

# 4-Channel Power Meter LMG450

Universal Meter for Motors, Power Electronics  
and Energy Analysis

Best  
Accuracy  
0.1%



**LMG450**

**General Information**

The 4-channel LMG450 power meter is another advanced product from ZES ZIMMER LMG series of precision power meters, tried and tested and with great acceptance in the market. It is designed as a universal meter for the entire field

of power electronics and network analysis. It can be used in practically all power electronics applications, in development and test systems, in quality assurance and maintenance. It is fully frequency inverter-compatible.

Of course, it can also be used for measurements in motors, transformers, conventional and switched power supply units. It is also suitable for mains analysis measurements.

**Easy operation thanks to colour graphics display and hotkeys for important measured values**

Various value tables can be called on the colour graphics display at the press of a key, either with 6 values in large letters, which can also be read at a glance from a greater dis-

tance, with 12 values or with up to 40 values e.g. in range setting or in harmonics table. The graphics display allows scope and plot functions for waveform and timing diagrams, as well as xy diagrams or bar charts for the harmonics. The status bar at the top of each display menu shows the

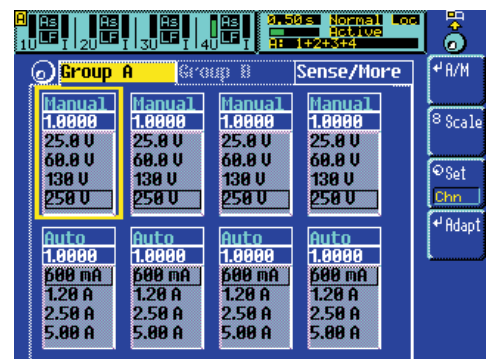
input level of the 4 voltage and the 4 current inputs – an important item of information for the quality of the measurement. The display also indicates what groups, A and B, the input channels are switched to and which signals the groups are synchronised to.



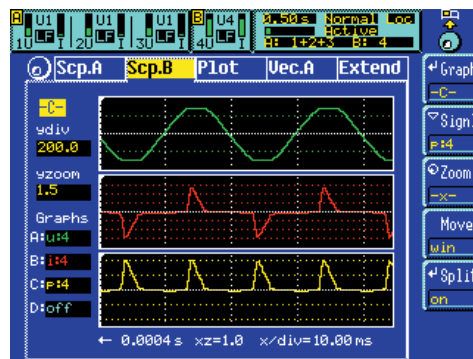
Status bar



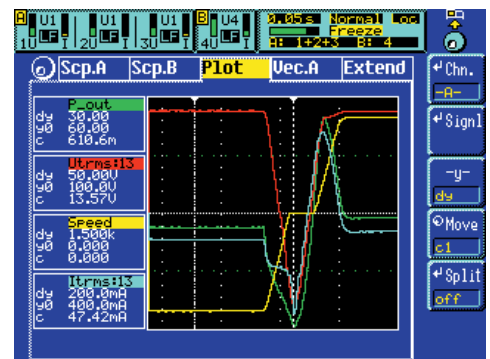
Channel 1 with 11 measuring values



Range setting and scaling



Scope function for waveform of sampling values



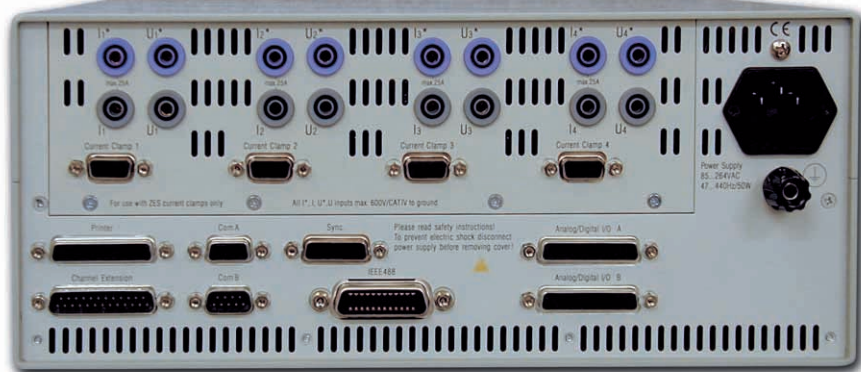
Plot function of calculated values

**Measurement inputs**

The direct measurement inputs for voltage and current have a very wide dynamic range: 8 voltage ranges from 6V to 600V, and 6 ranges for current from 0.6A to 16A. A further voltage input (6 ranges from 0.12V to 4V), designed for iso-

lating current sensors, extends the current measuring range almost indefinitely. With the help of the special current clamps supplied by ZES ZIMMER and designed for the LMG450, current can be measured during running operations, without

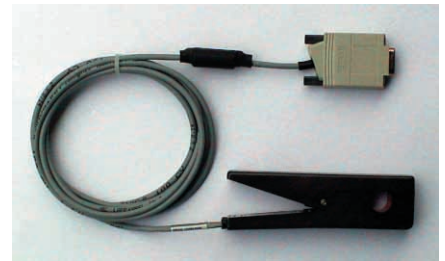
interrupting the current path, in the frequency range from 5Hz to 20kHz, and in the range from 45Hz to 1kHz even with the accuracy of direct current measuring inputs.



LMG450 - rear view

**Compensated current clamp**  
Part No. L45-Z06

A special current measuring device is the compensated current clamp by ZES ZIMMER. It features electronic compensation of amplitude and delay errors. Even at low current levels of 1A to 40A, measurement is exact in the frequency range from 5Hz to 20kHz. Due to its high dynamic common-mode rejection, this current clamp is also very suitable for carrying out measurements at the frequency inverter output.



Compensated current clamp L45-Z06

**Various methods of applying current to be measured**

	<p><b>Direct measurement</b> 0.6 ... 16A (6 Ranges) DC ... 20 kHz <math>\Delta I</math>: 0.25% (basic instruments accuracy) <math>\Delta P</math>: 0.3%</p> <p><b>Standard current clamps with current outputs &gt;0.5A</b> 100A ... 3000A 45Hz ... 3kHz <math>\Delta I</math>: 0.5% ... 1% <math>\Delta P</math>: &gt;1% (depends on phase error of clamp )</p>	<p><b>4mm safety sockets 600V CAT III</b></p> <p><b>HD15 sockets for external sensors</b></p>	<p><b>PSU600 Precision current transducer</b> 1A ... 600A<sub>peak</sub> DC ... 20kHz (300kHz, band width of sensor is limited by LM6450) <math>\Delta I</math>: 0.25% (basic instruments accuracy) <math>\Delta P</math>: 0.3%</p> <p><b>Standard current clamps with voltage/current (&lt;0.5A) outputs</b> 10A ... 200A 45Hz ... 3kHz <math>\Delta I</math>: 1% <math>\Delta P</math>: &gt;1% (depends on phase error of current clamp )</p> <p><b>Hall effect transducers</b> 5A ... 200A DC ... 20kHz <math>\Delta I</math>, <math>\Delta P</math>: 1%</p>
	<p><b>Compensated ZES current clamps</b> 1.2A ... 40A (6 Ranges) 5Hz ... 20kHz <math>\Delta I</math>: 0.25% (basic instruments accuracy) <math>\Delta P</math>: 0.3%</p> <p><b>Magneto-resistive current transducer modules</b> 5A ... 50A DC ... 20kHz <math>\Delta I</math>, <math>\Delta P</math>: 0.5%</p>		<p><b>DC/AC current clamps with voltage output e.g. for oscilloscopes</b> 10A ... 200A DC ... 20kHz <math>\Delta I</math>, <math>\Delta P</math>: &gt;2%</p>

**4 independent power measuring channels**

The current and voltage paths of the 4 power measuring channels are all isolated from each other and from earth. This allows a high degree of measuring freedom in many different power measurement applications.

The adjacent table shows various types of wiring for grouped and individual measurement channels. The table also assigns application examples for the respective types of wiring. Power measurement channels 1 and 4 can each be synchronised to their input signals (fundamental waves etc.) independent of each other.

Channels 1 and 4 are then the synchronisation references for the other channels contained in groups A and B.

This is a very useful method for carrying out efficiency measurements for equipment where the input and output have different frequencies, for example a 3-phase frequency inverter with single-phase mains supply.

Ch 1	Ch 2	Ch 3	Ch 4
4Ø 4W / 4Ø 5W			
1Ø 2W	1Ø 2W	1Ø 2W	1Ø 2W
3Ø 3W / 3Ø 4W / 4Ø 4W			1Ø 2W
3Ø 3W (Aron)		3Ø 3W (Aron)	
3Ø 3W (Aron)		1Ø 2W	1Ø 2W

Device	Measured Value	Ch 1	Ch 2	Ch 3	Ch 4	Appropriate setting of Wiring
4Ø motors	Power of all windings	Phase 1	Phase 2	Phase 3	Phase 4	A:1+2+3+4
High power batterie chargers (3Ø -> DC)	Input and output power, efficiency	Phase 1	Phase 2	Phase 3	DC-Out	A:1+2+3 B:4 (3+1, UΔ I* -> U* I*)
Rectifier section of inverters (3Ø -> DC)	Input power, rectifier efficiency	Phase 1	Phase 2	Phase 3	DC-Bus	A:1+2+3 B:4 (3+1, UΔ I* -> U* I*)
Output section of inverters (DC -> 3Ø)	Output power, chopper efficiency	AC-Out 1	AC-Out 2	AC-Out 3	DC-Bus	A:1+2+3 B:4 (3+1, UΔ I* -> UΔ IΔ)
1Ø -> 3Ø inverter Low power motor drives	Input and output power, efficiency	AC-Out 1	AC-Out 2	AC-Out 3	Phase 1	A:1+2+3 B:4 (3+1, UΔ I* -> U* I*)
Power supplies with multiple outputs	Input and output power, efficiency	DC-Out 1	DC-Out 2	DC-Out 3	Phase 1	A:1+2+3 B:4
1Ø Transformers with multiple output windings	Input and output power, efficiency	AC-Out 1	AC-Out 2	AC-Out 3	AC-In	A:1+2+3 B:4
3Ø loads with auxiliary supplies	Complete input power	Phase 1	Phase 2	Phase 3	Aux. AC or DC	A:1+2+3 B:4 (3+1, UΔ I* -> UΔ IΔ)
3Ø -> 3Ø inverter High power motor drives	Input and output power, efficiency	AC-In 1	AC-In 2	AC-Out 1	AC-Out 2	A:1+2 B:3+4 (2+2, UΔ I* -> UΔ IΔ)
3Ø -> 1Ø AC power source	Input-, output- and DC-Bus power, efficiency	AC-In 1	AC-In 2	DC-Bus	AC-Out	A:1+2 B:3+4 (2+2, UΔ I* -> U* I*)

Wiring settings in ( ) are featured by option „Star-Delta Conversion“

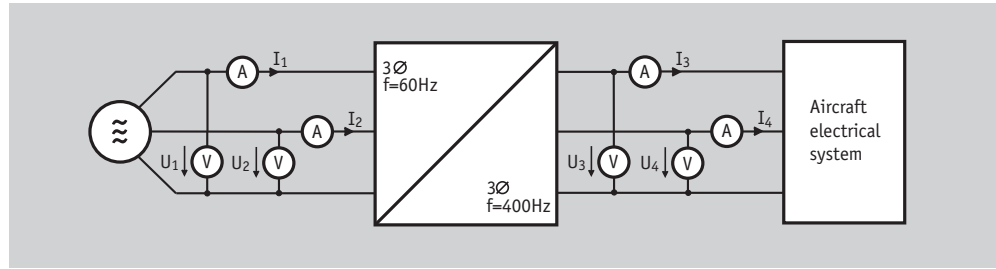
Group A  Group B

**Measurement on two systems with different frequencies**

In wiring A:1+2 B:3+4, the ARON circuit is two times used. The block diagram shows, that

only one LMG450 is needed for complete measurement. Generally frequency converters

for speed variable drives or frequency conversion have no neutral on input or output.

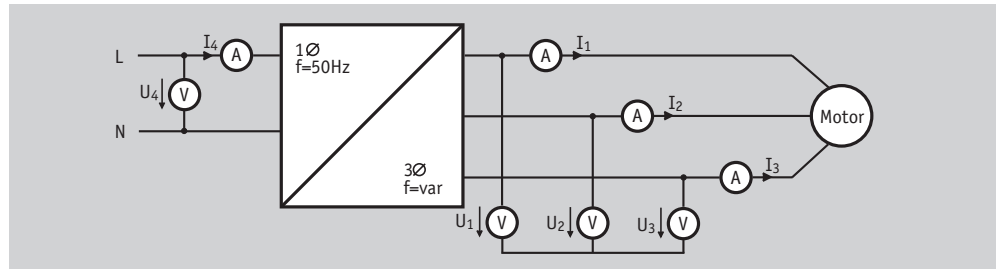


60Hz -> 400Hz

The following block diagram applies wiring A:1+2+3 B:4 and is typical for a low power

speed variable drive. This example is used to explain the settings and displays of the

LMG450. The screenshots were made with the free software BMP2PC from ZES ZIMMER.

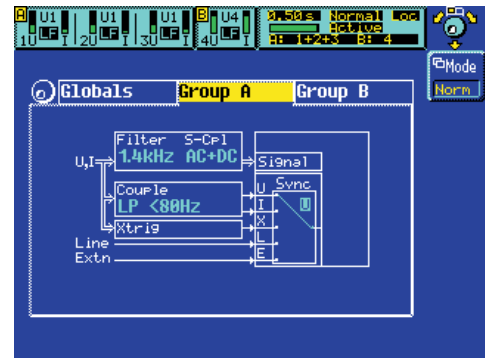


50Hz -> f=variable

Setting of global parameters, e.g. wiring (see table at previous page)



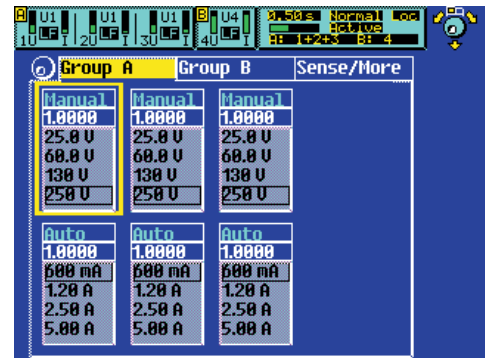
Configuration of measuring inputs and synchronisation source for group A



Configuration of measuring inputs and synchronisation source (same as before, but for group B)



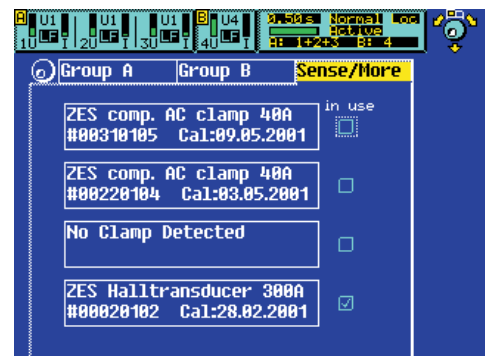
Measuring ranges, autorange or manual, setting of scaling factors for external CT's or VT's (group A)



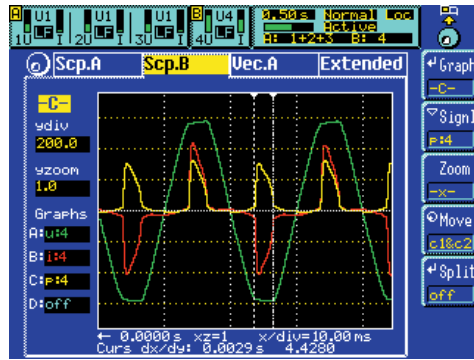
Measuring ranges, autorange or manual, setting of scaling factors for external CT's or VT's (group B)



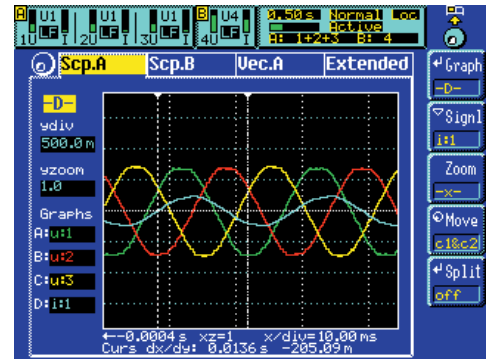
Display of different plugged external current sensor devices from ZES ZIMMER, here the bottom one is in use (enabled)



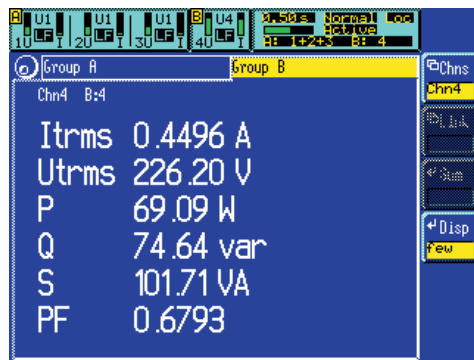
Scope of power (yellow), current (red) and voltage (green) of the frequency converter single phase input



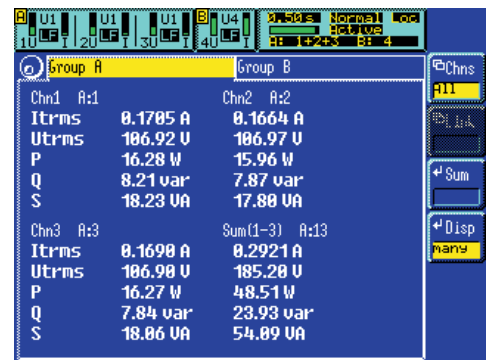
Scope display of the low pass filtered 3φ output, only the chopper frequency is removed



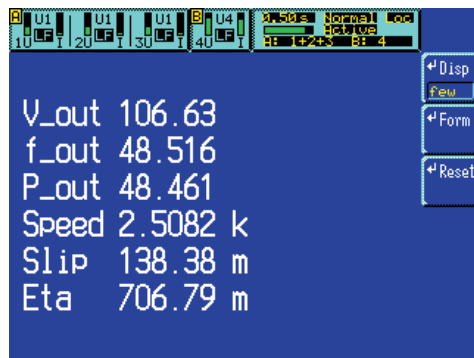
Large display with the most important values of the frequency converter input, measured in group B



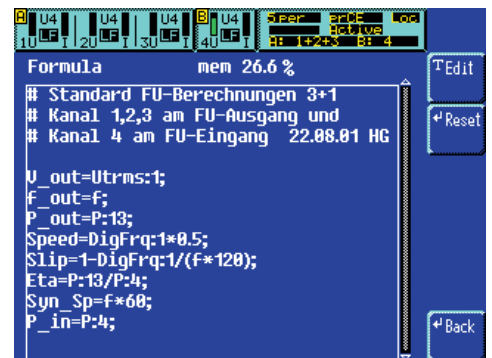
Phase values and summing values of the frequency converter 3φ output gives a quick overview (group A)



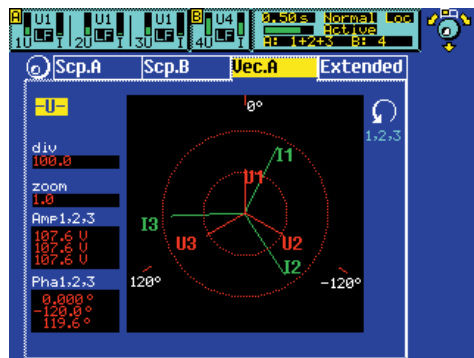
Efficiency, slip, speed and other interesting values calculated by user defined formulas



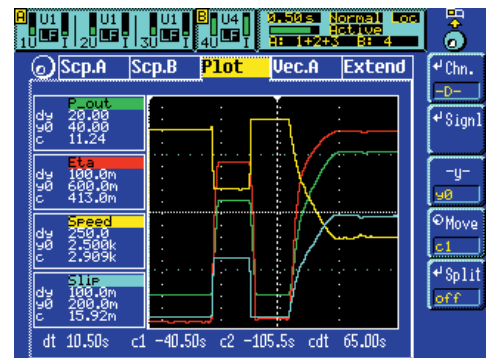
The formula editor provides the individual calculations shown in the previous picture



Vector display of 3φ systems immediately checks the phase sequence and shows phase interchanges



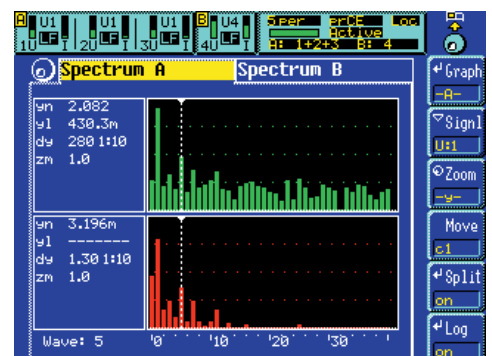
Plot display works like a strip chart recorder and can plot all measured or formula calculated values



Harmonic analysis conform to standard for precompliance tests



Spectrum as bar chart for current, voltage and their CE-limits, linear or logarithmic



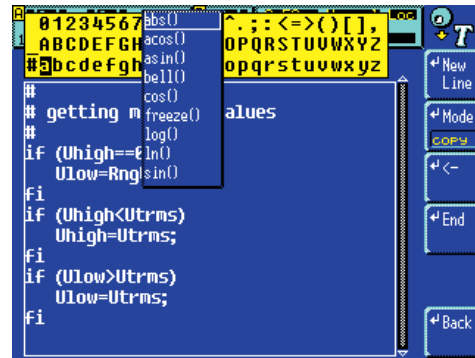
**All necessary functions in the basic device:**

- Printer interface
- RS232 interface
- Formula editor
- Harmonics analysis for CE pre-compliance

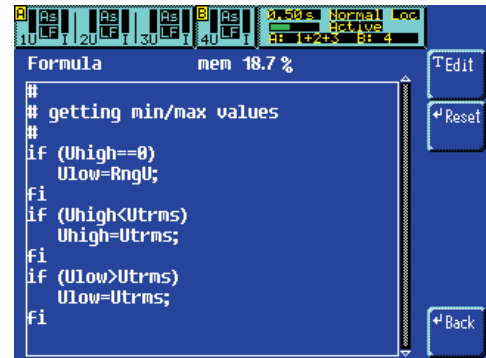
All necessary functions are included in the basic device at reasonable price.

Printer and RS232 interfaces, formula editor, harmonics analysis of current and voltage

for pre-compliance tests in accordance with EN61000-3-2.



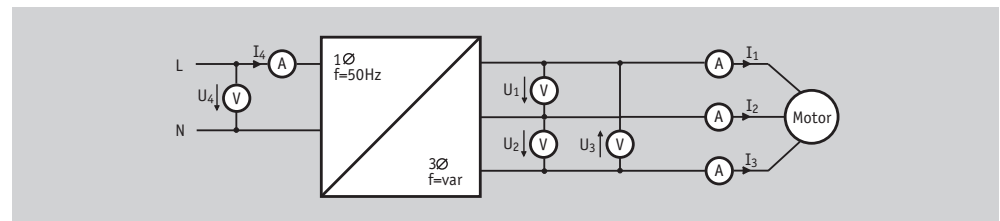
Formula editor: the window shows the available mathematical formulae, functions and logical conditions



Program example for the monitoring of overvoltage and undervoltage

**Options**

- **Star-Delta Conversion**  
Part No. L45-06

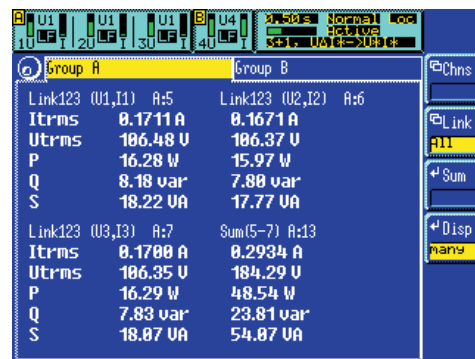


50Hz -> f=variable, motor in I\* UΔ wiring

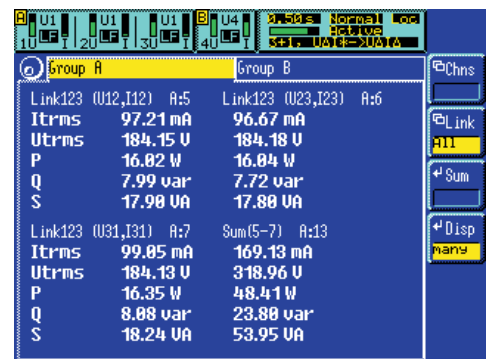
For detailed test and evaluation of 3φ motors the electrical quantities for each winding phase is needed. In some cases you have access to the motor terminal block with start and end of all three windings. Then you can measure all what you need. But in most cases the motor has only 3 terminals and

the internal star point or the delta winding as to measure its current is not accessible. Also far away from the motor you have only the three wires. With the option star-delta conversion you have the capability to calculate the not accessible values (e.g. voltages, currents, power, harmonics). This intelli-

gent solution with an additional DSP works well at all waveforms and every unbalance of mains and load. Simply connect the voltage paths in delta and click the current clamps around the wires. Select the internal connection of your load and press the "Link" softkey.



Calculation of the real values in the star connected winding phases (wiring: 3+1, UΔ I\* -> U\* I\*)



Calculation of the real values in the delta connected winding phases (wiring: 3+1, UΔ I\* -> UΔ IΔ)

**Further options:**

- **IEEE488 interface**  
Part No. L45-01
- **Disk or memory card**  
Part No. L45-02F or L45-02M
- **Flicker measurement,**  
Part No. L45-04
- **Process signal interfaces, digital and analog inputs and outputs**  
Part No. L45-03
- **Harmonics up to 99th from U, I and P,**  
Part No. L45-08
- **Transients**  
Part No. L45-05

The LMG450 can be expanded with the options mentioned here.

The **IEEE488 interface** can interpret the complete SCPI as well as the LMG450-specific command set. It has a data rate of up to 1 MByte/sec. The two memory media, **disk** or **memory card**, can be used as required. They serve to record measured and sampled values and to save and recall device settings (setups).

The **flicker measurement** option consists of a flicker

meter in accordance with EN61000-4-15, and signals are evaluated in accordance with EN61000-3-3.

Besides the current/voltage inputs for power measurement, further analog and digital measuring inputs and signal outputs are available in the so-called **process signal interface**. Further process magnitudes such as rotational speed and torque can be fed to the device to determine the efficiency level, using the formula editor. Signals can be derived

from the measured values and can be output again as control signals.

The **harmonics up to 99th** option can be used to analyse current, voltage and power related to the fundamental ranging from 0.1Hz to 1kHz. It is possible to detect interharmonics by a selectable division factor giving a new fundamental as reference. The **transients** option detects peaks and dips up to a resolution of 20µsec, scanning taking place at 50kHz.

## Dimensioning of insulation for all standard low voltages

The nominal voltage is dimensioned for 600V / Category III. This makes it possible to measure in all standard 3-phase low voltage networks. The adjacent table shows that the voltage "Line to Neutral/Earth" is always less than 600V.

3 Phase / 4 Wire	3 Phase / 3 Wire	Line to Line Voltage	Line to Neutral/Earth
66/115V		115V	66V
	120V	120V	69V
120/208V		208V	120V
	240V	240V	139V
230/400V		400V	230V
277/480V		480V	277V
	500V	500V	289V
400/690V		690V	400V
	1000V	1000V	578V

## Technical Data

### Voltage measuring ranges

Nominal value /V	6	12.5	25	60	130	250	400	600
Maximum trms value /V	7.2	14.4	30	60	130	270	560	720
Maximum peak value for full scale /V	12.5	25	50	100	200	400	800	1600
Overload capability	1500V for 1s							
Input impedance	1MΩ, 20pF							

### Current measuring ranges

Nominal value /A	0.6	1.2	2.5	5	10	16
Maximum trms value /A	1.3	2.6	5.2	10	18	18
Maximum peak value for full scale /A	1.875	3.75	7.5	15	30	60
Overload capability	18A permanent, 50A for 1s, 150A for 20ms					
Input impedance	2mΩ					

### Isolation

All direct current and voltage inputs of power measuring channels against each other and against earth isolated, max. 600V/CAT III

### Voltage measuring ranges for external isolated current transducers

Nominal value /V	0.12	0.25	0.5	1	2	4
Maximum trms value /V	0.15	0.3	0.6	1.2	2.5	5
Maximum peak value for full scale /V	0.25	0.5	1	2	4	8
Overload capability	250V for 1s					
Input impedance	100kΩ, 10pF					

### Measuring range selection

Automatic, manual or remotely controlled

### Measuring accuracy

45...65Hz, AC-Coupling	Measuring accuracy	± (% of measuring value + % of measuring range)			
		DC	1Hz..1kHz	1kHz..5kHz	5kHz...20kHz
0.05+0.05	Voltage	0.2+0.2	0.1+0.1	0.2+0.2	0.3+0.4
0.05+0.05	Current (direct)	0.4+0.4	0.15+0.1	0.2+0.2	0.5+0.5
0.07+0.08	Active power (direct)	0.5+0.5	0.2+0.1	0.3+0.2	0.6+0.5
0.05+0.05	Current (via ext. current transducer)	0.2+0.2	0.1+0.1	0.2+0.2	0.3+0.4
0.07+0.08	Active power (via ext. current transducer)	0.3+0.3	0.15+0.1	0.3+0.2	0.6+0.5

Accuracies based on:

1. sinusoidal voltage and current
2. ambient temperature 23 °C
3. warm up time 1h
4. definition of power range as the product of current and voltage range,  $0 \leq |\lambda| \leq 1$ , ( $\lambda$ =Power factor=P/S)
5. calibration interval 12 month

### Other values

All other values are derived from the current, voltage and active power values. Accuracies for derived values depend on the functional relationship (e.g.  $S = I * U$ ,  $\Delta S/S = \Delta I/I + \Delta U/U$ )

### Analysis window

Adjustable window for calculation and analysis of single or non periodic signals . Window adjustable over full memory range

### Synchronization

The measurement is synchronized on the signals period. There is a choice to determine the period from  $u(t)$ ,  $i(t)$ ,  $p(t)$ , further  $u^2(t)$ ,  $i^2(t)$  by using a settable filter . By this very stable readings are achieved, even at signals of pulse width modulated frequency inverter and amplitude modulated electronic ballast.

### Harmonic analysis prCE Harm

Measuring of current and voltage with evaluation according to EN61000-3-2 (Pre-compliance)

### Harmonic analysis Harm100

Analysis of current, voltage and power up to 99<sup>th</sup> harmonics (max. 10kHz), in total 100 harmonics, when including DC part. Fundamental in the range from 0.1Hz to 1kHz. By selectable integer divider (1...128) a new reference fundamental can be created as to detect interharmonics.

### Flicker measuring

Flicker Meter according to EN61000-4-15 with evaluation according to EN61000-3-3

### Scope function

Graphical representation of sampled values over the time

### Plot function

Time diagram of max. 4 readings, minimal resolution 50ms

### Computer interfaces

Interfaces: **RS232** and **IEEE488.2**, only one interface can be used at the same time  
 Remote control  
 Output data  
 Transfer rate  
 RS232: max.115200 Baud, IEEE488.2: max. 1MByte/sec

### Printer interface

Parallel PC-Printer interface with 25-pin SUB-D socket for printing measuring values, tables, graphics to matrix, inkjet or laser printers

### Processing signal interface

25 pin SUB-D socket with (The option processing signal interface can be built in twice):  
 4 analog inputs for registration of process magnitudes (16Bit, ±10V, 1kHz)  
 4 analog outputs for output of readings or measured magnitudes (16Bit, ±10V, 100kHz)  
 4 digital inputs for registration of states (1kHz,  $U_{LOW}<1V$ ,  $U_{HIGH}=4...60V/2,5mA$ )  
 4 digital outputs to signal states and alarms (open collector, output high max. 30V@100μA, output low max. 1,5V@100mA)  
 1 input for registration of frequency (0,1Hz...500kHz) and rotation direction of motors ( $U_{LOW}<1V$ ,  $U_{HIGH}=4...10V$ , 1MΩ)  
 In- and outputs are isolated groupwise against each other and against the other electronics (testing voltage 500V)

## Other data

Dimensions	- Bench case, W 320mm x H 147mm x D 307mm - 19"-chassis, 84PU, 3HU, D 307mm
Weight	about 6,5kg
Protection class	EN61010 (IEC1010, VDE0411), protection class I, overvoltage category III
Electromagnetic compatibility	EN50081, EN50082
Protection system	IP20 in accordance to DIN40050
Operating/storage temperature	0...40°C, -20...50°C
Climatic class	KYG in accordance to DIN40040
Power supply	85...264V, 47...440Hz, about 45W

## LMG450 accessories

### ZES ZIMMER compensated current clamps

Nominal value /A	1.2	2.5	5	10	20	40
Permissible trms value /A	2.6	5.2	10	20	40	80
Permissible peak value for full scale /A	3.75	7.5	15	30	60	120
Overload capability	500A for 1s					
Max. cord diameter	12mm					
Isolation	300V/CATIII, 600V/CATII					

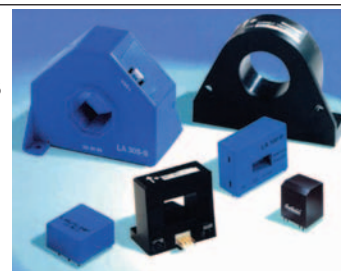
Part No. L45-Z06 (1 pc.)  
L45-Z07 (Set of 4 pc.)

Total measuring accuracy incl. clamp	± (% of measuring value + % of measuring range)				
	1Hz...10Hz	10Hz...45Hz	45Hz...1kHz	1kHz...5kHz	5kHz...20kHz
Current (via ZES-clamp)	1.5+0.5	0.4+0.3	0.15+0.1	0.3+0.3	1.0+0.5
Active power (via ZES-clamp)	1.5+0.5	0.5+0.3	0.2+0.1	0.4+0.3	1.5+0.5

## Hall current sensors for range extension

Current transducers with Hall effect sensors for range extension of LMG450, DC...20kHz, accuracy class 0,5 connected to LMG450 via HD15 sensor input, incorporated EEPROM for scaling and adjustment data as well as data for automatically setting of appropriate current range

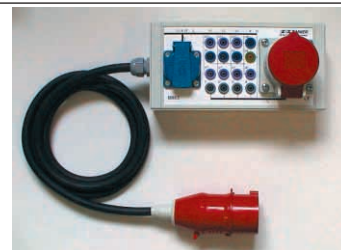
Part No.	Current			Supply
	nominal	trms	peak	
L45-Z09-Hall50	35A	50A	70A	Internally by LMG450 via HD15
L45-Z09-Hall100	60A	100A	120A	
L45-Z09-Hall200	120A	200A	240A	
L45-Z09-Hall300	250A	300A	500A	Externally
L45-Z09-Hall500	400A	500A	800A	
L45-Z09-Hall1000	600A	1000A	1200A	
L45-Z09-Hall2000	1000A	2000A	2100A	



## Adapter for 3-phase measurements

Part No. LMG-MAK3

- CEE-Plug, 5 pins, 16A, 2m supply cord
- CEE-Socket, 5 pins, 16A, for EUT
- Socket for supplying the meter LMG310
- 4mm safety sockets, measuring access to current and voltage
- Safety acc. IEC61010: 300V/CATIII



## Data Logging Mini PC

Part No. MINIPC

Data Logging Mini PC for flash cards connected to LMG450 via RS232 interface, control software TERM-L45L95 usable for all LMGs



## LMG450 application software

Product name (Part No.)

<b>LVDRV-L45</b>	Driver for LMG450 under LAB-View 5.1.1 for RS232 as well as IEEE488 interface, with programming samples
<b>LWINDRV-L45</b>	Driver for LMG450 under LAB Widows/CVI for RS232 as well as IEEE488 interface, with programming samples
<b>ZESVIEW</b>	Graphical presentation and analysis of LMG450, LMG310, LMG95 and LMG90 data (stored on PCMCIA-cards or in ASCII data files) in Windows.
<b>TERM-L45L95</b>	Data transfer from LMG450 (LMG95) via IEEE488 or RS232, online graphical presentation Configuration of Mini PC, setting recording parameters (values, intervals etc.), transfer of recorded data
<b>BMP2PC</b>	Bitmap transfer from LMG450 (LMG95) to PC via RS232, downloaded screens can be processed and scaled in Windows. Free download from the website <a href="http://www.zes.com">www.zes.com</a>

Subject to technical changes, especially to improve the product, at any time without prior notification.