MAVOWATT®45
Energy and Power Disturbance Analyzer

3-348-795-03
6/7.00

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 speed drives) 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 (optional harmonic analysis, power disturbance and flicker analysis), right on up to analysis and recording of energy consumption.

The Energy Analyzer 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. With the FFT option, it functions as a test instrument and compares harmonic current from load components with predefined limit values.

Thanks to its compact and rugged design, the MAVOWATT 45 is not restricted to stationary operation, but can also be used for mobile applications.

Included Basic Functions

Measuring

- Contemporary 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 three-phase systems as instantanuous (RMS) values in minimum cycles of 1s, as well as extreme values and mean values within adjustable interval (minimum 2 s):
  – phase-to-neutral and phase-to-phase voltages,
  – phase currents and neutral current,
  – active, apparent and reactive power and energy,
  – power demand, power factor and crest factor, frequency

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 variables
- Display of setup menus in various languages
- Display of operating and connecting instructions

Monitoring

- Acquisition of violated limit values (user adjustable) for four selectable measured quantities. Limit violation is indicated with a group alarm by switching a floating relay contact and triggers a print-out of the respective measured values on the optional printer module.

Registration and Documentation

The measurement data can be

- printed on a paper strip with the optional printer module (accessory *SECUTEST PSI*),
- stored to a plug-in PCMCIA flash memory card (accessory *Memory Card*),
- transmitted via the RS232 interface to a PC running the Windows software *METRAwin®45* (accessory) for presentation, analysis, documentation or export of the data to other programs.

Options

The instrument can be equipped with the following optional functions (for description see following pages):

- MAVO-FFT – Harmonic Analysis
- MAVO-PDA – Power Disturbance Analysis
- MAVO-TCM – Transient and Converter Measurements
- MAVO-FSA – Flicker Analysis

Options are installed by the user 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.

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General

Power Supply

For auxiliary power supply the MAVOWATT 45 requires 230Vac or 115Vac line voltage.

If the instrument is to be used for power disturbance analysis of its own power supply, and if power failures >30ms are expected to occur, a commercially available uninterruptible power supply (UPS) or the one being offered as accessory can be utilized.

Isolated Measurement Inputs

The MAVOWATT 45 has 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-high 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.

  The 2-pole, floating inputs are electrically isolated from one another.
- Three analog current measurement 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.

  The 2-pole, floating inputs are electrically isolated from one another.
- Three digital counter inputs Dig.-In. P4, P5, P6 for the determination of energy and power demand quantities through the use of interconnected pulse generators (usually meters with pulse outputs). The corresponding counter constant, *cconst*, can be selected individually for each input.

  The 2-pole, floating inputs (S_0 compatible, max. 48 V) are functionally isolated from one another.

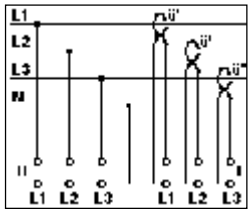
The SYNC. input enables synchronization of the two measuring time periods, *interval* (for determination of general minima, maxima and average values) and *period*, (aggregation time interval for demand power) to the clock pulse of the electricity supplier.

Simultaneous Signal Processing

The applied measurement signals run via internal voltage deviders to 16 bit A/D-converters. Signal conversion and processing is executed individually for each phase channel in real-time. By means of this simultaneous measurement an exact registration of the phase relation in a three-phase power system is achieved. The measuring principle is a waveform independent true r.m.s. (TRMS) measurement.

Each A/D-converter is coupled to a Digital Signal Processor (DSP) which calculates the values of the requested measurement quantities and transmits the results via opto-couplers with high insulation to the MAIN CPU. This processor controls all activities of acquisition, processing and presentation of the measured signals as well as inputs from the operating elements and outputs to LC Display, PC card and serial RS232 interface (printer module, PC).

Alphanumeric and Graphic Display



The illuminated LC dot-matrix display not only shows measurement results, status informations and setup menues, but also operating and connecting instructions. For the representation of measured values, series measurements and analyses at the LCD various display formats are available.

Multilingual Menu-Driven Operation

Measured quantities and functions are selected with the function selector rotary-switch. By means of four pushbuttons the menu-driven selection and adjustment of display formats, operating modes, parameters and functions is made. The fifth key, **i**, is used to query a directory which contains information concerning the current selector switch position.

For the language of the setup menus a choice can be made between two options (German/English as standard) Other language versions (French, Italian, Spanish, Dutch) are available as software modules on a diskette supplied with the instrument and can be uploaded into the device from a PC via its serial port.

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

High application safety is achieved and faulty operation is largely excluded due to the galvanic isolation of the three phase channels and the auto-ranging measurement inputs.

Storage of Measurements

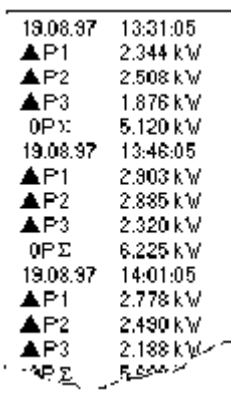
- As standard the MAVOWATT 45 contains a volatile RAM as operating memory (FIFO register) for approx. 900 measured values of the selected quantities including time stamp. The content of the register can be displayed in tabular form or as a Y-t graph and provides the basis for statistical analysis.
- A non-volatile image memory stores up to 15 „screen-shots“ which can be recalled into the display with the „REPlay Hardcopy“ function.
- The measuring results of all analysis functions can be stored to non-volatile measurement data memory with the plug-in PC card being available as accessory *Memory Card* (PCMCIA flash memory card; AMD Series C; memory density: approx. 250.000 meas. values/MByte).

  Measurement data of up to 20 quantities of power/energy analysis will be stored as MIN/MAX/AVR or present value with selectable interval in tabular format with date and time. Data of FFT, FSA, PDA and Transient measurements are stored in the chosen display format. Recorded data can be displayed at the LCD but for analysis of long-time recordings the use of software METRAwin®45 is recommended.

Printing

The following printing features are made possible with the optional SECUTEST PSI printer module:

- Manually triggered print-out of the current LC display;
- Time controlled print-out (interval printing) of respective measurement values at the end of a selected time period;
- Measurement value driven print-out (alarm printing) of measurement values for up to four selectable quantities dependent upon individually adjustable limit values.



Power and Energy Analysis

Available Measured Quantities

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 power demand analysis (E, P).

Up to 20 measured quantities can be assigned to each of the selector switch positions SEL1 through SEL4 in any desired order.

In total 75 different measured quantities are offered:

Formula Char.	Quantity	Unit of Meas.	Assignable Meas. Type				
U1	L1 phase-to-neutral voltage	V	▲	▼	■		
U2	L2 phase-to-neutral voltage	V	▲	▼	■		
U3	L3 phase-to-neutral voltage	V	▲	▼	■		
UΣ	Equivalent 3-phase wye voltage	V	▲	▼	■		
I1	L1 phase current	A	▲	▼	■		
I2	L2 phase current	A	▲	▼	■		
I3	L3 phase current	A	▲	▼	■		
IΣ	3-phase total current	A	▲	▼	■		
In	Neutral conductor current	A	▲	▼	■		
U12	L1-2 phase-to-phase voltage	V	▲	▼	■		
U23	L2-3 phase-to-phase voltage	V	▲	▼	■		
U31	L3-1 phase-to-phase voltage	V	▲	▼	■		
P1	L1 active power	W	▲	▼	■	0	1
P2	L2 active power	W	▲	▼	■	0	1
P3	L3 active power	W	▲	▼	■	0	1
PΣ	3-phase total active power	W	▲	▼	■	0	1
P4	Active power at digital counter input 4	W	▲	▼	■	0	1
P5	Active power at digital counter input 5	W	▲	▼	■	0	1
P6	Active power at digital counter input 6	W	▲	▼	■	0	1
PcΣ	Total active power at digital counter inputs 4+5+6	W	▲	▼	■	0	1
Q1	L1 reactive power	var	▲	▼	■	0	1
Q2	L2 reactive power	var	▲	▼	■	0	1
Q3	L3 reactive power	var	▲	▼	■	0	1
QΣ	3-phase total reactive power	var	▲	▼	■	0	1
Qc	Reactive power at digital counter input 4	var	▲	▼	■	0	1
S1	Apparent power at L1	VA	▲	▼	■	0	1
S2	Apparent power at L2	VA	▲	▼	■	0	1
S3	Apparent power at L3	VA	▲	▼	■	0	1
SΣ	3-phase total apparent power	VA	▲	▼	■	0	1
DQ1	Required compensating reactive power at L1 to attain preset power factor *PFnom*	var	▲	▼	■	0	1
DQ2	Required compensating reactive power at L2 to attain preset power factor *PFnom*	var	▲	▼	■	0	1
DQ3	Required compensating reactive power at L3 to attain preset power factor *PFnom*	var	▲	▼	■	0	1
DQΣ	Required total compensating reactive power to attain preset power factor *PFnom*	var	▲	▼	■	0	1
WP1	Active energy at L1	Wh				0	1
WP2	Active energy at L2	Wh				0	1
WP3	Active energy at L3	Wh				0	1
WPΣ	Total active energy in 3-phase system	Wh				0	1
WQ1	Reactive energy at L1	varh				0	1
WQ2	Reactive energy at L2	varh				0	1
WQ3	Reactive energy at L3	varh				0	1
WQΣ	Total reactive energy in 3-phase system	varh				0	1
WS1	Apparent energy at L1	VAh				0	1
WS2	Apparent energy at L2	VAh				0	1
WS3	Apparent energy at L3	VAh				0	1
WSΣ	Total apparent energy in 3-phase system	VAh				0	1
W4	Active, apparent or reactive energy at counter input 4 (depending upon type of interconnected impulsing meter)	VAh				0	1
W5	Active, apparent or reactive energy at counter input 5	VAh				0	1
W6	Active, apparent or reactive energy at counter input 6	VAh				0	1
WPT1	Total active energy cumulative for tariff zone 1	Wh				0	1
WPT2	Total active energy cumulative for tariff zone 2	Wh				0	1
WPT3	Total active energy cumulative for tariff zone 3	Wh				0	1
W4T1	Active, apparent or reactive energy at counter input 4, cumulative for tariff zone 1	VAh				0	1
W4T2	Active, apparent or reactive energy at counter input 4, cumulative for tariff zone 2	VAh				0	1
W4T3	Active, apparent or reactive energy at counter input 4, cumulative for tariff zone 3	VAh				0	1
W5T1	Active, apparent or reactive energy at counter input 5, cumulative for tariff zone 1	VAh				0	1
W5T2	Active, apparent or reactive energy at counter input 5, cumulative for tariff zone 2	VAh				0	1
W5T3	Active, apparent or reactive energy at counter input 5, cumulative for tariff zone 3	VAh				0	1
W6T1	Active, apparent or reactive energy at counter input 6, cumulative for tariff zone 1	VAh				0	1
W6T2	Active, apparent or reactive energy at counter input 6, cumulative for tariff zone 2	VAh				0	1
W6T3	Active, apparent or reactive energy at counter input 6, cumulative for tariff zone 3	VAh				0	1
PF1	Power factor at L1	cap./ind.	▲	▼	■		
PF2	Power factor at L2	cap./ind.	▲	▼	■		
PF3	Power factor at L3	cap./ind.	▲	▼	■		
PFΣ	Power factor for the 3-phase system	cap./ind.	▲	▼	■		
PFc	Power factor derived from counter inputs 4 (Q) and 5 (P)	cap./ind.	▲	▼	■		
cu1	Crest factor of voltage U1	–	▲	▼	■		
cu2	Crest factor of voltage U2	–	▲	▼	■		
cu3	Crest factor of voltage U3	–	▲	▼	■		
cuΣ	Mean crest factor of voltages U1, U2, U3	–	▲	▼	■		
f	Frequency of voltage U1	Hz	▲	▼	■		
ci1	Crest factor of current I1	–	▲	▼	■		
ci2	Crest factor of current I2	–	▲	▼	■		
ci3	Crest factor of current I3	–	▲	▼	■		
ciΣ	Mean crest factor of currents I1, I2, I3	–	▲	▼	■		
Rot	Phase sequence (rotation sense) for all voltages in the 3-phase system	> / <					

Individually for each selected quantity its evaluation can be performed in different Measurement Types:

– = Instantaneous: (RMS) value at present (acquired once per refresh cycle (minimum 1s) from an integral over 20 signal cycles),

▲ = MAX: Highest instantaneous value within adjustable interval (2 ...1800s),

▼ = MIN: Lowest instantaneous value within adjustable interval,

■ = AVR: Arithmetic mean value within adjustable interval,

0 = Period 0: Arithmetic mean value within currently running adjustable period,

1 = Period 1: Arithmetic mean value within last completed adjustable period.

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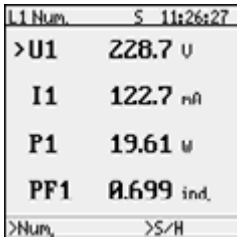
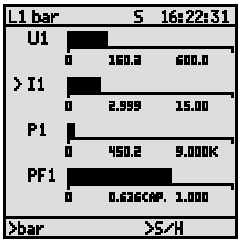
Representation of Measurement Values and Series Measurements

Various display formats are available for the representation of measurement values, series measurements and analysis at the LCD.



The numeric display format presents the currently measured values simultaneously for up to ten quantities as 4-digit numbers with floating decimal point, unit of measure and with polarity indication.

Evaluation is made considering the individually adjustable transmission ratios for the connected current and voltage transformers.

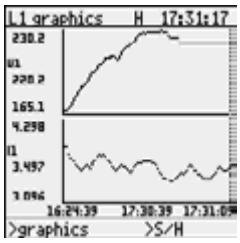


With bar-graph display mode the currently measured values for up to four quantities are displayed as horizontal bars.

Scaling is performed automatically in discrete ranges. In addition to the bar graph, the respective measurement values and ranges are also displayed numerically.

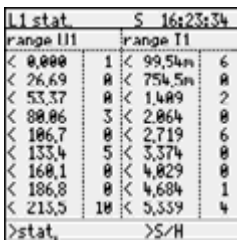
Numeric display of measurement values contained in the FIFO register for a measured quantity as a table including measurement value and time.

Logging the measured values into the table and if being used also into memory card takes place according to the set time interval.



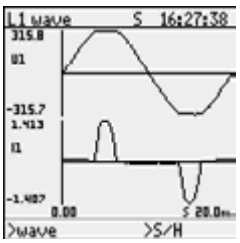
Graphic display of measurement values in the FIFO register for a given measured quantity as a Y-t graph.

For example when using an interval of 900 s, then under SEL1 ...4 the 15 minute average of a measurement quantity and/or ist min/max value(s) within each interval can be observed over a period of 23 hours.



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

The classes are defined automatically between the lowest and the highest registered value.

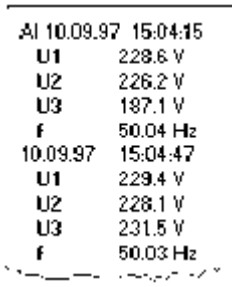


Graphic display of the voltage and/or current waveshape based upon the currently sampled values at the respective analog measurement input.

Scaling of the Y and t axes is performed automatically and indicates the respective signal peak amplitudes and the cyle time.

In this display mode also the distortion and phase shift of voltage and current can be recognized

Print-Out and Signalisation of Limit Value Violations



Upper and lower limit value violations can be printed out for four selectable measured quantities

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.

Violations of upper and/or lower limit values are also indicated by means of an alarm output (changeover contact) which functions as a group interrupt.

Alarm printing and signal response time correspond to the value refresh time of 1 s minimum. 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.

Evaluation of Power Consumption in Different Tariff Zones

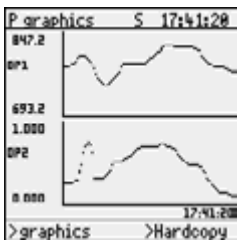
Tariffs established by the power utilities include a wide variety of tariff types with different tariff zones. Tariffs for special clients (i.e. large customers) further broaden the range of tariff types.

With the MAVOWATT 45 up to six times of a day can be assigned to three tariff types for recording of the specific energy consumption.

Evaluation of Peak Demand Power

As a matter of principal evaluation of chargeable demand for billing purposes is different to measurements in other fields of mains power metrology.

Therefore a second measuring interval (demand observation period) is available for power and energy measurements. Both measuring intervals ("Interval" and "Period") can be used simultanuosly for evaluation of mains quantities with different measurement types.



Based on the accumulated energy consumed within the set time period the periodic power demand is calculated, saved and then reset. The load curve results from the consecutive registration of periodic power values. Usually the (three) highest periodic power values which occur during given billing periods are used by the power utilities for evaluation of the chargeable demand.

The maximum or averaged power value within the set interval can simultanuously be registered. This shows the highest short-term loading of the system for rating of the system components.

Via a SYNC input both measurement intervals can be synchronized with the clock supplied by the power utility.

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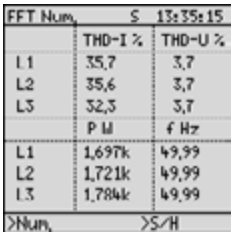
Harmonic Analysis (Option MAVO-FFT)

The harmonic analysis option is used for simultaneous acquisition, display and analysis of voltage and current harmonics up to the 50 th harmonic in power supply systems with fundamental frequencies ranging from 15 to 400Hz.

Fast Fourier Transformation is used for continuous, uninterrupted acquisition and analysis of DC components, fundamental frequencies and harmonics by means of a 16 period rectangular window in real-time at all three phases. Various analysis and display modes allow for quantitative and qualitative evaluations of semi-stable, as well as fluctuating harmonics.

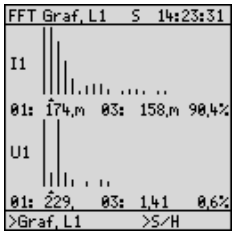


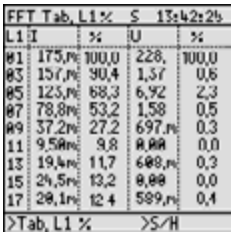
As a basic analysis, the measurement values for respective THD (total harmonic distortion) for all three phases can be simultaneously displayed in numeric format for both voltage and current, or can be statistically classified.

A detailed analysis can be displayed in either graphic or tabular form.

The graphic representation shows the frequency spectrum for harmonic content as a bar graph.

In addition to this, fundamental frequency measurement values, as well as one selectable harmonic or the DC component are displayed numerically.



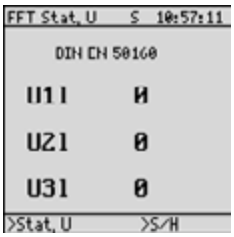


The tabular representation shows either fundamental frequency measurement values and the odd harmonics, or the DC components and the even harmonics. Phase angles as related to the voltage fundamental, or the respective percentage value for harmonic content can also be displayed.

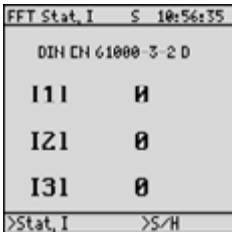
These displays appear for one selected phase only, although simultaneous recording to a PC memory card is possible for all three phases.

Furthermore the MAVO-FFT option offers two test functions:

- During non-gaping evaluation of the voltage harmonics and comparison to the limits of EN 50160 (Voltage characteristics of electricity supplied by public distribution systems) a counter registrates the number of violations within an adjustable time interval.



- During non-gaping evaluation of the current harmonics and comparison to the limits of EN 61000-3-2 (Limits for harmonic current emissions of equipment with input current <16 A/phase) a counter registers the number of violations within an adjustable time interval.



Power Disturbance Analysis (Option MAVO-PDA)

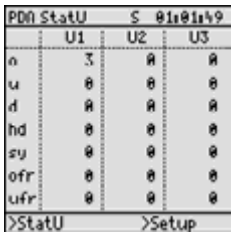
The MAVO- PDA option allows for the documentation of significant line voltage characteristics as required by EN 50160 on the one hand, and, for example, the analysis of dynamic parameters at load components as well.

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:

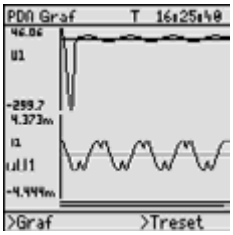
- Number and type of voltage and frequency events which occurred within an adjustable interval period;

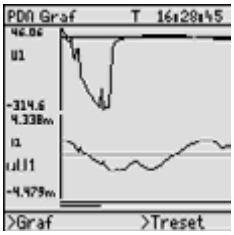


- Number and type of current events which occurred within an adjustable interval period;

- 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:





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Transient and Converter Measurements (Option MAVO-TCM)

The MAVO-TCM option expands the scope of functions as well as the applications possibilities for the MAVOWATT 45 through the inclusion of two special utilities for mains systems measurements:

- On the one hand, this option allows for the logging of short, transient events which occur in alternating or direct voltage systems, and at load components driven by such systems;
- On the other hand, the instrument is equipped with the capability of ascertaining the measurement quantities, which are included in the basic functions for power and energy analysis also at the outputs of frequency converters.

The Measurement of Transients

The MAVO-TCM option allows for logging of voltage and current transients with a duration of at least 20 µs, and voltage levels of up to 1500 V_p.

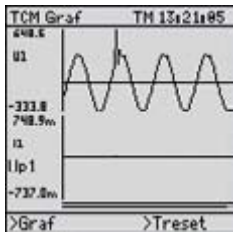
As opposed to the MAVO-PDA option with its RMS value trigger criteria, trigger parameters for the registration of line faults are based upon sampled values when the TCM function is active.

Level Triggers U_p and I_p: The trigger is derived from a comparison of the sampling value quantity and the set limit value.

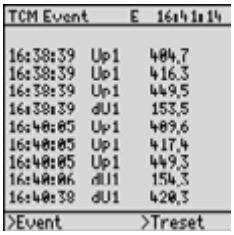
Slope Triggers *dU/dt* and *dI/dt*: The trigger results from a comparison of the rate of rise or fall of two consecutive sampled values and the set limit value (V/ms or A/ms).

The time interval between two consecutive sampling operations, and thus the minimum duration of recognizable events, can be selected in six steps ranging from 20 µs to 648 µs.

After an event has been recognized in the *Graph* display mode, approx. 3900 sample values (corresponds to 78 ms to 2.5 s of recording time) for current and voltage of the concerning phase are stored to memory and displayed as a characteristic curve with indication of the cause of triggering under consideration of the percentage value selected for the Pre-Trigger.



In addition to the logging of sporadic line voltage faults, this type of representation is also well suited for the recording of current and voltage signal characteristics when load components are switched on (e.g. motor start-up).



An *Events* list can be used for the recording of rapid, consecutive trigger events. Up to approximately 40 events per second are recorded in order of occurrence with date, time, cause of triggering, measurement magnitude and sampled or slope measurement value.

Frequency Converter Measurements

The frequency converters which are currently used for the control of electric motor speed are usually equipped with a high frequency square-wave output voltage which is pulse-width modulated by means of motor frequency. Measurement signals of this type require a special measuring process, by means of which the converter operating frequency is filtered out, and which is capable of determining the effective modulation frequency (fundamental frequency) at the motor. The MAVOWATT 45 can derive all of the power and energy analysis measurement magnitudes based on signals which have been conditioned in this fashion.

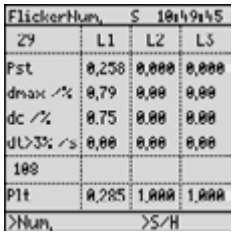
– The operating frequency must be greater than 1200 Hz and the fundamental frequency must lie within a range of 10÷100Hz.;
– For current sensing clip-on current transformers must be used.

Flicker Measurement (Option MAVO-FSA)

The MAVO-FSA option expands the MAVOWATT 45 to include a flicker meter function.

Flicker is defined as the subjective perception of brightness fluctuations at light fixtures caused by supply voltage fluctuations.

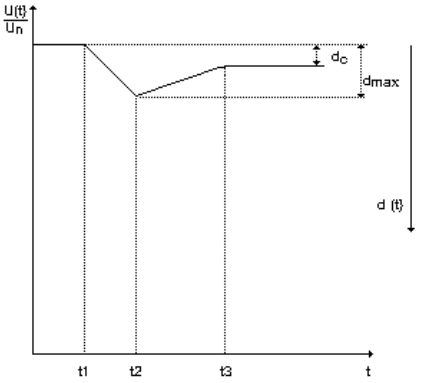
Fluctuations of this type can be measured and analyzed with the help of a flicker meter. EN 61000-4-15 (former EN 60868) defines the basic functional principle of the flicker meter, which simulates via an appropriate algorithm functional transfer characteristic of incandescent lamp → human eye → human brain. The flicker severity resulting from that serves as a measure for the human perception of disturbance caused by fluctuation of light intensity.



The values for the resulting measured quantities P_{st} (*10 min short-term flicker severity*) and P_{lt} (*2h long-term flicker severity*) 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 electrical equipment with rated current ≤16A with the CE mark as of 1 January 2001.

MAVOWATT®45
Energy and Power Disturbance Analyzer

Technical Data

Measuring Method

Acquisition	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 cycles of measured AC signal or 0.5s for DC within an adjustable refresh cycle ranging from 1 to 3600 s *FFT - Harmonic Analysis* (optional): gapless with a 16 cycles rectangular window *PDA - Power Disturbance Analysis* (optional): continuous with adjustable integration time for generation of RMS values = 2 / 4 / 8 / 16 cycles *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 using U1 signal zero crossings *FFT - Harmonic Analysis* (optional): determination of magnitude and phase angle 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 severity 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 four 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 values for voltage and current *FSA - Flicker Analysis* (optional): - short-term flicker severity Pst [x.xxx] - long-term flicker severity 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]

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

Memory

Image Memory

Function	non-volatile storage of any present measurement 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
Storage 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.YYYY Time hh:mm:ss
Resolution	1 s
Deviation	max. 1 minute per month

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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_{rms}	15	120	1000
Range Limit	Sine V_{rms}	14.5	138	1030
	Peak/DC V_{pk}	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_{rms}	120m	1
Range Limit	Sine V_{rms}	200m	1.7
	Peak/DC V_{pk}	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%
Waveform: Sine
cosφ: 1

1) Indicated measurement uncertainties apply under reference conditions after a warm-up period of 15 minutes for 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

Synchronisation 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

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

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

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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

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

Standard Equipment

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

- MAVOWATT 45L - M815C

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

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

1 power cable with grounding pin and recessed plug

1 RS232 interface cable

1 carrying case for instrument and accessories

1 floppy disc with software for the installation of instrument firmware in various languages

1 operating instruction 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, ident number Z823B

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

1 K45 hard cover case (instead of soft carrying case)

MAVOWATT®45
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Accessories

SECUTEST PSI Printer Module

The SECUTEST PSI report printer can be integrated into the instrument's housing cover and allows for on-site documentation.

Function	Print-out of measuring results, events and setup menus
Print Trigger	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

MAVO-RC8 Memory-Card

8 MB PCMCIA flash RAM memory card (PC card) for recording of long-term measurements.

The resulting measurement values of all analysis functions can be stored non-volatile to the plug-in memory card.

Recording capacity: approx. 2 million measured values.

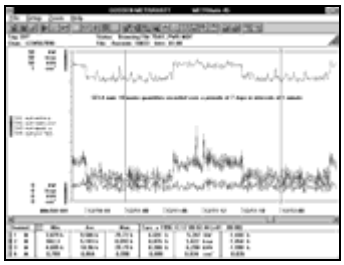
K45 Plastic Case

Hard cover carrying case with foam inserts for MAVOWATT 45 and accessories.

METRAwin®45 Analysis Software

METRAwin 45 software for Windows can be used for read-out, storage, presentation and processing of measurement data from the MAVOWATT 45 at a PC.

Data transfer is accomplished either online (except with optional functions) or from the PC-Card directly via the RS 232 interface or by means of modem.

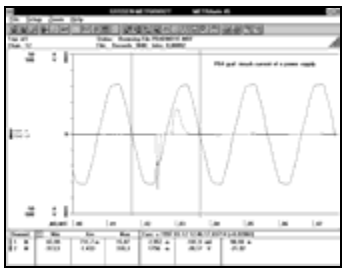


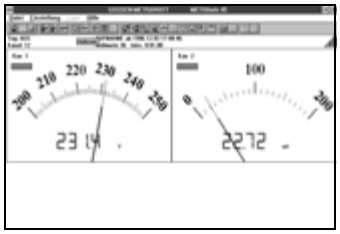
Y- t Recorder

Recorded measurement values from up to four freely selectable channels are displayed at the monitor as a line diagram with a horizontal time axis, and are measured off with two cursors. Amplitude and the time axis of stored signals can be expanded (zoom) and compressed.

High- Speed Y- t Recorder

Voltage and current signals recorded with the PDA/ TCM graph function at the MAVOWATT 45 can be analyzed with a time resolution of up to 20 µs.





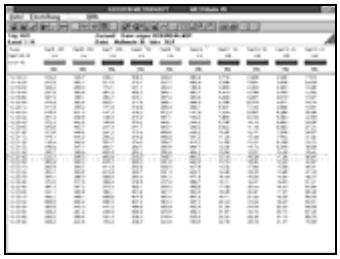
Multimeter

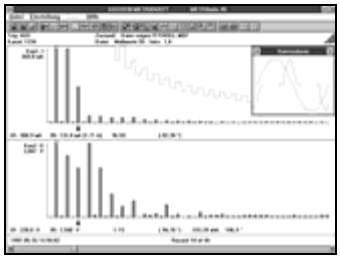
Transmitted measurement values from up to four freely selectable channels are displayed at the monitor in digital form with an additional analog scale in online operation, or as an analog pointer instrument with an additional digital display.

Tabular Display

Recorded measurement data from up to 10 channels are numerically displayed at the monitor in an easy to read table.

Measurement values can be exported to other programs via the clipboard.





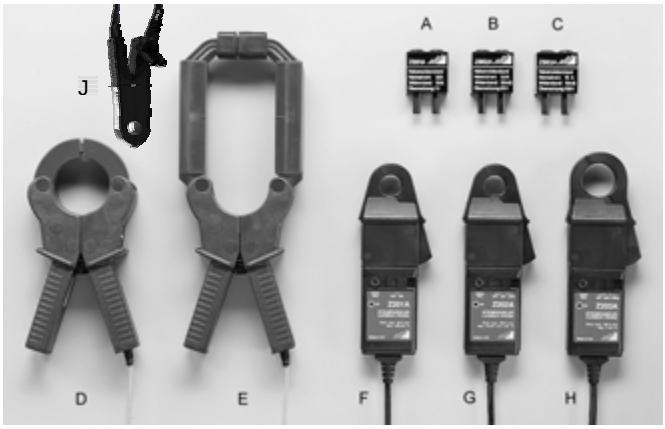
FFT Frequency Spectrum

Harmonic measurement data recorded with the FFT Tab. function at the MAVOWAT T45 are displayed as a frequency spectrum with a vertical bar graph. Limit value boundaries for various standards and reconstructed wave-shapes can also be displayed.

Minimum System Requirements

Hardware	PC with processor 80486 / 33 MHz / 4 MB RAM / min. 4 MB free memory on harddisk / mouse / diskette drive 3.5‘‘/1.44 MB / 1 free COM port / VGA monitor / printer, if print-outs are desired
Software	Operating system Windows 3.x/95/98 or NT4.0

Current Sensors



Type	Fig.	Description	suitable for*)	Measuring Range Nominal	Measuring Range Useable Range with MAVOWATT 45	Overall Meas.Uncert. (Sensor+M'WATT45) @ Ref. Conditions ±[...% of rdg. + ... A]	Output - Signal	Ident Number
Z201A	F	Active clip-on current-voltage transformer, DC…20 kHz, with 9V battery (service life appr. 30 hrs.)	b, c	AC: 20 A_{rms} DC: 30 A	appr. 0.1 ... 17 A_{rms} (24 A_{pk}) appr. 0.1 ... 24 A	1.2% + 0.1 A_{rms} 1.2% + 0.1 A	100 mV~/A~ 100 mV/A	Z201A
Z202A	G	Active clip-on current-voltage transformer, DC…10 kHz, with 9V battery (service life appr. 50 hrs.)	b, c	AC: 20 A_{rms} AC: 200 A_{rms} DC: 30 A DC: 300 A	appr. 0.1 ... 20 A_{rms} appr. 1 ... 200 A_{rms} appr. 0.1 ... 20 A appr. 1 ... 200 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	Z202A
Z203A	H	Active clip-on current-voltage transformer, DC…10 kHz, with 9V battery (service life appr. 50 hrs.)	b, c	AC: 200 A_{rms} AC: 1000A_{rms} DC: 300 A DC: 1000 A	appr. 1 ... 200 A_{rms} appr. 1 ... 1000 A_{rms} appr. 1 ... 200 A appr. 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	Z203A
WZ12F	J	Passive clip-on current-voltage transformer; 30 Hz…500 Hz	a, (c)	AC: 15 A_{rms}	appr. 0.02…15 A_{rms}	2.2% + 2 mA_{rms}	100 mV~/A~	Z823E
WZ12E	J	Passive clip-on current-voltage transformer; 30 Hz…500 Hz	a, (c)	AC: 150 A_{rms}	appr. 0.2…150 A_{rms}	2.2% + 20 mA_{rms}	10 mV~/A~	Z823D
Z823B	D	Passive clip-on current-voltage transformer; 45 Hz…10 kHz	a, b, (c)	AC: 1000A_{rms}	appr. 1 ... 1200 A_{rms}	0.7% + 0.8 A_{rms}	1 mV~/A~	Z823B
Z821B	E	Passive clip-on current-voltage transformer; 30 Hz…5 kHz	a, b, (c)	AC: 3000A_{rms}	appr. 1 ... 3000 A_{rms}	0.7% + 1 A_{rms}	0.333mV~/A~	Z821B
AF033A	I	„Amp*FLEX*“ flexible current-voltage transformer, 10Hz…20kHz, with 9V battery (service life 150hrs.)	(a), b, c	AC: 30 A_{rms} AC: 300 A_{rms}	appr. 0.5 ... 17 A_{rms} (24 A_{pk}) appr. 0.5 ...170 A_{rms} (240A_{pk})	1.2% + 0.5 A_{rms} 1.2% + 0.6 A_{rms}	100 mV~/A~ 10 mV~/A~	Z207A
AF33A	I	„Amp*FLEX*“ flexible current-voltage transformer, 10Hz…20kHz, with 9V battery (service life 150 hrs.)	(a), b, c	AC: 300 A_{rms} AC: 3000A_{rms}	appr. 0.5 ...170 A_{rms} (240A_{pk}) appr. 0.5 …1700A_{rms}(2400A_{pk})	1.2% + 0.6 A_{rms} 1.2% + 3 A_{rms}	10 mV~/A~ 1 mV~/A~	Z207B
AF101A	I	„Amp*FLEX*“ flexible current-voltage transformer, 10Hz…20kHz, with 9V battery (service life 150 hrs.)	(a), b, c	AC: 1000A_{rms} AC: 10 kA_{rms}	appr. 5…1000A_{rms}(2400A_{pk}) appr. 5A …10kA_{rms} (24kA_{pk})	1.2% + 3 A_{rms} 1.2% + 20 A_{rms}	1 mV~/A~ 0.1 mV~/A~	Z207C
AF11A	I	„Amp*FLEX*“ flexible current-voltage transformer, 10Hz…20kHz, with 9V battery (service life 150 hrs.)	(a), b, c	AC: 1000A_{rms}	appr. 5 ... 1000 A_{rms}	1.2% + 3 A_{rms}	1 mV~/A~	Z207D
Z860A	A	Plug-on shunt 50 Ω, 0.2%, 1.5 W	a, b	AC: 20mA_{rms} DC: 20 mA	appr. 50µ …32mA_{rms}(48mA_{pk}) appr. 50 µA ... 48 mA	0.8% + 20 μA_{rms} 0.8% + 20 µA	50mV~/mA~ 50 mV/mA	Z860A
Z861A	B	Plug-on shunt 1Ω, 0.2%, 1.5 W	a, b	AC: 1 A_{rms} DC: 1 A	appr. 1 mA_{rms} …1A_{rms} (2.4A_{pk}) appr. 1 mA ... 1.2 A	0.4% + 1 mA_{rms} 0.4% + 1 mA	1 V~/A~ 1 V/A	Z861A
Z862A	C	Plug-on shunt 0.05 Ω, 0.2%, 1.5 W	a, b	AC: 5 A_{rms} DC: 5 A	appr. 0.02 ... 5 A_{rms} (40 A_{pk}) appr. 0.02 ... 5 A	0.4% + 20 mA_{rms} 0.4% + 20 mA	50 mV~/A~ 50 mV/A	Z862A
Z863A	C	Plug-on shunt 0.01 Ω, 0.2%, 1.5 W	a, b	AC: 16 A_{rms} DC: 16 A	appr. 0.1 ... 16 A_{rms} (40 A_{pk}) appr. 0.1 ... 16 A	0,4% + 0,01 A_{rms} 0.4% + 0.01 A	10 mV~/A~ 10 mV/A	Z863A

*) a = long-term measurements b = harmonic measurements c = frequency converter measurements

MAVOWATT®45
Energy and Power Disturbance Analyzer

USV Pulsar EL2

The Uninterruptable Power Supply Pulsar EL2 provides instantanuous power for mains supplied equipment at unstable line voltage.

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.

Input

Mains voltage	184 …264 V AC; 50 Hz
Connector	10A IEC inlet plug connector, mains power cable with earthing contact plug included

Output

Voltage	230 V~ ±5%
Frequency	50 Hz ±1 Hz
Power	220 VA / 120 W
Hold-up time	>4 min @ 200 VA >30 min @ 30 VA
Connector	2x 10 A IEC 320

Construction

Energy storage	NiCd accumulator 12V/1.3 Ah
Dimensions	H x W x D: 165 x 73 x 195 mm
Weight	1 kg
Electrical safety	EN 50091-1
EMC	EN 50022/B, EN 50091-2

Training classes are available – Please contact your local agent or the factory.

Ordering Informations

Designation	Type	Article Number
3-phase Energy Analyzer with RS232 interface, memory card slot, 3 pairs of measurement cables with 6 plug-on alligator clips, 4 measurement jumper cables with safety plugs, mains power cable, RS232 cable, carrying pouch, firmware diskette, operating instructions	MAVOWATT 45L	M815C
Same as MAVOWAT T45L, except with FFT, PDA, FSA and TCM options installed, incl. 3 passive clip- on current- voltage transformers Z823B, in K45 plastic case	MAVOWATT 45S	M815E
Options		
Software option for Harmonic Analysis	MAVO-FFT	Z850B
Software option for Power Disturbance Analysis	MAVO-PDA	Z851B
Software option for Transient Recording and Converter Measurement	MAVO-TCM	Z851C
Software option for Flicker Measurement	MAVO-FSA	Z851D
Accessories		
PSI printer module for MAVOWATT 45	SECUTEST PSI	GTM5016 000R0001
PCMCIA Flash memory card 8 MB	MAVO-RC8	Z845D
Plastic case with foam inserts for MAVOWATT 45 and accessories	K45	Z845C
Uninterruptable power supply 120W/220VA	USV Pulsar EL2	Z864B
Current sensors		
See page 11		
Software		
PC software for analysis of MAVOWATT 45 data (German, English, Spanish)	METRAwin 45	Z852B
Consumable material		
Pack of 10 rolls of recording chart paper for the SECUTEST PSI printer	PS-10P	GTZ3229 000R0001
Pack of 10 ink ribbon cartridges for the SECUTEST PSI printer	Z3210	GTZ3210 000R0001

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