged for numeric display. The order of the measured quantities can be changed as desired in switch positions SEL1 through SEL4.

Example: Measured quantities are arranged in the following order for switch position L1: U1, I1, P1, PF1. If I1 is selected as the first (top) quantity, P1 will be the second quantity displayed in the statistical, tabular and graphic display formats. P1 cannot be display in the wave format, in which case only I1 is displayed.

5.2.2 Bar Graph Display

Available for: L1 / L2 / L3 / Y / Δ / SEL1...4 / E / P.



Current measurement values for measured quantities available in the selected switch position are displayed as horizontal bars.

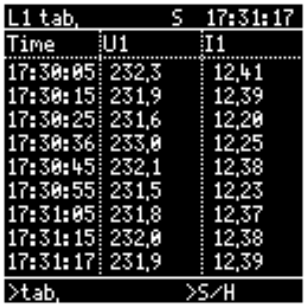
Scaling is performed automatically in discrete measuring ranges.

In addition to the bar graph, the respective measurement values and measuring ranges are also displayed numerically (without unit of measure in order to save space).

Measurement values for up to 4 measured quantities can be displayed within one display page. If more than 4 quantities have been defined for a given switch position, the additional values can be viewed with the next page by advancing the arrow **>** beyond the upper or lowermost position with the scroll keys ▼ ▲.

5.2.3 Tabular Display

Available for: L1 / L2 / L3 / Y / Δ / SEL1...4 / E / P.



Numeric display of measurement values contained in the FIFO register for a measured quantity as a table including measurement value and time.

A maximum of two measured quantities can be displayed simultaneously. Selection of the measured quantities to be displayed is made in the *num*eric display format by positioning the arrow **>** with the scroll keys ▼ ▲ at the desired quantity.

The current measurement value(s) and time always appear in the lowermost line of the table in the "Sample" operating mode (updated at the selected *cycle time* interval). These are moved to the next highest line at the end of each *interval*, as are all of the other previous entries to the table.

The current memory content is frozen if the "Hold" operating mode is selected, and the operator can browse through memory with the scroll keys ▼ ▲.

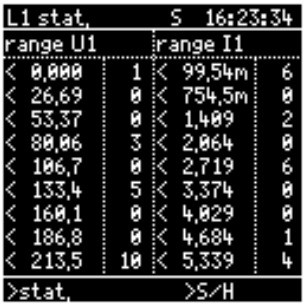
The example above shows the list generated using a 5 second interval for the measurement of instantaneous RMS values for U1 and I1.

Time data may fluctuate by as much as 1 second due to rounding.

Measurement values are displayed with weighting factors (*m*, *k*, ...), but without units of measure in order to save space.

5.2.4 Statistical Display

Available for: L1 / L2 / L3 / Y / Δ / SEL1...4 / P.



The statistical distribution of the measurement values present in the FIFO register are displayed over 9 value ranges (classifications) for two measured quantities.

Up to two measured quantities can be displayed simultaneously. Selection of the measured quantities to be displayed is made in the *num*eric display format by positioning the arrow **>** with the scroll keys ▼ ▲ at the desired quantity.

Functional Principle:

After a measuring function has been selected with the function selector switch, the FIFO register is empty. When measurements are being performed ("Sample" operating mode), the current measurement values for all of the quantities selected for the respective measuring function are saved to memory along with the time of day at the end of the selected *interval* period. The memory has enough capacity for approx. 900 values. The maximum number of data records the memory can hold is thus dependent upon the number of available measured quantities for the respective selector switch position.

Example for L1:

1 data record consists of
4 (measurement) values
+ 1.5 values (required memory space for time)

⇒ Max. number of data records = 900/5.5 = approx. 163

The limits used for automatic distribution into 9 classifications with equal value range widths for the statistical display of a measured quantity result from the highest and lowest measurement values in the FIFO register for a measured quantity.

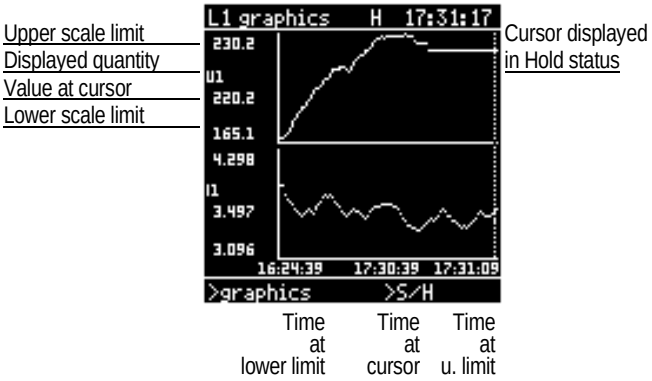
The following can be inferred from the above display example for measured quantity U1:
The following values have been recorded since the beginning of measurement in function L1:

1 value of 0.000 V,
3 values between 53.37 V and 80.06 V
5 values between 106.7 V and 133.4 V
10 values between 186.8 V and 213.5 V

5.2.5 Graphic Display

Available for: L1 / L2 / L3 / Y / Δ / SEL1...4 / E / P

Graphic display of measurement values in the FIFO register for a given measured quantity as a Y-t graph.



Up to two measured quantities can be displayed simultaneously. Selection of the measured quantities to be displayed is made in the *num*eric display format by positioning the arrow **>** with the scroll keys ▼ ▲ at the desired quantity.

Scaling of the Y axes is performed automatically depending upon the respective value range to be displayed. The value is displayed numerically next to the Y axes.

The horizontally displayed time range encompasses 93 pixels. Each measurement value is displayed as an individual pixel. The maximum displayable time period is thus equal to 92 times the interval. The beginning and end of the time axis are scaled with the corresponding time of day in the format: hh:mm:ss.

Example:

15 minute mean values, or the highest and lowest values for a measured quantity which occur during this time period, can be displayed with an *interval of 900 s* for a period of 23 hours for SEL1 through SEL4, as long as no more than 8 measured quantities have been defined for the selected function.

The measuring point which appears at the right-hand edge of the display corresponds to the current measurement value for the respective measured quantity in the "Sample" operating mode (updated at the selected *cycle time* interval).

Current content of the FIFO register is frozen when the "Hold" mode is activated. A vertical cursor line appears in the graphic display, which can be advanced over the time axis with the scroll keys ▼ ▲, and with which the measuring point can be selected. The measurement series can be analyzed with the additionally displayed numeric data including time and the measurement value for the selected measuring point.

It can be inferred from the above graphic display example in the hold status, that the instantaneous values at 17:30:39 were: U1 = 220.2 V and I1 = 3.497 A.

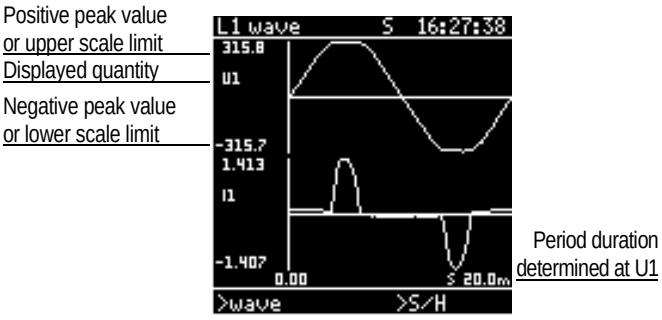
Time data may fluctuate by as much as 1 second due to rounding.

Measurement values are displayed with weighting factors (*m*, *k*, ...), but without units of measure in order to save space.

5.2.6 Wave Display

Available for: L1 / L2 / L3 / SEL1 ... SEL4, but only for directly measured quantities: U1, U2, U3, I1, I2, I3.

Graphic display of the voltage and/or current waveshape based upon the current sample values at the respective analog measurement input.



Up to two measured quantities can be displayed simultaneously. Selection of the measured quantities to be displayed is made in the *num*eric display format by positioning the arrow **>** with the scroll keys ▼ ▲ at the desired quantity.

Scaling of the Y axes is performed automatically depending upon the respective signal amplitudes. Values displayed next to the Y axes thus correspond to the (sampled) peak values for the displayed measured quantities (prerequisite: measuring voltage at the U inputs > approx. 0.7 V_{ss}, measuring voltage at the I inputs > approx. 10 mV_{ss}).

The time range is displayed numerically and the bottom right-hand edge of the display (example: s 20.0m = 20.0 ms). For AC signals, the time range usually corresponds to 1 period duration for U1 measuring voltage and is derived from zero crossings.

The wave display for U1 always starts with the first zero crossing of the positive half-wave where stable signal characteristics prevail. The phase angles for all other measuring signals are displayed in relationship to this reference.

5.3 Sample / Hold – Measure / Interrupt a Measurement

Operating Procedure:

2 x **M** Press the M key twice.
⇒ The cursor moves to the Operating Mode menu (right-hand field of the menu line).

▼▲ Select *S/H* with the scroll keys.

↵ Acknowledge your selection with Enter.
⇒ The instrument is shifted to the Hold status (display mode with frozen measurement) if measurement was previously active (**S**ample mode), and vice versa.

The current operating status is displayed in the headline: *S* = Sample, *H* = Hold

5.3.1 Sample Operating Mode

A measurement value is sampled for each of the measured quantities defined for the respective selector switch positions at the selected *cycle time* interval in the Sample operating mode, and is displayed at the LCD in accordance with the selected display format.

The current measurement values for these measured quantities, as well as time of day, are stored to the FIFO register at the end of each *interval* period. The register has enough capacity for approx. 900 values and is always empty immediately after a measuring function has been selected with the rotary switch. The maximum number of data records the memory can hold is thus dependent upon the number of available measured quantities for the respective selector switch position.
Example for L1:
1 data record consists of
4 (measurement) values
+ 1.5 values (= required memory space for time)
⇒ Max. number of data records = 900 / 5.5 = prox. 163

When the memory is full, the oldest measurement value record is overwritten by the current record (first-in first-out). Stored measurements are thus continuously updated.

Measurement series taken over lengthy periods of time are stored to the PC-Card (accessory). These can be displayed alphanumerically at the LCD, or can be uploaded to, and analyzed at a PC with METRAwin 45 software which is available as an accessory.

5.3.2 Hold Operating Mode – Observance of a Measurement Series

Measurement is stopped after the Hold operating mode has been activated.

The values which were recorded immediately prior to activation of the Hold mode appear in the *numeric* and *bar graph* display formats. The *statistical* display format indicates values which were calculated before switching to the Hold mode in the individual classifications.

The waveforms (for voltage and current) are not saved to memory. However, their display is possible in the Hold mode if switching from the Sample to the Hold mode is initiated when the *wave* display format is active.

By preference, the current FIFO register contents are displayed as a *table* or a *graph*. A vertical cursor marks the position of the current measuring point in the *graphic* display format. The time axis is labeled with start and stop times, as well as with the point in time of the current cursor position. The graphic representation is entirely suitable for analysis purposes thanks to the inclusion of the highest and lowest values of the displayed measurement series.

Operating Procedure:

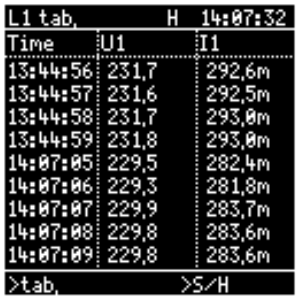
Stop measurement as described in chapter 5.3.

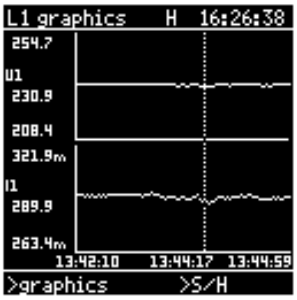
▼▲ Position the arrow **>** at the measured quantity which is to appear at the top in the numeric display format.
(→ 5.2.1: Numeric Display / Selection of Quantities to be Displayed).

M Select the desired display format: *table* or *graphics*. Proceed as described in chapter 5.2.
▼▲
↵

▼▲ Browsing through the measurement series is possible with the scroll keys.

▲ = scroll backwards
▼ = scroll forwards





Notes:

- No measuring points are stored to memory in the Hold mode. If the measurement series is continued, the measuring points which were sampled during the interruption are lost. If a measurement series is recorded to the PC-Card and replayed with METRAwin 45 software, the measuring points and time allocations are lost. Use of the Hold mode should therefore be avoided when recording to the PC-Card.
- Return the instrument to the Sample mode after the measurement series has been viewed.

5.4 Saving and Replaying Display Images

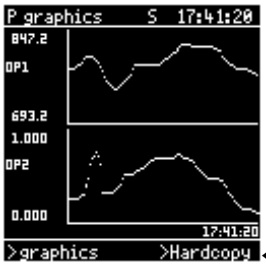
5.4.1 Hardcopy – Saving the Current Display Image

The current measured quantity display at the LCD can be saved as a permanent record to non-volatile memory with the *Hardcopy* command in the Operating Modes menu. Especially interesting operating characteristics and waveshapes can thus be saved for analysis or printout at a later point in time.

The image memory has enough capacity for 15 hardcopies. When the memory is full, the oldest image is deleted each time a new image is saved (FIFO). Clearing the image memory is neither possible, nor necessary.

Operating Procedure:

M 2 x → ▼▲ *hardcopy* → ↵



← ↵ ⇒ Image stored to memory.

5.4.2 REPlay Hardcopy – Displaying Stored Images

Stored images (hardcopies) can be replayed at the LCD in selector switch position REP.

This function is independent of current display format and operating mode.

Running measurement series are interrupted when the replay function is activated.

Operating Procedure:

REP Turn the function selector switch to REP.
⇒ The last image stored to memory is displayed at the LCD.

▼▲ Select the desired hardcopy with the scroll keys.

▲ = scroll backwards
▼ = scroll forwards

The hardcopies can be printed out individually with the optionally integrated printer for purposes of documentation. Press the PRINT key at the printer module in order to print out a copy.

5.5 Printing

The following print-outs can be made with the protocol printer from the optionally integrated SECUTEST PSI module:

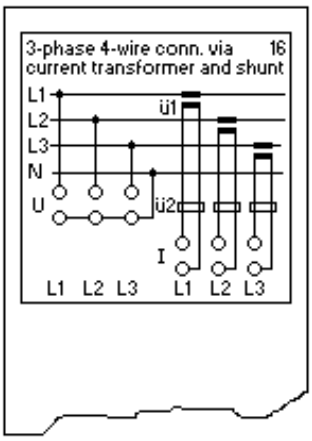
– Manually controlled print-out of the current LCD display
– Time controlled print-out (interval printing) of respective measurement values at the end of the selected interval
– Measurement value controlled print-out (alarm printing) of measurement values for up to four selectable measured quantities depending upon individually adjustable limit values for the measurement values

5.5.1 Printing the Current LCD Display

If the PRINT key at the printer module is pressed, the current contents of the LCD are printed out to the recording chart together with the two top lines and two bottom lines being defined under MENU > printer.

Documentation of the following and more is thus enabled:

- Current measured quantity display
- Stored hardcopies
- Wiring instructions from online help
- Instrument settings
- Operating steps



Notes

- After pressing the PRINT key, the contents of the LCD are stored briefly to a buffer memory. Display formats, functions and selector switch positions can be changed without interrupting the printing process. Active measurements are also continued during printing. If the active measurement series is observed, it is thus possible to document a measuring point as a printed copy of the LCD at any given point in time.
- Activation of the printing function is not possible after communication with a PC via the RS232 interface. In this case, the instrument must first be switched off briefly.

5.5.2 Printing Out a Measurement Series (interval printing)

In order to print out a measurement series with the integrated printer, a time *interval* is selected for the measuring points and the *printer* parameter is set to *on*. Both of these parameters can be configured in the *setup* menu in any one of the below named selector switch positions. The function selector switch is then set to the position which includes the measured quantities which require documentation. The respective values are then printed out at the end of the interval.

Operating Procedure:

L1 / L2 / L3 / E / P / FFT / PDA (statU/statI) →

M 2 x → ▼▲ *setup* → ↵

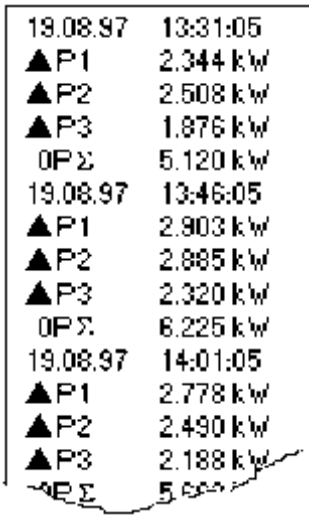
Set the *interval* parameter to the desired time period for the measuring points.

Set the *printer* parameter to *on*.

Set the function selector switch to the position which includes the desired measured quantities, e.g. SEL1.

Print-outs are always generated in tabular form and include date and time in all switch positions for power and energy analysis (L1, L2, … P) independent of the selected display format (see example at right).

For the optional functions print-outs correspond to the selected display format.



Notes:

- Always select a time period between measuring points (*interval* parameter) which is greater than the required printing time. When selecting the interval, don't forget that print-out of up to 20 measured quantities per measuring point is possible for selector switch positions SEL1 through SEL4.
- It usually makes more sense to document intervalic measured-quantity mean values (■U1) and/or extreme values (▼U1, ▲U1), instead of instantaneous RMS values for the measured quantity (e.g. U1). This is possible for measured quantities available with SEL1 through SEL4 by means of corresponding definition of the measurement type.

5.5.3 Alarm Printing – Print-Out of Limit Value Violations Alarm Signals and Limit Value Monitoring Function

Upper and lower limit value violations can be printed out for the measured quantities which are assigned to the first four positions in the SEL4 measured quantity display mode menu. Violations of upper and/or lower limit values are also indicated by means of an alarm output which functions as a group interrupt (changeover contact to sockets 1, 2 and 3 at the front panel).

Operating Procedure

The following operations must be performed one after the other in order to set up alarm printing, or the limit value monitoring function:

a) Define the measured quantities to be monitored in SEL4

SEL4 → **M** 2 x → ▼▲ *setup* → ↵

Define the measured quantities to be monitored in SEL4 – setup (→ chapter 4.4.1).

Example: In the example at the right, measured quantities U1, U2, U3 and f have been selected for monitoring.

Note: If a measured quantity with assigned measurement type *maximum* (e.g. ▲U1) or *minimum* (e.g. ▼U1) violates the selected limit value, a continuous alarm is triggered. As a rule, only measured quantities with measurement types *effective* (instantaneous RMS value), *average* (mean value) or *period 0/1* are monitored for limit value violations for this reason.

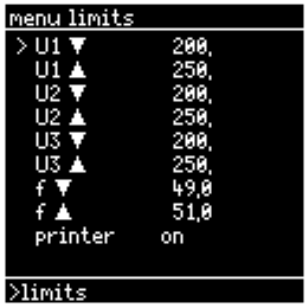
b) Selecting the Limit Values, Activating Alarm Printing

MENU → **M** → ▼▲ *limits* → ↵

Select a lower and an upper limit value for each measured quantity in the limits menu (→ chapter 4.3.3).

In order to activate alarm printing, set the *printer* parameter to *on* and acknowledge your selection with ↵ Enter.

Example



c) Activating Measurements with Limit Value Monitoring

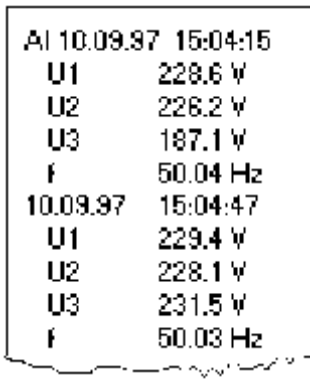
SEL4

Set the function selector switch to the SEL4 position and make sure that the instrument is in the Sample operating mode (= measurement active).

Alarm Printing

If the printer is switched on, alarm printing is started as soon as one of the measurement values for the monitored quantities violates one of the selected limit values. The following are documented in the print-out:

- "Al" identifies the alarm condition
- Date and time
- The measurement values of the monitored quantities when the alarm occurred



If an additional measured quantity subsequently violates a limit value, printing is not triggered. Printing does not occur again until all of the monitored quantities have returned to within the defined tolerances (this time with no identification for the alarm condition). This print-out is however not activated if the monitored quantities return to within their defined tolerances before the previous alarm print-out was completed.

Alarm Signal

The (group interrupt) alarm signal is triggered as soon as one of the measurement values for the monitored quantities violates one of the defined limit values, and is reset when the measurement values for all monitored quantities have returned to within the defined tolerances.

Limit Value Violation	Contact 1 - 2	Contact 2 - 3
no	closed	open
yes	open	closed

Notes

- Limit value monitoring is deactivated as soon as selector switch position SEL4 is exited.
- The storage of measurement values to the PC card is not effected by the alarm functions.
- Alarm printing and signal response time correspond to the selected *cycle time* (as a rule 1s). These functions are therefore not suited for the documentation or signaling of very brief limit value violations. The MAVO-PDA and MAVO-TCM options are provided for this purpose.

5.6 Synchronization of Interval and Period

The synchronization of the two measuring time periods, *interval* and *period*, is required when *period*-related measured quantities (e.g. 0P1, 1PΣ) are to be:
– Recorded to the PC card
– Documented with the interval printing function
– Displayed in *tabular* or *graphic* form
– or simultaneously displayed or recorded along with *interval*-related measured quantities (e.g. ■P1, ▲PΣ).

This is thus only relevant for measurements performed in selector switch positions SEL1 through SEL4 or P.

The timers for the two measuring periods, *interval* and *period*, are not synchronized immediately after the instrument is switched on, as well as after any adjustment to these parameters, i.e. the starting and end points of the two measuring intervals do not coincide with one another. After manual or external synchronization, the timers for both measuring periods are simultaneously started at zero.

However, synchronization is only possible when *period* is set to a whole number multiple of *interval*:
period = n • *interval* | (n = 1; 2; 3; …)

The following two diagrams illustrate this relationship.

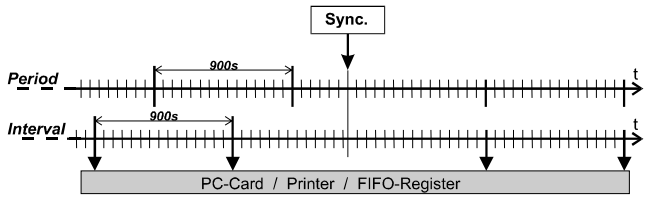


Figure 5.6a: Synchronization where *period* = *interval*

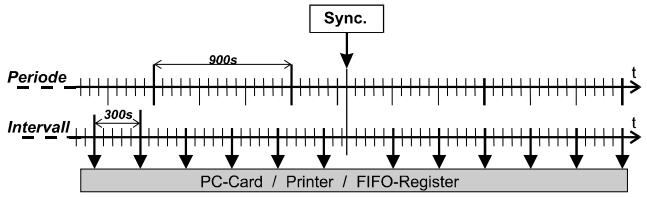


Figure 5.6b: Synchronization where *period* = 3 • *interval*

Synchronization can be performed manually by pressing a key (→ 5.6.1) or with an external electrical signal at the SYNC input (→5.6.2).

Observe the following:

☝ The timers must be resynchronized after every adjustment to *interval* or *period* settings.

☝ If external synchronization is selected, synchronization is only performed once at the beginning of the measurement. A measurement series is only started after synchronization has taken place.

Recording to the PC-Card is also only started after synchronization has occurred. External synchronization can thus also be used to start recording to the PC-Card with an external electrical signal.

5.6.1 Manual Synchronization

Selecting the Manual Synchronization Mode

☞ Turn the selector switch to the E or P position and open the setup menu via the menu line.

☞ Set the *sync* parameter to *time* and acknowledge your entry.

Initiating Manual Synchronization

◐ Turn the function selector switch to the desired position, SEL1 through SEL4 or P, and select the desired display format.

2xM Press the M key twice.
⇒ the cursor moves to the operating mode menu.

▼▲ ↵ Select the *sync.* operating mode with the cursor and acknowledge with Enter.

⇒ The internal timers for *interval* and *period* are reset to zero and start running simultaneously – the two timers have now been synchronized.

This procedure can be repeated at any time.

5.6.2 External Synchronization

Selecting the External Synchronization Mode

☞ Turn the selector switch to the E or P position and open the setup menu via the menu line.

☞ Set the *sync* parameter to *external* and acknowledge your entry.

Initiating External Synchronization

◐ Turn the function selector switch to the desired position, SEL1 through SEL4 or P, and select the desired display format.

⇒ The "W" at the right side of the headline indicates that "External Synchronization" has not yet been completed; and that the instrument is waiting.

SYNC ⇒ The first time the external synchronization signal occurs at the SYNC input, the internal timers for *interval* and *period* are reset to zero and start running simultaneously – the two timers have now been synchronized. The "W" disappears and recording of the measurement series is started.

External synchronization occurs one time only after applying a 24 VDC signal to the SYNC input at the instrument. Additional signals are ignored. Repeated synchronization cannot be performed until the parameter *sync* has been set to *time* and then returned to *external*.

Connecting the SYNC Input

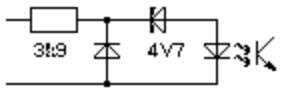
The 2-pole SYNC input (jacks 4 and 5 at the instrument's front panel) is a floating input (optocoupler). It is S_0 compatible and requires a binary DC signal generated with an external, auxiliary voltage source (Safety Extra-Low Voltage!):

Signal Level

Level	Signal Voltage	Signal Current
low	< +4 V (max. –48 V)	0 mA @ 0...+4 V
high	> +12 V (max. +48 V) nominal +24 V	approx. 2.6 mA @ +12 V approx. 6 mA @ +24 V

Synchronization occurs when the signal level is switched from low to high. High-level signal duration: at least 0.5 s.

Connection [9+10]: Connection to the two 4 mm safety jacks at the instrument's front panel is established by means of a signal cable which must be fabricated specifically for the application.

Terminal Assignments		Internal Circuit
Jack 5	+	
Jack 4	–	

ATTENTION!

The instrument may be damaged if a voltage of greater than 48 V is applied to the SYNC input.

The SYNC input can be connected to the S_0 compatible Sync output of a suitable energy meter. Observe electrical utilities guidelines if the Sync input is connected to a billing meter.

5.7 PC-Card – Recording and Replaying Measurements

5.7.1 General Notes for Saving Data to the PC-Card

a) Memory Type

The measuring results for analysis functions can be stored to non-volatile memory with the plug-in memory card (accessory PC Card). A PCMCIA flash memory card is used (type I, 5 volt, AMD, series C, 1 to 10 MByte).

Due to the fact that high speed recording is required for some of the analysis functions (up to 1000 measurement values per second), data is always written to the memory card in a linear fashion. The ATA formatting standard which is frequently used with these memory cards does not apply in this case. This results in the following restrictions:

- ☝ Only memory cards of the above mentioned type from AMD (Advanced Micro Devices) with a capacity of 1 to 10 MB may be used, or other 100% compatible types.
- ☝ The read-out of recorded measurement data to a PC is only possible via the RS232 interface at the MAVOWATT 45 (with interconnected modem if required). Direct read-out of the memory card to a PCMCIA slot at the computer is not possible.
- ☝ The memory card can only be cleared in its entirety: The deletion of individual recordings is not possible.

b) Type and Number of Recorded Measurement Data

The type and number of recorded data depends upon the selected measuring functions and the display format.

- Power / Energy Analysis (basic function)
  Measurement series for power / energy analysis can only be recorded in the SEL4 selector switch position.

  The measurement values for all of the measured quantities defined for SEL4 (max. 20) are cyclically recorded at the selected *interval*. Due to the fact that date, time and (memory) interval are only stored at the beginning of a recording, discontinuous recording of measurement values at varying intervals is not possible.

  Data are recorded in the form of a numeric measurement value table independent of the selected display format (*numeric*, *bar graph*, *table* …).

Display Format	Recording Interval	Number (type) of Quantities per Data Record
num./bar/stat./ tab./graph/wave	cyclical at end of *interval*	1… 20, as selected (num. meas. value table)

  Various display formats can be selected as desired during recording, but the SEL4 switch position cannot be exited.

- Harmonic Analysis (FFT option)
  Data available in the selected display format (measurement values or counter readings for the statistics function) are stored cyclically at the selected *interval* for harmonic analysis (selector switch position FFT).

FFT Display Format	Recording Interval	Number (type) of Quantities per Data Record
num.	cyclical at end of *interval*	12 (as displayed)
stat.THD	cyclical at end of *interval*	30 (as displayed)
stat.I / U	cyclical at end of *interval*	3 (respectively, as displayed)
graph L1/L2/L3	cyclical at end of *interval*	102 (measurement data for respective phase)
tab.L1 tab.L1%	cyclical at end of *interval*	20 (meas. data from L1)
tab.L2 tab.L2%	cyclical at end of *interval*	408 (meas. data from L1 & L2)
tab.L3 tab.L3%	cyclical at end of *interval*	612 (meas. data: L1, L2 & L3)

  Neither the selected display format nor the selector switch position can be changed during recording.

  → Additional information concerning the storage of harmonic analysis data can be found in the operating instructions for the MAVO-FFT option.

- Power Disturbance & Transient Analysis (PDA/TCM options)
  Data available for the selected display format are recorded for power disturbance and transient analysis (selector switch position PDA):

PDA / TCM Display Format	Recording Interval	Number (type) of Quantities per Data Record
PDA stat U	cyclical at end of *interval*	21 (number of respective events during interval)
PDA stat I	cyclical at end of *interval*	15 (number of respective events during interval)
PDA/TCM graph	event controlled upon fulfillment of trigger conditions	7680 (3840 sampled values each for U and I from the given phase)
PDA/TCM event	event controlled upon fulfillment of trigger conditions	4 (time, date, trigger cause and applicable measurement value)

  Neither the selected display format nor the selector switch position can be changed during recording.

  → Additional information concerning the storage of power disturbance and transient data can be found in the operating instructions for the MAVO-PDA and MAVO-TCM options.

- Flicker Analysis (FSA option)

FSA Display Format	Recording Interval	Number (type) of Quantities per Data Record
num.	cyclical at end of *fli.interval*	15 (as displayed)

  Neither the display format nor the selector switch position can be changed during recording.

  → Additional information concerning the storage of flicker analysis data can be found in the operating instructions for the MAVO-FSA option.

c) Memory Capacity

A recording is identified with the word *run* and a consecutive number (run 1, run 2 etc.). Individual measurement series can thus be distinguished for analysis at a PC.

No more than 20 runs (measurement series) can be stored to a memory card, even if additional capacity is available.

Memory density amounts to approximately 250,000 measurement values per MB of memory capacity.

The maximum number of data records (measuring intervals) which can be recorded to a memory card depends upon the number of measured quantities per data record (→5.7.1b):

$$\text{max. number of data records} = \frac{\text{memory density} \bullet \text{memory capacity [MB]}}{\text{number of measured quantities per data record}}$$

Greatest possible recording time can be calculated for recordings with cyclical data storage:

max. recording time = max. number of data records • interval

This calculation is performed by the instrument based upon remaining capacity at the PC-Card. The results of this calculation are used to set the parameters *end date* and *end time* in the *PC-Card* setup menu to the latest possible point in time.

Please observe the corresponding configuration instruction in chapter 4.4.1 for the most advantageous exploitation of memory capacity for long-term recording for power / energy analysis with SEL4.

Maximum possible recording time cannot be determined for recordings with event controlled data storage (for PDA or TCM with display format *event* or *graph*), because the interval at which events occur is unknown. The parameters *end date* and *end time* in the *PC-Card* setup menu are automatically set to fictitious values in this case (start time + 1 year).

Example 1:

10 measured quantities have been defined for SEL4. The *Interval* has been set to 60 seconds.

⇒ 250,000 • 2 / 10 = 50,000 measuring intervals can be recorded to the PC-Card with a memory capacity of 2MB. Maximum recording time is equal to 50,000 • 60 sec = 50,000 min = 34.7 days.

Example 2:

Sporadic power disturbances are to be acquired with the PDA option, and recorded in the *graph* display format.

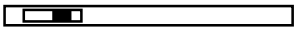
⇒ 250,000 • 2 / 7680 = 65 events can be recorded to the PC-Card with a memory capacity of 2 MB.

5.7.2 Inserting and Removing the PC-Card

☞ The instrument must be switched off before the PC-Card is inserted.

Presence and characteristics of the PC-Card are only checked during the initialization sequence after the instrument has been switched on, at which time memory characteristics are uploaded to the firmware. The PC-Card is not detected if it is inserted while the instrument is switched on.

☝ Make sure that the PC-Card's write-protect switch has been deactivated before insertion.



☝ The PC-Card can only be inserted or removed if the carrying handle at MAVOWATT 45 has been extended to at least the second detent position.

☞ Carefully insert the PC-Card into the slot [26] in the housing's left side panel with the write-protect switch aligned to the eject button. Press the PC-Card all the way in until the ejection button is visible.

☞ The instrument can now be switched (back) on.

☞ Carefully press the eject button in order to remove the PC-Card.

ATTENTION!

Do not eject the PC-Card if the carrying handle has not been sufficiently extended! The ejector mechanism may otherwise be irreparably damaged.

5.7.3 Configuring the Recording Parameters

Configurations are performed in the *PC-Card* setup menu as described in chapter 4.2.

The PC-Card setup menu is only available after the memory card has been inserted, and only for selector switch positions which allow for recording (SEL4, FFT, PDA).

☞ SEL4 / FFT / PDA → M 2 x → ▼▲ *PC-Card* → ↵

☞ Set the parameters (recording) *interval*, *start time* / *date*, and *end time* / *date* in accordance with your individual requirements.

→ Configuration instructions are included in the next chapter.

No plausibility testing is performed by the instrument.

Example: The instrument calculates maximum recording time based upon the number of measured quantities to be recorded, the settings for *interval* and *start time* and *date*, and the amount of capacity available at the memory card and configures the parameters *end time* and *date* automatically to the latest possible point in time. A later point in time can be entered, although this is not sensible.

5.7.4 Starting a Recording

Recording to the PC-Card can be started:
a) Immediately by pressing a key
b) With time delay by entering start date and time
c) Automatically when the instrument is switched on
d) With an external signal at the SYNC input

☝ Before starting a recording, make sure that the following conditions have been fulfilled:

- The measurement inputs are correctly connected (→7.2).
- The real-time clock is set to correct time (→ 4.3.1).
- Measurement is active (→ 5.3.1 Sample mode).
- If measured quantities are to be recorded with reference to *periods*: *interval* - *period* synchronization must be initialized, or will be initialized with a signal to the SYNC input (→ 5.6).
- If energy quantities also need to be recorded: If required, meter readings for all energy quantities must be reset to 0.000 Wh / VAh / varh by acknowledging *reset yes* in the setup menu for selector switch position P or E (→ 4.3.4).

a) Start Recording Immediately

☞ Set the parameter *store* to *yes* in the PC-Card setup menu and acknowledge with **Enter**.

⇒ If no later point in time has been entered for *start time* and *date*, recording is started immediately. The operating mode display changes to "SM" (Sample & Memorize) in the headline.

b) Time Controlled Recording Start-Up

☞ Set the parameters *start time* and *start date* in the PC-Card setup menu to the desired starting time.

☞ Set the *store* parameter to *yes* and acknowledge with Enter.

⇒ Recording has now been initialized, but is not yet active. The operating mode display changes to "SE" (Sample & Enabled) in the headline.

⇒ Recording is started as soon as *Start Time* and *Start Date* have been exceeded. An active recording can be recognized by the display "SM" (Sample & Memorize) in the headline.

Automatically repeated, time controlled recording start-ups (e.g. each day at certain times) are not possible with the instrument itself. This can however be accomplished by switching the instrument on and off with a common time switch (→ c).

c) Automatic Start of Recording after Powering Up

If supply power is switched off, or if it fails during a recording, recording is stopped. After supply power has been switched back on or restored, recording is started again automatically after the memory mode initialization sequence, as long as the function selector switch position has not been changed. However, the next highest consecutive run number is assigned to the recording.

On the one hand, this feature allows for the recognition of an interruption due to mains failure or manipulation. On the other hand, it also allows for advance configuration and testing of the parameters required for a planned recording (performed by a person who is familiar with the functions of the instrument), after which the instrument can be moved to the location at which recording is required. The instrument and measuring accessories need only be correctly connected at the recording site (e.g. by a semiskilled worker in accordance with a wiring diagram).

If the function selector switch position has been changed when the instrument is switched back on, the following applies as regards the memory mode:

- For recordings in switch position SEL4:
  Correct, automatic resumption of memory mode operation does not occur. Switch the instrument back off and reset the selector switch to the SEL4 position before switching it back on again, or end recording via the PC-Card menu (→ 5.7.5).
- For recordings in switch position FFT or PDA:
  Correct, automatic resumption of memory mode operation is no longer possible. End recording via the PC-Card menu (→ 5.7.5), and start a new recording.

d) Externally Controlled Recording Start-Up

The SYNC input for the synchronization of *interval* and *period* (→ 5.6) can also be used to start recording of a measurement series for power / energy analysis with an external signal.

☞ First set the *sync.* parameter in the setup menu for switch position E or P to *external* and acknowledge with Enter.

⇒ The operating mode display changes from "S" to "SW" (Sample & Wait).

☞ Set the function selector switch to SEL4 and open the PC-Card menu.

☞ Acknowledge the setting *store yes* with Enter and then switch to the desired measured quantity display format (num. / bar / graphics / …).

⇒ The instrument now waits until a high-level signal is applied to the SYNC input before starting recording (→5.6.2), even if no interval or period related measured quantities have been defined for the SEL4 selector switch position.

Note: Changing the display format for the measured quantities available in SEL4, or changing back and forth between measured quantity display and the PC-Card menu has no effect on the active recording. Changes to the display format during recording are not possible for the FFT, PDA, FSA and TCM functions.

5.7.5 Ending a Recording

Proper ending of a recording to the PC-Card can be accomplished:
a) Immediately by means of manual key operation
b) Time controlled by entering end time and date

a) Manual Ending of a Recording

☞ Set the parameter *store* to *no* in the PC-Card menu and acknowledge with Enter.

⇒ The recording is immediately stopped and is identified with the next available consecutive number. The operating mode display in the headline changes from "SM" to "S".

Alternatively, an active recording can be stopped by switching the instrument off and removing the PC-Card.

In such a case, switch the instrument back on again with the PC-Card removed, because a new recording would otherwise be started automatically when the instrument is switched back on (→ 5.7.4c).

b) Time Controlled Ending of Recording

An active recording is ended automatically as soon as *end time* and *end date* have been exceeded. No additional steps are necessary. As is the case with manual ending, a consecutive number is assigned to the concluded recording.

The recording parameters *end time* and *end date* must be set to the desired values in the PC-Card menu before a new recording is started.

The values displayed for *end time* and *end date* when the PC-Card menu is opened define the latest possible point in time for the ending of recording for recordings with cyclical storage of measured quantities. These values are recalculated and updated automatically each time a change is made to the recording parameters (number of measured quantities to be recorded, *start date*, *start time*, *interval*). The entry of a later end time is not sensible.

5.7.6 Displaying a Recording at the LCD

Measurement series (runs) which have been recorded to the PC-Card can only be displayed at the LCD in the selector switch positions for which recording is possible (SEL4, FFT and PDA).

Viewing of any given recording is also possible during recording of another measurement series.

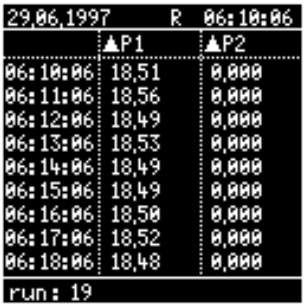
☞ In order to display a measurement series at the LCD which has been recorded to the PC-Card, open the PC-Card menu via the menu line.

⇒ The bottom line in the menu shows the number of *runs* which have been stored to the PC-Card.

☞ Set the blinking cursor at *read* and press the Enter key.

⇒ The cursor moves to the entry field for selection of the consecutive number assigned to the recording (*00* to *20*).

☞ Select the number of the run to be displayed with the scroll keys ▼▲ and acknowledge your selection with Enter.



⇒ Recorded data appear at the display beginning at the start time of the recording. The "Read PC-Card" operating mode is indicated with an "R" in the headline. Recording time and date of the currently displayed measurement data also appear in the headline.

☞ The scroll keys ▼▲ can be used to browse through the recording.

☞ If menu key M is activated, the display returns to the PC-Card menu at the entry field for the consecutive number for the recording to be displayed. A different recording can now be selected with the scroll keys ▼▲.

Ending Display of Stored Data

☞ If the M key is pressed repeatedly, the cursor returns to the position marker and finally to the menu line for the selection of the measured data display format, which was previously acknowledged with the Enter key.

⇒ Current measurement data once again appear at the LCD in the selected display format.

☞ If the instrument is not in the recording mode, the same can be accomplished by simply turning the function selector switch.

Selection of Quantities to be Displayed for SEL4 Recordings

If more than two measured quantities have been recorded in the SEL4 switch position, the quantities to be displayed must be selected. First select the numeric display format. Place the blinking cursor at measured quantity which is to be displayed in the left-hand quantity column when the recording is read out (see also chapter 5.2.1). Then return to the "Read PC-Card" operating mode.

Note that the correlation between measurement values and measured quantities is only maintained if the current SEL4 measured quantity selection (i.e. the number and order of measured quantities and measurement types) corresponds to the selection which was active when the recording was made. If this is no longer the case, define any measured quantity selection in the SEL4 selector switch position with a sufficient number of measured quantities, and then proceed item for item.

Note

Due to the fact that the number of measurement data which can be simultaneously displayed at the LCD is quite restricted, the evaluation of long-term recordings at the display is very time consuming. For this reason, METRAwin 45 data acquisition and analysis software is recommended for read-out, viewing and documentation of PC-Card recordings (→ 6.4). Operating instructions for the read-out of recordings from the PC-Card can be found in the online help.

5.7.7 Deleting Recordings from the PC-Card

☞ Set the *delete* parameter to *yes* in the PC-Card menu and acknowledge with Enter.

⇒ The recordings stored to the PC card are deleted. "Deleting PC card" appears at the display until deletion is complete.

Partial deletion is not possible (e.g. selected runs only). Once the deletion process has been started, it should not be interrupted. However, a partially deleted PC-Card (e.g. due to mains failure) can be fully deleted later.

6 Communications via the RS232 Interface

The RS232 interface, which is provided as standard equipment, allows for the following operating modes:

- Printer Mode: Read-out of printer data to the report printer at the SECUTEST PSI module(→ chapter 5.5)
- PC Download Mode: For the enabling of optional instrument functions, updating the operating software (firmware update) and changing the language for the operating menus and online help (→ chapter 2.2.4)
- PC Online Mode: Read-out of current measurement data to a PC
- PC Off-Line Mode: Read-out of measurement data stored to the PC-Card to a PC

Remote control of instrument functions is currently not possible.

We recommend the use of METRAwin 45 Windows software (→ 6.4), which is available as an accessory, for computer-aided analysis and processing of data gathered with the MAVOWATT 45.

Generally speaking, the MAVOWATT 45 can be integrated into other measurement data acquisition and analysis systems via the RS232 interface. The following chapters provide information on this subject.

6.1 Establishing an Interface Connection to the PC

☞ If the interval printing or the alarm printing function has been activated, communications between the PC and the instrument are not possible. Make sure that the parameter *printer off* has been selected in L1 setup and MENU limits.

☞ Switch the MAVOWATT 45 off and disconnect the report printer (SECUTEST PSI) from the instrument.

☞ Connect the interface at the MAVOWATT 45 labeled RS232 to the serial port at your PC (e.g. COM1). Use the included signal cable to this end (extension cable, 9-pin socket to 9-pin plug). Do not use a zero modem cable!.

☞ After the instrument has been switched back on and the initialization sequence has been completed, the instrument is ready for communication via the RS232 interface.

Note: A connection can also be established, for example via the telephone lines, through the use of two interconnected modems.

6.2 Data Transfer Format

Transmission Speed	9600 baud (bits per second) (= default setting after switching the instrument on)
Number of Data Bits	8
Parity	none
Stop Bits	1
Flow Control	Xon/Xoff

The transmission of commands and responses takes place in the 8 bit ASCII format. All commands can be transmitted either as upper or lower case letters. The commands are listed in the following interface protocol in upper case letters for improved clarity. Non-printable ASCII characters are shown in brackets { } with their common names.

Each command must terminated with a delimiter. The following delimiters are allowed:

{CR} (carriage return) = ($0D_h$) or
{NL} (new line) = {CR} & {LF} = ($0D_h$) & ($0A_h$)

{CR} (carriage return) = ($0D_h$) is used as a delimiter for response messages.

6.3 Interface Protocol

Command	Meaning	Reaction / 'Response'. [1]	Explanation
OP MW45	Open RS232 Activates communications and querying of instrument functions	'MAVOWATT·45·SN:··xxxxxx··OPT:··yy·REV:···z.zz{CR}' Example 'MAVOWATT·45·SN:·139401··OPT:·11·REV:···3.16'	*xxxxxx* 6 digit instrument serial number *yy* Recognition of integrated options *z.zz* Firmware revision level
CL	Close RS232	'MAVOWATT·45·CLOSE{CR}'	Ends communications
BA **BB** **BC**	Changes baud rate to – 9600 bits/s (= default) – 19,200 bits/s – 38,400 bits/s	The transmission speed (baud rate) of the RS232 interface is set to the corresponding value.	The baud rate is always set to 9600 immediately after the instrument is switched on.
ST	Status Query Status Change Message	The instrument reads out a data string which provides information concerning current status in response to the query command ST, as well as automatically after each change in status which has been caused by a manual key operation: 'SW*xx*{CR} MD*yy*{CR} ML*menuline*{CR} MW*zz*:·$n_1$$·$$e_1$$;·$$n_2$$·$$e_2$$;$.....{CR} C*cxxxyyy*{CR}' Example 'SW·7 MD·0 ML>num.·>setup MW10:·U1·V;·P1·W;·S1·VA;·cu3··;·U1·V;·cu1··;·cuä··;·WQ1·varh;·WP1·Wh;·DQ1·var; CO··6·15'	*xx* current function selector switch setting ·0 L1 ·1 L2 ·2 L3 ·3 Y ·4 Δ ·5 SEL1 ·6 SEL2 ·7 SEL3 ·8 SEL4 ·9 E 10 P 11 Replay 12 FFT 13 PDA 14 MENU 15 TCM (PDA) 16 FSA (PDA) *yy* current display format ·0 num. / PDA stat.U / FFT num. / TCM event / FSA num. ·1 bar / PDA stat.I / FFT stat.THD / TCM graf. ·2 tab. / PDA event / FFT stat.U ·3 stat. / PDA graf. / FFT stat.I ·4 graphics / FFT graf.L1 ·5 wave / FFT graf.L2 ·6 FFT graf.L3 ·7 FFT tab.L1 ·8 FFT tab.L2 ·9 FFT tab.L3 10 FFT tab.L1% 11 FFT tab.L2% 12 FFT tab.L3% *menuline* current menu line content *zz* number of measured quantities $n_n$$ measured quantity designation $e_n$$ unit of measure *c* O = cursor on, F = cursor off *xxx* X coordinates for current cursor position *yyy* Y coordinates for current cursor position

Command	Meaning	Reaction / 'Response'. [1]	Explanation
DA	Query an individual measurement data block	The last block of measurement values for the currently displayed measured quantities are read out immediately. Example Measurement data block for L1 num.: '·232.6··170.5··14.29k··0.360kap.' Measurement data block for FFT: '·0.00 ÿ000.0 0.00 ÿ000.0 0.00 ÿ000.0 0.00 ÿ000.0 0.00 ÿ000.0 0.00 ÿ000.0 0.00 ÿ000.0 0.00 ÿ000.0 0.00 ÿ000.0 25.4m ÿ046.5 407.m ÿ117.1 165.m ÿ023.6 64.4m −065.6 54.7m −067.3 14.3m −060.2 33.8m −003.0 30.6m −021.1 26.0m −039.2	Format: numeric, as displayed, with decimal point if applicable, polarity (minus sign or blank), as well as unit of measure weighting factor (µ/m/k/M/G); Number and order of measurement values: as per response MW... to status query ST. Value separator: blank space (20_h) Conditions Power / energy analysis: num. display, FFT: any display format; PDA, TCM: no query possible, FSA: num. display
DS	Continuous measurement data transmission	The measurement values for the currently displayed measured quantities are read out cyclically. This status remains active until the command SP (stop data transfer) is received, or manual operation of the instrument takes place.	Format, number and order of measurement values, value separator and conditions same as for DA command. Data block separator: {NL} Block data rate: Power/energy analysis: 1 data block / second FFT: approx. 3 data blocks per second at 50 Hz fundamental frequency of measuring signal
SP	Stop data transfer	Continuous transfer of measurement data is stopped after completion of the current data block.	If a data block has already been transferred to the output buffer at the time the command is received, it is transmitted as well.
DI	Read out PC-Card directory	Information concerning recordings which have been stored to the PC-Card are read out. '*xxx;aaaaaaaa;dd.mm.yyyy;hh:mm:ss;iiii;nnn;*n_1*$;$*e_1*$;·n_2$*e_2*$;…;llllll;f*;END{CR}'	*xxx* consecutive number of recording (run) (000 ... 020) *aaaaaaaa* initial address of the run *dd.mm.yyyy* start date of the run *hh:mm:ss* start time of the run *iiii* recording interval *nnn* number of quantities per data block n_n*$* measured quantity designation e_n*$* unit of measure *llllll* number of data blocks per run *f* memory status flag: 0 = saving process complete 1 = currently saving to memory END delimiter
CH;*aaaaaaaa;llllll* **CB;*aaaaaaaa;llllll***	Read out recordings (runs) from PC-Card – hexadecimal – binary	*llllll* measurement data blocks will be queried and read out from the run identified with initial address *aaaaaaaa* (see response for DI).	The read-out of recordings is also possible when the recording function is active.

1) The quotation marks used here to delimit the beginnings and ends of the response messages are not transmitted.
Blank spaces (20_h) are identified with '·'.
Utilized special characters and their hexadecimal values:
▲ (measurement type max. value) = CF_h
▼ (measurement type min. value) = $D0_h$
■ (measurement type avrg. value) = DB_h
Σ (summated measured quantity) = $E4_h$

6.4 Measurement Data Analysis with METRAwin 45

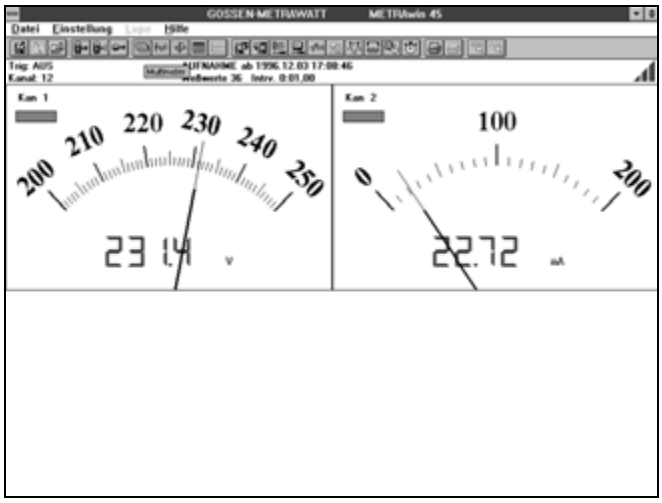
METRAwin 45 software for Windows (compatible with Windows 3.x, 95 and NT4) can be used for read-out, display and processing of measurement data from the MAVOWATT 45 at a PC.

Data transfer is accomplished either online (except for optional functions) or from the PC-Card either via the RS232 or by means of modem.

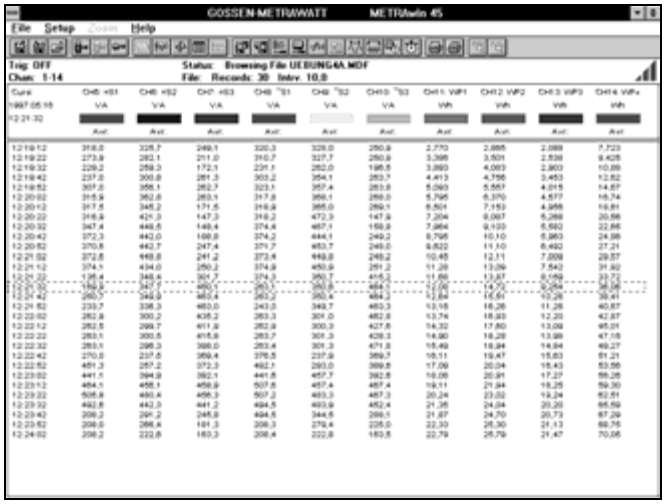
Measurement data can be displayed and printed in numeric or tabular form, graphically as Y-t or X-Y graphs, or as an FFT frequency spectrum, and can be exported to other Windows programs. Measured quantities can also be mathematically linked. Limit value boundaries for various standards, or in accordance with user defined tolerances, as well as waveforms for voltage and current signals can be displayed for FFT measurements.

METRAwin 45 offers several languages for the user interface and includes integrated online help and operating instructions. Help texts are also present in the WRI file format and can be printed out by selecting the menu items *>Help >Read Documentation…*.

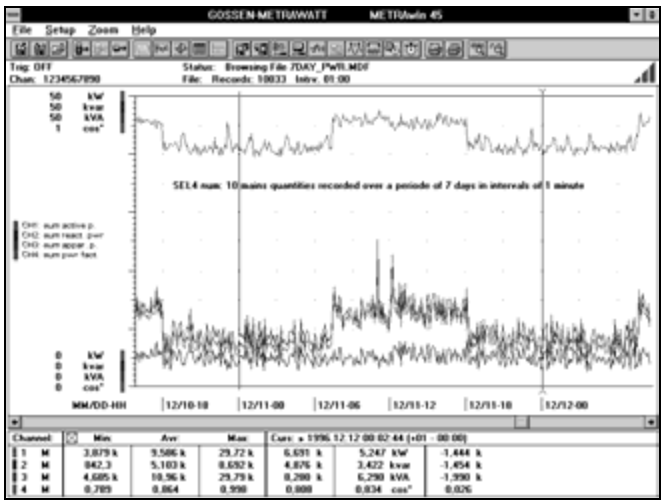
The following graphics offer examples of the various measurement data display formats.



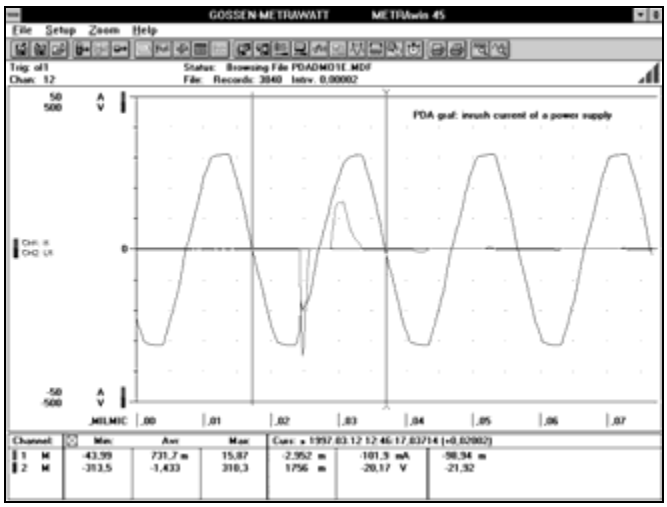
Multimeter display of measurement values for up to four selectable measured quantities (for online operation only)



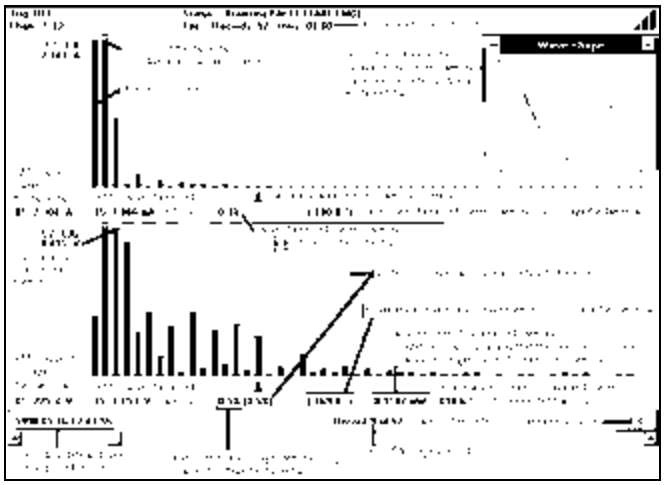
Data logger display of measurement values for up to ten selectable measured quantities



Y-t graph display of measurement values from a long-term recording of power / energy quantities



Y-t graph display of measurement values from a PDA events recording (for off-line operation only)



Frequency spectrum display of an FFT-Tab. L3 recording with reconstructed waveform (for off-line operation only). Example includes explanations regarding the displayed information

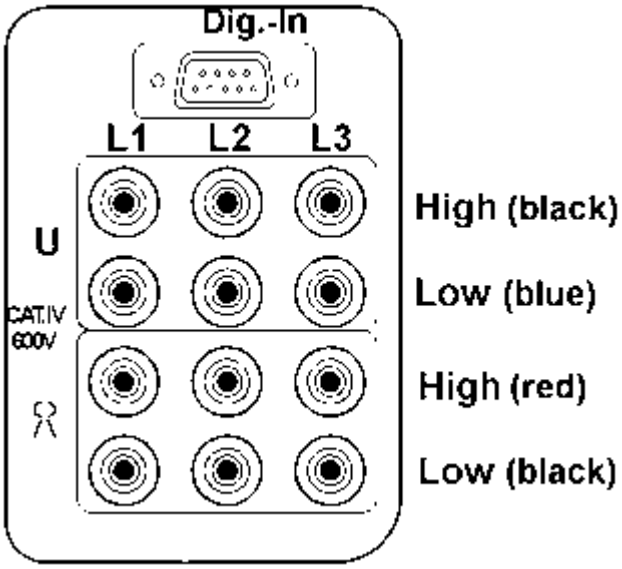
7 Measuring Hookups for Power / Energy Analysis

7.1 General Hookup Instructions

The MAVOWATT 45 is equipped with three electrically isolated, two-channel phase inputs, L1, L2 and L3, for acquiring analog measuring signals. They are all of identical design except in the case of frequency measurement, which is performed in the voltage path for phase L1, and allow for measurement in :

- Three independent DC systems
- Three single-phase AC systems of same frequency
- One 3 or 4-wire three-phase system

The three counter inputs, Dig.-In 4, 5 and 6, allow for the recording of meter pulses from impulsing meters (predominantly from active power meters). They do not provide any information concerning measured quantity or unit of measure. The meter reading can be allocated to the appropriate measured quantities and measurement values based upon system-specific meter constants.



Notes

- The analog measurement inputs have been designed for connection to overvoltage category IV electrical circuits of up to 600 V (or CAT. III to 1000 V).

  If the instrument is used in systems of this type, all measuring accessories (e.g. clip-on current transformers, shunts, measuring cables etc.) must also be in compliance with the respective category. See accessory specifications for accessory categories.
- Low potential from the respective voltage and current path must be connected to the corresponding jack (Low).
- Connections between the voltage jacks (Low) for the measuring hookups shown in the following chapter cannot be made internally within the instrument: they must be established externally.

7.2 Measurement via Phase Inputs L1 through L3

Current measurement is performed in phases L1, L2 and L3, and voltage measurement between each of the phases L1, L2 and L3 and the neutral conductor for single-phase AC systems, 4-wire three-phase systems and DC systems.

- Frequency measurement is performed in the phase L1 voltage path. Voltage U1 must therefore always be connected for voltage and/or current measurements in any given phase.

Two current measuring channels are sufficient for measurements in 3-wire three-phase systems. Current is measured, as usual, in L1 and L3. Voltage measurement is performed with the MAVOWATT 45 in the three voltage paths with an artificial neutral point. The *mains type* is set to *3-wire* in MENU general.

Phase related measured quantities are identified with indices 1, 2 and 3. Each is permanently allocated to a single phase. Current and voltage for a given phase are connected to the corresponding phase input. Incorrect connections lead to erroneous interpretations.

The instrument does not differentiate between single and three-phase measurements. No information is displayed at the LCD concerning complete and correct connection of the device under test. For example, a phase which has not been connected for a three-phase measurement may lead to erroneous interpretations during observation of the 3-wire measured quantities (e.g. U13, U23, U31, UΣ PΣ). Non-connected phase inputs are assigned a value of 0, and are entered correspondingly to the calculation of cumulative measured quantities (UΣ, PΣ ...).

The plausibility of the measuring results should therefore be evaluated after measurements have been started. In selector switch positions L1, L2 and L3, special attention is required as regards:

- Correct settings for *Uratio* and *Iratio* for the respective input based upon the magnitude of displayed U and I measurement values
- Correct polarity of the current measuring hookup based upon the polarity of the P measurement values
- Correct phase sequence based upon the phase angle which can be seen in the *wave* display (also recognizable in selector switch position Y based upon the measured quantity in Rot (phase sequence).

If the Z201A, Z202A or Z203A active clip-on current-voltage transformers are used for current measurement, careful zero balancing is also required, because active power measurement values would otherwise be distorted. Select the respective *wave* display format to this end (I1, I2, I3). Switch the clip-on transformer on (without positioning it around a current conductor), push the adjusting wheel and turn it until the signal line is as close as possible to the zero line.

7.2.1 Measurements in 4-Wire Three-Phase Systems

Measurements in 4-wire three-phase systems are performed with current and voltage measurements at the individual phases. Voltage is measured between the phase and the neutral conductor, and current within the individual phases. 4-wire three-phase systems are normally low-voltage systems (115/200 or 230/400 V), which means that a voltage transformer is not required for the measurement hookup.

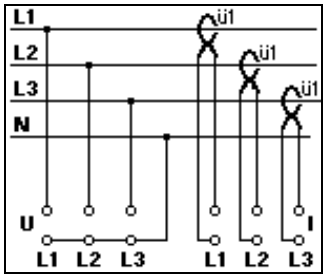
The following applies to the measurements shown below:

- ☞ The current and voltage paths from a given phase are connected to the same phase input.
- ☞ The *2/4-wire mains type* is selected in selector switch position MENU.
- ☞ Measuring parameters are configured as follows:

a) Clip-On Current Transformer with Voltage Output

Uratio is set to *1* in setup for L1 through L3.

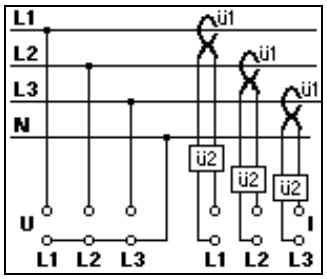
Iratio corresponds to the transformation ratio of the clip-on transformer (e.g. 10mV/A: *Iratio = 100*).



b) Clip-On Current Transformer with Current Output and Shunt

Uratio is set to *1* in setup for L1 through L3.

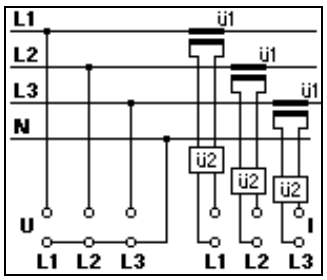
Iratio is the product of the transformation ratios of the clip-on current transformer and the shunt.
(ü = ü1•ü2).



c) Current Transformer and Shunt

Uratio is set to *1* in setup for L1 through L3.

Iratio is the product of the transformation ratios of the current transformer and the shunt.
(ü = ü1•ü2).



7.2.2 Measurements in 3-Wire Three-Phase Systems with the Two-Wattmeter Method

Measurements can be made with the two-wattmeter method within systems which do not include a neutral conductor. The fact that no neutral conductor current is present is taken advantage of in this case. This type of system is used for the medium and high-voltage ranges. In special cases it is also used in the low-voltage range.

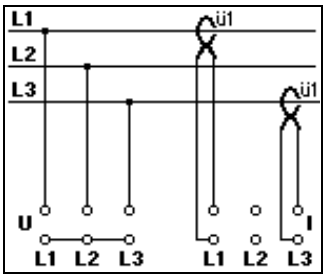
The following applies to the measurements shown below:

- ☞ The current and voltage paths from a given phase are connected to the same phase input.
- ☞ The *3-wire mains type* is selected in selector switch position MENU.
- ☞ Current measurement is performed in L1 and L3.
- ☞ Measuring parameters are configured as follows:

a) Clip-On Current Transformer with Voltage Output

Uratio is set to *1* in setup for L1 through L3.

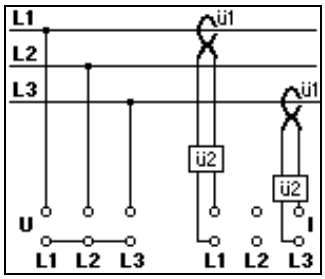
Iratio corresponds to the transformation ratio of the clip-on transformer (e.g. 10mV/A: *Iratio =100*).



b) Clip-On Current Transformer with Current Output and Shunt

Uratio is set to *1* in setup for L1 through L3.

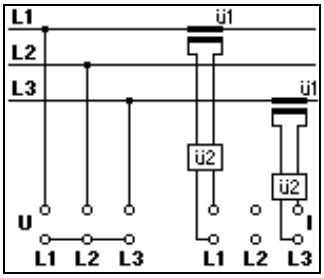
Iratio is the product of the transformation ratios of the clip-on current transformer and the shunt.
(ü = ü1•ü2).



c) Current Transformer and Shunt

Uratio is set to *1* in setup for L1 through L3.

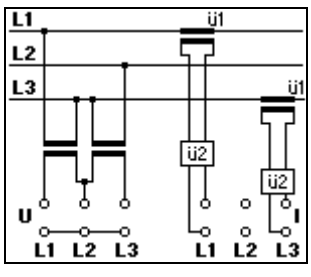
Iratio is the product of the transformation ratios of the clip-on current transformer and the shunt.
(ü = ü1•ü2).



d) Measurements in AC Medium-Voltage Systems with Voltage Transformer, Current Transformer and Shunt

Uratio is set in accordance with the transformation ratio of the voltage transformer in setup for L1 through L3.

Iratio is the product of the transformation ratios of the current transformer and the shunt.
(ü = ü1•ü2).



7.2.3 Measurements in 3-Wire Three-Phase Systems with Artificial Neutral Point

The three-wattmeter method with artificial neutral point represents an additional possibility for measurement within 3-wire three-phase systems. The artificial neutral point is created through the use of resistors of equal value in the voltage paths. This measuring method is especially advantageous for 3-wire low-voltage systems with extreme load fluctuations, or with greatly unbalanced load.

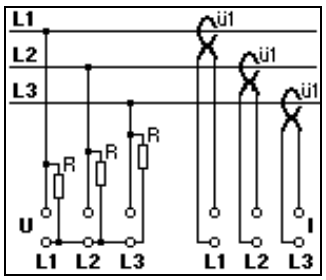
The following applies to the measurements shown below:

- ☞ The current and voltage paths from a given phase are connected to the same phase input.
- ☞ An artificial neutral point is generated through the use of resistors of equal value in the voltage paths.
- ☞ The *2/4-wire mains type* is selected in selector switch position MENU.
- ☞ Measuring parameters are configured as follows:

a) Clip-On Current Transformer with Voltage Output

Uratio is set to *1* in setup for L1 through L3.

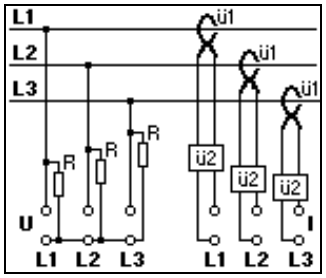
Iratio corresponds to the transformation ratio of the respective clip-on current transformer (e.g. 10mV/A: *Iratio =100*).



b) Clip-On Current Transformer with Current Output and Shunt

Uratio is set to *1* in setup for L1 through L3.

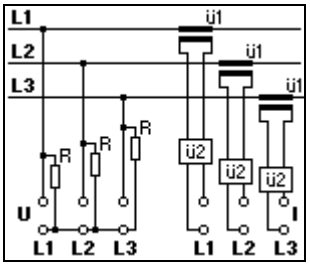
Iratio is the product of the transformation ratios of the clip-on current transformer and the shunt.
(ü = ü1•ü2).



c) Current Transformer and Shunt

Uratio is set to *1* in setup for L1 through L3.

Iratio is the product of the transformation ratios of the current transformer and the shunt.
(ü = ü1•ü2).



7.2.4 Measurements in Single-Phase AC Systems

Up to three measuring points can be connected to the three phase inputs with the MAVOWATT 45 in single-phase AC systems. Frequency measurement must always be performed in the voltage path for phase L1.

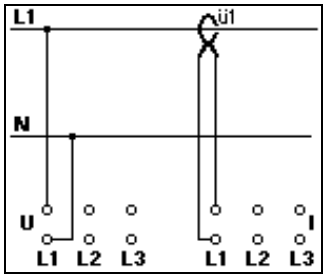
The following applies to the measurements shown below:

- ☞ Current and voltage paths are connected to phase input L1.
- ☞ The *2/4-wire mains type* is selected in selector switch position MENU.
- ☞ Measuring parameters are configured as follows:

a) Clip-On Current Transformer with Voltage Output

Uratio is set to *1* in setup for L1.

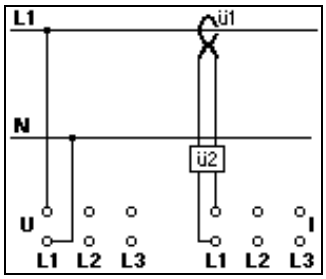
Iratio corresponds to the transformation ratio of the clip-on current transformer.
Two additional measuring points within the same single-phase AC system can be measured simultaneously with phase inputs L2 and L3.



b) Clip-On Current Transformer with Current Output and Shunt

Uratio is set to *1* in setup for L1.

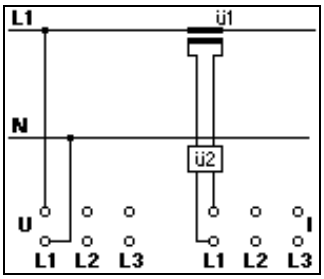
Iratio is the product of the transformation ratios of the clip-on current transformer and the shunt.
(ü = ü1•ü2).
Two additional measuring points within the same single-phase AC system can be measured simultaneously with phase inputs L2 and L3.



c) Current Transformer and Shunt

Uratio is set to *1* in setup for L1 through L3.

Iratio is the product of the transformation ratios of the current transformer and the shunt.
(ü = ü1•ü2).



7.2.5

7.2.6 Measurements in Low-Voltage DC Systems

Measurements in DC systems are generally performed with a Hall-effect clip-on current transformer in the current path. Special attention must be paid to the potential relationships for the performance of direct current measurements with a shunt in the current path in low-voltage DC systems. This hookup is used primarily in the low-voltage range.

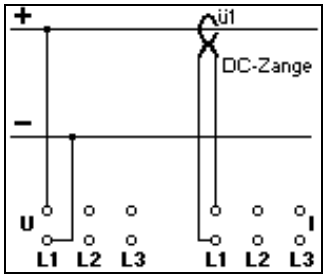
The following applies to the measurements shown below:

- ☞ Current and voltage paths of a given system are connected to the same phase input.
- ☞ The *2/4-wire mains type* is selected in selector switch position MENU.
- ☞ Measuring parameters are configured as follows:

Hall-Effect Clip-On Current Transformer with Voltage Output

Uratio is set to *1* in setup for L1.

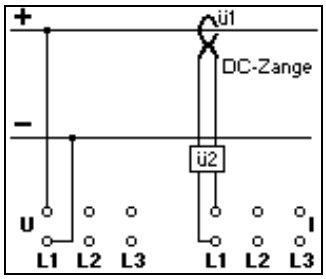
Iratio corresponds to the transformation ratio of the clip-on current transformer.
Two additional measuring points within the same or a different DC system can be measured simultaneously via inputs L2 and L3.



b) Hall-Effect Clip-On Current Transformer with Current Output and Shunt

Uratio is set to *1* in setup for L1.

Iratio is the product of the transformation ratios of the current transformer and the shunt.
(ü = ü1•ü2).
Two additional measuring points within the same or a different DC system can be measured simultaneously via inputs L2 and L3.

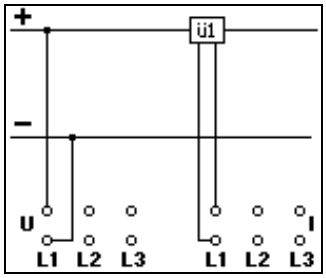


c) Shunt in Current Path

Uratio is set to *1* in setup for L1.

Iratio corresponds to the current-voltage transformation ratio of the shunt.
= 1/R in A/V.

(Example: R = 50mΩ
Iratio = 1/0.05 = 200).



7.3 Energy / Power Measurements via the Digital Inputs

The digital counter inputs are generally used for energy metering. They are designated with the indices 4, 5 and 6. Where required, the additional index c (counter) is used to allow for differentiation from the analog inputs.

Measurement is performed with impulsing meters which are equipped with a floating contact or an S_0 compatible pulse output. The number of pulses counted is a measure of energy consumption. When evaluated by means of the energy meter's *cconst* meter constant, the load curve can be derived from the recorded pulse string.

The meter pulses are converted to an energy value with the following formula:

$$\text{Energy}\left[kVAh\right] = \frac{\text{number of pulses}\left[counts\right]}{\text{cconst}\left[counts/kVAh\right]} \ .$$

The meter constant is indicated as follows on the impulsing meters:

Example 1: label: 750 U/kWh
cconst = 750 unit of measure: kWh

Example 2: label 1 Imp = 0.5 Wh
cconst = 2000 unit of measure: kWh

Example 3: label 1 Wh = 4 Impulse
cconst = 4000 unit of measure kWh

Counter inputs do not provide any information concerning measured quantity or unit of measure. They can be used for other counting tasks as well (e.g. piece counts). In this case, the corresponding unit of measure can be defined for analysis with METRAwin 45 PC software.

8 Technical Data

Measuring Method

Acquirement	Simultaneous sampling of the voltage and current inputs with A-D conversion of instantaneous values
Sampling Frequency	50 kHz
Sampling Resolution	16 Bit
Measuring Cycle	*Power / Energy Analysis:* effective measuring time = 20 measuring signal periods or 0.5s for DC within an adjustable cycle time ranging from 1 to 3600 s *FFT - Harmonic Analysis* (optional): continuous with a 16 period rectangular window *PDA - Power Disturbance Analysis* (optional): continuous with adjustable integration time for generation of RMS values = 2 / 4 / 8 / 16 periods *TCM - Transient Measurement* (optional): adjustable sampling interval = 20 / 40 / 81 / 162 / 324 / 648 µs *FSA - Flicker Analysis* (optional): adjustable interval (60 / 600 s)
Synchronization	To L1 voltage measuring signal (zero crossings)
Measurement Value Generation	Determination of TRMS values for voltage and current as well as all power and energy quantities and power and crest factors by means of mathematical derivation under consideration of selected scaling factors Determination of frequency based on U1 signal zero crossings *FFT - Harmonic Analysis* (optional): determination of magnitude and phase of voltage and current harmonics, as well as THD based upon the principle of Fast Fourier Transformation as per EN61000-4-7 *FSA - Flicker Analysis* (optional): determination of short-term and long-term voltage flicker strength in compliance with EN61000-4-15 (EN60868)
Measurement Types	*Power / Energy Analysis:* instantaneous (RMS) measurement value or max. value, min. value, mean value with adjustable interval ranging from 2s to 1800s

Display

Display Unit	Graphics compatible dot matrix LCD, 128 x 128 pixels (64 x 64 mm) with illumination and adjustable contrast
Display Functions	Measuring results, setup menus, status information, operating instructions and wiring diagrams
Available Measured and Calculated Quantities	*Power / Energy Analysis:* a total of 75 different measured quantities with 4 measurement types each: - RMS value for voltages U_{L-N} and U_{L-L}, currents I_L and I_N, crest factors, frequency and phase sequence - Active, apparent and reactive power, compensating reactive power, power factor - Active, apparent and reactive energy, *FFT - Harmonic Analysis* (optional): - RMS values for fundamental, harmonics (2 ... 50) and DC component of voltages and currents - phase angle with reference to voltage fundamental - RMS value relationship between harmonic and fundamental as a percentage - THD as a percentage *PDA - Power Disturbance Analysis* (optional): - RMS values of voltages and currents - THD of voltages and currents as a percentage – Frequencies of the three phase voltages - Unbalance of the three phase voltages - Unbalance of the three phase currents *TCM - Transient Measurement* (optional): - Sampled measurement value for voltage and current *FSA - Flicker Analysis* (optional): - short-term flicker strength Pst [x.xxx] - long-term flicker strength Plt [x.xxx] – largest relative voltage change dmax [x.xx %] – relative constant voltage deviation dc [x.xx %] – maximum duration of deviation dt>3% [x.xx s]
Display Formats for Measuring Results	*Power / Energy Analysis*: - *Numeric*: measured quantity as formula character with measurement type symbol if applicable, 4-place numeric value with floating decimal point and minus sign if applicable, unit of measure with prefix if appl.; - *Bar Graph*: horizontal bar with numeric display of measurement value and measuring range - *Statistic*: statistical distribution of measurement values within 9 value range classifications - *Table*: List of measurement values and times - *Graphic*: measurement value trend as curve in an automatically scaled Y-t graph - *Wave*: voltage and current waveshape *FFT - Harmonic Analysis* (optional): - *Numeric*: THD_U and THD_I measurement value as xx.x%, as well as for active power and frequency as 4-place numeric value with floating decimal point, with unit prefix if applicable - *Statistical THD:* statistical distribution of THD_U and THD_I measurement values within 5 value range classifications; - *Statistical I*: number of analyzed measurement cycles with violations of limit values defined in EN 61000-3-2 for current harmonics - *Statistical U*: number of analyzed measurement cycles with violations of limit values defined in EN 50160 for voltage harmonics - *Graphic L1/2/3*: display of all voltage and current harmonics from the respective phase as a frequency spectrum, and numeric display of the measurement values for a selectable harmonic - *Table L1/2/3*: list of RMS values and phase angles for even and odd current and voltage harmonics from the respective phase - *Table L1/2/3%*: List of RMS values and their percentage values for even and odd current and voltage harmonics from the respective phase as related to the fundamental *PDA - Power Disturbance Analysis* (optional): - *Event*: list of logged events with indication of point in time of occurrence, triggering cause and the applicable (RMS) measurement value - *Graphic*: characteristic signal waveshape for voltage and current of the respective phase after recognition of an event over a time period of approx. 80 ms with expandable time axis - *Statistical U*: number of events which have occurred per phase and per voltage triggering criterion - *Statistical I*: number of events which have occurred per phase and per current triggering criterion *TCM - Transient Measurement* (optional): - *Event*: list of logged events with indication of point in time of occurrence, triggering cause and the applicable sampled value - *Graphic*: characteristic signal waveshape for voltage and current of the respective phase after recognition of an event over a time period of approx. 80ms ...2.5s with expandable time axis *FSA - Flicker Analysis* (optional): - *Numeric*: measured quantity as formula character with unit of measure, numeric value with fixed decimal point

Voltage Measurement Inputs

Function: Three 2-pole voltage inputs with automatic range selection and individually adjustable scaling factors for U-U transformer, electrically isolated from one another (manual range selection for PDA, TCM, FSA functions)

Measuring Range	Nominal V_{eff}	15	120	1000
Range Limit	Sine V_{eff}	14.5	138	1030
	Peak/DC V_s	21	195	1460

Measurement Uncertainty [1]	at Frequency:	±(% of reading + mV•Uratio)		
	DC/15…65Hz	0.6%+5mV	0.2%+50mV	0.2%+0.3V
	65…500 Hz	0.9%+5mV	0.3%+50mV	0.4%+0.3V
	0.5…2 kHz	—	0.4%+50mV	0.8%+0.6V
	2…10 kHz	—	2%+100mV	2%+1 V

Overload Capacity: 1200 V continuous, 4000 V for 1.2/50µs

Input Impedance: 4 MΩ

Connectors: 1 pair ea. 4 mm safety sockets

Current Measurement Inputs (for CT or shunt)

Function: Three 2-pole voltage inputs with automatic range selection and individually adjustable scaling factors for I-U transformer, electrically isolated from one another (manual range selection for PDA, TCM functions)

Measuring Range	Nominal V_{eff}	120m	1
Range Limit	Sine V_{eff}	200m	1.7
	Peak/DC V_s	290m	2.4

Measurement Uncertainty [1]	at Frequency:	±(% of reading + mV•Iratio)	
	DC/15…65Hz	0.2%+0.1mV	0.2%+1mV
	65…500 Hz	0.3%+0.1mV	0.2%+1mV
	0.5…2 kHz	0.5%+0.2mV	0.4%+2mV
	2…10 kHz	2%+0.5mV	2%+5mV

Overload Capacity: 250 V continuous

Input Impedance: approx. 11 kΩ

Connectors: 1 pair ea. 4 mm safety sockets

Accuracy of Derived Quantities

- Active Power

Measurement Uncertainty [1]	at Frequency:	±(% of reading + % of meas. range [2])
	DC/15…65Hz	0.4%+0.1%
	65…500 Hz	0.6%+0.1%
	0.5…2 kHz	1%+0.2%
	2…10 kHz	3%+0.5%

- Other Quantities

Measurement Uncertainty [1]: All other quantities are derived from the basic measured quantities: voltage, current and active power. The error limits for these quantities result from the functional relationship under consideration of the respectively active measuring ranges [2] for the basic measured quantities (e.g. $S=U \bullet I$; $\Delta S/S=\Delta U/U + \Delta I/I$).

Reference Conditions

Ambient Temp.: 20…25° C

Humidity: 50 ± 5% relative humidity

Power Supply: 230 V ±10% or 110 V ±10%

Waveshape: Sine

cosφ: 1

1) Indicated measurement uncertainties apply under reference conditions after a warm-up period of 15 minutes with a calibration interval of 12 months.

2) Power measuring range = voltage measuring range x current measuring range (corresponds to displayed upper scale limit in the "bar graph" display format).

Pulse Inputs (for impulsing meters)

Function: Three S_0 compatible pulse inputs with individually adjustable scaling factors (meter constants) for energy measurement with impulsing meters, electrically isolated from one another

DC Signal Level: low < 4 V, high 12…24 V (6 mA @ 24 V) generated with an external auxiliary voltage source

Overload Capacity: 48 V, continuous

Connector: 9-pin D-Sub plug

Synchronizing Input

Function: One S_0 compatible pulse input for synchronizing the start times of the measuring intervals

DC Signal Level: low < 4 V, high 12…24 V (6 mA @ 24 V) generated with an external auxiliary voltage source

Overload Capacity: 48 V, continuous

Connectors: 1 pair 4 mm safety sockets

Alarm Output

Function: One electrically isolated switching output for the indication of limit value violations for up to 4 measured quantities

Switching Element: relay switchover contact

Switching Capacity: 50 V, 0.5 A

Assignments: freely programmable measured quantities and limit values

Connectors: 3 ea. 4 mm safety socket

Data Interface

Function: Read-out of printer data to the printer module
Read-out of measurement data to a PC (online)
Read-out of measurement data stored to the memory card to a PC (off-line)

Type: V.24/RS232C

Operating Mode: full duplex

Baud Rate: 9600 / 19 200 / 38 400 baud (bits per second)

Data Bits: 8

Parity: none

Stop Bits: 1

Flow Control: Xon/Xoff

Connector: 9-pin D-Sub socket

Operating Elements

1 Rotary Switch: with 15 positions for the selection of instrument functions and measured quantity combinations

5 Keys: 4 keys for menu driven configuration
1 key for querying operating and hookup instructions

1 Mains Switch: for switching the instrument on and off, illuminated for indication of on/off status

Power Supply

Line Voltage: switchable: 115/230 V~ ±10%

Line Frequency: 45 … 65 Hz

Power Consumption: approx. 20W / 30VA

Hold-upTime: > 30 ms

Connector: 10-A inlet connector with earthing contact (

Memory

Image Memory

Function	non-volatile storage of any current measurement value display as a copy of the LCD
Capacity	15 images (FIFO)

Setup Memory

Function	non-volatile storage of current instrument configuration (measuring parameters, measured quantity selections) and meas. values for cumulative energy quantities

Internal Measurement Value Memory (operating memory)

Function	volatile storage of measurement values from power / energy analysis at the selected time interval
Capacity	approx. 900 measurement values (FIFO register)

Plug-In Measurement Value Memory (accessory memory card)

Function	non-volatile storage of measurement values and analyses for all analysis functions at the selected time interval, or events controlled
Memory Medium	PCMCIA flash RAM card (type I PC Card)
Type	AMD series C, 5 V
Capacity	1 to 10 MB
Density	approx. 250,000 measurement values per MB

Clock

Type	real-time quartz clock with back-up battery "year 2000 compatible"	
Time Format	date	DD.MM.YY
	Time	hh:mm:ss
Resolution	1 s	
Deviation	max. 1 minute per month	

Printer (optional PSI module)

Function	Print-out of measuring results, events and setup menus
Triggering	manual / time controlled / measurement value controlled
Mechanism	4 needle matrix printer
Print Medium	paper recording chart rolls, 58 mm wide
Printing Width	48 mm
Operating Elements	alphanumeric keyboard for text entry, "PRINT" and "FF" (paper advance)
Power Supply	via pin 9 at the RS232 interface from the MAVOWATT 45 with 6.5 to 12V-/0.5A

Electrical Safety

Protection Class	I per EN 61010-1	
Overvoltage Category	CAT III per EN 61010-1 measurement inputs: CAT IV for 600 V	
Test Voltages	measurement inputs-housing	5.5 kV~
	measurement inputs- outputs	5.5 kV~
	power supply-outputs	3.7 kV~

Electromagnetic Compatibility

Interference Immunity	per EN 50082-2
Interference Emission	per EN 50081-1

Ambient Conditions

Climatic Category	3z/0/75/90% in compliance with VDI/VDE 3540	
Ambient Temperature	Operating	0 … +55° C
	Storage / Transport	-25 … +75° C
Humidity	max. 90% relative humidity, no condensation	
Air Pressure	max altitude above sea level: 2000 m	

Mechanical Design

Type	benchtop instrument with carrying handle	
Protection	per DIN VDE 0470 T1 / EN 60529	
	housing	IP40
	connectors	IP20
Dimensions	150 x 290 x 290 mm (not including carrying handle)	
Weight	without PSI printer module	4.0 kg
	with PSI printer module	4.8 kg
	complete with carrying case and accessories	10 kg

Applicable Regulations and Standards

IEC 61010-1 EN 61010-1 VDE 0411 T1	Safety requirements for electrical equipment for measurement, control and laboratory use
IEC529 EN 60529 DIN VDE 0470	Protection provided by enclosures (IP code)
IEC 68	Basic environmental test procedure
VDI/VDE 3540Bl.2	Reliability of measuring, control and regulating devices – Climatic categories for devices and accessories
EN 50081-1 VDE 0839 T81-1	Generic standard for interference emission; residential, business and light industry
EN 50082-2 VDE 0839 T82-1	Generic standard for interference immunity; residential, business and light industry
IEC 61000-3-2 DIN EN 61000-3-2 VDE 0838 T2	Limit values for harmonic current from instruments with less than 16 A per phase
IEC 61000-3-3 EN 61000-3-3 VDE 0838 T3	Limitations of voltage fluctuations and flicker in low-voltage supply systems for equipment with rated current ≤16A (Option FSA)
IEC 61000-4-7 EN 61000-4-7 VDE 0847 T4-7	Procedures and instruments for the measurement of harmonics
IEC 61000-4-15 EN 61000-4-15 VDE 0847 T4-15	Testing and measuring techniques– Flickermeter – Functional and design specifications; Replacement for IEC 868/EN 60868 (Option FSA)
EN 50160 VDE 0839 T160	Voltage characteristics in public power supply systems
VDE 0843 T1-6	EMC for measurement and control instruments
DIN 40110 T1/T2	AC quantities in 2-wire / multi-wire power systems
DIN 43864	Current interface for pulse transmission between impulsing meters and tariff devices

Technical Data for Measuring accessories

- Z201A
  Active clip-on current-voltage transformer
  with 9 V battery (service life approx. 30 hr.);
  0…30 A_{DC}, 0…20 A_{AC}, 10 mV/A, DC…20 kHz
- Z202A
  Active clip-on current-voltage transformer
  with 9 V battery (service life approx. 50 hr.);
  0…30/300 A_{DC}, 0…20/200 A_{AC}, 10/1 mV/A, DC…10 kHz
- Z203A
  Active clip-on current-voltage transformer
  with 9 V battery (service life approx. 50 hr.); 0…300/1000 A DC, 0…200/1000 A_{AC}, 1 mV/A, DC…10 kHz
- WZ12F
  Passive clip-on current-voltage converter,
  0.02 to 15 A_{AC}, 100 mV/A, 30 Hz to 500 Hz
- WZ12E
  Passive clip-on current-voltage converter,
  0.2 to150 A_{AC}, 10 mV/A, 30 Hz to 500 Hz
- Z823B
  Passive clip-on current-voltage transformer,
  0 to 1000 A_{AC}, 1 mV/A, 45 Hz…10 kHz
- Z821B
  Passive clip-on current-voltage transformer,
  0…3000 A_{AC}, 0.333 mV/A, 30 Hz…5 kHz
- AF11A
  Flexible "Amp*FLEX*" current-voltage transformer
  with 9 V battery (service life approx. 150 hr.); length 45 cm;
  (0.5…) 5…1000 A_{AC}, 1 mV/A, 10Hz…20kHz
- AF033A
  Flexible "Amp*FLEX*" current-voltage transformer
  with 9 V battery (service life approx. 150 hr.); length 60 cm
  (0.5…) 5…30/300 A_{AC}, 100/10 mV/A, 10Hz…20kHz
- AF33A
  Flexible "Amp*FLEX*" current-voltage transformer
  with 9 V battery (service life approx. 150 hr.); length 90 cm
  (0.5…) 5…300/3000 A $_{AC}$, 10/1 mV/A, 10Hz…20kHz
- AF101A
  Flexible "Amp*FLEX*" current-voltage transformer
  with 9 V battery (service life approx. 150 hr.); length 120 cm
  (5…) 50A…1/10 kA_{AC}, 1/0.1 mV/A, 10Hz…20kHz
- Z860A
  Plug-on shunt: 50 Ω, 0.2%, 1.5 W,
  50 mV/mA (0…20 mA → 0…1 V)
- Z861A
  Plug-on shunt: 1Ω, 0.2%, 1.5 W,
  1 mV/mA (0…1 A→ 0…1 V)
- Z862A
  Plug-on shunt: 0.05 Ω, 0.2%, 1.5 W;
  50 mV/A (0…5 A → 0…0.25 V)
- Z863A
  Plug-on shunt: 0.01 Ω, 0.2%, 1.5 W,
  10 mV/A (0…16 A → 0…0.16 V)

Type	Suitable for Measurements: A = Long-Term B = Harmonics C = Frequency Converter	Measuring Range Nominal Value	Measuring Range Useable Range with MAVOWATT 45	Overall Measurem. Uncertainty (Current sensor+MAVOWATT45) under Reference Conditions ±[...% of reading + ... A]	Output Signal	*Iratio* [A/V]
Z201A	B, C	AC: 20 A_{rms} DC: 30 A	approx. 0.1 ... 17 A_{rms} (24 A_{pk}) approx. 0.1 ... 24 A	1.2% + 0.1 A_{rms} 1.2% + 0.1 A	100 mV~/A~ 100 mV/A	*10* *10*
Z202A	B, C	AC: 20 A_{rms} AC: 200 A_{rms} DC: 30 A DC: 300 A	approx. 0.1 ... 20 A_{rms} approx. 1 ... 200 A_{rms} approx. 0.1 ... 30 A approx. 1 ... 300 A	1.2% + 0.1 A_{rms} 1.2% + 1 A_{rms} 1.2% + 0.1 A 1.2% + 1 A	10 mV~/A~ 1 mV~/A~ 10 mV/A 1 mV/A	*100* *1000* *100* *1000*
Z203A	B, C	AC: 200 A_{rms} AC: 1000 A_{rms} DC: 300 A DC: 1000 A	approx. 1 ... 200 A_{rms} approx. 1 ... 1000 A_{rms} approx. 1 ... 200 A approx. 1 ... 1000 A	1.2% + 1.3 A_{rms} 1.2% + 1.3 A_{rms} 1.2% + 1.3 A 1.2% + 1.3 A	1 mV~/A~ 1 mV~/A~ 1 mV/A 1 mV/A	*1000* *1000* *1000* *1000*
WZ12F	A, (C)	AC: 15 A_{rms}	approx. 0.02 ... 15 A_{rms}	2.2% + 10 m A_{rms}	100 mV~/A~	*10*
WZ12E	A, (C)	AC: 150 A_{rms}	approx. 0.2 ... 150 A_{rms}	2.2% + 0,1 A_{rms}	10 mV~/A~	*100*
Z823B	A, B, (C)	AC: 1000 A_{rms}	approx. 1 ... 1200 A_{rms}	0.7% + 0.8 A_{rms}	1 mV~/A~	*1000*
Z821B	A, B, (C)	AC: 3000 A_{rms}	approx. 1 ... 3000 A_{rms}	0.7% + 1 A_{rms}	0.333mV~/A~	*3000*
AF033A	(A), B, C	AC: 30 A_{rms} AC: 300 A_{rms}	approx. 0.5... 17 A_{rms} (24 A_{pk}) prox. 0.5 ... 170 A_{rms} (240 A_{pk})	1.2% + 0.5 A_{rms} 1.2% + 0.6 A_{rms}	100 mV~/A~ 10 mV~/A~	*10* *100*
AF33A	(A), B, C	AC: 300 A_{rms} AC: 3000 A_{rms}	prox. 0.5 ... 170 A_{rms} (240 A_{pk}) prox. 0.5...1700 A_{rms}(2400A_{pk})	1.2% + 0.6 A_{rms} 1.2% + 3 A_{rms}	10 mV~/A~ 1 mV~/A~	*100* *1000*
AF101A	(A), B, C	AC: 1000 A_{rms} AC: 10000 A_{rms}	approx. 5…1000A_{rms}(2400A_{pk}) approx. 5A ...10kA_{rms} (24kA_{pk})	1.2% + 3 A_{rms} 1.2% + 20 A_{rms}	1 mV~/A~ 0.1 mV~/A~	*1000* *10000*
AF11A	(A), B, C	AC: 1000 A_{rms}	approx. 5...1000A_{rms}(2400A_{pk})	1.2% + 3 A_{rms}	1 mV~/A~	*1000*
Z860A	A, B, C	AC: 20 mA_{rms} DC: 20 mA	50µA_{rms} ...32mA_{rms} (48mA_{pk}) approx. 50 µA ... 48 mA	0.8% + 20 µA_{rms} 0.8% + 20 µA	50 mV~/mA~ 50 mV/mA	*0.02* *0.02*
Z861A	A, B, C	AC: 1 A_{rms} DC: 1 A	prox. 1mA_{rms} ...1A_{rms} (2.4A_{pk}) approx. 1 mA ... 1.2 A	0.4% + 1 mA_{rms} 0.4% + 1 mA	1 V~/A~ 1 V/A	*1* *1*
Z862A	A, B, C	AC: 5 A_{rms} DC: 5 A	approx. 0.02 ... 5 A_{rms} (40 A_{pk}) approx. 0.02 ... 5 A	0.4% + 20 mA_{rms} 0.4% + 20 mA	50 mV~/A~ 50 mV/A	*20* *20*
Z863A	A, B, C	AC: 16 A_{rms} DC: 16 A	approx. 0.1 ... 16 A_{rms} (40 A_{pk}) approx. 0.1 ... 16 A	0.4% + 0.01 A $_{rms}$ 0.4% + 0.01 A	10 mV~/A~ 10 mV/A	*100* *100*

9 Glossary

Available Power
: Active power which can be used during the current →period without exceeding maximum allowable →periodic power (demand). Equal to the difference between allowable maximum active power (chargeable →demand) and current →trend power, if the result is positive.

Chargeable Demand
: Mean value derived from a number of maximum periodic values, which occur during specific time intervals. This value is used by the power utilities for billing purposes. The value is determined by means of various methods (see note under →Period).

Class
: The range of values which lies between two defined →measurement values. The range between the maximum and the minimum of all stored measurement values is subdivided into several portions of equal scope. This subdivision is used for the statistical evaluation of measurement values. For example, a frequency distribution is displayed in the statistics display format, which shows the number of measurement values which lie within each of the range subdivisions.

  This is also understood as allowable error under reference conditions for the classification of measuring equipment accuracy (DIN 43780 for measuring equipment with analog display, DIN 43751 for measuring equipment with digital display).

Compensating Reactive Power
: Reactive power which is required for the attainment of a predetermined →power factor ($\cos\varphi$ = *PFnom*). Is used for the rating of compensating power for reactive power load components (asynchronous motors, transformers, underexcited asynchronous machines, electronic power converters, overhead lines etc.). Unit of measure: (k)var.

Correction Active Power
: Active power which must be disconnected during the current →period in order to avoid exceeding maximum allowable chargeable →demand. It is the difference between the maximum allowable value for active power (chargeable demand) and current →trend power, if the result is negative.

Crest Factor
: Relationship between peak value and RMS value for an alternating signal.

Counter Constant
: →Meter Constant

Cycle Time
: Time interval at which displayed →measurement values are refreshed at the LCD.

Demand
: →Periodic Power

DF (Distortion Factor)
: Measure of harmonic content with reference to the RMS value of the signal. Results from the relationship of the root of the sum of the squares of all RMS harmonic values to the RMS value of the overall signal.

Energy (also Work)
: Electrical energy is the electrical power which is transported during a given observation period. Active energy depends upon the duration and the amount of active power P which is demanded by the load component.

FIFO Memory: First In First Out
: The first data stored to memory are overwritten by current data if memory capacity is depleted.

Form Factor
: relationship between the RMS value and the rectified value of a signal.

Fundamental Factor
: The relationship between the RMS value of the fundamental to the RMS value of the overall signal (DIN 40110).

Hardcopy
: Stored display image. Up to 15 hardcopies can be stored to the instrument's internal memory. If a 16th image is stored to memory, the oldest is overwritten.

Interval
: Period of time for the logging of →max. and →min. values for the measured quantities, as well as for the calculation of →mean (average) values. The instantaneous (RMS) value registered at the end of the interval, the interval's minimum and maximum values and the mean value are determined for each interval. These values can be displayed in a suitable format at the LCD (e.g. table), read out to the printer or stored to the PC-Card.

Iratio
: Current transformation ratio for primary current to secondary current. If two current transformers are connected in series, the overall transformation ratio is the product of the individual transformation ratios.

  Example: current transformer 30 A/5A ⇒ ü1 = 6
  shunt 5 A (50 mV/A) ⇒ ü2 = 20
  Iratio = ü1 • ü2 = 120

Load Curve
: Measurement series for →periodic power. Calculated periodic power (Period 1) is displayed numerically or graphically for purposes of analysis.

Maximum
: Greatest →measurement value (instantanuous RMS) occurred during an →interval period.

Mean Value
: The value of a measured quantity averaged over the duration of the →interval (arithmetic mean value). Floating mean value generation is performed for the numeric display of measured quantities at intervals defined by the →cycle time.

Measured Quantity
: A physical quantity which has been applied to the input of a measuring instrument or functional unit. Examples: U, I, P.

Measurement Series
: Measurement values with identical measuring parameters from a measurement taken with uniform, pre-selected time →intervals. A measurement series is comprised of all of the →measuring points from a given measurement.

Measurement Value
: The value of a →measured quantity expressed as a number (result). Example: Voltage: 233 V.

Measurement
: The acquisition of a real, physical condition by means of an evaluation of one or more significant conditional parameters in relationship to comparison quantities.

Measuring Point
The number of all →measurement values and →measured quantities, which have been logged or calculated, and displayed or stored at a (given) point in time.

Meter Constant (Counter Constant)
A measure of (imported) energy for power meters.

Equivalent to revolutions per kWh for conventional meters (Ferraris meters).
The meter disc is provided with a marking which allows for visual reading of the pulses. The number of pulses is thus equal to the number of revolutions per kWh.

The output pulse value is stated as pulses per kWh or kWh per pulse for impulsing meters (e.g. pulse generator at Ferraris meter or static meter with pulse output).

Minimum
Smallest →measurement value (instantanuous RMS) occurred during an →interval period.

Period 0
Current measuring period. →Trend power is calculated based upon energy consumed from the beginning of the period up to the current point in time.

Period 1
The completed measuring period which immediately precedes the current period (Period 0).

Period
Measuring time period for the determination of →periodic power, which is used by the power utilities as the basis for the billing of consumed power to large customers. As a rule, the period has a duration of 15 minutes and is defined by the power utilities through the use of a periodic clock pulse.

Note: The three highest periodic power (demand) values which occur during given billing periods are generally averaged for a determination of consumed power (e.g. the three highest values during a billing year or the three highest values from the periods January through April, May through August and September through December). The highest determined periodic value is multiplied by a network factor (e.g. $1/\cos\varphi = 1/0.9$), and chargeable demand determined in this way is billed at the price per kW.

Periodic Power (Demand)
If energy consumption is calculated for a period of one hour during a measuring period (kWh per hour), the resulting value is equal to demanded electrical power (periodic power). The maximum values for specific periods are used by the power utilities for the calculation of chargeable demand.

Power Factor
Quotient of active power and apparent power: PF = P/S (= $\cos\varphi$ for sinusoidal signals).

Reactive Factor
Relationship between reactive power and apparent power: $\sin\varphi = Q/S$.

REP (Replay →Hardcopy)
Replay of a stored display image.

Summated (Active) Energy (Total Energy)
The sum of energy consumption for the individual phases during a specific time interval.

Summated (active) energy may be expressed with reference to the overall time interval, as well as to the tariff zone interval (e.g. on-peak and off-peak tariff zones).

Summated (Active) Power (Total Power)
Sum of power from the individual phases. Same as three-phase power for three-phase load components.

Summated Current (Total Current)
Sum of current from all phases.

Sync
Clock pulse generator for resetting →periodic power energy meters. The energy reading is reset at the beginning of the measuring period. Energy is accumulated during the newly started →period until the next sync pulse is generated, stored to memory and then reset again.

Total Harmonic Distortion (THD)
Measure of harmonic content with reference to the fundamental. The relationship between the root of the sum of the square of the harmonics for the alternating signal to the RMS value of the fundamental.

Trend Power
(Active) power which will have been achieved at the end of the current period (→Period 0). Trend power is projected in a linear fashion based upon energy consumption since the beginning of the current period.

$P_{trend} = E * 3600/t_{actual}$ (energy consumption since start of period x 3600 [sec]/time since start of period [sec].

Two-Wattmeter Method
Measuring setup for the measurement of active power in balanced or unbalanced load, 3-wire three-phase systems with only two measuring systems. The measuring instrument must be set to *3-wire mains* system.

Unit of Measure
Unit for the measured quantity, e.g. current is measured in amperes [A].

Uratio
Voltage transformation ratio for primary voltage to secondary voltage [V/V].

Example: Nominal (primary) voltage in a medium-high voltage system amounts to 20 kV. Measurement is performed in the measuring cell at 100 V (secondary).
A Uratio of 200 must be selected in order to apply the measurement to primary voltage.

10 Maintenance and Repair

Housing

No special maintenance is required for the housing. Keep outside surfaces clean. Use a slightly dampened cloth for cleaning. Avoid the use of cleansers and abrasives.

Fuses

The power power supply of the MAVOWATT 45 is equipped with fuses at both the primary and the secondary sides:

- Mains Power Input (primary)

The mains power fuses are located next to the mains inlet and are accessible from outside the instrument.

Fuses appropriate for the mains voltage configuration at the instrument must be used here.

For 230 V: 2 ea. fuse link, 5 x 20 mm, T0.3A/250V

For 115 V: 2 ea. fuse link, 5 x 20 mm, T0.6A/250V

Replacing Fuses → see chapter 2.1.1.

Observe **WARNING 12**!

- Power Supply Output (secondary)

These fuses are located inside the instrument and are not accessible from the outside. They may blow, for example, if an incorrect cable is connected to the RS232 interface which causes short-circuiting of supply power for the PSI printer at pin 9.

2 ea. fuse link, 5 x 20 mm T1.8A/250V

Replacing Fuses

☞ Disconnect the instrument at all poles from the measuring circuits and mains power.

☞ Loosen the two screws at the bottom of the instrument, press the two green buttons to the side and lift the housing base at the same time.

☞ The two secondary fuses are now accessible and can be inspected and replaced if necessary.

Observe WARNINGS 11 and 12!

Battery

The instrument is equipped with an internal lithium battery which has a service life of approximately 8 years for powering the real-time clock, and for maintaining instrument configurations and energy measurement readings.

This battery must be replaced as soon as it has been determined that these parameters no longer remain in memory after the instrument has been switched off.

The battery is soldered to an assembly board which is situated behind the instrument's front panel, and can only be accessed with special tools. We therefore recommend that you send the instrument to the service address shown below for repair, especially since a general overhaul of the instrument is recommended as well after such a long period of time.

SECUTEST PSI Printer Module (Option)

- Batteries

The memory included with the SECUTEST PSI is not used in combination with the MAVOWATT 45, and no batteries need to be installed for this reason.

- Recording Chart

Check to make sure that sufficient recording chart paper is in the printer at regular intervals. The dot matrix printer should not be operated without paper, because damage to the printing head might otherwise occur.

The recording chart paper may become deformed within the printer if high humidity and excessive ambient temperatures prevail. The printing mechanism is then no longer able to advance the recording chart. In such cases, remove the deformed paper as well as approximately an additional 20 cm of recording chart and reinsert.

The designation (order no.) for 1 package of 10 rolls of recording chart paper is: PS-10P.

- Ink Ribbon Cartridge

Approximately 6 rolls of recording chart can be printed with 1 ink ribbon cartridge. If the print-out has a faded appearance, the ink ribbon cartridge should be replaced.

The designation (order no.) for 1 package of 10 ink ribbon cartridges is: Z3210.

- Installing Recording Charts and/or Ink Ribbon Cartridges

☞ Loosen the two knurled screws at the PSI module and remove it from the lid of the instrument.

☞ First open the rear cover for the paper compartment, and then the printer cover with the tear-off edge.

☞ Gently press on the right side of the ink ribbon cartridge until it swings out of its holder. Carefully remove the ink ribbon cartridge.

☞ Slide the leading edge of the recording chart into the guide slot in the printing mechanism from below, and turn the feed roll until the leading edge of the recording chart protrudes through the guide slot.

☞ Feed the paper between and through the ink ribbon and the cartridge.

☞ Insert the ink ribbon cartridge with the ribbon tensioning screw pointing to the left into the left-hand guide. Snap the cartridge into its holder by gently pressing on the right-hand side. Make sure that the ink ribbon is flat and smooth, and that it is situated entirely underneath the recording chart. Tension at the ink ribbon can be adjusted with the ink ribbon tensioning screw.

☞ Return the tear off edge to its original position and close the paper compartment cover by pressing until it audibly snaps into position.

Repair and Replacement Parts Service

If required please contact:

GOSSEN-METRAWATT GMBH
Service
Thomas-Mann-Strasse 16-20
D-90471 Nuremberg, Germany

Telephone +49 911 8602-410 / 411
Telefax +49 911 8602-253

This address is only valid in Germany.
Please contact our representatives or subsidiaries for service in other countries.

Product Support

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