1 to 8 Channel
Precision Power Meter LMG500

Cut to Half!
Active Power
0.015% rdg + 0.01% rng

- Accuracy 0.03%
- Bandwidth 10MHz (DC, 0.05Hz to 10MHz)
- 3MSamples/s simultaneously on each U and I channel
- Sampling absolutely gapless with evaluation of all sampling values, therefore captures all inrush currents and signal changes
- Harmonics and interharmonics up to 50kHz/1MHz
- Flicker, interactions between network and load

To improve Motors, Transformers,
Frequency Inverters, Power Electronics,
Power Supplies, Lightings, Automotives
   in Efficiency, Reliability,
   Electromagnetic Compatibility and Life-Cycle Costs
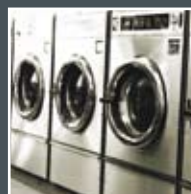
LMG – A Synonym for Precision Power Measurement

Precision Power Meters (German: Präzisions-**L**eistungs**M**ess**G**eräte) of the series **LMG** by ZES ZIMMER – LMG90 and LMG95 for single phase, LMG310, LMG450 and **LMG500** for multiphase measurements – have been proved in many various applications. The character string **LMG** has become a synonym for precise and wide band measurement of electrical power. The magnitudes correlated with electrical power like current, voltage, harmonics, flicker and energy have to be acquired precisely as to optimise your products in efficiency, reliability, electromagnetic compatibility (EMC), life-cycle costs.

LMGs are used for measurement at:

- Components, e.g. ferrite cores, semiconductors, capacitors
- Devices, e.g. motors, inverters, lightings
- Installations and parts of those, also power grids to identify their parameters
- CE-mark tests on devices, supplied by power sources (simulating an ideal power network), to investigate the feedback of harmonics and flicker (load variations)
- Interactions of network and appliance

The most important highlight features of the LMG500:

- Group delay between U- and I- measuring input <3ns as standard to assure very precise measurement at low $\cos\varphi$ and/or high frequencies
- High dynamics in level control, ranges from 3V to 1000V/3200V_{peak}, 20mA to 32A/120A_{peak} in direct measurement only by a single pair of sockets each for voltage as well as for current input
- 3MSample/s, absolutely gapless sampling with evaluation of all sampling values
- Capturing transients and fast signal changes by event triggering which is always active in the background of the „normal mode"
- Harmonics and interharmonics up to 50kHz internal and up to 1MHz with an external PC
- Flicker measurement, interactions between network and load
- Modular with 1 to 8 power measuring channels
- Ergonomic operation shell for easy, intuitive use of the power meter
- Real-time evaluation of the measurements in numeric tables and diagrams
- Interfaces with high data transfer rate (IEEE488.2, RS232, USB, Ethernet)

Measuring inputs for ultimate requirements

- **Separated HF current inputs I_{HF}*:
  150mA to 1.2A/DC to 10MHz**

- **Current inputs I*, high dynamic
  of range: 20mA to 32A/120A_{peak}
  by only one socket pair,
 no need and incommode change
  of external shunts!**

- **Measuring with external sensors:
  Inputs I_{Sensor} and U_{Sensor}
  30mV to 4V/DC to 10MHz**

- **Voltage inputs U*:
  3V to 1000V/3200V_{peak}**

- **Auxiliary voltage ±15V and
  Identification of external sensors**

- **Very low capacity of measurement inputs against earth <30pF, thereby no interference of measured signals**
- **High bandwidth of 10MHz, shortest pulsed signals will be measured precisely**
- **All inputs isolated against each other and against earth (max. 1000V/CAT III)**
- **Gapless sampling and evaluation with 3MSamples/s at any duration, measuring cycle max. 60s**
- **Up to 8 power measuring channels with 8 channel compact meter or with two connected LMG500, all channels absolutely synchronously sampling with 3MSamples/s**

Clear representation of measuring process
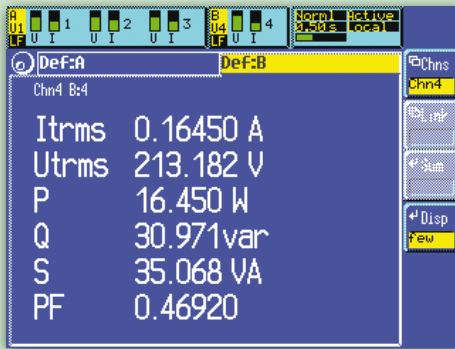

Measurement display with six values
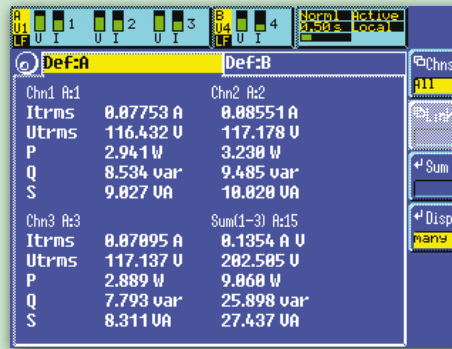
Measurement display with 20 values

- **Status bar permanently displayed in all menues**
- **Measurement display for one or four power channels, alternatively with six or 20 values, 40 values or more to scroll**
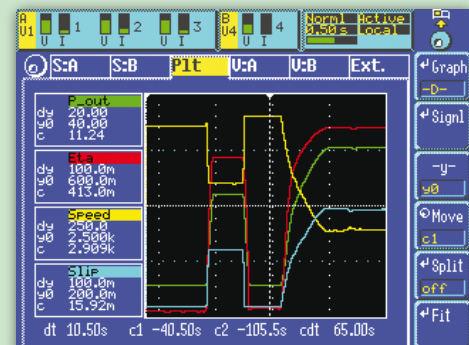

Status bar to overview active measurements

- **Graphical display for wave form, line plot (trend display), phasor diagram and bar graph for harmonic analysis**
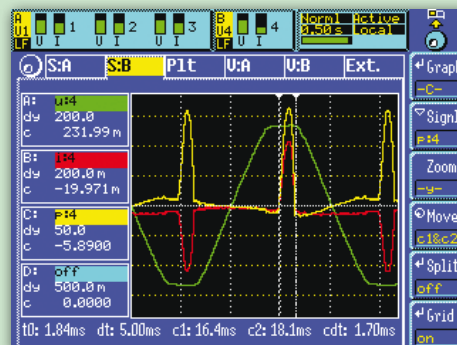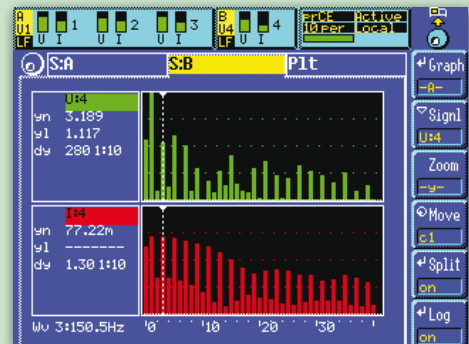

Graphical display for wave form

Line plot (trend display)
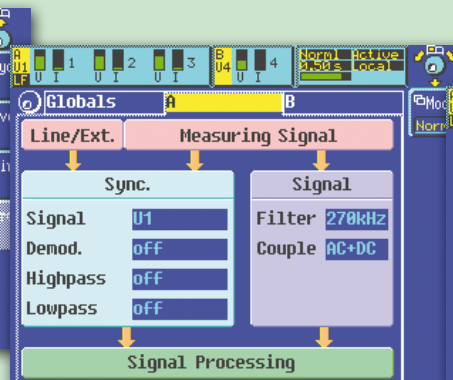

Phas or diagram

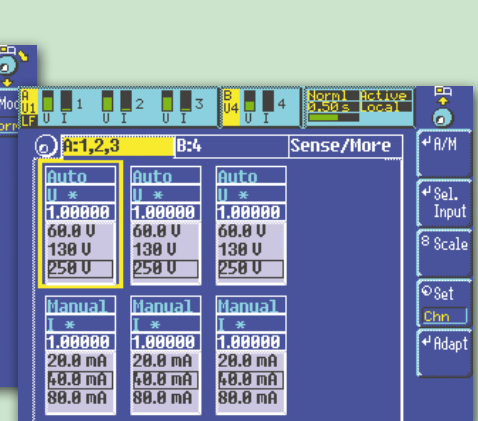*Representation of harmonics as bar graph*

Device settings easily and intuitively over menues

Global settings, for example the star-delta conversion

Independent setting of synchronisation and measurement path

Selection of input sockets, scaling and measurement range

- **Global settings**
- **Two independent filter sets to process synchronisation and measurement signal**
- **Manual or automatic setting of measurement ranges**

Flexible use of the power measurement channels

Eight power measurement channels, each of them sampled absolutely synchronously with 3MSamples/s, can be provided:

- Either by a coupled 2nd device
- Or by the LMG500 with its compact 8 channel enclosure.

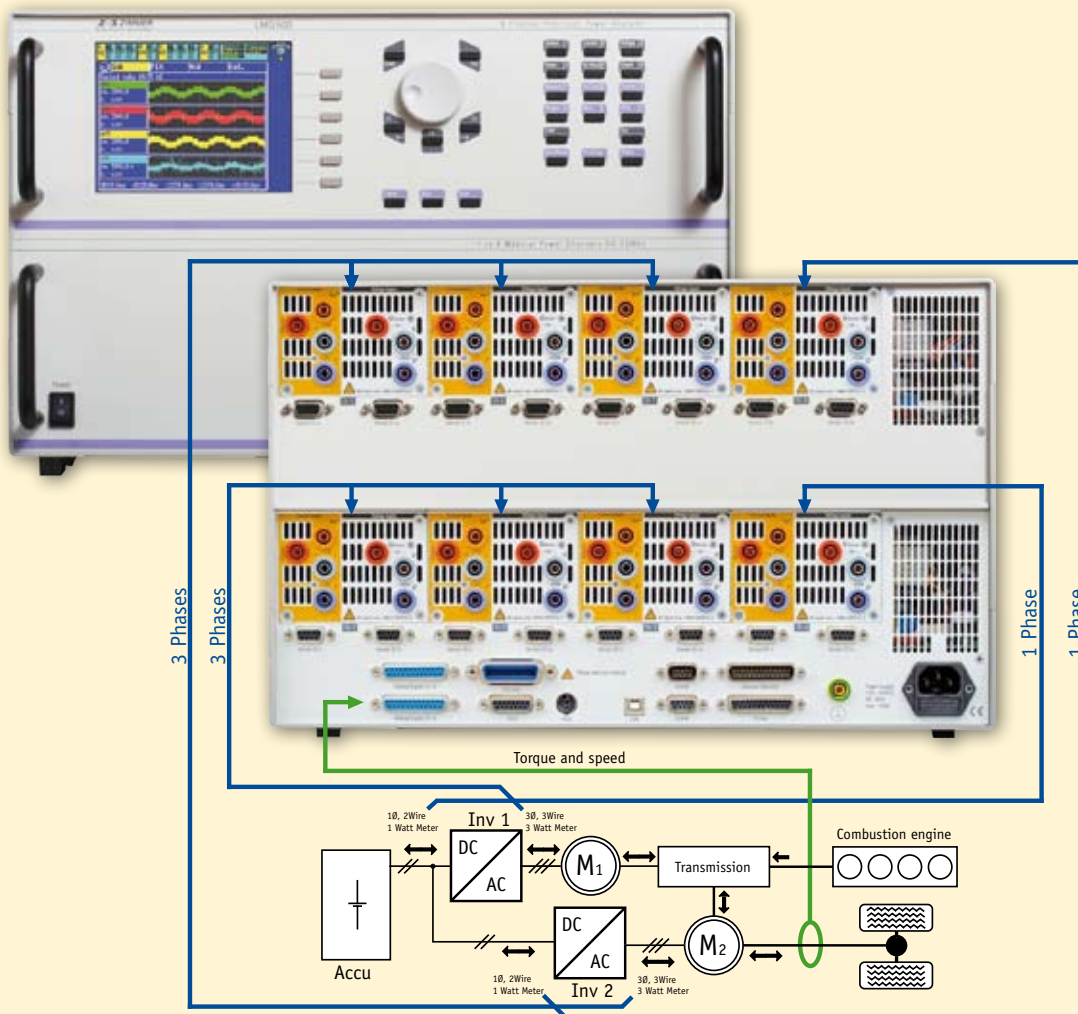The current and the voltage paths of the power measurement channels are all isolated against each other and against earth. This enables a free structuring of measurement on various power applications. The channels are arranged within up to 4 groups (see listed table): channels 1 to 4 (device 1) into group A and B and channels 5 to 8 (device 2) into group C and D. Each group is synchronised by a group specific signal. The synchronisation with an external signal or by „line" is also possible.
The settings of group A and B for certain wirings are independent to the settings of group C and D.

Channel No.	Ch. 1	Ch. 2	Ch. 3	Ch. 4	Ch. 5	Ch. 6	Ch. 7	Ch. 8
Group formation	A		B		C		D	
Possible wiring in the groups A to D	4Ø 4Wire				4Ø 4Wire			
	4Ø 5Wire				4Ø 5Wire			
	1Ø 2W	1Ø 2W	1Ø 2W	1Ø 2W	1Ø 2W	1Ø 2W	1Ø 2W	1Ø 2W
	3Ø 3Wire			1Ø 2W	3Ø 3W			1Ø 2W
	3Ø 4Wire				3Ø 4W			
	4Ø 4Wire				4Ø 4W			
	3Ø 3W (Aron)/2Ø 3W		3Ø 3W (Aron)/2Ø 3W		3Ø 3W (Aron)/2Ø 3W		3Ø 3W (Aron)/2Ø 3W	
	3Ø 3W (Aron)/2Ø 3W		1Ø 2W	1Ø 2W	3Ø 3W (Aron)/2Ø 3W		1Ø 2W	1Ø 2W

LMG500 – Compact with 8 Channels

Hybrid Automotive Drives

Torque and speed

1Ø, 2Wire
1 Watt Meter

Inv 1

3Ø, 3Wire
3 Watt Meter

DC / AC

M₁

Transmission

Combustion engine

Accu

1Ø, 2Wire
1 Watt Meter

Inv 2

DC / AC

M₂

3Ø, 3Wire
3 Watt Meter

3 Phases   3 Phases   1 Phase   1 Phase

Optimisation of the energy management of hybrid automotive drives through analysing the power flow in various operation modes and conditions:

1. Automotive drives through combustion engine with or without booster of the inverter fed 3-phase electrical machines M1 and M2.
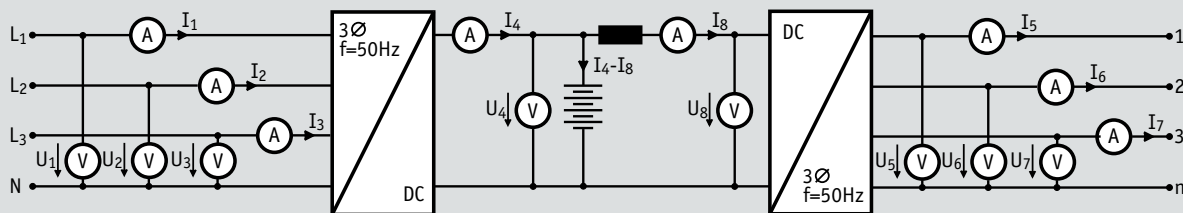
2. Energetic feedback of the braking energy into the battery.
3. Charging/recharging of the battery with combustion engine. Eight power measurement

channels and the process signal interface for torque and speed acquire exactly synchronously all data to precisely define efficiency.
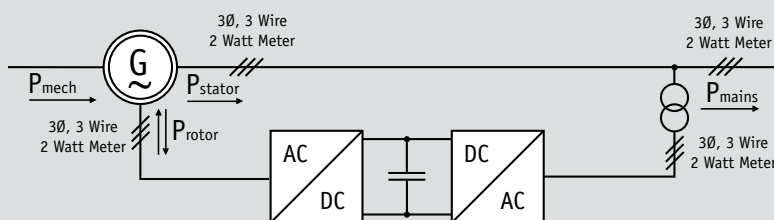
LMG500 – Compact with 8 Channels

Uninterruptible Power Supply with DC-Link

Determination of efficiency at different operation points and conditions

Double Fed Asynchronous Machines

Stator power, rotor power, mains power, mains specific inverter power in each case with two watt meters in Aron circuit

Wind generators without gearing but with an extended range for revolution speed.

With fixed frequency at stator side and by setting the rotor frequency the double fed asynchronous machine can work as a generator with high efficiency at different wind speeds.

Transformers with Multiple Windings
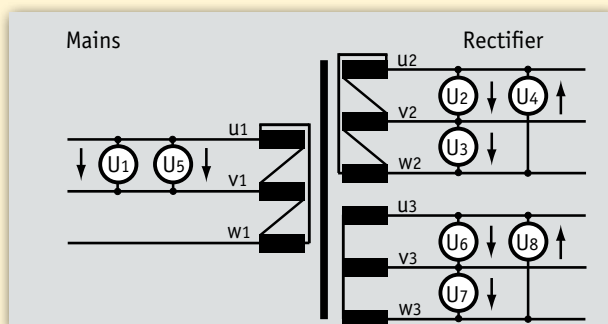
Eight channel measurement at 12pulse rectifier transformer

A three winding transformer with two by 30° electrically shifted outputs coils feeds two 6puls rectifiers. Thereby the primary winding suppresses harmonics, e. g. the 5th, 7th, 17th and 19th. The power measurement channels are configured as two groups with channels 1 and 5 in parallel. Therewith all measurement channels have the same phase reference and special rectifier transformers with (n·30°) deviating phase angles can be measured exactly.

Gapless Data Capturing

Energy Efficiency Classification for White Goods and PCs Standby Consumption

Benchmark like SPECpower_ssj2008 have been set up to ascertain power consumption of PCs and servers as a function of computing power. The LMG500 is listed for this. Standby consumption of domestic appliances are covered by standards like IEC 62301. The LMG500 fulfils this requirements. Low currents (µA) can be measured by using the shunt SH-100-P.
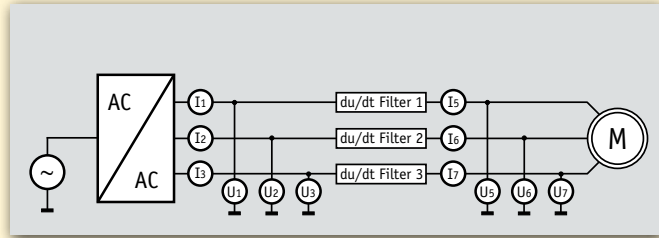
Power Loss of Filters for Frequency Inverters
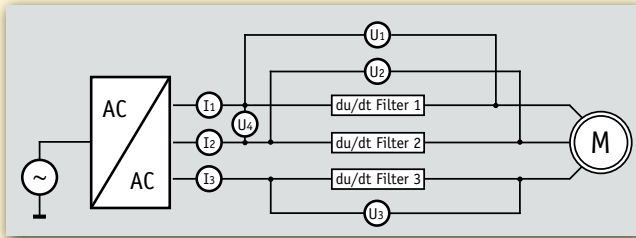
*Power loss through measurement across the filter*

Power loss through difference measurement before and behind the filter

To increase efficiency of modern PWM frequency inverters fast switching semiconductors are used for minimising the switching losses in the output stage. However, the extremely steep voltage edges cause capacitive currents that stress bearings and isolation of the motors – this leads to an early break down.

Motor filters (e. g. du/dt-filters) attenuate the voltage edges in rise and fall, but generate power losses by the filters' transient oscillations (typ. >100kHz).

The high bandwidth and the very small group delay time of U-/I-measuring channels, <3ns as standard, allows extremely precise power loss measurements at those frequencies, also when measured across the filter at small cosφ.
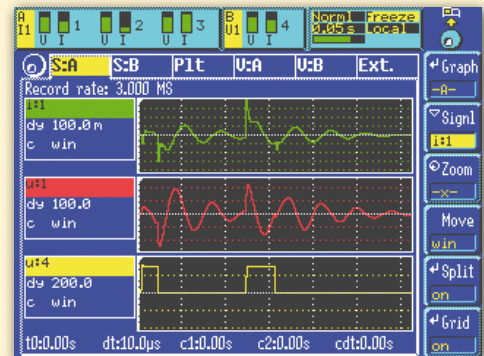
L-L voltage U4 before the filter,
voltage U1 across the filter and filter input current I1

Menu to compensate the delay time of external sensors

Currents >30A are measured by means of external sensors. Wide band (>100kHz) current transducers for more than 100A, e. g. ZES ZIMMER type PSU, are used. The error caused through the group delay of the current transducer can be corrected by assistance of the delay time menu inserting the necessary time adjustment.

An outstanding tool with an easy to use menu.

Delay time menu with compensation values for I in phase 1,2 and 3

## Losses at lowest power factors of transformers, chokes and capacitors

Power measurement up to 10MHz requires that current and voltage channels are so designed that delays between each other are very small. With the LMG500 they are less than 3ns and this means an angel error <1 µrad at 50Hz. Due to this feature incorporated in the LMG500 it is best suited to measure the power losses of transformers, chokes and capacitors at very low power factor. The instruments with the standard factory settings fully comply to the requirements of these measurements. Options or adjustments are not necessary.

A calibration protocol [order no. KR L50 LPF] to proof measurement accuracies at power factors in the range of 0.01 can be supplied. Usually current or voltage transducers will be used for measuring power transformers. The phase angular error of this transducers can be corrected in the delay time menu which improves the accuracy of the measurement. Various definitions, e.g. IEC 60076-1, can handle the calculation of the corrected power. This can be calculated easily by using the powerful formular editor regarding to the requirements.
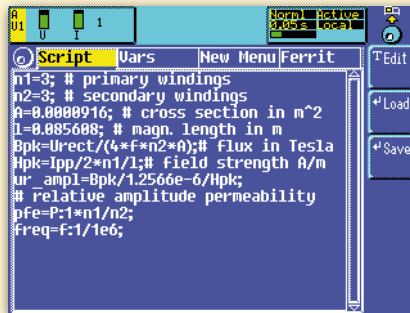

Source: Siemens AG

Core Losses and Parameters up to 10MHz
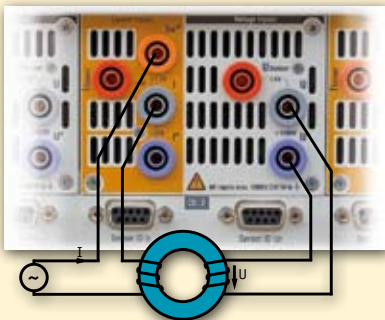
Circuitry

Script editor

Custom menu with numerical results

The power measured with the exciting current I and the induced voltage U at the sensor winding (core magnetisation voltage) directly yields the core losses without copper losses. With the rectified value of the sensor voltage U – a measure for the voltage-time area and therewith the induced flux –, the exciting current I and the geometric core data, the characteristic curves e.g. $P(B_{pk})$, $B_{pk}(H_{pk})$ can be generated. With the high-performance script editor the respective curve points are calculated measuring cycle by measuring cycle. Please request special application note.

Chopped Ballasts of Modern Lighting
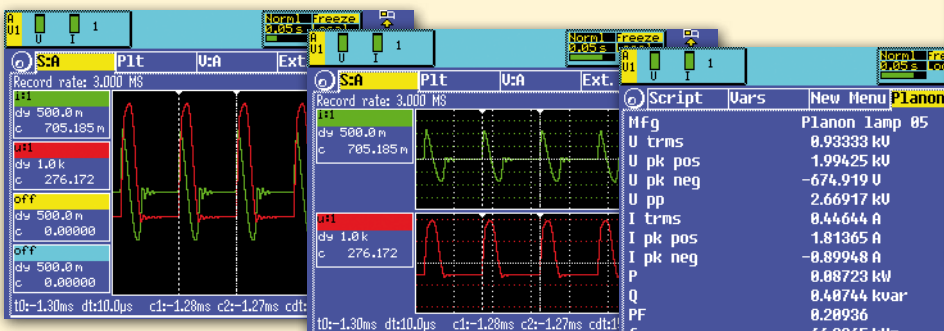
Wave forms of current and voltage

Custom menu with numerical results

Modern flat panel lamp

Due to the low earth capacitance of the LMG500 measuring inputs (<30pF) pulsed currents and voltages can directly be measured and displayed on the LMG500 screen without any deviation. The figures shows the 70kHz pulses (U_{pp}=2.5kV, I_{pp}=2.7A) that permanently ignite and therewith keep ionisation of the gas discharge flat lamp (light tile) alive. Only based on the very small group delay difference of U and I channel, <3ns as standard, precise power measuring can be effected at this sample with its challenging signals.

Transient Currents at the Output of a Frequency Inverter

Through the high bandwidth of 10MHz high-frequency current peaks at the frequency inverter output can be sampled and visualised.
Transient current peaks are produced on each switching edge – currents which flow via the winding capacitance. They yield a multiple of the nominal current. You will get the high ratio from the values Ipp1 and Itrms1 from the shown custom menu.
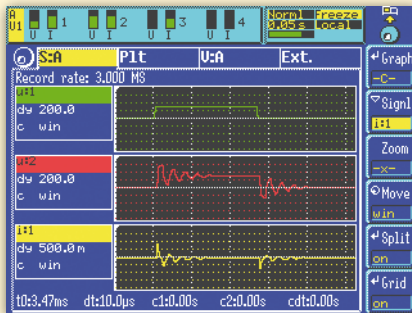

Line current and the three line to line voltages

Extra high current peaks at simultaneous switching edges

Custom menu with numerical results

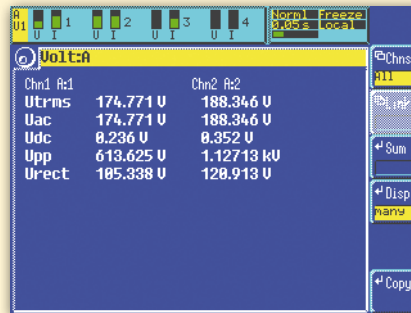# Bandwidth DC-10MHz • Delay Time < 3ns • Capacity against Earth < 30pF

Transient Voltages with Long Connecting Lines

*Voltage at inverter output as well as voltage and current at motor with long connection cables*

Easy to recognize: Double increase of peak value U_{pp}

Voltage peaks by reflexion occur on long connection cables between frequency inverter and motor. They attain up to the double of the transmitted voltage pulse and stress isolation in addition. On account of the high bandwidth of the LMG500 these voltage peaks are captured properly.
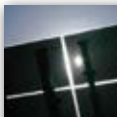
Avionics: Monitoring Harmonics up to 150kHz
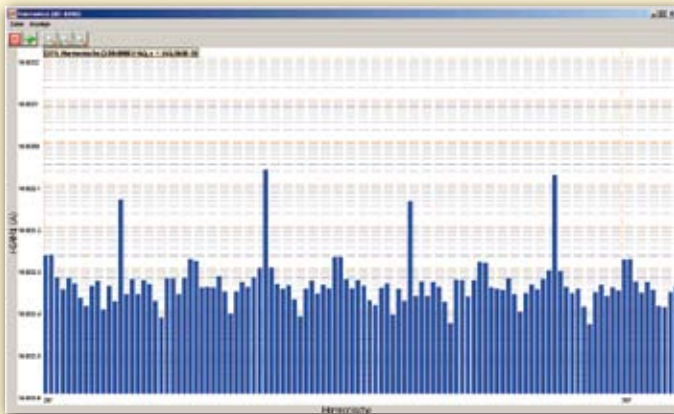
Harmonic Analysis by ZES ZIMMER software LMG-CONTROL

The on-board power supplies of modern large scale aircraft are operating with frequency up to 800Hz. Basic standards like EUROCAE ED-14D and ABD0100.1.8 are created to define limit values, as to specify those power supplies. Fundamental frequency from 360Hz to 800Hz must be assessed by their harmonics in ranges up to 150kHz. Therefore the LMG500 is best applicable.
The spectral analysis of currents and voltages DC to 1MHz is supported by a separate ZES ZIMMER application software LMG-CONTROL. You will get graphical data representation in linear or logarithmic scaling. The values can also be exported as tables e. g. into MS Excel.

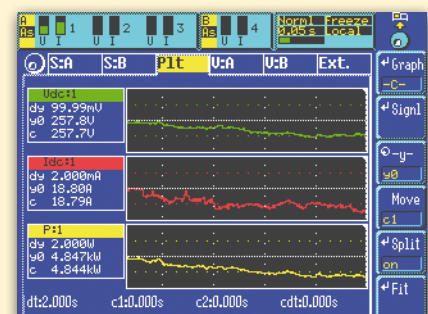Harmonic analysis with LMG-CONTROL ranges up to 1MHz. The fundamental can be set user-defined from 0.07Hz to 1MHz.

High Basic Accuracy – High Range Dynamics

Solar Technology

Voltage, current and effective power high precise without range switching
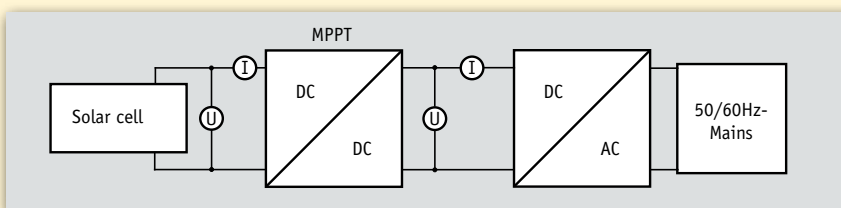
By assistance of the Maximum Power Point Tracker (MPPT) the operating point of a solar generator can always be kept in its optimum. While non steady solar radiation currents and power can vary between a few percent and nominal value in short time intervals. The tracking can only be optimised if measuring is consistently and without dropout e.g. that may occur while measuring range is switched. The high nominal accuracy of 0.03% allows a correct measuring of very low currents also in the 32A range.

High Quality Basic Configuration

The high quality basic configuration of the LMG500 at reasonable price allows comfortable working. Already included are RS232 interface, a printer interface and a powerful script editor.

Options and Accessories for Operating Extensions

IEEE488 interface
(Order no. L50-01)
Interpretation of the complete SCPI, as well as the LMG500 specific command set. The data transfer rate yields up to 1Mbyte/s.

USB interfaces
(Order no. L50-02USB)
For connection of a memory stick (front side) and another USB interface for data transfer and remote (backside).

Ethernet converter
(Order no. L50-Z318)
External adapter, all connectors will fixed and supplied by LMG.

Processing signal interface, digital and analogue in- and outputs (Order no. L50-03)
To monitor further process magnitudes like revolution, torque etc. With assistance of the script editor efficiency and other magnitudes can be deduced and be applied as control parameters.

Flicker meter
(Order no. L50-04)
Compliant to EN61000-4-15. The evaluation of the voltage fluctuations by currents up to 16A compliant to EN61000-3-3, by currents up to 75A compliant to EN61000-3-11.

Event triggering
(Order no. L50-05)
Display and save abnormal events.
Further description see below.

Star to delta conversion
(Order no. L50-06)
for 3phase-3wire systems.
Further description see below.

Harmonics up to 99th for U, I, P, Q und S (Order no. L50-08)
Current, voltage and power are analysed up to 50kHz on fundamentals ranging from 0.1Hz to 1.2kHz. Evaluation of inter-harmonics is possible by dividing the given fundamental to a lower one using it as reference. With use of the sampling values the harmonic analysis up to 1.5MHz on a external PC is given.

CE Harmonics (Order no. L50-09)
Up to the 40th, for currents up to 16A in compliance with EN61000-3-2, for currents from 16A to 75A in compliance with EN61000-3-12

DSP Modules (Order no. L50-010)
Necessary to operate particular options.


Option: Event triggering
Order no. L50-05

If trigger conditions are set this option operates in the background of the normal measuring mode and can be conditioned for max. four measurement values u, i, p coming from different measuring channels. By detection of given trigger conditions the scope display will be „frozen" (display „finish" in the status line). However, the normal measuring proceeds without any gaps, evaluating completely all sample values. Four logical connectable trigger events, which are selected via the menu, can be defined to control the U- and I measuring inputs. In each trigger event you can ascertain: Value larger/smaller, inside of/ outside of a window, event time 330ns...10s. By this and the sampling with 3Msamples/s particular peaks and dips will be detected. Via the printer interface the aligned scope picture can be printed, also the 2 million samples representing the event can be transferred via the data interface, on request. With the soft key button RUN the scope display is switched again to the current measuring mode until a new event is detected.
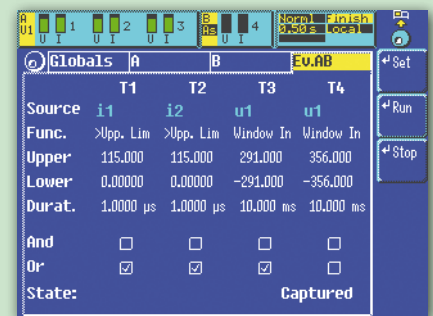
Conditioning of event triggering

Option: Star to delta conversion for 3phase-3wire system
Order no. L50-06
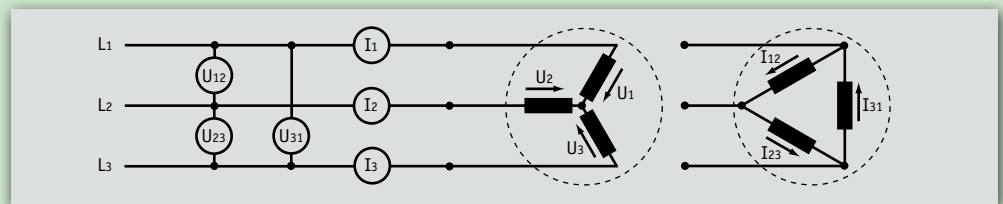
3phase-3wire system: measurement of line to line voltages and line currents

At 3phase-3wire systems only the line to line voltages U_{12}, U_{23} and U_{31} and the line currents I_1, I_2 and I_3 are available for measurement.
By assistance of the star to delta conversion the line to line voltages can be converted into those not directly accessible phase voltages (line to neutral voltages, i. e. the phase voltages of the load as if star-connected) and the assigned active powers can be defined. In analogy the line currents can be converted into the „linked" currents (line to line currents of the delta connected load). Out of the calculated „linked" values other magnitudes are deduced, as well as harmonics can be assessed.
Unbalance of net and load, as well as distorted wave forms are handled correctly by the star to delta conversion.

Calculated values (linked values) of the star connected windings (Wiring: 3+1, UΔ I -> U* I*)*

Calculated values (linked values) of the delta connected windings (Wiring: 3+1, UΔ I -> UΔ IΔ)*