ZES ZIMMER
Electronic Systems

Multi Channel
Power Meter

LMG500

User manual

EG-Konformitätserklärung   CE Conformity Declaration

für das

Mehrkanal Leistungsmeßgerät

for the

Multi Channel Powermeter

LMG500

Hiermit wird bestätigt, daß das oben aufgeführte Gerät den Anforderungen der Richtlinien (2004/108/EG) und (2006/95/EG) der Europäischen Gemeinschaft entspricht.

We certify that the above device accomplishes with all requirements which are defined in the directives (2004/108/EC) and (2006/95/EC) of the European Community.

Diese Erklärung gilt für alle Geräte, die nach anhängenden Fertigungsunterlagen - die Bestandteil dieser Erklärung sind - hergestellt werden.

This certificate is valid for all devices that are produced according to the appending production instructions (which are a part of this certificate).

Zur Beurteilung der Sicherheit und elektromagnetischen Verträglichkeit wurden folgende Normen herangezogen:

For the judgement of safety and electromagnetic compatibility of the product the following standards were used:

EN61010-1:2001

EN61326-1:2006

EN61000-3-2:2006

EN61000-3-3:1995+A1:2001+A5:2005

Diese Erklärung wird vom Hersteller

This certificate of the manufacturer

Z E S ZIMMER Electronic Systems GmbH
Tabaksmühlenweg 30
D-61440 Oberursel

abgegeben durch

is given by

Georg Zimmer, Geschäftsführer

Oberursel, 1. Juni 2007

Georg Zimmer, Geschäftsführer

Test Certification

Instrument Type:

Serial Number:

ZES ZIMMER Electronic Systems GmbH certifies the above instrument to comply with all specifications contained in the delivered user manual. It has left the factory in mechanically and electrically safe condition.

The measuring instruments, tools and standards used in production, adjustment and calibration are calibrated according to ISO9000 (traceable to national standards) and correspond to the standard of precision required to maintain the specified accuracies.

ZES ZIMMER
Electronic Systems

Date

Tabaksmühlenweg 30
D-61440 Oberursel
Germany

Quality Control

Request/order for a calibration

ZES ZIMMER
Electronic Systems

Instrument: O LMG90   O LMG95   O LMG310

                        O LMG450   O LMG500   O other:

Serial number:

For the above instrument the following should be done:

O Calibration (order-no KR-xxx)	O Adjustment with following calibration (order-no JKR-xxx)	O Input calibration, adjustment and output calibration (order-no KJKR-xxx)
O I **don't** want to get the latest software in the instrument (free of charge). I want to keep the actual implemented software version.		

Note:

Calibration is **only** to proof the differences between the instrument and the 'true' values

Adjustment is to set-up an instrument to meet its specifications.

Company   :

Street   :

ZIP/City   :

Country   :

Email   :

Name (responsible for

calibration)   :

Phone   :

Fax   :

Department   :

Customer number (if available):

Date: Sign:

Please send this paper via post or fax to:

Z E S ZIMMER Electronic Systems GmbH   Tel. +49 (0)6171/628750

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D-61440 Oberursel   Email sales@zes.com

Germany

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1   Instructions and Warnings

1.1   Safety Instructions

This instrument conforms to the EN61010-1 guide lines concerning the protection of electrical instrumentation and has left the factory in a mechanically and electrically safe condition. To maintain safe operation, the user must follow the instructions and warnings contained in this manual. The instrument satisfies the requirements of **protection class I** (protective earthing). Accessible metal parts of the instrument are tested with respect to the mains connection using a potential of 1500V/50Hz. Before connecting the apparatus to the mains supply, ensure that the voltage displayed on the type plate equals the available mains supply voltage. A possibly installed power supply selector has to be set up. The mains plug must only be connected to an earthed mains outlet. The earth connection must not be discontinued or broken by using an extension lead without earth connection. The instrument must be connected to the mains supply before any measurement or control circuits are connected to it. Any disconnection of the earth lead inside or outside of the instrument will endanger the operating personal. Deliberate disconnection of the earth is not permitted. When the instrument is used in combination with other instruments, then proceed as follows:

The external earth connector on the back of the instrument must not be used to earth other electrical equipment. It is only intended to provide additional earthing of the instrument in case an error occurs in the circuit under test which may cause an earth current to flow in excess of 10A which cannot be carried by the mains supply cable. If this further earthing cannot be implemented, then the measuring circuit must be suitably fused prior to its connection to the instrument. In this case, it is necessary to connect the measuring instrument to an earth connection point via the earth connector using a conductor with sufficient cross section. If this is not possible, the instrument has to be connected to the circuit to be tested via adequate fuses. The measuring inputs are isolated to case for operating voltages up to 1000V according to protection class I.

By opening the instrument components are exposed which may be raised to a hazardous potential. All voltage sources must be disconnected from the instrument before any instrument covers are removed for the purpose of calibration, service, repair or changing components. When access is required for calibration, service or repair, only suitably qualified personnel are permitted access to an opened and energised instrument.

Fuses may only be replaced with the same ratings and the same types. The use of repaired or short circuited fuses is not permitted. The instrument should be disconnected and disabled from accidental use when it is suspected that its safe operation cannot be warranted. The required

repair work must then be carried out by a suitably qualified person who is familiar with any dangers involved.

It must be considered unsafe to operate the instrument:

- if there is visual evidence of physical damage
- if the instrument fails to operate correctly
- after long-term storage under unfavourable circumstances
- if there are condensation forms due to excessive temperature changes
- following rough transport conditions

If the instrument was opened, a high voltage test according to the technical data and a test of the protective conductor are necessary following the closing of the instrument.

Storage temperature range: -20°C to +55°C

Climatic class: KYG according to DIN 40040
                                              0°C...40°C, humidity max. 85%, annual average 65%, no dewing

The instrument conforms to protection class I. A suitable mains cable is supplied with the instrument for connection to an earthed mains supply point. When in use the unit must be securely earthed; continuity of the mains earth connection should be checked. Make sure that attention is paid to the following points:

⚠ **Warning!**   The green/yellow safety jack on the back of the instrument must be used for additional earthing in case an earth current in excess of 10A might result accidentally in the system under test. Since the earthing conductor of the mains supply is unable to carry such currents, the instrument have to be connected to a suitable earth point via an adequately rated cable. If reliable earthing cannot be realised, the connections between the system under test and the instrument must be fused appropriately. The earth terminal on the instrument must not be used as the only earth connection for the instrument nor must the test circuit be earthed from this terminal.

⚠ **Attention!**   Before connecting the mains cable to an electricity supply, confirm that the mains supply voltage corresponds to the voltage printed on the model's identification plate.

⚠ **Warning!**   Remove all power supplies to a test circuit before connecting a probe for measurement purposes.

⚠ **Attention!**   The following maximum values must not be exceeded:

I^*, I: maximum 32A

I_{HF},I   maximum 1.2A

I_{Sensor}, I: maximum 10V signal voltage.

U^*,U: maximum 1000V

U_{Sensor}, U   maximum 10V signal voltage

All inputs: if unused jacks are open, maximum
1000V CAT II
600V CAT III
300V CAT IV,
if unused jacks are plugged or covered, maximum
1000V CAT III
600V CAT IV
operating voltage against earth, instrument casing and
other current or voltage channels.

⚠ **Attention!**   External current transformers with 1A or 5A secondary current should only be connected to the I* and I jacks, because of their bigger overload capability.

⚠ **Attention!**   Use only cables with **safety** connectors and sufficient cross section (obtainable from the equipment manufacturer). Please take care that this cables have a sufficient testing voltage and are useable for the wanted over voltage category.

⚠ **Attention!**   Cables of external sensors like clamps are often designed to operate with low voltages (<10V). For the operation itself this is ok, but if this cables touch a bare conductor this can be dangerous!

⚠ **Attention!**   When the instrument is switched off do not exceed 10A continuously nor 150A for 10ms

2 General

The Multi Channel Power Meter LMG500 extends the ZES multimeter product range for power measurement. It benefits from experience and know-how gained from the successful ZES LMG310, LMG95 and LMG450 series.

Due to the high sampling rate which is used in this instrument, it is now possible to make accurate power and efficiency measurements in 1 to 8 phase system configurations with a variety of load and signal components containing frequencies in the precision range from DC to 10MHz.

Monitoring and storing transients, harmonic analysis as well as time domain views of signals' waveform on the graphical display (oscilloscope mode) are all available with this instrument.

A special feature of the instrument is the simple, direct and intuitive topology of the operating buttons. The display of different quantities and menus for setting up the instrument is normally achieved with only a single touch of one button.

2.1 Features and application areas

Voltages and currents can be measured over a wide dynamic range. This makes the LMG500 instrument suitable for almost all professional measurement applications such as converter-fed alternating current machines and power- and energy electronic applications. Various wire- and phase configurations can be pre-selected to suit any required user application.

Another feature of the instrument is to suppress high frequency harmonics by means of selectable filters. This makes it possible to take only the fundamental harmonics into account, which build the torque and the mechanical power at the motor output.

Due to the exceptionally good common mode rejection of each current/voltage input channel it is possible to measure currents and voltages which float up to 1000V and at high frequencies with respect to earth. This is particularly important for measurements in inverter- and rectifier circuitry and in switched mode power supply applications.

The harmonics measuring mode (standard in the base instrument) permits the compliance measurement of high frequency harmonic reflections in networks according to EN61000-3-2 standard.

The extended harmonic mode up to the 99th available as option provides to obtain the energy distribution over different frequency ranges and can thus investigate their relative contribution to the total consumption of energy.

The LMG500 is suitable for measurements in electromagnetically noisy environments to EN61000-4. This feature is of particular importance for measurements in power electronics.

Other applications include the measurement of reactive and non-linear component losses (such as in transformers, chokes, motors, capacitors, power supplies), the computation of the efficiencies of photovoltaic modules and other alternative energy components. Further on you can calculate energy and charge, e.g. of accumulators.

A further highlight are the special ZES ZIMMER current clamps. This unique accessories combine both, the easy usage of clamp-on current transformers with the high accuracy of fix installed current transformers with primary winding for small currents from 0.1A to 80A. They are compensated for very small errors for amplitude and phase over frequency. So they can be used in power measurement in a wide current and frequency range. With them you can measure with <u>power</u> accuracies up to 0.3% in the frequency range 5Hz to 20kHz. So it is possible to measure the output of a PWM inverter without interrupting the wires.

2.2   Usage of the manual

The LMG500 is operated either by pressing buttons with hard-wired functions (in the following characterised by *italic* style), or by using softkeys (**bold** style) which will perform tasks that depend on a particular menu choice. This approach makes it possible to call all functions using a limited number of buttons without a need to call double or triple functions with one button. There are no menu trees so that the user does not need to fight his way through a menu jungle in order to call a particular display. Each menu can be called by simply pressing a single button.

The upper 6 buttons of the numerical keypad (*Default, Current, Voltage, Power, Int. Value and Graph*) enable the display of the standard measuring values by simply pressing a single button. In this menu a specified selection of the respective measuring values can be displayed using the soft keys.

The menus for the parameter set-up is called via the lower 6 buttons of the numerical keypad (*Measuring, Int. Time, Custom, Range, Misc., IF/IO,*). Thereby, all the instrument parameters can be adjusted using the soft keys.

Despite the simple and intuitive operation of the controls, it is recommended that even experienced users should carefully read and work through this manual to eliminate operational mistakes and to explore the full capability of the instrument.

There are following measuring modes:

- normal mode
  In this mode the LMG500 works as a power-meter with integrated scope function. The

TRMS values of voltage and current, the power and derived values are measured via the power measuring channels.

- CE harmonics mode
  In this mode the LMG500 works as an harmonic analyser. All measurements are judged according to the standards. There is only a minimum of settings to prevent set-up errors. This mode can only be used for precompliance measurings.

- CE flicker mode
  In this mode the LMG500 works as a full compliance flicker meter. All measurements are judged according to the standards. There is only a minimum of settings to prevent set-up errors.

- Harm100 mode
  In this mode the LMG500 works as an harmonic analyser for 100 harmonic components. You get many values like phase angles and the power at each frequency.

The active mode depends on the setting in the *Measuring* menu. Some other menus also depend on this setting (see the respective description).

For each measuring mode you find a chapter in the manual. Inside this chapter the different menus for this operating mode are described.
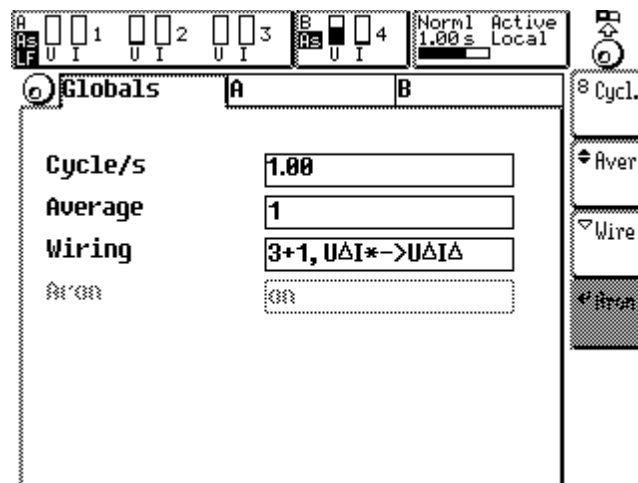
Figure 1: Measuring menu

2.3   General handling of the instrument

The main menus are reached by pressing the corresponding key of the keypad. In many menus you find softkeys which change their function depending on the menu. Above the softkey list you have symbols for the actual behaviour of the rotary knob:

blank   The rotary knob is inactive (neither rotating nor pushing has any effects)

By rotating the knob, you can select different tabs. By pushing the knob, you get a new selection of softkeys in a lower menu layer.

By rotating the knob, you can select different actions (depends on the context of the menu). By pushing the knob, you go back one menu to the upper menu layer.

You are entering a text. The effect of the rotating depends on the softkey settings. By pushing the knob, the character at the cursor position of the selection list is copied to the input field. See also '4.5, Entering identifiers, characters and text'

All softkeys are of following types. They are identified by the small symbol in the upper left corner. The text in the softkeys depends on the context of the menu.

Execution softkey. The action described by the text is executed immediately without the possibility to cancel it.

Branch softkey. After pressing this softkey a new list of softkeys will appear. Now you can select one of this new softkeys or you can cancel the action be pressing *ESC*.

List softkey. After pressing this softkey you get a selection list. You can choose one element of the list (with the rotary knob) and then you can confirm your choice by pressing the rotary knob or *ENTER* or you can cancel the selection by pressing *ESC*.

Text edit softkey. After pressing this softkey you can enter identifiers (for example in the script editor or to output values via the analogue outputs). This kind of text input is described in '4.5, Entering identifiers, characters and text'

Rotary knob action softkey. This is a group of one or more softkeys. The softkey with the knob symbol is the actual active (in this case the knob would move the window). All inactive softkeys have no symbol in the upper left corner. If you in this example press on **Zoom** the symbol will change to this softkey.

If you have a small box like the '-x-' in the above Zoom button, the text in this box represents the actual setting. In the above example you would zoom the signal in X direction. If you press again this button, the content of the small box changes to '-y-' and you would zoom the signal in Y direction.

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Count softkey. After pressing this softkey you can adjust the depending values with the opening up and down buttons in fixed steps.

Time softkey. After pressing this softkey you can adjust a time setting. The values for hours, minutes and seconds must be separated by a colon, pressing the button *Misc*. Then you can confirm your adjustments by pressing the rotary knob or *ENTER* or you can cancel the selection by pressing *ESC*.

Date softkey. After pressing this softkey you adjust a date. The values for day, month and year must be separated by a colon, pressing the button *Misc*. Then you can confirm your adjustments by pressing the rotary knob or *ENTER* or you can cancel the selection by pressing *ESC*.

Time duration softkey. After pressing this softkey you can adjust a time duration, in which e.g. an integration of values should be made. You can set up the duration in several data formats e.g. in seconds without a hyphen or by values for hours, minutes and seconds separated by a colon (pressing the button *Misc*.). Confirm your choice by pressing the rotary knob or *ENTER* or you can cancel the selection by pressing *ESC*.
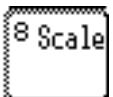
Digit softkey. After pressing this softkey you must enter numbers. Then you can confirm your choice by pressing the rotary knob or *ENTER* or you can cancel the selection by pressing *ESC*.

2.4   The group concept

The power measuring channels of each unit allow a lot of measuring capabilities, but they require also a special handling. For this reason we have used so called 'groups'. In one group you find one or more measuring channels which belong logically together. A group is a logical unit and there are several menus which display values out of one group or which set-up parameters for one group (e.g. ranges). The groups are defined by the selected wiring (see the chapters about the measuring menu). There are maximum 2 groups in each instrument. If two LMG500 are combined, up to two groups per instrument can occur.

For example with 4 measuring channels you can have three principle measuring situations:

- You measure with all channels (group A) at the same system (which means you have the same frequency at each input). Examples for such systems are 4 phase motors driven by frequency converters or standard main supply with L1, L2, L3, N and PE (in this case you could for example measure I_N and U_{NPE}!)
  In this situation there is no group B!
  The standard wiring for this is '4+0 channels'.

- You measure with the first channels (group A) at one system and with the last channel (group B) at another system. Examples for such systems are standard 3 phase systems with one phase output, motor applications at frequency converters where the torque is measured with the 4th channel or car applications, where the 4th channel measures the DC power of the battery.
  The standard wiring for this is '3+1 channels'.
  If you have installed the option star to delta conversion, (L50-O6) you have three further possible wirings:
  '3+1, U*I*->UΔIΔ'
  '3+1, UΔI*->UΔIΔ'
  '3+1, UΔI*->U*I*'

- You measure with 2 channels (group A) at one system and with the other two channels (group B) at the second system. Examples for this could be three phase converter from 50Hz to 60Hz.
  Both groups are measured in 2 wattmeter method. There are two possible applications:
  You measure a 3phase, 3wire system (aron circuit, **Aron** set to on)
  You measure a 2phase, 3wire system.(**Aron** set to off).
  The standard wiring for this is '2+2 channels'.

If a group has more than one measuring channel, you can get additional information about the group:

- In many cases the instantaneous values of all used measuring channels are calculated together. By this you can see for example the not measured voltages and currents in wiring 'A:1+2 B:3+4' (aron circuit).
  This virtual channel can be used like a standard channel (you get all values, scope, harmonics, flicker, ...)
  This kind of channels we call 'linked channels'

- The total values of a group are calculated (total active power, total power factor, total energy, ...).
  This kind of channels we call 'sum channels'.

Following you find an overview over the different wirings, the groups, the measured values and where you can find the values in the display. The definition of the header can be found in chapter 5.4, 'Display of values'.

Wiring '1+0 Channels'

Display channel	Group	Meaning	Header
1	A	The values measured with the first measuring channel	Chn1 A:1

Wiring '2+0 Channels'

Display channel	Group	Meaning	Header with Aron set to **off**
1	A	The values measured with the first measuring channel	Chn1 (U12, I1) A:1
2	A	The values measured with the second measuring channel	Chn2 (32, I3) A:2
9	A	The calculated (not measured) current I_3 and voltage U_{12} of group A (linked channel)	Link12 (U31, I2) A:9
15	A	The total values (sum channel) of group A (display channel 1 to 2)	Sum(1-2) A:15

Wiring '2+0 Channels'

Display channel	Group	Meaning	Header with Aron set to **on**
1	A	The values measured with the first measuring channel	Chn1 A:1
2	A	The values measured with the second measuring channel	Chn2 A:2
9	A	The calculated (not measured) current I_3 and voltage U_{12} of group A (linked channel)	Link12 (U3,I3) A:9
15	A	The total values (sum channel) of group A (display channel 1 to 2)	Sum(1-2) A:15

Wiring '1+1 Channels'

Display channel	Group	Meaning	Header
1	A	The values measured with the first measuring channel	Chn1 A:1
2	B	The values measured with the second measuring channel	Chn2 B:2

Wiring '3+0 Channels'

Display channel	Group	Meaning	Header
1	A	The values measured with the first measuring channel	Chn1 A:1
2	A	The values measured with the second measuring channel	Chn2 A:2
3	A	The values measured with the third measuring channel	Chn3 A:3
15	A	The total values (sum channel) of group A (display channel 1 to 3)	Sum(1-3) A:15

Wiring '2+1 Channels'

Display channel	Group	Meaning	Header with Aron set to **off**
1	A	The values measured with the first measuring channel	Chn1 (U12, I1) A:1
2	A	The values measured with the second measuring channel	Chn2 (U32, I3) A:2
3	B	The values measured with the third measuring channel	Chn3 B:3
9	A	The calculated (not measured) current I_3 and voltage U_{12} of group A (linked channel)	Link12 (U31, I2) A:9
15	A	The total values (sum channel) of group A (display channel 1 to 2)	Sum(1-2) A:15

Wiring '2+1 Channels'

Display channel	Group	Meaning	Header with Aron set to **on**
1	A	The values measured with the first measuring channel	Chn1 A:1
2	A	The values measured with the second measuring channel	Chn2 A:2
3	B	The values measured with the third measuring channel	Chn3 B:3
9	A	The calculated (not measured) current I_3 and voltage U_{12} of group A (linked channel)	Link12 (U3,I3) A:9
15	A	The total values (sum channel) of group A (display channel 1 to 2)	Sum(1-2) A:15

Wiring '4+0 Channels'

Display channel	Group	Meaning	Header

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Display channel	Group	Meaning	Header
1	A	The values measured with the first measuring channel	Chn1 A:1
2	A	The values measured with the second measuring channel	Chn2 A:2
3	A	The values measured with the third measuring channel	Chn3 A:3
4	A	The values measured with the fourth measuring channel	Chn4 A:4
15	A	The total values (sum channel) of group A (display channel 1 to 4)	Sum(1-4) A:15

For typical measuring circuit see 3.3.1, 'Measuring circuit for typical line applications using the internal current path'.

Wiring '3+1 Channels'

Display channel	Group	Meaning	Header
1	A	The values measured with the first measuring channel	Chn1 A:1
2	A	The values measured with the second measuring channel	Chn2 A:2
3	A	The values measured with the third measuring channel	Chn3 A:3
4	B	The values measured with the fourth measuring channel	Chn4 B:4
15	A	The total values (sum channel) of group A (display channel 1 to 3)	Sum(1-3) A:15

For typical measuring circuit see 3.3.2, 'Measuring circuit for measuring efficiency of 3/1phase systems'.

Wiring '2+2 Channels'

Display channel	Group	Meaning	Header with Aron set to **off**
1	A	The values measured with the first measuring channel	Chn1 A:1
2	A	The values measured with the second measuring channel	Chn2 A:2
3	B	The values measured with the third measuring channel	Chn3 B:3
4	B	The values measured with the fourth measuring channel	Chn4 B:4
9	A	The calculated (not measured) current I_3 and voltage U_{12} of group A (linked channel)	Link12 (U3,I3) A:9

Display channel	Group	Meaning	Header with Aron set to **off**
10	B	The calculated (not measured) current I_3 and voltage U_{12} of group B (linked channel)	Link34 (U3,I3) B:10
15	A	The total values (sum channel) of group A (display channel 1 to 2)	Sum(1-2) A:15
16	B	The total values (sum channel) of group B (display channel 3 to 4)	Sum(3-4) B:16

For typical measuring circuit see 3.3.5, 'Measuring circuit for measuring efficiency of 3/3phase systems' if you replace 'L2' by 'N'.

Wiring '2+2 Channels'

Display channel	Group	Meaning	Header with Aron set to **on**
1	A	The values measured with the first measuring channel	Chn1 (U12,I1) A:1
2	A	The values measured with the second measuring channel	Chn2 (U32,I3) A:2
3	B	The values measured with the third measuring channel	Chn3 (U12,I1) B:3
4	B	The values measured with the fourth measuring channel	Chn4 (U32,I3) B:4
9	A	The calculated (not measured) current I_2 and voltage U_{31} of group A (linked channel)	Link12 (U31,I2) A:9
10	B	The calculated (not measured) current I_2 and voltage U_{31} of group B (linked channel)	Link34 (U31,I2) B:10
15	A	The total values (sum channel) of group A (display channel 1 to 2)	Sum(1-2) A:15
16	B	The total values (sum channel) of group B (display channel 3 to 4)	Sum(3-4) B:16

For typical measuring circuit see 3.3.5, 'Measuring circuit for measuring efficiency of 3/3phase systems'.

For further information about this tables see also chapter 5.3, 'Definition of measuring values'.

So a general rule what you see is:
All measuring channels
All channels calculated from sample values (linked channels)
All channels calculating the total values of a group (sum channels)

2.5   Linked values, star to delta conversion (option L50-O6)

If you have installed the option star to delta conversion you can calculate values, which you can't measure directly (for example if you have a load in delta circuit, and want to know, how big is the power in each load, you could use the wiring '3+1, UΔI*->UΔIΔ'. Then you would measure the current in the three phases and the voltages between the phases. As linked values you get the voltage, current, power and all other values of each load, refer the following figure).
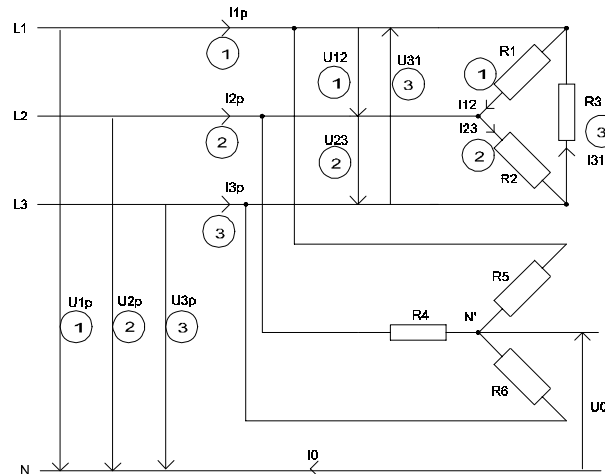
Figure 2: Allocations of the different linked values

Important note!

You can only perform a star to delta conversion, if this is physically possible. For the calculation we assume following conditions:

- u1+u2+u3 = 0
- u12+u23+u31 = 0
- i1+i2+i3 = 0
- i12+i23+i31 = 0

This assumption may not be met in following examples:

- You have a load in star circuit and there is a current flow out of the midpoint. So you can't transform this circuit to a equivalent delta circuit, because this would only have 3 wires instead of 4! This can be a typical problem when using frequency converters: Due to the high clock frequencies there might be a capacitive earth current which is the fourth „wire".
- You have a circuit in a delta configuration. If there are additional sources in one or all of the three 'loads' (e.g. by induction), there can flow a current inside the delta circuit.

Following you find an overview over the different wirings, the groups, the measured values and where you can find the values in the display. After the grouping of the wiring you see how the signals are connected to instrument and what values are calculated.

Wiring '3+0, U*I*->UΔIΔ'

Display channel	Group	Meaning	Header
1	A	The values in star circuit measured with the first measuring channel (U_1, I_1)	Chn1 (U1,I1) A:1
2	A	The values in star circuit measured with the second measuring channel (U_2, I_2)	Chn2 (U2,I2) A:2
3	A	The values in star circuit measured with the third measuring channel (U_3, I_3)	Chn3 (U3,I3) A:3
9	A	The values in delta circuit, calculated from display channel 1 to 3 (U_{12}, I_{12})	Link123 (U12,I12) A:9
10	A	The values in delta circuit, calculated from display channel 1 to 3 (U_{23}, I_{23})	Link123 (U23,I23) A:10
11	A	The values in delta circuit, calculated from display channel 1 to 3 (U_{31}, I_{31})	Link123 (U31,I31) A:11
15	A	The total values (sum channel) of group A (display channel 9 to 11)	Sum(9-11) A:15

For typical measuring circuit see 3.3.2, 'Measuring circuit for measuring efficiency of 3/1phase systems'.

Wiring '3+0, UΔI*->UΔIΔ'

Display channel	Group	Meaning	Header
1	A	The values measured with the first measuring channel (U_{12}, I_1)	Chn1 (U12,I1) A:1
2	A	The values measured with the second measuring channel (U_{23}, I_2)	Chn2 (U23,I2) A:2
3	A	The values measured with the third measuring channel (U_{31}, I_3)	Chn3 (U31,I3) A:3
9	A	The values in delta circuit, calculated from display channel 1 to 3 (U_{12}, I_{12})	Link123 (U12,I12) A:9
10	A	The values in delta circuit, calculated from display channel 1 to 3 (U_{23}, I_{23})	Link123 (U23,I23) A:10
11	A	The values in delta circuit, calculated from display channel 1 to 3 (U_{31}, I_{31})	Link123 (U31,I31) A:11
15	A	The total values (sum channel) of group A (display channel 9 to 11)	Sum(9-11) A:15

For typical measuring circuit see 3.3.3, 'Measuring circuit (typical) for star to delta conversion (option L50-O6)'.

Wiring '3+0, U∆I*->U*I*'

Display channel	Group	Meaning	Header
1	A	The values measured with the first measuring channel (U_{12}, I_1)	Chn1 (U12,I1) A:1
2	A	The values measured with the second measuring channel (U_{23}, I_2)	Chn2 (U23,I2) A:2
3	A	The values measured with the third measuring channel (U_{31}, I_3)	Chn3 (U31,I3) A:3
9	A	The values in star circuit, calculated from display channel 1 to 3 (U_1, I_1)	Link123 (U1,I1) A:9
10	A	The values in star circuit, calculated from display channel 1 to 3 (U_2, I_2)	Link123 (U2,I2) A:10
11	A	The values in star circuit, calculated from display channel 1 to 3 (U_3, I_3)	Link123 (U3,I3) A:11
15	A	The total values (sum channel) of group A (display channel 9 to 11)	Sum(9-11) A:15

For typical measuring circuit see 3.3.3, 'Measuring circuit (typical) for star to delta conversion (option L50-O6)'.

Wiring '3+1, U*I*->U∆I∆'

Display channel	Group	Meaning	Header
1	A	The values in star circuit measured with the first measuring channel (U_1, I_1)	Chn1 (U1,I1) A:1
2	A	The values in star circuit measured with the second measuring channel (U_2, I_2)	Chn2 (U2,I2) A:2
3	A	The values in star circuit measured with the third measuring channel (U_3, I_3)	Chn3 (U3,I3) A:3
4	B	The values measured with the fourth measuring channel	Chn4 B:4
9	A	The values in delta circuit, calculated from display channel 1 to 3 (U_{12}, I_{12})	Link123 (U12,I12) A:9
10	A	The values in delta circuit, calculated from display channel 1 to 3 (U_{23}, I_{23})	Link123 (U23,I23) A:10
11	A	The values in delta circuit, calculated from display channel 1 to 3 (U_{31}, I_{31})	Link123 (U31,I31) A:11
15	A	The total values (sum channel) of group A (display channel 9 to 11)	Sum(9-11) A:15

For typical measuring circuit see 3.3.2, 'Measuring circuit for measuring efficiency of 3/1phase systems'.

Wiring '3+1, UΔI*->UΔIΔ'

Display channel	Group	Meaning	Header
1	A	The values measured with the first measuring channel (U_{12}, I_1)	Chn1 (U12,I1) A:1
2	A	The values measured with the second measuring channel (U_{23}, I_2)	Chn2 (U23,I2) A:2
3	A	The values measured with the third measuring channel (U_{31}, I_3)	Chn3 (U31,I3) A:3
4	B	The values measured with the fourth measuring channel	Chn4 B:4
9	A	The values in delta circuit, calculated from display channel 1 to 3 (U_{12}, I_{12})	Link123 (U12,I12) A:9
10	A	The values in delta circuit, calculated from display channel 1 to 3 (U_{23}, I_{23})	Link123 (U23,I23) A:10
11	A	The values in delta circuit, calculated from display channel 1 to 3 (U_{31}, I_{31})	Link123 (U31,I31) A:11
15	A	The total values (sum channel) of group A (display channel 9 to 11)	Sum(9-11) A:15

For typical measuring circuit see 3.3.3, 'Measuring circuit (typical) for star to delta conversion (option L50-O6)'.

Wiring '3+1, UΔI*->U*I*'

Display channel	Group	Meaning	Header
1	A	The values measured with the first measuring channel (U_{12}, I_1)	Chn1 (U12,I1) A:1
2	A	The values measured with the second measuring channel (U_{23}, I_2)	Chn2 (U23,I2) A:2
3	A	The values measured with the third measuring channel (U_{31}, I_3)	Chn3 (U31,I3) A:3
4	B	The values measured with the fourth measuring channel	Chn4 B:4
9	A	The values in star circuit, calculated from display channel 1 to 3 (U_1, I_1)	Link123 (U1,I1) A:9

Display channel	Group	Meaning	Header
10	A	The values in star circuit, calculated from display channel 1 to 3 (U_2, I_2)	Link123 (U2,I2) A:10
11	A	The values in star circuit, calculated from display channel 1 to 3 (U_3, I_3)	Link123 (U3,I3) A:11
15	A	The total values (sum channel) of group A (display channel 9 to 11)	Sum(9-11) A:15

For typical measuring circuit see 3.3.3, 'Measuring circuit (typical) for star to delta conversion (option L50-O6)'.

For further information about this tables see also chapter 5.3, 'Definition of measuring values'.

2.6   More than 4 power measuring channels

If you connect a 2nd LMG500 or an extension box to the basic instrument, you can use up to 4 additional power measuring channels. They are placed in the groups 'C' and 'D'. In principle for the second unit you have the same wiring selections:

Wiring '1+0 Channels'

Display channel	Group	Meaning	Header
5	C	The values measured with the first extension/fifth measuring channel	Chn5 C:5

Wiring '2+0 Channels'

Display channel	Group	Meaning	Header
5	C	The values measured with the first extension/fifth measuring channel	Chn5 C:5
6	C	The values measured with the second extension/sixth measuring channel	Chn6 C:6
12	C	The calculated (not measured) current I_3 and voltage U_{12} of group C (linked channel)	Link56 (U3,I3) C:12
17	C	The total values (sum channel) of group C (display channel 5 to 6)	Sum(5-6) C:17

Wiring '1+1 Channels'

Display channel	Group	Meaning	Header
5	C	The values measured with the first extension/fifth measuring channel	Chn5 C:5
6	D	The values measured with the second extension/sixth measuring channel	Chn6 D:6

Wiring '3+0 Channels'

Display channel	Group	Meaning	Header
5	C	The values measured with the first extension/fifth measuring channel	Chn5 C:5
6	C	The values measured with the second extension/sixth measuring channel	Chn6 C:6
7	C	The values measured with the third extension/seventh measuring channel	Chn7 C:7
17	C	The total values (sum channel) of group C (display channel 5 to 7)	Sum(5-7) C:17

Wiring '2+1 Channels'

Display channel	Group	Meaning	Header
5	C	The values measured with the first extension/fifth measuring channel	Chn5 C:5
6	C	The values measured with the second extension/sixth measuring channel	Chn6 C:6
7	D	The values measured with the third extension/seventh measuring channel	Chn7 D:7
12	C	The calculated (not measured) current I_3 and voltage U_{12} of group C (linked channel)	Link56 (U3,I3) C:12
17	C	The total values (sum channel) of group C (display channel 5 to 6)	Sum(5-6) C:17

Wiring '4+0 Channels'

Display channel	Group	Meaning	Header
5	C	The values measured with the first extension/fifth measuring channel	Chn5 C:5

Display channel	Group	Meaning	Header
6	C	The values measured with the second extension/sixth measuring channel	Chn6 C:6
7	C	The values measured with the third extension/seventh measuring channel	Chn7 C:7
8	C	The values measured with the fourth extension/eighth measuring channel	Chn8 C:8
17	C	The total values (sum channel) of group C (display channel 1 to 4)	Sum(5-8) C:17

Wiring '3+1 Channels'

Display channel	Group	Meaning	Header
5	C	The values measured with the first extension/fifth measuring channel	Chn5 C:5
6	C	The values measured with the second extension/sixth measuring channel	Chn6 C:6
7	C	The values measured with the third extension/seventh measuring channel	Chn7 C:7
8	D	The values measured with the fourth extension/eighth measuring channel	Chn8 D:8
17	C	The total values (sum channel) of group C (display channel 5 to 7)	Sum(5-7) C:17

Wiring '2+2 Channels'

Display channel	Group	Meaning	Header with Aron set to **off**
5	C	The values measured with the first extension/fifth measuring channel	Chn5 C:5
6	C	The values measured with the second extension/sixth measuring channel	Chn6 C:6
7	D	The values measured with the third extension/seventh measuring channel	Chn7 D:7
8	D	The values measured with the fourth extension/eighth measuring channel	Chn8 D:8
12	C	The calculated (not measured) current I_3 and voltage U_{12} of group C (linked channel)	Link56 (U3,I3) C:12

Display channel	Group	Meaning	Header with Aron set to **off**
13	D	The calculated (not measured) current I_3 and voltage U_{12} of group D (linked channel)	Link78 (U3,I3) D:13
17	C	The total values (sum channel) of group C (display channel 5 to 6)	Sum(5-6) C:17
18	D	The total values (sum channel) of group D (display channel 7 to 8)	Sum(7-8) D:18

Wiring '2+2 Channels'

Display channel	Group	Meaning	Header with Aron set to **on**
5	C	The values measured with the first extension/fifth measuring channel	Chn1 (U12,I1) A:1
6	C	The values measured with the second extension/sixth measuring channel	Chn2 (U32,I3) A:2
7	D	The values measured with the third extension/seventh measuring channel	Chn3 (U12,I1) B:3
8	D	The values measured with the fourth extension/eighth measuring channel	Chn4 (U32,I3) B:4
12	C	The calculated (not measured) current I_2 and voltage U_{31} of group C (linked channel)	Link56 (U31,I2) C:12
13	D	The calculated (not measured) current I_2 and voltage U_{31} of group D (linked channel)	Link78 (U31,I2) D:13
17	C	The total values (sum channel) of group C (display channel 5 to 6)	Sum(5-6) C:17
18	D	The total values (sum channel) of group D (display channel 7 to 8)	Sum(7-8) D:18

Wiring '3+0, U*I*->U∆I∆'

Display channel	Group	Meaning	Header
5	C	The values in star circuit measured with the first extension/fifth measuring channel (U_1, I_1)	Chn5 (U1,I1) C:5
6	C	The values in star circuit measured with the second extension/sixth measuring channel (U_2, I_2)	Chn6 (U2,I2) C:6
7	C	The values in star circuit measured with the third extension/seventh measuring channel (U_3, I_3)	Chn7 (U3,I3) C:7

Display channel	Group	Meaning	Header
12	C	The values in delta circuit, calculated from display channel 5 to 7 (U_{12}, I_{12})	Link567 (U12,I12) C:12
13	C	The values in delta circuit, calculated from display channel 5 to 7 (U_{23}, I_{23})	Link567 (U23,I23) C:13
14	C	The values in delta circuit, calculated from display channel 5 to 7 (U_{31}, I_{31})	Link567 (U31,I31) C:14
17	C	The total values (sum channel) of group C (display channel 12 to 14)	Sum(12-14) C:17

Wiring '3+0, U∆I*->U∆I∆'

Display channel	Group	Meaning	Header
5	C	The values measured with the first extension/fifth measuring channel (U_{12}, I_1)	Chn5 (U12,I1) C:5
6	C	The values measured with the second extension/sixth measuring channel (U_{23}, I_2)	Chn6 (U23,I2) C:6
7	C	The values measured with the third extension/seventh measuring channel (U_{31}, I_3)	Chn7 (U31,I3) C:7
12	C	The values in delta circuit, calculated from display channel 5 to 7 (U_{12}, I_{12})	Link567 (U12,I12) C:12
13	C	The values in delta circuit, calculated from display channel 5 to 7 (U_{23}, I_{23})	Link567 (U23,I23) C:13
14	C	The values in delta circuit, calculated from display channel 5 to 7 (U_{31}, I_{31})	Link567 (U31,I31) C:14
17	C	The total values (sum channel) of group C (display channel 12 to 14)	Sum(12-14) C:17

Wiring '3+0, U∆I*->U*I*'

Display channel	Group	Meaning	Header
5	C	The values measured with the first extension/fifth measuring channel (U_{12}, I_1)	Chn5 (U12,I1) C:5
6	C	The values measured with the second extension/sixth measuring channel (U_{23}, I_2)	Chn6 (U23,I2) C:6
7	C	The values measured with the third extension/seventh measuring channel (U_{31}, I_3)	Chn7 (U31,I3) C:7
12	C	The values in star circuit, calculated from display channel 5 to 7 (U_1, I_1)	Link567 (U1,I1) C:12

Display channel	Group	Meaning	Header
13	C	The values in star circuit, calculated from display channel 5 to 7 (U_2, I_2)	Link567 (U2,I2) C:13
14	C	The values in star circuit, calculated from display channel 5 to 7 (U_3, I_3)	Link567 (U3,I3) C:14
17	C	The total values (sum channel) of group C (display channel 12 to 14)	Sum(12-14) C:17

For typical measuring circuit see 3.3.3, 'Measuring circuit (typical) for star to delta conversion (option L50-O6)'.

Wiring '3+1, U*I*->U∆I∆'

Display channel	Group	Meaning	Header
5	C	The values in star circuit measured with the first extension/fifth measuring channel (U_1, I_1)	Chn5 (U1,I1) C:5
6	C	The values in star circuit measured with the second extension/sixth measuring channel (U_2, I_2)	Chn6 (U2,I2) C:6
7	C	The values in star circuit measured with the third extension/seventh measuring channel (U_3, I_3)	Chn7 (U3,I3) C:7
8	D	The values measured with the fourth extension/eighth measuring channel	Chn8 D:8
12	C	The values in delta circuit, calculated from display channel 5 to 7 (U_{12}, I_{12})	Link567 (U12,I12) C:12
13	C	The values in delta circuit, calculated from display channel 5 to 7 (U_{23}, I_{23})	Link567 (U23,I23) C:13
14	C	The values in delta circuit, calculated from display channel 5 to 7 (U_{31}, I_{31})	Link567 (U31,I31) C:14
17	C	The total values (sum channel) of group A (display channel 12 to 14)	Sum(12-14) C:17

Wiring '3+1, U∆I*->U∆I∆'

Display channel	Group	Meaning	Header
5	C	The values measured with the first extension/fifth measuring channel (U_{12}, I_1)	Chn5 (U12,I1) C:5

Display channel	Group	Meaning	Header
6	C	The values measured with the second extension/sixth measuring channel (U_{23}, I_2)	Chn6 (U23,I2) C:6
7	C	The values measured with the third extension/seventh measuring channel (U_{31}, I_3)	Chn7 (U31,I3) C:7
8	D	The values measured with the fourth extension/eighth measuring channel	Chn8 D:8
12	C	The values in delta circuit, calculated from display channel 5 to 7 (U_{12}, I_{12})	Link567 (U12,I12) C:12
13	C	The values in delta circuit, calculated from display channel 5 to 7 (U_{23}, I_{23})	Link567 (U23,I23) C:13
14	C	The values in delta circuit, calculated from display channel 5 to 7 (U_{31}, I_{31})	Link567 (U31,I31) C:14
17	C	The total values (sum channel) of group C (display channel 12 to 14)	Sum(12-14) C:17

Wiring '3+1, UΔI*->U*I*'

Display channel	Group	Meaning	Header
5	C	The values measured with the first extension/fifth measuring channel (U_{12}, I_1)	Chn5 (U12,I1) C:5
6	C	The values measured with the second extension/sixth measuring channel (U_{23}, I_2)	Chn6 (U23,I2) C:6
7	C	The values measured with the third extension/seventh measuring channel (U_{31}, I_3)	Chn7 (U31,I3) C:7
8	D	The values measured with the fourth extension/eighth measuring channel	Chn8 D:8
12	C	The values in star circuit, calculated from display channel 5 to 7 (U_1, I_1)	Link567 (U1,I1) C:12
13	C	The values in star circuit, calculated from display channel 5 to 7 (U_2, I_2)	Link567 (U2,I2) C:13
14	C	The values in star circuit, calculated from display channel 5 to 7 (U_3, I_3)	Link567 (U3,I3) C:14
17	C	The total values (sum channel) of group C (display channel 12 to 14)	Sum(12-14) C:17

3   Installation

3.1   Unpacking and putting into operation

Having unpacked the equipment, it should be checked for signs of damage. Damage due to transportation should be reported to the equipment supplier at the earliest opportunity. If it is uncertain to use the damaged equipment safely, then the equipment should not be used.

The package should be stored for further transports (e.g. for the annual calibration according to ISO9000).

After delivery the following items should be present:
- 1   LMG500 with the ordered number 'n' of measuring channels
- 1   User manual
- n*4   Safety laboratory leads, 2.5mm², 1m, 1/2 in violet, 1/2 in grey
- 1   Mains supply cable

Further accessories as listed in the delivery note.

The instrument should only be used in a clean and dry environment and must never be operated in excessively dusty or moist spaces. To ascertain sufficient air circulation the instrument should be operated in a horizontal position or tilted only to the degree possible by of the adjustable handle. The instrument should not operate in direct sunlight.

3.2   General set-up

In general the instrument stores the actual settings as well as the last used menu. Pressing the both lower softkeys when switching on the instrument will reset all settings to the default parameters.

By this you can delete faulty scripts, which could block the instrument.

3.3   Connections of the LMG500

First of all please refer to chapter 1.1, 'Safety Instructions'.

To ensure correct power measurement polarity, connect the cabling to the test circuit so that the grey terminals (U and I) are used as a reference. In other words, the signal source should point towards the terminals U^*, U_{Sensor}, I^*, I_{HF} and I_{Sensor}.

When working with DC voltages/currents, these terminals are the positive connections.

The following diagrams are some examples for typical connections of the instrument. But all other measuring circuits are also possible (e.g. circuits which measure the correct current instead of the correct voltage).

3.3.1   Measuring circuit for typical line applications using the internal current path
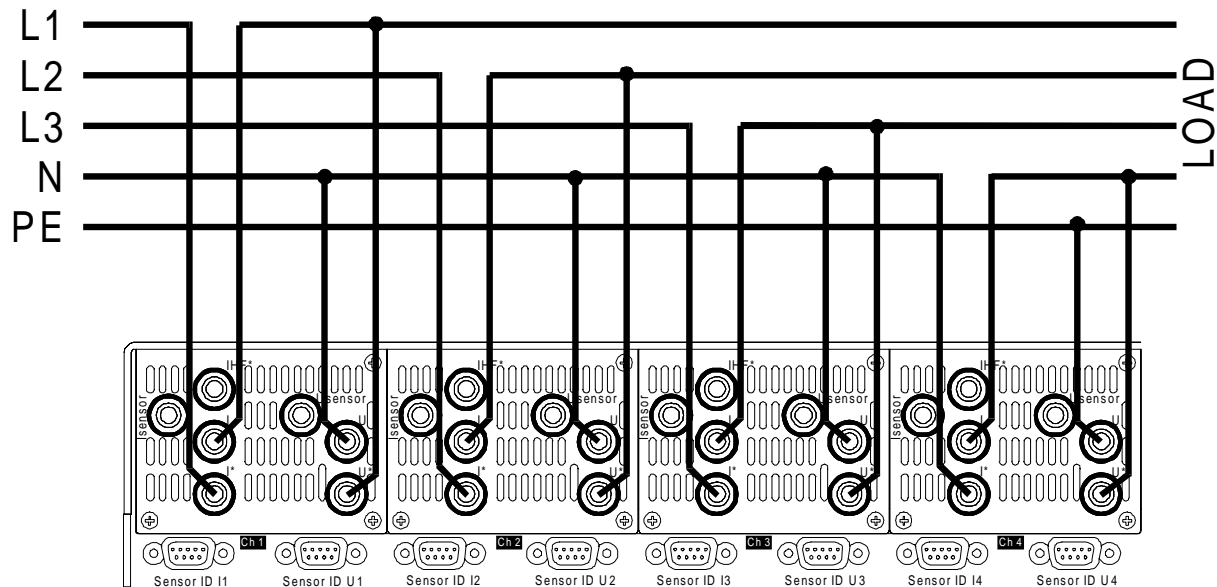
Figure 3: Measuring circuit 3 phase system with neutral

In this circuit we measure with the first three channels the voltage, current and power of the three phase system. With the fourth channel we measure additionally the current in the neutral wire and the voltage between neutral and earth. Of course you can use the same circuit without the fourth channel, if you are not interested in this values.

This circuit should be measured with wiring '3+1 Channels'.
Wiring '4+0 Channels' is also possible, but then the measured power of channel 4 would be added to the total power of the system (this could be correct, but depends very much on what you want to measure!).

3.3.2   Measuring circuit for measuring efficiency of 3/1phase systems
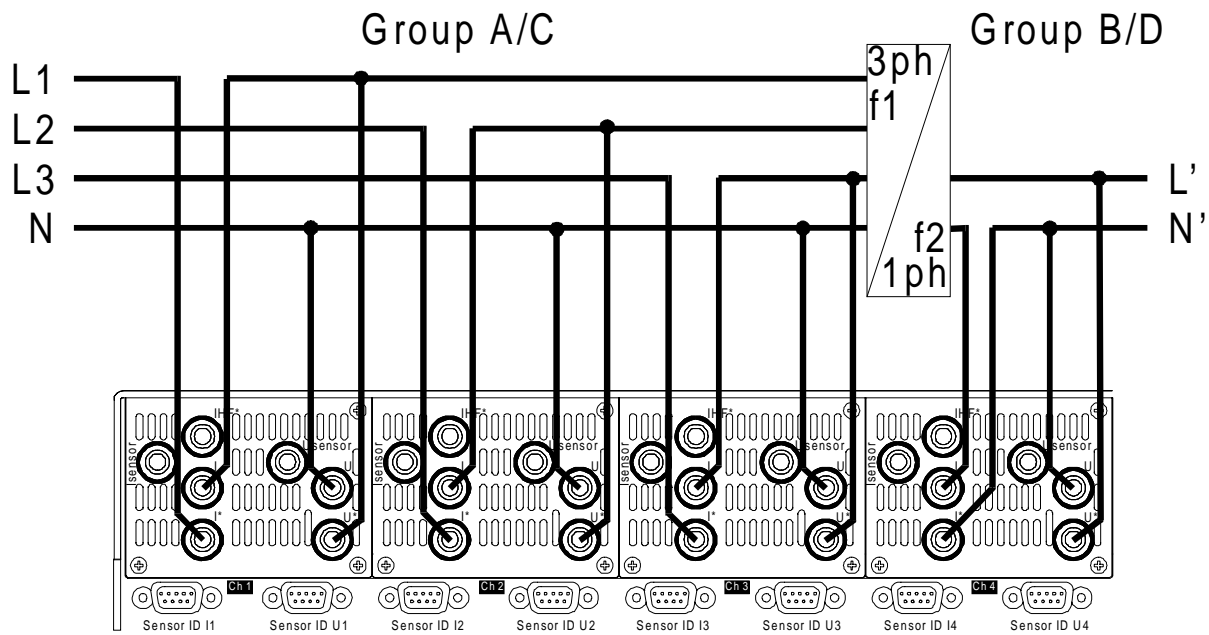
Figure 4: Measuring circuit for measuring efficiency (3/1phase)

With group A you measure the three phase power, with group B the one phase power of the system. The frequencies of group A and B can be different.

You can use this circuit also in the other direction, when you have a one phase source and a 3 phase load (e.g. solar panel pushing energy to the mains).

This circuit should be measured with wiring '3+1 Channels'. If your 3phase load is an delta circuit and you have the option L50-O6 (star to delta conversion) implemented, you can also use the wiring '3+1, U*I*->U∆I∆' to determine all the values of the delta circuit.

3.3.3   Measuring circuit (typical) for star to delta conversion (option L50-O6)
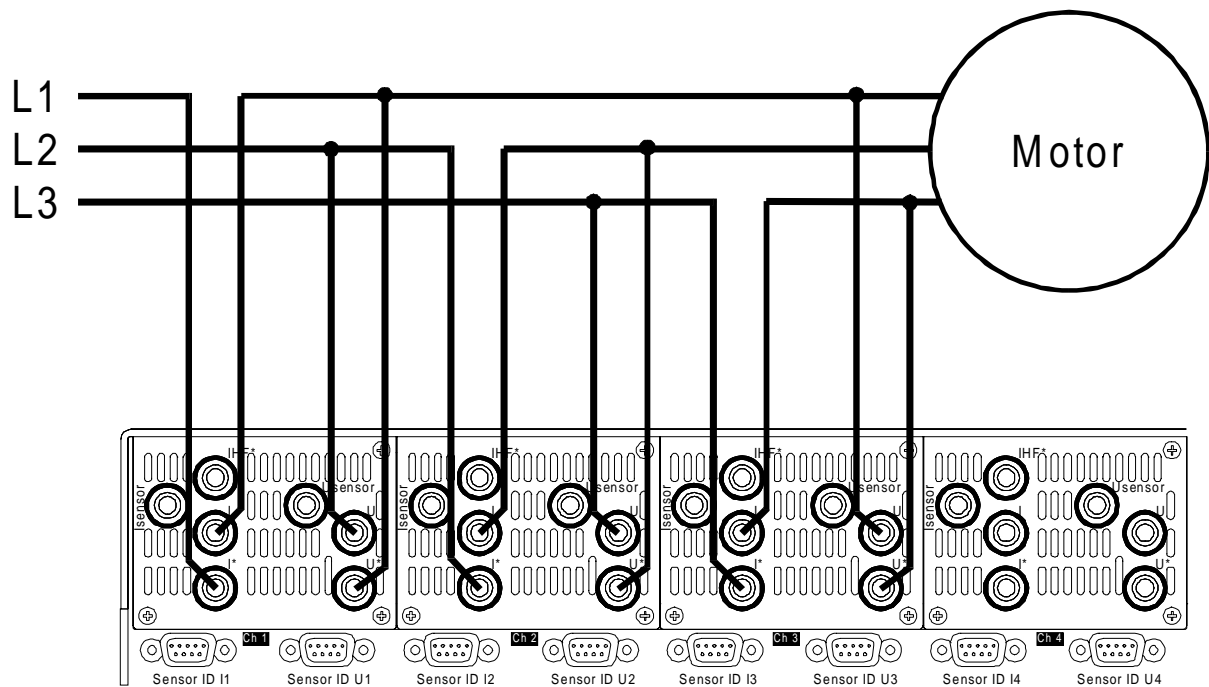
Figure 5: Star to delta conversion

With group A you measure the linked voltages and the currents in the phases. The LMG500 calculates with this both values a power for each channel, but this power will not be the power of the system, because the measured voltages (U_{12}, U_{23} and U_{31}) belong not to the currents (I_1, I_2 and I_3). The power values are a mix from star and delta values.

But with the star to delta conversion, you can either transform the voltages to star voltages or you can transform the currents to delta currents. This will depend on your load. Now you have voltage and current in the same circuit and now you have also power values which exist in your circuit.

However the group B can be used independently like in the above examples.

This circuit should be measured with wiring '3+1, UΔI*->UΔIΔ' or '3+1, UΔI*->U*I*'.

3.3.4   Aron wiring
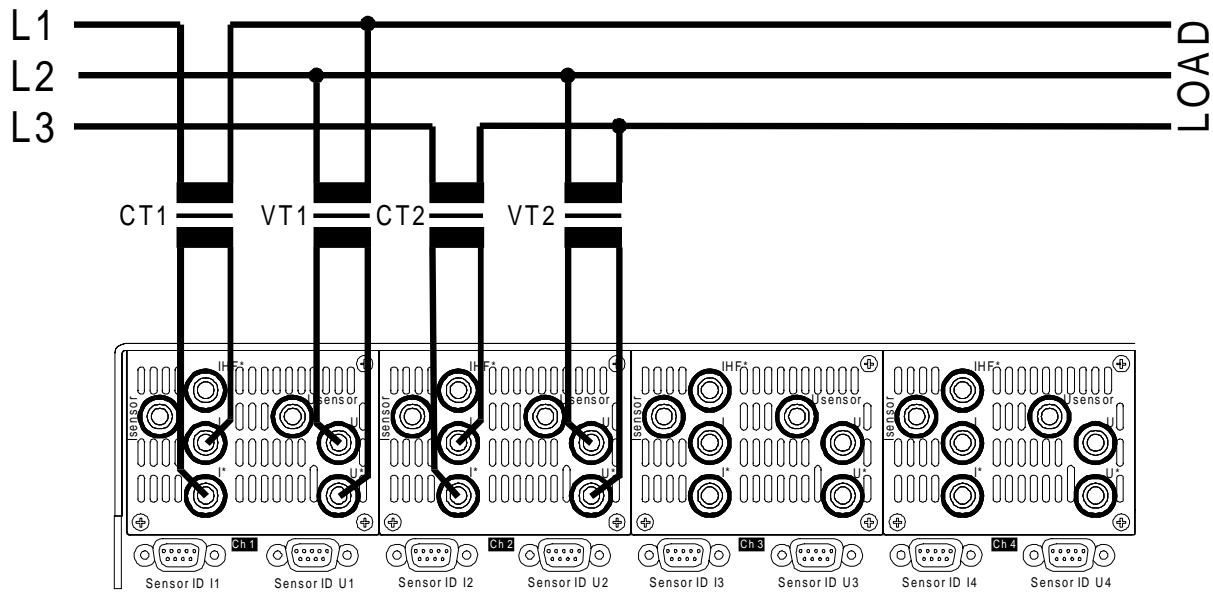
Figure 6: Measuring circuit with current and voltage transformers in Aron wiring

This wiring is for measuring the power of a three phase system without a neutral conductor. This circuit should be measured with wiring '2+0 Channels', '2+1 Channels' or '2+2 Channels'. Here current and voltage are measured with transformers to enlarge the ranges, e. g. for measuring in middle or high voltage systems with also high currents. The both free channels could be used to measure another three phase system: refer „3.3.5 Measuring circuit for measuring efficiency of 3/3phase systems".

When using voltage or current transformers please watch the applicable safety standards (e.g. earthing, isolation, ...)!

3.3.5   Measuring circuit for measuring efficiency of 3/3phase systems
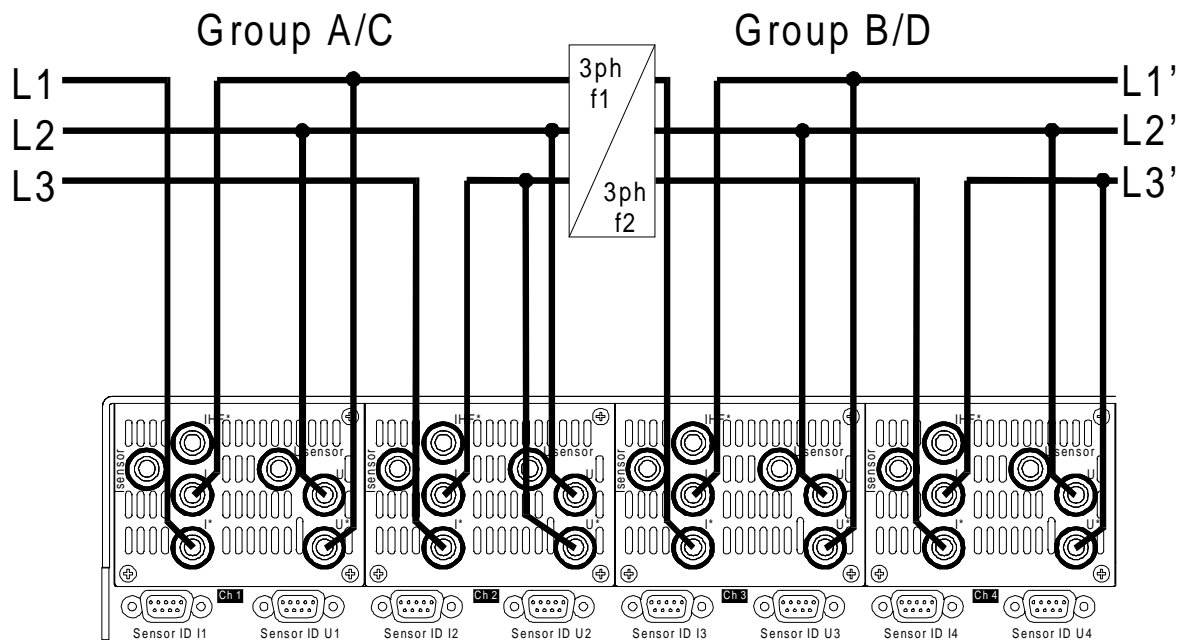
Figure 7: Measuring circuit for measuring efficiency (3/3phase)

With group A you measure the first three phase power, with group B the second one. The frequencies of group A and B can be different. This is a double aron circuit.

This circuit should be measured with wiring '2+2 Channels'.

3.3.6   Measuring circuit using an external current sensor
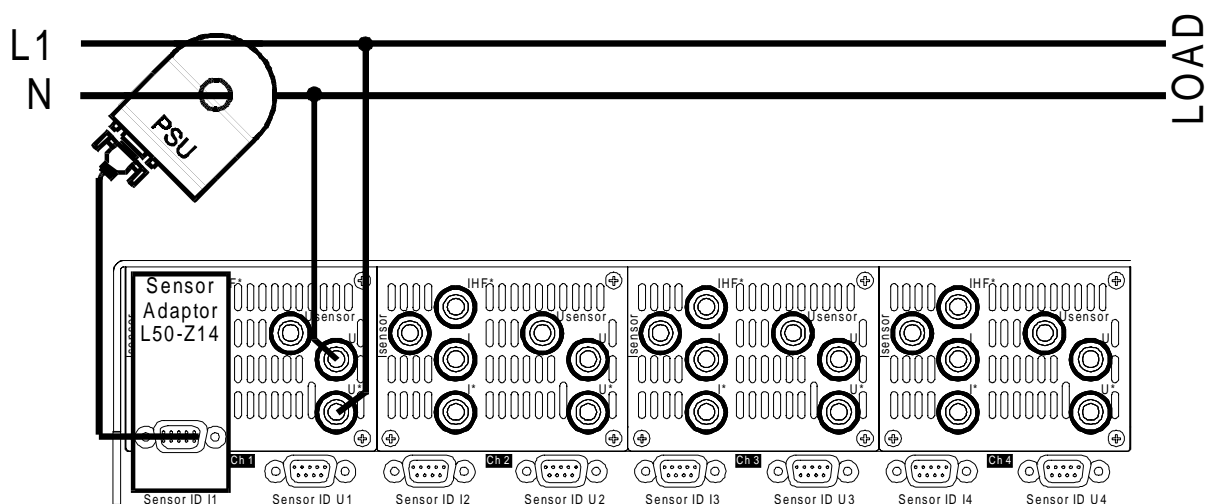
Figure 8: Measuring circuit with external current sensor

Here you see, how to install your current sensor.

For easy usage all ZES sensors have an EEPROM implemented in which we have stored the name, scaling, ranges, adjustment and delay time. The LMG500 recognises automatically, which ZES sensor is connected and sets up the range menu. Further on we correct some of the

errors the sensor produces (transfer error, delay time). So you get the best measuring results with each sensor.

In this monophase application you could use every wiring.

3.3.7   Measurements at middle and high voltage systems
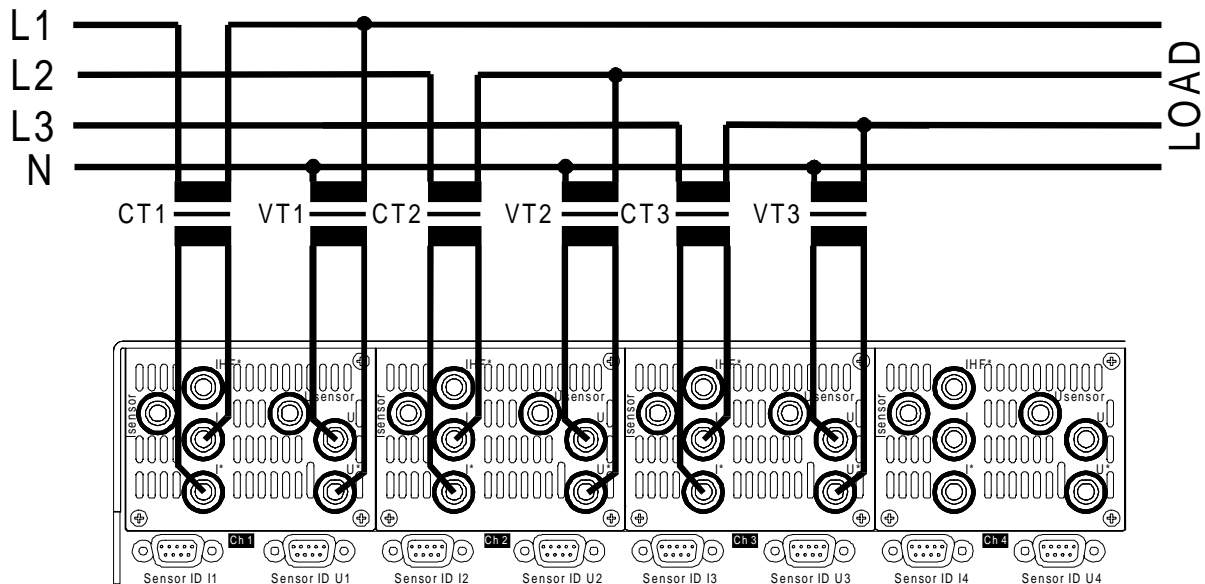
Figure 9: Measuring circuit for measuring in middle and high voltage systems

This is the measuring circuit for measuring in middle and high voltage systems. You can see that there is no PE conductor. For very high currents and voltages, there are transformers in each path implemented. The chosen wiring should be '3+0 Channels' or '3+1 Channels'.

When using voltage or current transformers please watch the applicable safety standards (e.g. earthing, isolation, ...)!

3.3.8   Measurements at middle and high voltage systems without N
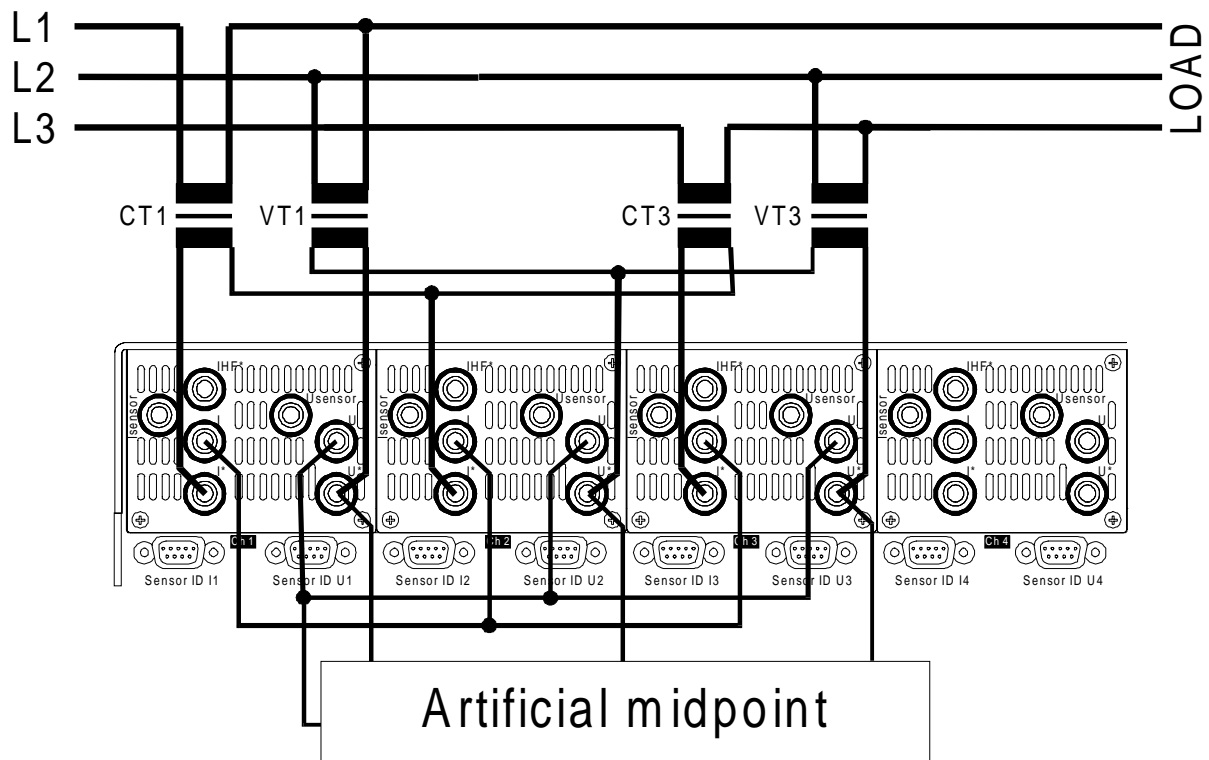
**Figure 10: Measuring circuit for measuring in middle and high voltage sytems without N
Using artificial midpoint**

This is the measuring circuit for measuring in middle and high voltage systems without the neutral N. You can see that there is no PE conductor. You just need each two transformers for voltages and currents. The chosen wiring should be '3+0 Channels' or '3+1 Channels'.

When using voltage or current transformers please watch the applicable safety standards (e.g. earthing, isolation, ...)!

3.3.9   Measurements at middle and high voltage systems without N
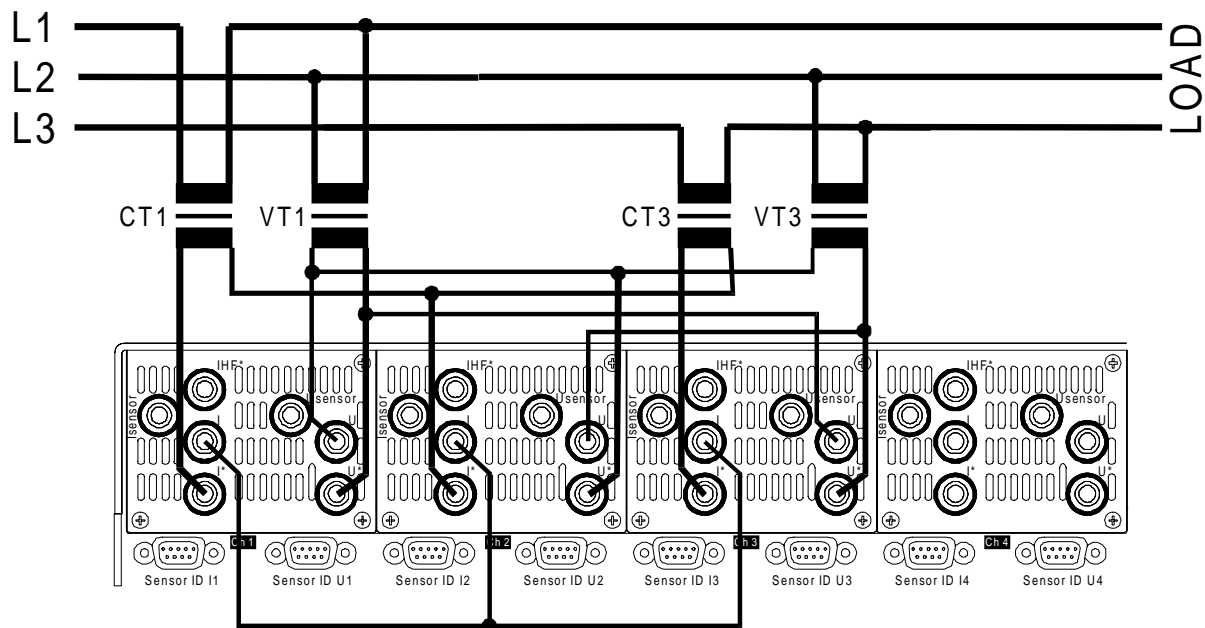
**Figure 11: Measuring circuit for measuring in middle and high voltage sytems without N
Using star to delta conversion**

This is the measuring circuit for measuring in middle and high voltage systems without the
neutral N. You can see that there is no PE conductor. You just need each two transformers for
voltages and currents. The chosen wiring should be '3+x, UΔI*->UΔIΔ' or '3+x, UΔI*-
>U*I*'.

When using voltage or current transformers please watch the applicable safety standards (e.g.
earthing, isolation, ...)!

3.4   Coupling of two LMG500 (L50-Z13) for a 8 channel instrument

Two LMG500 can be coupled to build up an instrument with 8 power channels. For this you
need the coupling cable L50-Z13 which is connected to the 'channel extention' jacks of both
instruments.

One instrument has to be configured to be the slave. How to do this you find in 4.4.1, 'Misc.'.
The slave is now just a housing and supply for the channels. All other electronics is disabled, as
well as the slave's options. The slave channels run with the same options like the master
instrument.

The additional channels are displayed in the master instrument as channels 5 to 8 and with the
new group identifiers 'C' and 'D'. All the other handling is the same like in the basic
instrument.

4   Instrument controls

4.1   Front panel
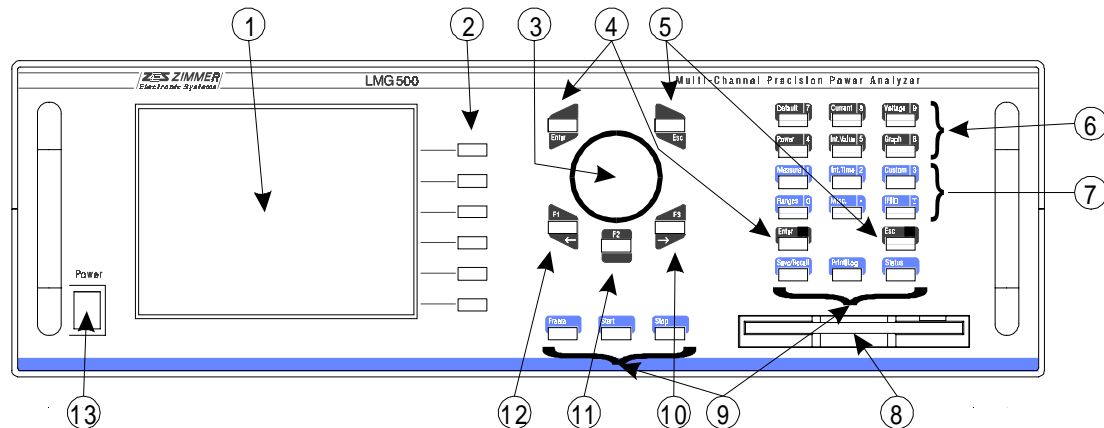
Figure 12: Front panel of the instrument

1. Graphical Display

2. Softkeys

   Their function depends on the indicated function in the display.

3. Rotary knob

   This knob is used for several number settings, for selections in lists and for cursor moving.
   A turn to the right increases the number. In many cases you can also push the knob to
   confirm a selection.

4. ENTER key

   This key is used to finish an entering and to quit an error message

5. ESC key

   This key is used cancel an entering mode and to quit an error message.

6. Dark menu selection keys

   With this keys you can call different menus with the pure measuring values:
   Default, Current, Voltage, Power, Int. Value and Graph.
   A second function of this keys is to enter the digits from '4' to '9' when in a number
   entering mode.

7. Violet menu selection keys

   With this keys you can call several menus for setting up the instrument:
   Measure: The main measuring parameters
   Int. Time: The parameters for time dependent measuring

Custom: The set-up of the custom defined menus

Ranges: The range selection of the measuring channels

Misc.:   Setup of date, time and display brightness.

IF/IO: Setup of options

A second function of this keys is to enter the digits from '0' to '3' and '.' and '-' when in a number entering mode.

8. Floppy disk drive. Alternatively there can be a USB memory stick adapter instead of the floppy (option L50-O2USB) . This USB adapter can be used for memory sticks <u>only</u>!

9. Special function keys

Status: Here you get status information about the LMG500

Start: This key is used to start time dependent measurements

Stop: This key is used to stop time dependent measurements

Save/Recall: The actual menu is stored to the memory card

Print/Log: The actual menu is send to the printer output or logger

Freeze: Holds the measuring values of the last cycle in the display or enables the refresh of the display after each cycle

10. Special Function Key F3

11. Special Function Key F2

12. Special Function Key F1

13. Mains switch

4.2   Rear panel
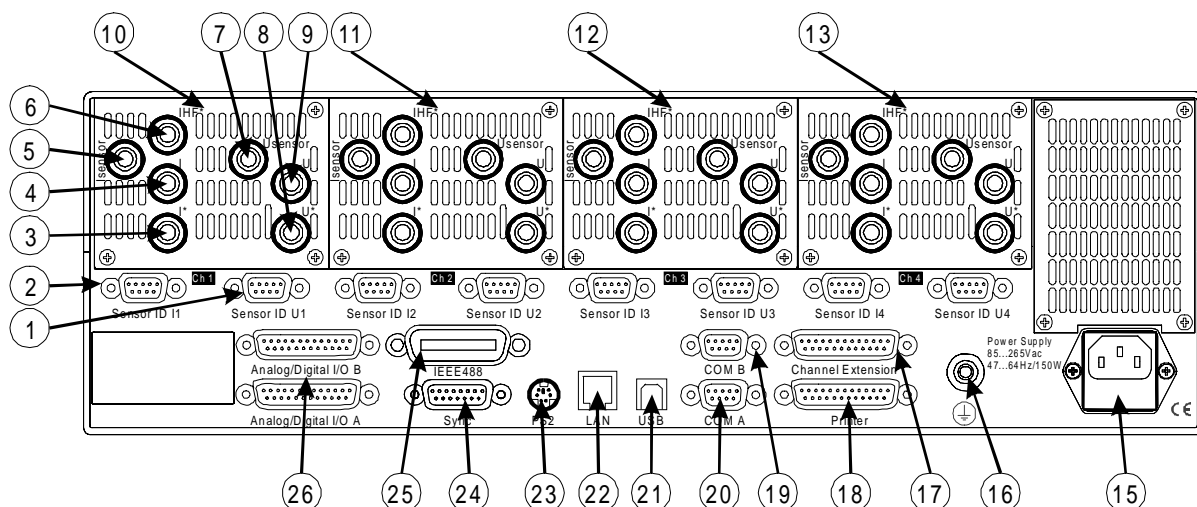
Figure 13: Rear panel of the instrument

First measuring channel:

1. External voltage sensor identification
   Identification input for external voltage sensors. It is used together with sensor adaptor L50-Z14. 9-pin SUB-D socket.

2. External current sensor identification
   Identification input for external current sensors. It is used together with sensor adaptor L50-Z14. 9-pin SUB-D socket.

3. I*
   Wide dynamic current input (high), 4mm violet safety socket

4. I
   Current input (low), 4mm grey safety socket. This is the reference socket for the I*, I_{HF} and I_{sensor} input.

5. I_{sensor}
   Voltage input for external current sensors (high), 4mm red safety socket.

6. I_{HF}
   High frequent current input (high), 4mm orange (violet at older instruments) safety socket

7. U_{sensor}
   Voltage input external voltage sensors (high), 4mm red safety socket.

8. U*
   Voltage input (high), 4mm violet safety socket

9. U
   Voltage input (low), 4mm grey safety socket. This is the reference socket for the U* and U_{sensor} input.

10. First measuring channel.

11. Second measuring channel with same sockets like first channel

12. Third measuring channel with same sockets like first channel

13. Fourth measuring channel with same sockets like first channel

14. Not used

15. Mains
    Fused chassis plug with holder for fuses. Mains voltage 85...264V, 47...64Hz, up to 150W, depending on installed options, 2 fuses T3.15A/250V, 5x20mm, IEC127-2/3

16.PE

Connector for additional earthing, 4mm green/yellow safety socket

17.Channel extension

Here you can connect additional measuring channels from the extension box LMG500-E or a second LMG500.

18.Printer

Centronics compatible interface or printer connection
25-pin SUB-D socket

19.ComB: Serial RS232 interface

This is a serial interface which is reserved for further usage
9-pin SUB-D jack

20.ComA: Serial RS232 interface

This is the standard serial interface for remote control of the instrument.
This interface is also used for software updates and service purposes.
9-pin SUB-D socket

21.Not used, reserved for future usage

22.Not used, reserved for future usage

23.PS/2

Connector for an external keyboard. This can be connected to enter for example formulas in a comfortable way.

24.Sync.

Socket for external synchronisation and measuring time control of the instrument.
15-pin SUB-D socket

25.IEEE488

Parallel interface, 24-pin micro-ribbon socket

26.I/O card

Additional analogue and digital inputs and outputs for auxiliary signals. Two 25-pin SUB-D sockets.

4.3   Display

The display is divided into 3 sections:

- The softkeys at the right border change their meaning depending on the actual menu. A softkey with a black background is an active softkey. A dotted softkey can not be used.
- The elements of the status line at the top of the display are described in '4.3.1 Status line'. In this line you can see the most important status information of the instrument. This line is always visible.
- In the main display the different menues are displayed. This can be measuring values, set up menues or graphs.
  At the bottom of this region a possible error message is displayed. This error messages have to be quit by pressing *Enter* or *Esc*.

4.3.1   Status line

Figure 14: Status line

The status line has the following sub sections (from left to right):

- The voltage and current signal level indicators. Here you can see how much of the actual voltage/current range has been used. This display is important for the selection of the measuring range. At the left side three information: The upper one is the group (A to D), in the middle is synchronisation source of the channel. Here you can find:

Un	for the voltage channel n
In	for the current channel n
Li	for line synchronisation
Ex	for external synchronisation
As	(inverse) for asynchronous (no synchronisation)

  The lower information can be:

  'LF' (inverse displayed) indicating that the signal of the channel is low pass filtered.

- The mode indicator. In this line you see the chosen measuring mode. Possible values are 'Normal', 'CE-Harm', 'CE-Flk', 'HRM100' and 'Trans'.
  In the line below, the time base indicator shows the actual chosen cycle time. The bar below this number shows how much of the cycle time is over.

- The 'Active' indicates, that the display is updated with measuring values. 'Freeze' indicated a frozen display. The current displayed values don't change until 'Active' is chosen again (key *Freeze*).
  Below: the remote indicator. 'Remote' indicates that the instrument is remote controlled by a PC. Some setting can now only be done by the PC but not at the front panel. 'Local' indicates, that the instrument works as a stand alone instrument.

4.4   General menues

If you are in a sub menu of a menu, you can reach the main menu by pressing the correct softkey, until you are in the main menu or you can press the menu button (e.g. *IF/IO*) again.

Here you find the description of menues which are equal for all measuring modes.

4.4.1   Misc.

Globals tab

Here you can do 4 settings:

Date   Here you can enter the actual date. This date is used inside the instrument.

Time   Here you can enter the actual time. This time is used inside the instrument. Instead of the ':' you have to enter a '.'.

Keyboard Here you can define the layout of a PC keyboard which is connected to the PS/2 connector at the rear .

Color   Here you can set-up the colours of the display.
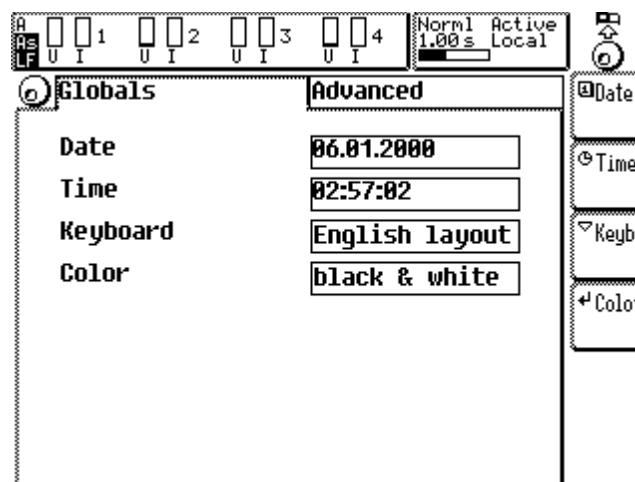
Figure 15: Misc. menu

Advanced tab

Here you can set-up some advanced, special things which should not be used under usual conditions. Just users which are sure to know what they do should change values in this menu. With wrong settings measuring results might be wrong! Following things can be set-up:

Zero   The zero point rejection (see 12.2, 'Display of values') can be switched off. It will be activated again each time you restart the instrument.

Phan. Vals. The rejection of phantom values can be deactivated. Phantom values appear for example at wiring '3+1, UΔI*->UΔIΔ', because the measured star current has physically nothing to do with the measured triangle voltage. But the power measuring channel sees both signals at the same time and calculates a power for them, the phantom power.

Slave Defines this instrument as the slave in a Master/Slave configuration

Z-Adj. allows you to adjust the zero point of the instrument. You can only adjust the actual selected voltage and current jacks.
You can reset the instrument to the factory settings of calibration by holding the lower two softkeys pressed while switching on the instrument (for about 10s, until the instrument beeps).
Be careful with this function because you can also deadjust the instrument!!!
For the exact adjustment steps please refer to 11.3.3 'Zero adjustment of the instrument'.

4.4.2   IF/IO

In this menu you can set-up all features which are available as instrument options. Further on you see the actual software version and the installed options. With **List** you can choose a short list or detail list. In the last one you can scroll with the rotary knob.

4.4.2.1   Interfaces for remote control

With exception of the IEEE interface all interfaces could also be used for data logging (see 10, 'Logging of values to drives, printer and interfaces'. To remote control the LMG you first have to set-up the wished interface for this job.

Press several times *IF/IO* to reach the IF/IO menu. By pressing **IF** you can set-up the remote device. You have several available 'profiles' from which you can select one (with **Dev.**). These profiles are predefined but they can be modified when necessary (with **Set**).
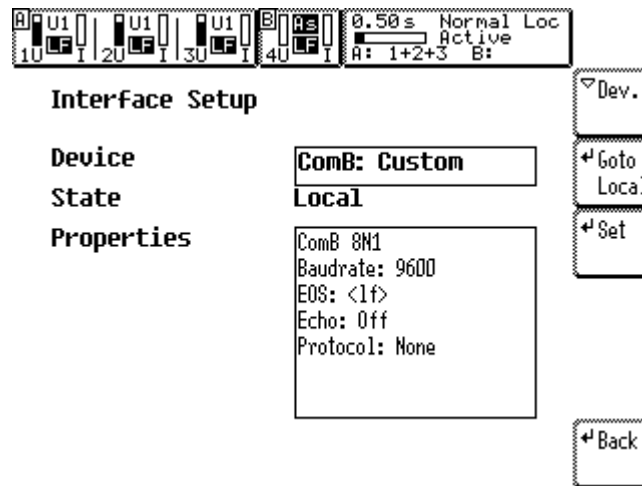
Figure 16: Interface Setup

If you modify the remote control profile for ComA the data logging profile for ComA is not changed!

If you want to reserve an interface for logging, it can happen that this interface is already used for logging. In this case you are asked, if you want to reassign it for logging. Press *Enter* to do this or *Esc* to cancel.

4.4.2.1.1   Remote control profiles

The actual setting of a profile are displayed under properties. You can change them by pressing **Set**.

Following profiles are available. You get just these displayed which are physically present:

ComA: Terminal

Choose this profile if you are not familiar with the remote possibilities of the LMG and you want to try to enter some commands manually via a terminal program. You can just change the baud rate. The other parameters are set up to values (EOS=Terminal, Echo=off, Protocol=None) so that you can work with most terminal programs directly. The default value for the baud rate is 9600 baud.

ComA: Script

Instead of entering a script via the rotary knob you can also transfer it via the serial interface. If you want to do this, you can get a freeware program from ZES. This profile is predefined to communicate with this program. You just have to set-up the profile, connect LMG and PC with a 1:1 cable and start the software.

With this software you can create, read out, modify, write and save a script.

ComA: OEM Appl

This should be chosen for external software like SYS61K, TERM-L5 or other software from ZES (if no other specification in the software exists). Most parameters are fixed (EOS=<lf>, Echo=off, Protocol=RTS/CTS) and you can just modify the baudrate. Default value is 38400 baud.

ComA: Custom

If you want to implement the LMG into your own system, you can set-up in this profile all parameters:

Baudrate   The serial interface supports baud rates from 1200 (maximum about 100 characters per second) up to 115200 baud (10000 characters per second). Usually you use the biggest value. Some old PC support just up to 38400 baud.

EOS   End-Of-String character(s). This are the characters which mark the end of a command or answer. Possible values are '<lf>', '<cr>, <cr><lf>' and 'Terminal'. In 'Terminal' mode each '<cr>' of the computer is answered by a '<cr><lf>' of the instrument. By this you get a nice display if you use an terminal program (if you have also activated the echo).

Echo   If this is set on, each character you send to the LMG is returned to the sender. By this you can check, if the cable is working and in a terminal program you see, what you have typed.

Protocol   The LMG supports 'None' protocol and 'RTS/CTS'. The last one is a hardware handshake. It should be used, if the computer can't read all data in real time and it gets very many data.

ComB: Custom

Same like ComA. Please note that you have to use a null modem cable.

GPIB

If you want to use this interface you need a GPIB controller in your PC. You have just to set-up the address of the LMG (in the range from 1 to 30).

4.4.2.1.2   remote <-> local

If you send any characters to the LMG it changes to the remote state (you see a 'REM' in the status line). Then it is impossible to change any parameters like cycle time, because this might conflict with an actual remote command.

To leave this remote state you can send an 'go-to-local' command via interface or you can press the **Goto Local** softkey.

If you send further characters to the instrument it changes back to the remote state.

4.4.2.2 Processing signal interface (option L50-O3)

With **IO** you reach the set-up menus for the processing signal interface. With the rotary knob you can select four tabs ('A_In', 'A_Out', 'D_In' and 'D_Out'). By pressing the rotary knob you can set-up each tab. **Back** returns to the *IF/IO* menu.

4.4.2.2.1 Analogue Input tab

If you are in the setting mode of this menu, you can with the rotary knob select a channel.

Zero   Here you set-up, which value will be displayed with 0V input.

FS   Here you set-up, which value will be displayed with 10V input.

Diff   Specifies, if the inputs are single ended („off") against AIn_GND (default setting) or differential („on"). With differential inputs, the inputs 2, 4, 6 and 8 disappear and the differences AIn1-AIn2, AIn3-AIn4, AIn5-AIn6 and AIn7-AIn8 are display in the channels 1, 3, 5 and 7.

Example: You select **Zero** '30' and **FS** '120'. Now you get with 0V input a display of 30, with 10V input a display of 120 and with 5V input a display of 75. The output is updated every measuring cycle.
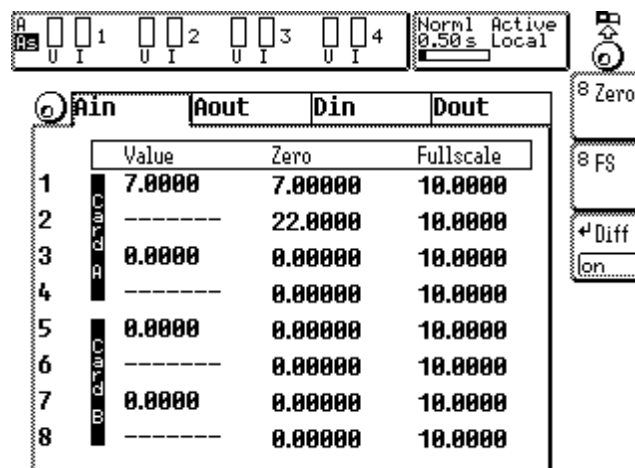
Figure 17: Analogue inputs

Pressing the rotary knob returns you to the tab selection.

4.4.2.2.2 Analogue Output tab

If you are in the setting mode of this menu, you can with the rotary knob select a channel.

Value   This allows you to set-up the value which should be output. See chapter 4.5, 'Entering identifiers' for details.

Zero   Here you set-up, which value of **Value** will result an output of 0V.

FS   Here you set-up, which value of **Value** will result an output of 10V.
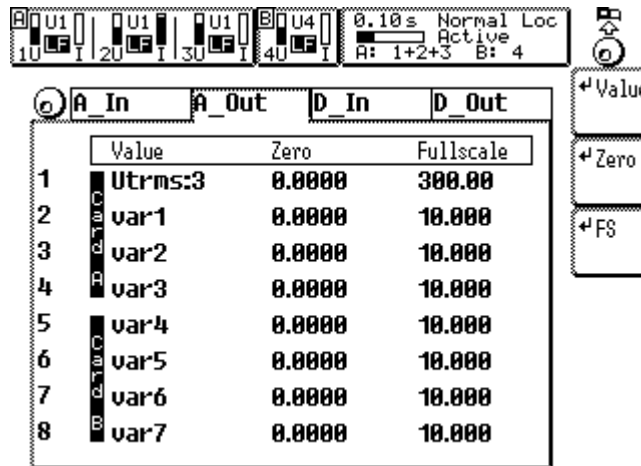
Figure 18: Analogue outputs

Example1:   You select **Value** 'Utrms', **Zero** '200' and **FS** '250'. Now you get with Utrms=200V an output of 0V, with Utrms=250V an output of 10V and with Utrms=230V an output of 6V. The output is updated every measuring cycle, because the values are calculated every measuring cycle.

Pressing the rotary knob returns you to the tab selection.

4.4.2.2.3 Digital Inputs tab

In this menu you get the actual state of the digital inputs. The inputs 1 to 4 of each card are only used for state indication. The inputs 5 and 6 can be used as state indicators or for frequency and direction input (determined by the phase shift between input 5 and 6). In the last case the input 5 is used to measure the frequency. This is multiplied with the 'Scale' value and displayed under 'Frequency'. A negative frequency value indicates a reverse rotation direction. To change the scaling press the rotary knob and **Scl.A** (or **Scl.B** for the card B).
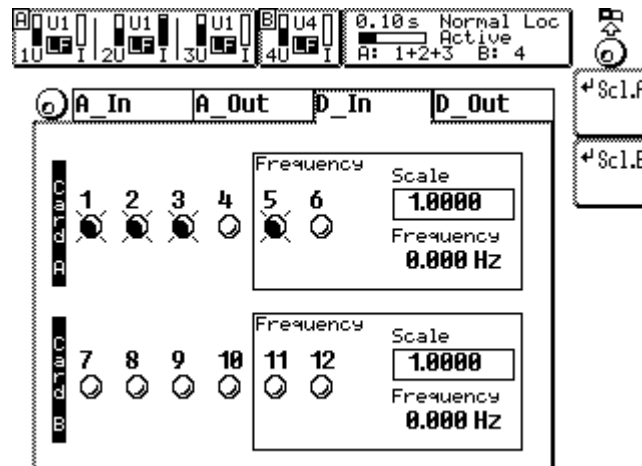
Figure 19: Digital inputs

Pressing the rotary knob returns you to the tab selection.

4.4.2.2.4 Digital Outputs tab

If you are in the setting mode of this menu, you can with the rotary knob select a channel.

Value   This allows you to set-up the value which should be output. See chapter 4.5, 'Entering identifiers' for details.

Cond   Here you set-up, under which condition the output is in the 'alarm state' (= high impedance of output, symbolised lamp is on!):
   on: The output has always alarm state.
   off: The output has never alarm state.
   >=:   The output has alarm state if the **Value** is bigger or equal to the **Limit**.
   <:   The output has alarm state if the **Value** is smaller than the **Limit**.

Limit   Here you set-up, which limit is compared to the **Value.**

Example: You select 'Utrms:1 < 200V'. Now you get an alarm for every voltage smaller than 200V. The output becomes a high impedance state because a 'fail save' function is assumed.
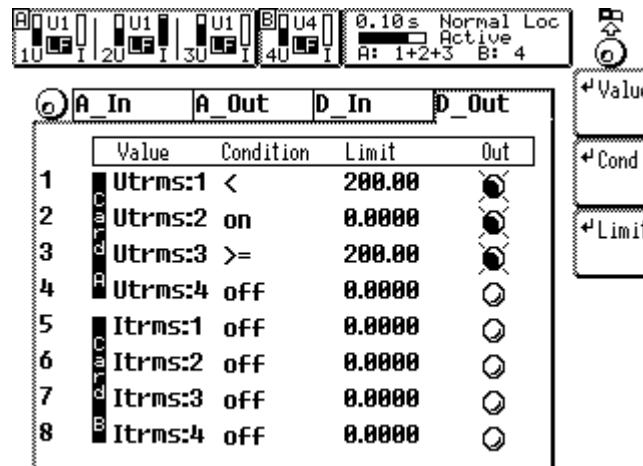
Figure 20: Limit menu

Pressing the rotary knob returns you to the tab selection.

Fail Save Principle

The fail save principle should offer you highest safety in critical applications. The principle is, that a high impedance state is the alarm (active) state. By this also broken or not connected wires as well as not switched on instruments are recognized as fail. Only the low impedance state is recognized as no alarm (deactive).

4.4.2.3   Options key

If you press on the softkey with the key symbol you get an actual software key which represents all installed options in your instrument. Some options of the instrument are software options which can be released by another key. If you for example want to install the 100 Harmonics you send us or your local sales company an order about this option together with your Current Option Key and with your serial number (SN).

Then you get back a second key which you can enter after pressing the key symbol. If the second key is correct, the option is installed.

Note

If you can access the instrument via an interface, you can use LMG-CONTROL to read out and update the key. This is much easier than working with the front panel.

4.4.3   Custom menu

In the standard menus *Voltage*, *Current*, ... (see chapters below) we have defined some values to be displayed which should fit to most customers. For some special applications you can define in the *Custom* menu your own values and graphics which should be displayed. Further

on you can define your own values by using the integrated script editor (see 4.4.4, 'Script/Formula editor').

When entering you get at least two tabs. To change between the tabs, you have to use the rotary knob. To get the softkeys inside a tab you have to press the rotary knob.

4.4.3.1   New menu tab

Here you first have to define the name of a new (user defined) tab with **Name**. Then you have to define the mask for the menu with **Form**. Depending on this mask you can define up to 50 values for a menu. If everything is finished you can create the new menu by pressing **Make new**. The new menu appears as a new tab which can be edit (see 4.4.3.3, 'User defined tab').

You can define up to 8 menus.

With **Load** you can recall a previously saved menu from memory card or floppy if installed. You have to select a filename from the list.

4.4.3.2   Vars tab

In the Vars tab you see all variables. By default they are named 'var0' to 'var11'. With **Reset** you can set them all to '0.0'.

4.4.3.3   User defined tab

Here you do the definitions, which values appear at which place. With the rotary knob you choose the position an press **Edit Item**. In the dialog you choose with **Typ** the kind of data do display:

empty	The item will displayed blank. Choosing this is the same like pressing the **Del Item** softkey.
Value	When choosing this have to choose with **Prop** a measuring value which should be displayed as value with unit, but without identifier. How to enter the **Prop** value see 4.5, 'Entering identifiers, characters and text'.
Name+Value	When choosing this have to choose with **Prop** a measuring value which should be displayed as value with unit and with leading identifier. How to enter the **Prop** value see 4.5, 'Entering identifiers, characters and text'.
String	When choosing this have to choose with **Prop** a text which should be displayed. How to enter the **Prop** value see 4.5, 'Entering identifiers, characters and text'.
Graph	Here you get a list of all possible graphs. In principle you can display copies of graphs which you have already set-up in the *Graph* menu. 'Scp.A:1' selects the first waveform of the group A scope, 'Scp.B:3' the third

waveform of group B scope. The 'Plot:x' is for selecting one of the four plot functions.

To modify the graphical display you have to change to the *Graph* menu.

With **Font** you can choose another than the predefined font for the display.

With **Copy menu** you create a copy of the complete tab which can then be modified. With **Del menu** you can remove the complete tab. In a pop up menu you have to confirm this a second time.

To give a menu another name, please use **Edit Name**.

With **Save** you can store the menu to a memory card or floppy if installed. You have to select a filename from the list or enter a new one with **File name**.

4.4.4   Script/Formula editor

You reach the script/formula editor by pressing **Edit** in 'Script' tab in *Custom* menu.

With **Edit** you start entering the script. This is done like written in 4.5, 'Entering identifiers, characters and text'.
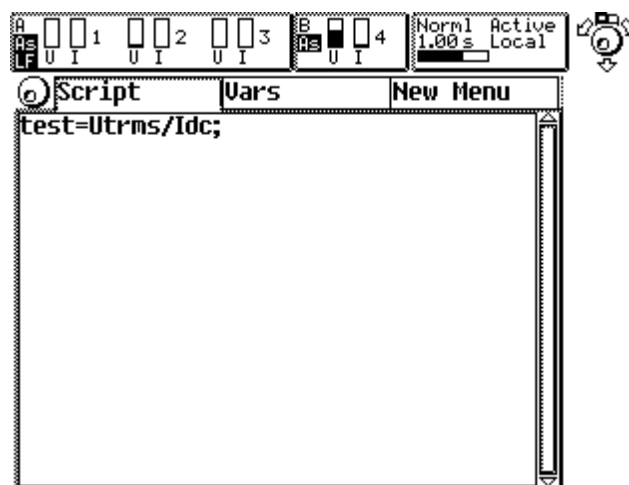
Figure 21: Script editor

With **Save** you can store the script to a memory card or floppy if installed. You have to select a filename from the list or enter a new one with **File name**.

With **Load** you can recall a previously saved script.

4.4.4.1   General

The script editor is similar like a simple programming language. The code is entered line by line. It is allowed to have several instructions in one line. Each instruction has to end with a ';'. Therefore an instruction can be written in more than one line. It is also allowed to have

white spaces in the instruction as long as the keywords and identifiers are not divided by them. At the end of a line an automatic carriage return and linefeed are performed. A '`#`' indicates the begin of a comment. The comment lasts, until a return is detected (can be entered with **new line**). An automatic inserted newline will NOT end the comment!

The instruction

`v0=Utrms*Itrms;`
is identical to

`v0 = Utrms* Itrms ;`
or

`v0 =`
`Utrms * Itrms;`
`<-` deletes the character left of the cursor. If the cursor is at the first position of a line, it jumps to the last position of the previous line.

You leave the script editor by pressing **End**. The program is now checked for correct syntax. Above the editor window you see then how many percent of the available memory space have been used.

The script (which includes the formulas) is executed when all values of a cycle have been calculated.

With **Reset** all variables are preset to 0.0 but the script is still valid. This is important if you use recursive formulas or conditions.

4.4.4.2   Grammar

4.4.4.2.1   Instructions

Instructions control the program flow while execution. If there are no conditioned instructions, the flow is in the same order like the listing. The results of an instruction can be used afterwards.

An instruction consists of one or more expressions. Each instruction (except `if,` `else` and `fi`) has to be finished with '`;`'. An instruction can be longer than one line. The result must not be assigned to a variable.

4.4.4.2.2   Condition instruction

Condition instructions choose between two alternative program flows. This is done by the expression following immediately to the word `if` .

```
if(expression) Instructions; fi
or
if(expression) Instructions; else Instructions; fi
```

The brackets for the expression are necessary. Then there could be one or more semicolon separated instructions which are executed if the expression was true. The end of the conditional execution is marked with `fi`, which is also necessary. The `else` part is optional.

Condition instructions can be nested, for example to realise a logical AND:

```
if(expression1)
   if(expression2)
      Instruction 1;
         :
      Instruction n;
   fi
fi
```

Example

```
if (Utrms>227.5)
   dout_off(1);
   dout_off(2);
else
   dout_on(4);
fi
```

If the voltage is bigger than 227.5V the digital outputs 1 and 2 are set to off. In the other case the output 4 is set to on.

4.4.4.2.3 Expressions

An expression is a sequence of operators, operands and functions. Expressions are in general recursive, which means they can be nested. But there is a practical limit in CPU power and memory which can cause the message „out of memory".

The order of evaluation of an expression depends on the priority of operands and on the brackets (see below).

4.4.4.2.4 Constants

Constants are always floating point. The valid range is $\pm 3.4E-34$ to $\pm 3.4E+34$. The number can be entered in usual or scientific notation. The decimal dot is only necessary for floating point numbers.

4.4.4.2.5 Variables

There is a distinction between read only variables and read write variables. The first ones are all measuring values of the LMG but also values like cycle time and measuring ranges. This variables can be used for calculation like constants. The second one are the user defined variables.

So following is o.k.

```
v0=Utrms;
```

but

`Utrms=0;`
is not allowed.

A unit can be assigned to the variable. To assign the unit 'cm' to the varaible 'a' write:
`a.cm=...`

The result of expressions can only be stored in the user defined variables with the default identifiers 'var0' to 'var11'. This identifiers are valid until they are redefined in a script. The redefinition is simply be done by using a not existing identifier. This identifier replaces the first variable which was not changed until now. The maximum length of the new identifier is 10 characters. In 'Example 2' the identifier `Uhigh` replaces the identifier `var0` and `Ulow` replaces `var1`. As you can see the identifiers are replaced in the order of the occurrence. If you press **End**, all occurrences of `var0` are replaced with `Uhigh` and so on. So you get in the user defined menu or the plot menu the new identifiers.

The read-only variables are identical to the identifiers in the menus (see 4.5, 'Entering identifiers'.

4.4.4.2.5.1   Local variables

A third kind of variables are local variables. They are also user defined, but are not displayed in the custom menu. A local variable starts always with a '`$`' character:

`$test=Utrms*19.234;`
`b=Iac*$test;`
In this example `$test` is not displayed, but only `b`.

4.4.4.2.5.2   Environment variables

These variables are accessible via the '`Env`' ID as an array: `Env[0...7]`.

They are (in opposite to standard variables) not displayed, but they can (in opposite to local variables) be used externally (e.g. in the processing signal interface). Further on they can be set directly by the interface (see 9.2.2.1.1, 'ENVironment   ENV   Env').

4.4.4.2.6   Keywords

These are strings which are no variables or constants but which are used for controlling the script editor:

`if`   The start of a conditioned program sequence. The condition have to follow in the round brackets.

else   The end of the program sequence which is used if the condition of the **if** was true (no semicolon at the end!). All command after the **else** until the next **fi** are used, if the condition of the **if** was **not** true. The else is optional.

fi   The end of the program sequence which is used if the condition of the **if** was true (no semicolon at the end!).

4.4.4.2.7 Functions

The following functions are implemented at the moment (x is the result of a valid expression, constant or function):

abs(x)   absolute value of x

acos(x)   arcus cosine of x (result in radiant!)

asin(x)   arcus sine of x (result in radiant!)

bell()   generates a short sound with the internal speaker

btst(x, bit_no)   Returns true, if in variable x bit number bit_no is set. The bits are counted from 1 to 32. You should only apply this function onto integer values like digital inputs or result of flicker measuring. Usually you should not use it with float numbers.

cos(x)   cosine of x (argument in radiant!)

digin(mask)   Returns the value of the digital inputs. The values are coded in one byte: input 1-4 correspond to bit 0-3 and input 7-10 to bit 4-7. So if the inputs 1 and 8 are active, the returned value would be 33. With mask you can define, which values are checked: With a mask of 32 only the input 8 is checked. In this case the return value can only be 32 or 0. The mask is useful when checking the status of one input, independent from the others. If you want to check all inputs, you should use a mask of 255!

dout_off(nr)   Switches digital output number nr. off (into no-alarm state). 1≤nr≤8

dout_on(nr)   Switches digital output number nr on (into alarm state). 1≤nr≤8

freeze()   freezes the display (like key *Freeze*)

isrun()   Returns 1, if the integration is running

isstop()   Returns 1, if the integration is stopped

`ln(x)`	$\log_e$ of x
`log(x)`	$\log_{10}$ of x
`print()`	Prints the menu in which you started the logging in 'by script' mode (see 10.3.1, 'Output intervals').
`reset()`	Same like **Reset** Softkey in *Time Int.* menu
`scale_i(chn,x)`	Scale the current input, chn. is the number of the channel, x the scaling factor.
`scale_u(chn,x)`	Scale the voltage input, chn. is the number of the channel, x the scaling factor.
`sin(x)`	sine of x (argument in radiant!)
`sqrt(x)`	The square root of x
`start()`	Same like pressing *Start*
`stop()`	Same like pressing *Stop*
`unfreeze()`	reactivates the frozen display

4.4.4.2.8 Operators

Operators are symbols which cause actions, when they meet variables, constants or formulas. The script editor offers following operators, sorted by priority:

high priority

`:`	Channel separator, usually used only for multi channel devices (like analogue inputs). E.g. `Ain:3` is the third analogue input channel.
`[ ]`	Index operator, used for indexed values (arrays), e.g. `U[5]` is the 5th harmonic of the voltage
`()`	Function call, the value inside the brackets is the parameter to the function
`-`	Negation
`^`	Exponent
`/ *`	Division and Multiplication
`+ -`	Addition and Subtraction

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`<, ==, >` smaller, equal, bigger (comparator operators)

`=`   Assignment of a value

`<>`   not equal

low priority

If there are no brackets, the operators are used in the order listed above.

The result of:

`3^2*4` is 36

`-(3^2)*-4` is also 36

4.4.4.2.9 Remarks

Each line starting with a '`#`' is a remark. See '4.4.4.2.14 ,Example 5:Switching digital outputs, depending on harmonics'. Only the first '`#`' is important, the other don't care.

4.4.4.2.10 Example 1: Freeze at limit violation

If the 23rd harmonic of voltage of channel 1 is bigger than 10V the display should be frozen and the instrument should inform you with a sound.

```
if(Uh:1[23] > 10)
    freeze();
    bell();
fi
```

Attention!
The function `freeze()` can cause the display to freeze at the start-up of the instrument. So be careful when using this function.

4.4.4.2.11 Example 2: Getting min/max values

You want to measure the biggest and smallest TRMS values of the voltage.

```
if (Uhigh==0)
    Ulow=RngU:1;
fi
if (Uhigh<Utrms:1)
    Uhigh=Utrms:1;
fi
if (Ulow>Utrms:1)
    Ulow=Utrms:1;
fi
```
The first `if` condition is used for resetting the minimum value: With **Reset** it would be set to 0 which is not sufficient, because this is already the smallest TRMS value. So if the maximum TRMS value is reset to 0.0, the minimum value is set to the range value which will not be

reached under proper conditions. The second and third condition compute the maximum and minimum value and store them in the variables `Uhigh` and `Ulow` which can be read out in the *Custom* menu.

4.4.4.2.12 Example 3: Calculating THD+N

You want to measure the total distortion factor including noise (THD+N) of the voltage of channel 2:

```
THDN=sqrt((Utrms:2^2-Uh:2[1]^2)/Uh:2[1]^2);
```
Please note that this will only work in the harmonic mode, because `Uh:2[1]` is only calculated there!

4.4.4.2.13 Example 4: Counting pulses

You want to count the number of current pulses of a battery above 3A (the pulse width has to be bigger than twice the cycle time!)

```
ibat=abs(Idc:1);
if (ibat>3.0)
   if (r == 0)
      n=n+1;
      r=1;
   fi
fi
if (ibat < 3.0)
   r=0;
fi
```

4.4.4.2.14 Example 5:Switching digital outputs, depending on harmonics

```
### Wave1 ###
if(Ih:1[1]>0.08) dout_on(1);
else dout_off(1);
fi
### Wave3 ###
if(Ih:1[3]>0.068) dout_on(2);
else dout_off(2);
fi
### Wave5 ###
if(Ih:1[5]>0.05) dout_on(3);
else dout_off(3);
fi
```
The digital outputs 1 to 3 are switched on if the corresponding harmonic 1 to 5 is bigger than a defined value. In the other case the output is switched off.

4.4.4.2.15 Example 6: Calculation of the efficiency of a motor with torque and frequency input

For the measurement of the efficiency of a motor you can use the analogue and the frequency inputs. To input the torque of the motor use the analogue input (e.g. 1) and for the frequency use the digital frequency input (e.g. card1 Pin 12). For calculation of the efficiency you can use the following formula:

```
M=Ain:1;
n=DigFrq:1;
Pmech=M*n;
eta=Pmech/P:13*100;
```
Important Note: The motor frequency connected to the frequency input (No.1) has to be counted and scaled in Hz. Then you get a result in percent.

4.4.4.3   Printing scripts

You can printout the scripts you have set-up (see 10, 'Logging of values to drives, printer and interfaces'). Please note, that the complete script editor is printed out, not only the visible part.

4.4.4.4   Speed and torque calculation (option MotorTorque-SOFT)

This option provides two functions which calculate the values speed and torque from motor current and voltage. The motor must be a three phase asynchronous standard motors according IEC. There are just some information from type plate or catalogue data necessary. There is no need of a torque measuring shaft or a speed sensor. The motor can be connected to the lines or to a frequency converter.

Measuring error between no-load operation and 1.5 fold nominal torque typical below 2% of nominal torque resp. rotation speed for motors from 1kW to 100kW nominal power and rotation speed between -40% to +20% of nominal speed. The calculation is also possible with other nominal power, but with increased error.

For the calculation, following requirements must be met:

- Wiring
  3+x, UΔI*->U*I*
- Filter
  Smaller than half clock frequency. So just the fundamental must be measured, the clock ripple must be rejected.
- Signal coupling
  AC
- Sync
  Such, that the fundamental frequency is displayed (e.g. I1, LP<300Hz)

The two functions are:

`torque(Pn, fn, Un, In, pfn, pz, Rk, sc, mk)`	Calculates the torque in Nm. The parameters are:

Pn: Nominal output power in W

fn: Nominal frequency in Hz

Un: Nominal line line voltage of the motor in V

In: Nominal current in A

pfn: Nominal power factor

pz: Number of poles (twice the number of pole pairs)

Rk: Stator line-line copper resistance in Ω

sc: Number of the sum channel, here 15 or 17

mk   No load torque correction

`speed(Pn, nn, fn, Un, In, pfn, pz, Rk, sc, mk)`	Calculates the speed in min^{-1}. The parameters are:

Pn: Nominal output power in W

n: Nominal speed in min^{-1}

fn: Nominal frequency in Hz

Un: Nominal line line voltage of the motor in V

In: Nominal current in A

pfn: Nominal power factor

pz: Number of poles (twice the number of pole pairs)

Rk: Stator line-line copper resistance in Ω

sc: Number of the sum channel, here 15 or 17

mk   No load torque correction

The copper resistance has to be measured at the same point, where the voltage is measured by the LMG. The advantage is, that you can measure for example from a cabinet and that the copper resistance of the wiring is included and by this eliminated from the calculation.

The results of `torque()` and `speed()` can be displayed in a user defined menu or transfered via an interface.

A typical script could look like this:

```
# M-n-calculation
# Detailed motor description
# 2.2kW Motor DDA 90 L
# Input of the motor parameters
```

```
$cn=0.84; # Nominal powerfactor
$nn=2845; # Nominal speed 1/min
$pz=2;    # Number of poles
          # (2* pole pairs)
$jn=4.66; # Nominal current in A
$un=400;  # Nominal L-L voltage in V
$pn=2200; # Nominal output power in W
$fn=50;   # Nominal frequency in Hz
$rk=19.7; # resistor in Ohm
          # terminal to terminal
          # (hot resistor)
$mk=20;   # No load torque
M.Nm=torque($pn,$fn,$un,$jn,$cn,$pz,$rk,15,mk);
n=speed($pn,$nn,$fn,$un,$jn,$cn,$pz,$rk,15,mk);
```

No load torque correction

Set mk=0, enter all other data and make a no load measurement of the motor. Use the read out torque with opposite sign as new value for mk. By this tolerances of the motor nominal values are corrected.

4.4.5   Saving and restoring configurations

You can save up to 8 different set-ups for the instrument. With **Reset** you get the factory settings. Everything is reset, but not the 8 stored configurations.

4.4.5.1   Loading a configuration

After pressing *Save/Recall* you can load previously saved configurations. For this purpose choose the wanted one with the rotary knob and press **Recll.** All set-up values like range settings, scripts and measuring settings are restored. The actual settings are lost.

In the field 'Active configuration mod()' you see now the name of the selected configuration. If mod(*) is displayed, any of the settings are changed.

4.4.5.2   Saving the configuration

After pressing *Save/Recall* you can save the actual configuration. For this purpose choose the wanted position with the rotary knob and press **Save.** Now you have to specify a name for this entry (see chapter 4.5, 'Entering identifiers, characters and text'). If the entry exists, it will be overwritten. All setup values like range settings, scripts and measuring settings are saved.

4.5   Entering identifiers, characters and text

In some menus (e.g. in the plot menu or in the menu for the digital outputs) you have to enter an identifier or text to specify which value should be worked with (e.g. plotted).

If the cursor is at the first position and you press ←, the complete input field will be deleted.

If you have pressed the softkey to modify the identifier or text, you can either enter the desired value by moving the rotary knob (**Mode** has to be set to copy!) to the wished letter and press *Enter* or the rotary knob. In this case you have to enter the letters in the same way you see them in the menus (e.g. 'Utrms'). Or you can press the key of any valid menu (e.g. *Voltage*, *Current*, ...) and you get a list of the available values (in this mode).

Following values are available in the different menus:

Normal measuring mode

Default	Current	Voltage	Power	Int. Value	Measure	Custom	Misc.	IF/IO
f	f	f	f	q	Aver	Env	abs()	Ain
Iac	Iac	OvrU	P	EP	DisCyc	var0-11	acos()	DigFrq
Icf	Icf	Uac	PF	EQ	Cycle		asin()	Zero
Idc	Idc	Ucf	PHI	Et	Mtime		bell()	
Idcn	Idcn	Udc	Q	ES	Rcyc		cos()	
Idcp	Idcp	Udcn	Rser	tsec			digin()	
Itrms	Itrms	Udcp	S	Pm			dout_on()	
Iff	Iff	Utrms	Xser	Qm			dout_off()	
Iinr	Iinr	Uff	Z	Sm			freeze()	
Iphi	Iphi	Uphi					isrun()	
Ipkn	Ipkn	Upkn					isstop()	
Ipkp	Ipkp	Upkp					log()	
Ipp	Ipp	Upp					ln()	
Irect	Irect	Urect					reset()	
RngI	RngI	RngU					scale_i()	
Iscal	Iscal	Uscal					scale_u()	
Env	OvrI						sin()	
OvrI							sqrt()	
OvrU							start()	
P							stop()	
PF							unfreeze()	
PHI							if();fi	
Q							2.7182818 (*e*)	
Rser							3.1415927 (π)	
S							1.2566e-6 (μ_0)	
Uac							8.854e-12 (ε_0)	
Ucf								
Udc								
Udcn								
Udcp								
Utrms								
Uff								
Uphi								
Upkn								
Upkp								

Default	Current	Voltage	Power	Int. Value	Measure	Custom	Misc.	IF/IO
Upp								
Urect								
RngU								
Uscal								
var0-11								
Xser								
Z								

CE-Harm Harmonic measuring mode

Default	Current	Voltage	Power	Measure	Custom	Misc.	IF/IO
f	f	f	f	Per	Env	abs()	Ain
Ih	Ih	Uh	Ph	Mtime	var0-11	acos()	DigFrq
Imav	Imav	Uthd	Pav			asin()	Zero
Iav	Iav	UL	PFm			bell()	
Ifm	Ifm	UMax	Qh			cos()	
Ithd	Ithd	UP	Sh			digin()	
IL	IL	OvrU	P			dout_on()	
Im	Im	Utrms	PF			dout_off()	
IP	IP	RngU	Q			freeze()	
Ipohl	Ipohl		Rser			isrun()	
Ph	Ipohc		S			isstop()	
Pav	Ithc		Xser			log()	
PFm	Itrms		Z			ln()	
Ipohc	RngI					reset()	
Qh	Iscal					scale_i()	
Sh	OvrI					scale_u()	
Ithc						sin()	
Uh						sqrt()	
Uthd						start()	
UL						stop()	
UMax						unfreeze()	
UP						if();fi	
Itrms						2.7182818 (e)	
RngI						3.1415927 (π)	
Iscal						1.2566e-6 (μ_0)	
Env						8.854e-12 (ε_0)	
OvrI							
OvrU							
P							
PF							
Q							
Rser							
S							
Utrms							
RngU							

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Default	Current	Voltage	Power	Measure	Custom	Misc.	IF/IO
Uscal							
var0-11							
Xser							
Z							

CE Flicker measuring mode

Default	Current	Voltage	Power	Int. Value	Measure	Custom	Misc.	IF/IO
Uhwcf	f	Uhwcf	Phw	Uhwcf	Per	Env	abs()	Ain
dcl	dcs	dcl	f	dcl	Mtime	var0-11	acos()	DigFrq
dtl	dts	dtl	P	dmaxl	FlkPer		asin()	Zero
dmaxl	dmaxs	dmaxl	PF	Pltl			bell()	
Pltl	Plts	Pltl	Q	Pmoml			cos()	
Pmoml	Pms	Pmoml	Rser	Pstl			digin()	
Pml	Pmoms	Pml	S	Upkph			dout_on()	
Phw	Uhws	Phw	Xser				dout_off()	
Uhwl	Psts	Uhwl	Z				freeze()	
Pstl	Ithd	Pstl					isrun()	
Upkph	Itrms	Upkph					isstop()	
f	RngI	f					log()	
dcs	Iscal	Uthd					ln()	
dts	OvrI	OvrU					reset()	
dmaxs		Utrms					scale_i()	
Plts		RngU					scale_u()	
Pms		Uscal					sin()	
Pmoms							sqrt()	
Uhws							start()	
Psts							stop()	
Ithd							unfreeze()	
Uthd							if();fi	
Itrms							2.7182818 (e)	
RngI							3.1415927 (π)	
Iscal							1.2566e-6 (μ_0)	
Env							8.854e-12 (ε_0)	
OvrI								
OvrU								
P								
PF								
Q								
Rser								
S								
Utrms								
RngU								
Uscal								
var0-11								
Xser								

Default	Current	Voltage	Power	Int. Value	Measure	Custom	Misc.		IF/IO
Z									

HARM100 measuring mode

Default	Current	Voltage	Power	Measure	Custom	Misc.	IF/IO
D	f	f	D	Per	Env	abs()	Ain
f	Ih	Uh	f	Mtime	var0-11	acos()	DigFrq
Ih	Ithd	Uthd	Ph			asin()	Zero
Ithd	IP	UP	Qh			bell()	
IP	Itrms	Utrms	Sh			cos()	
Ph	RngI	RngU	P			digin()	
Qh	Iscal	Uscal	PF			dout_on()	
Sh	OvrI	OvrU	Q			dout_off()	
Uh			Rser			freeze()	
Uthd			S			isrun()	
UP			Xser			isstop()	
Itrms			Z			log()	
RngI						ln()	
Iscal						reset()	
Env						scale_i()	
OvrI						scale_u()	
OvrU						sin()	
P						sqrt()	
PF						start()	
Q						stop()	
Rser						unfreeze()	
S						if();fi	
Utrms						2.7182818 (e)	
RngU						3.1415927 (π)	
Uscal						1.2566e-6 (μ_0)	
var0-11						8.854e-12 (ε_0)	
Xser							
Z							

Select one value with the rotary knob and press *Enter* or the rotary knob to copy the list item into the edit line. If you have a multi channel value (e.g. analogue inputs) you have to enter a ':' behind this value and then the number of the channel (e.g. the identifier for the analogue input 3 would be 'Ain:3'). If you don't specify this number, '1' is the default value. Confirm your choice with *Enter*.

If the value is an array value, the desired index is entered in brackets '[' and ']' (example the 5th harmonic of the voltage would be Uh[5]). You can also combine this values: Uh:2[5] would be the 5th harmonic of the voltage of the second channel. If you don't specify this number, '0' is the default value. Confirm your choice with *Enter*.

To select another position in the text, you have to set **Mode** to 'move' or 'line'. With 'move' you move character by character, with 'line' you move line by line, which is much faster in bigger text.

With **new line** you can insert a linefeed (if you have a multi line input box). Especially in conjunction with the script editor you can reach a list of useful functions and operators by pressing *Misc.*

Finally close you inputs with **End**.

4.6   Entering numerical values

If you have entered a value by the numerical keypad and move the cursor to the right end and move the rotary knob to the right then the modifiers 'μ', 'm', 'k' and 'M' appear. So it is more simple to enter big or small values.

5   Normal measuring mode

In the normal measuring mode the LMG500 works as a power meter. The voltage, current and power are measured directly, many other values are derived from these values.

5.1   Measuring configuration (Measuring)

When you have come to this menu by pressing *Measure* you first have to choose **Norm(a)l** to enter this mode. With the rotary knob you can select three tabs ('Globals', 'Group A', 'Group B', ...). Pressing the rotary knob you can do several settings in each tab.

5.1.1   Globals tab

Here you setup all values which are global to the instrument (independent from the groups).

Cycle   Here the cycle time in seconds is defined. Valid values are from 0.05s to 60s. Any value in steps of 10ms is allowed. A value of 0ms defines the external cycle time. During every cycle time the values of voltage, current and power are measured. At the end of each interval the measured values are computed to the displayed values. The cycle time has always to be bigger or same like the (fundamental or basic) period time of the signal.

Aver   Here you can setup, how many measuring cycles are averaged for the display. For example: If you choose 5 cycles, the display will always be averaged over the last 5 cycles (sliding average!).

Wire   Here you can setup, with which wiring you want to measure. Please see chapter 2.4, 'The group concept' for further details.

Aron   This point is only available when you have chosen wiring '2+0 Channels', '2+1 Channels', '2+2 Channels'.
            If you connect a 3 phase 3 wire system in aron circuit (see chapter 3.3.5, 'Measuring circuit for measuring efficiency of 3/3phase systems') you have to measure the voltages U_{13} and U_{23}. U_{12} is calculated by the instrument. But usually you would use the three voltages U_{12}, U_{23} and U_{31}. So you measure U_{13} instead of U_{31} with $U_{13}=-U_{31}$. For most values this does not matter, but in the scope display, you would see, that U_{13} has not 120° against U_{12} but 60°. This is physically correct (you see the voltages connected to the instrument), but this is not what you expected. So if you switch the **Aron** setting to 'on' the display of U_{13} is inverted, so that you see U_{31}.
            Only in the case you have a real 2 phase 3 wire system, you should set **Aron** to 'off'

to see the real phase shift between the phases.
The voltage measured with the third channel is also inverted.

If you have a master/slave configuration, the settings '**Aron**' and '**Wire**' can be done for each instrument independently

5.1.2   Group A/B/C/D tab

The settings in the groups are identical, so they are just described once. Each setting influences all channels which belong to the group!

First the coupling settings for the synchronisation signal:

Sync   Selects the signal which is used for synchronisation of all channels belonging to this
group. There are following possible settings:
Un   The voltage signal is used (n is one of the channels in the group)
In   The current signal is used (n is one of the channels in the group)
Line   The line signal is used
Extn   The signal at the external synchronisation jack is used.

Demod Selects the demodulator for the AM demodulation of the synchronisation signal.
off   No AM demodulation
<1kHz   Demodulation for signals with carrier <1kHz (like rapid fire control)
>1kHz   Demodulation for signals with carrier >1kHz (like electronic lamp balasts)

HP   Selects a high pass filter for the synchronisation signal.
off   No filter selected
>0.5Hz Signals >0.5Hz are used
>30Hz   Signals >30Hz are used

LP   Selects a low pass filter for the synchronisation signal.
off   No filter selected
If you select another value, a low pass filter with respective frequency is used.
Following values are possible:
5Hz, 10Hz, 20Hz, 50Hz, 100Hz, 200Hz, 500Hz, 1kHz, 2kHz, 5kHz, 10kHz, 20kHz,
50kHz.

Now the settings for the measured signal:

Filt   Here you can switch on/off the lowpass filters in the measuring signal path of voltage
and current. This filters are only in the signal way (they influence the sampling values)
and don't influence the synchronisation settings. Possible settings are:
270kHz, 150kHz, 138kHz, 90kHz, 42kHz, 30kHz, 21kHz, 11kHz, 10kHz, 9.2kHz,
6kHz, 2.8kHz, 2kHz, 1.4kHz, 700Hz, 350Hz, 175Hz, 87.5Hz, 60Hz, 30Hz

S-Cpl   Here you define the signal coupling. This setting has **<u>no</u>** influence to the trigger signal! Possible settings are:

        AC+DC: All parts of the signal are taken into calculation.

        AC   Only the AC parts of the signal are taken into calculation. The DC part is separated. Please note, that this separation is done by software after the measuring and not by hardware! So you don't have any advantages concerning the measuring range and no influence to the scope values. The advantage of this coupling mode is the better accuracy, because all DC errors are eliminated.
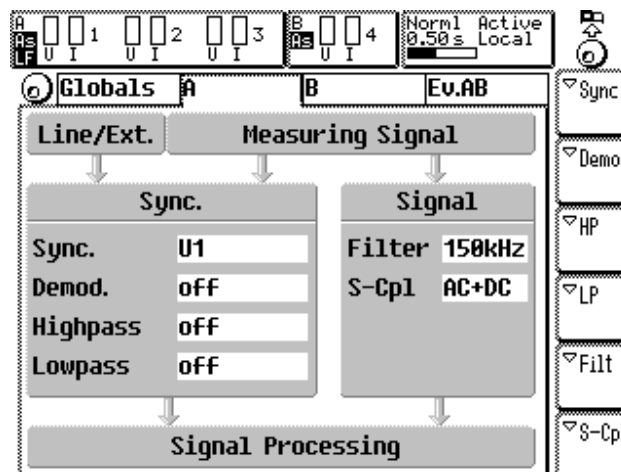
Figure 22: Measuring menu in normal mode

5.1.3   Ev. AB/CD tab (option L50-O5)

Here the transient trigger is setup. For the channles 1-4 as well as 5-8 you can define up to 4 transient events. If the entered conditions are met and a global event is generated, the sample values of the scope function are freezed. The standard values are measured continuously.
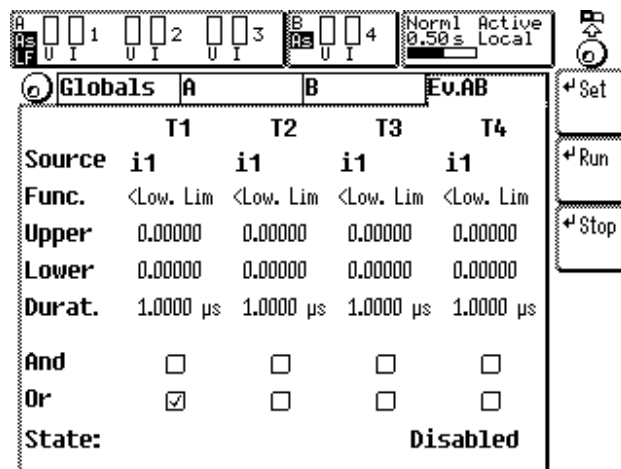
Figure 23: Measuring menu, transient settings

Set   Is used to change the values. Further on you have to select the transient T1 to T4 (also called an event channel). Now you have following softkeys available:

Src: This selects the signal which should be observed.

Func This selects, what should be observed at this signal:
<low. limit
>upp. limit
Window Out (<low. limit or >upp. limit)
Window In (>low. limit and <upp. limit)

Up Defines the upper limit. The unit is V, A or W depending on the signal.

Low Defines the lower limit. The unit is V, A or W depending on the signal.

Dur. Defines how long the function has to be met, before this channel notifies an event.

Cond. This defines, how an event channel is handled:
off: No action
and: A global event is generated, if all event channels with 'and' condition have an event
or: A global event is generated if this event channel is true.

Run Starts the search for a new transient. The search can only be performed, if <u>all</u> measuring channels of <u>all</u> groups are set to manual!

Stop Stopps the search

5.2 Measuring ranges (Range)

When you came to this menu by pressing *Range* you can setup all the ranges and scalings for the different measuring channels. You see three tabs ('Group A', 'Group B', ... and 'Sense/More').
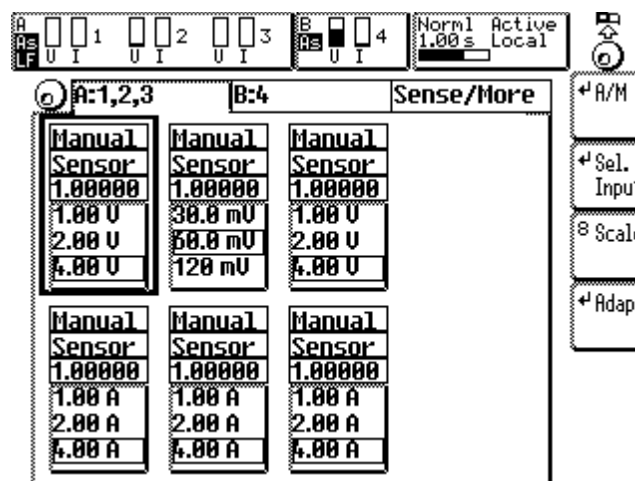
Figure 24: Range menu

5.2.1   Group A/B tab

The settings in group A and B are identical, so they are just described once.

With the keys *F1(<-)* and *F3(->)* beside the rotary knob, you can select another U/I channel. With the rotary knob itself, you can select another range within the selected channel.

A/M   With **A/M** the automatic or manual range setting is selected. This is only possible in the normal measuring mode. In all other modes the manual range is selected.

Sel.Input By this you can select the jack which should be used as input jack for this channel.

Scale   The **Scale** button allows you to enter a scaling factor. With this scaling factor all values of this channel (and the power) are multiplied. This setting is usually used to enter the transformer ratio of current clamps or voltage transformers.
Example 1:
You have a current clamp with 1000A/1A ratio. In this case enter 1000 as scaling factor.
Example 2:
You have a current clamp with 1A/10mV ratio. This is equal to 100A/V, so you have to enter 100 as scaling.

Adapt   By this you force all channels of this group to work with the same settings like the actual one. If the actual one works in automatic mode all other work also in automatic mode. In manual mode all channels get the same range.
Please note, that the scaling is not adapted! The reason is, that sometimes the scaling factor is used to adjust an external sensor. If the scaling would also be adapted, the adjustment would be lost.

By pressing the rotary knob again you leave the set mode and can select another tab.

Some notes for auto ranging

There are some special points you have to know, when using the auto range function:

- If you want to measure a single peak value never use the auto range function. The reason for this is, that the autorange function does not detect a too low range until it is overloaded! When it is overloaded and the range is changed, the last measurement might be invalid.

- Do not use the auto range function for very precise measurements. While a measurement you don't directly see which range is actually selected. Afterwards it is not possible to say what was the selected range and therefore you can't make an error calculation.

- Do not use the autorange function for measurings without gaps (e.g. energy, harmonics or flicker). The reason for this is the setup time of the measuring channels after a range change.

5.2.2   Sense/More tab

Here you get information about the connected external current sensors. If they are connected, you get automatically a new list of current ranges (depending on the connected sensor).

5.2.3   Delay

In this menu, the group delay of an external sensor can be adjusted.
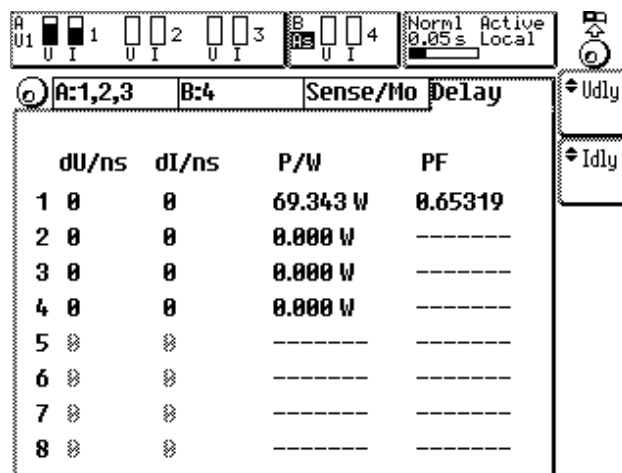
Figure 25: Delay menu

With **Udly** and **Idly** you can compensate the group delay of external wires and sensors. With positive values the signal is delayed, with negative values it is negative delayed (so it becomes faster!)

Example: You have a voltage sensor with a group delay of +150ns. If you want to correct this group delay, you have to set the voltage delay to -150ns.

While changeing the U-delay or I-delay you can see the actual measured power and power factor. This can help to estimate the group delay of an external system, if this is unknown from other sources.

5.3   Definition of measuring values

Following you find the definitions for all measuring values in the normal operation mode. The values are divided in two sections:

- The values from single measuring are measured while one measuring cycle and are independent from all other measuring cycles.

- The integrated values are calculated over several cycles.

The following basic definitions are used:

u(t)   The instantaneous value if the voltage used for calculation

i(t)   The instantaneous value if the current used for calculation

T   The time of an integer number of the periods of the synchronisation signal. The integer factor depends on the chosen measuring cycle time. This time can vary from cycle to cycle! T is the real measuring time.

The values u(t) and i(t) used for calculation can be the directly in channel n measured values $u_n(t)/i_n(t)$ or calculated from them (depending on the wiring and the selected display channel):

Wiring '1+0 Channels'

Display channel	u(t)	i(t)
1	$u_1(t)$	$i_1(t)$

Wiring '2+0 Channels'

Display channel	u(t)	i(t)
1	$u_1(t)$	$i_1(t)$
2	$u_2(t)$	$i_2(t)$
9	$-u_1(t)+u_2(t)$	$-i_1(t)-i_2(t)$

Wiring '1+1 Channels'

Display channel	u(t)	i(t)
1	$u_1(t)$	$i_1(t)$
2	$u_2(t)$	$i_2(t)$

Wiring '3+0 Channels'

Display channel	u(t)	i(t)
1	$u_1(t)$	$i_1(t)$
2	$u_2(t)$	$i_2(t)$
3	$u_3(t)$	$i_3(t)$

Wiring '2+1 Channels'

Display channel	u(t)	i(t)
1	$u_1(t)$	$i_1(t)$
2	$u_2(t)$	$i_2(t)$
3	$u_3(t)$	$i_3(t)$
9	$-u_1(t)+u_2(t)$	$-i_1(t)-i_2(t)$

Wiring '4+0 Channels'

Display channel	u(t)	i(t)
1	$u_1(t)$	$i_1(t)$
2	$u_2(t)$	$i_2(t)$
3	$u_3(t)$	$i_3(t)$
4	$u_4(t)$	$i_4(t)$

Wiring '3+1 Channels'

Display channel	u(t)	i(t)
1	$u_1(t)$	$i_1(t)$
2	$u_2(t)$	$i_2(t)$
3	$u_3(t)$	$i_3(t)$
4	$u_4(t)$	$i_4(t)$

Wiring '2+2 Channels'

Display channel	u(t)	i(t)
1	$u_1(t)$	$i_1(t)$
2	$u_2(t)$	$i_2(t)$
3	$u_3(t)$	$i_3(t)$
4	$u_4(t)$	$i_4(t)$
9	$-u_1(t)+u_2(t)$	$-i_1(t)-i_2(t)$
10	$-u_3(t)+u_4(t)$	$-i_3(t)-i_4(t)$

For further information about the tables see also chapter 2.4, 'The group concept'.

Linked values

If you have installed the option L50-O6 (star to delta conversion) you get the following additional wirings. The values in the column 'Measuring channel numbers' define the internal calculation of the DSPs (the numbers are the numbers of the measuring channels!!). The column 'Circuit number' defines the physical values of your circuit. This relations are correct, if you connect your instrument in the correct way. For this refer to the measuring circuit chapter below each table.
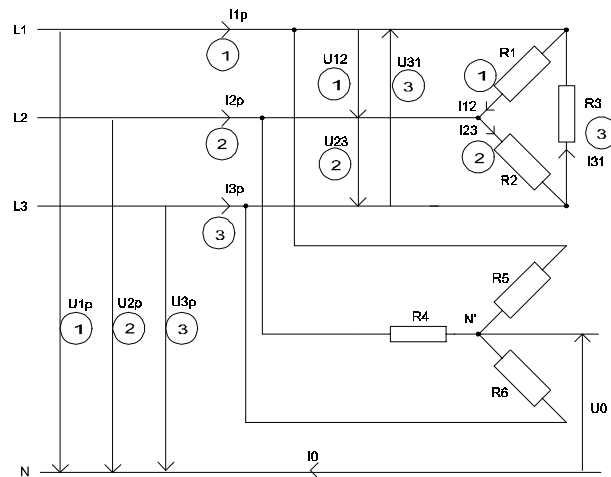
Figure 26: Allocation of the different linked values

Please not also the hints and restrictions given in 2.5, 'Linked values, star to delta conversion (option L50-O6)'

Wiring '3+0, U*I*-> UΔIΔ'

	Measuring channel numbers		Circuit numbers	
Display channel	u(t)	i(t)	U	I
1	$u_1(t)$	$i_1(t)$	U1	I1
2	$u_2(t)$	$i_2(t)$	U2	I2
3	$u_3(t)$	$i_3(t)$	U3	I3
9	$u_1(t)$-$u_2(t)$	$\dfrac{i_1(t)-i_2(t)}{3}$	U12	I12
10	$u_2(t)$-$u_3(t)$	$\dfrac{i_2(t)-i_3(t)}{3}$	U23	I23
11	$u_3(t)$-$u_1(t)$	$\dfrac{i_3(t)-i_1(t)}{3}$	U31	I31

For circuit see 3.3.2, 'Measuring circuit for measuring efficiency of 3/1phase systems'

Wiring '3+0, UΔI*-> UΔIΔ'

	Measuring channel numbers		Circuit numbers	
Display channel	u(t)	i(t)	U	I
1	$u_1(t)$	$i_1(t)$	U12	I1
2	$u_2(t)$	$i_2(t)$	U23	I2
3	$u_3(t)$	$i_3(t)$	U31	I3
9	$u_1(t)$	$\dfrac{i_1(t)-i_2(t)}{3}$	U12	I12

	Measuring channel numbers		Circuit numbers	
Display channel	u(t)	i(t)	U	I
10	$u_2(t)$	$\dfrac{i_2(t) - i_3(t)}{3}$	U23	I23
11	$u_3(t)$	$\dfrac{i_3(t) - i_1(t)}{3}$	U31	I31

For circuit see 3.3.3, 'Measuring circuit (typical) for star to delta conversion (option L50-O6)'

Wiring '3+0, U∆I*-> U*I*'

	Measuring channel numbers		Circuit numbers	
Display channel	u(t)	i(t)	U	I
1	$u_1(t)$	$i_1(t)$	U12	I1
2	$u_2(t)$	$i_2(t)$	U23	I2
3	$u_3(t)$	$i_3(t)$	U31	I3
9	$\dfrac{u_1(t) - u_3(t)}{3}$	$i_1(t)$	U1	I1
10	$\dfrac{u_2(t) - u_1(t)}{3}$	$i_2(t)$	U2	I2
11	$\dfrac{u_3(t) - u_2(t)}{3}$	$i_3(t)$	U3	I3

For circuit see 3.3.3, 'Measuring circuit (typical) for star to delta conversion (option L50-O6)'

Wiring '3+1, U*I*-> U∆I∆'

	Measuring channel numbers		Circuit numbers	
Display channel	u(t)	i(t)	U	I
1	$u_1(t)$	$i_1(t)$	U1	I1
2	$u_2(t)$	$i_2(t)$	U2	I2
3	$u_3(t)$	$i_3(t)$	U3	I3
4	$u_4(t)$	$i_4(t)$	U4	I4
9	$u_1(t)-u_2(t)$	$\dfrac{i_1(t) - i_2(t)}{3}$	U12	I12
10	$u_2(t)-u_3(t)$	$\dfrac{i_2(t) - i_3(t)}{3}$	U23	I23
11	$u_3(t)-u_1(t)$	$\dfrac{i_3(t) - i_1(t)}{3}$	U31	I31

For circuit see 3.3.2, 'Measuring circuit for measuring efficiency of 3/1phase systems'

Wiring '3+1, U∆I*-> U∆I∆'

	Measuring channel numbers		Circuit numbers	
Display channel	u(t)	i(t)	U	I
1	$u_1(t)$	$i_1(t)$	U12	I1
2	$u_2(t)$	$i_2(t)$	U23	I2
3	$u_3(t)$	$i_3(t)$	U31	I3
4	$u_4(t)$	$i_4(t)$	U4	I4
9	$u_1(t)$	$\dfrac{i_1(t) - i_2(t)}{3}$	U12	I12
10	$u_2(t)$	$\dfrac{i_2(t) - i_3(t)}{3}$	U23	I23
11	$u_3(t)$	$\dfrac{i_3(t) - i_1(t)}{3}$	U31	I31

For circuit see 3.3.3, 'Measuring circuit (typical) for star to delta conversion (option L50-O6)'

Wiring '3+1, U∆I*-> U*I*'

	Measuring channel numbers		Circuit numbers	
Display channel	u(t)	i(t)	U	I
1	$u_1(t)$	$i_1(t)$	U12	I1
2	$u_2(t)$	$i_2(t)$	U23	I2
3	$u_3(t)$	$i_3(t)$	U31	I3
4	$u_4(t)$	$i_4(t)$	U4	I4
9	$\dfrac{u_1(t) - u_3(t)}{3}$	$i_1(t)$	U1	I1
10	$\dfrac{u_2(t) - u_1(t)}{3}$	$i_2(t)$	U2	I2
11	$\dfrac{u_3(t) - u_2(t)}{3}$	$i_3(t)$	U3	I3

For circuit see 3.3.3, 'Measuring circuit (typical) for star to delta conversion (option L50-O6)'

For further information about the tables see also chapter 2.5, 'Linked values'.

5.3.1   More than 4 power measuring channels

If you connect a 2nd LMG500 or an extension box to the basic instrument, you can use up to 4 additional power measuring channels. They are placed in the groups 'C' and 'D'. In principle for the second unit you have the same wiring selections, but of course other channels:

Wiring '1+0 Channels'

Display channel	u(t)	i(t)
5	$u_5(t)$	$i_5(t)$

Wiring '2+0 Channels'

Display channel	u(t)	i(t)
5	$u_5(t)$	$i_5(t)$
6	$u_6(t)$	$i_6(t)$
12	$-u_5(t)+u_6(t)$	$-i_5(t)-i_6(t)$

Wiring '1+1 Channels'

Display channel	u(t)	i(t)
5	$u_5(t)$	$i_5(t)$
6	$u_6(t)$	$i_6(t)$

Wiring '3+0 Channels'

Display channel	u(t)	i(t)
5	$u_5(t)$	$i_5(t)$
6	$u_6(t)$	$i_6(t)$
7	$u_7(t)$	$i_7(t)$

Wiring '2+1 Channels'

Display channel	u(t)	i(t)
5	$u_5(t)$	$i_5(t)$
6	$u_6(t)$	$i_6(t)$
7	$u_7(t)$	$i_7(t)$
12	$-u_5(t)+u_6(t)$	$-i_5(t)-i_6(t)$

Wiring '4+0 Channels'

Display channel	u(t)	i(t)
5	$u_5(t)$	$i_5(t)$
6	$u_6(t)$	$i_6(t)$
7	$u_7(t)$	$i_7(t)$
8	$u_8(t)$	$i_8(t)$

Wiring '3+1 Channels'

Display channel	u(t)	i(t)
5	$u_5(t)$	$i_5(t)$
6	$u_6(t)$	$i_6(t)$
7	$u_7(t)$	$i_7(t)$

Display channel	u(t)	i(t)
8	$u_8(t)$	$i_8(t)$

Wiring '2+2 Channels'

Display channel	u(t)	i(t)
5	$u_5(t)$	$i_5(t)$
6	$u_6(t)$	$i_6(t)$
7	$u_7(t)$	$i_7(t)$
8	$u_8(t)$	$i_8(t)$
12	$-u_5(t)+u_6(t)$	$-i_5(t)-i_6(t)$
13	$-u_7(t)+u_8(t)$	$-i_7(t)-i_8(t)$

Wiring '3+0, U*I*-> UΔIΔ'

Display channel	Measuring channel numbers		Circuit numbers	
	u(t)	i(t)	U	I
5	$u_5(t)$	$i_5(t)$	U1	I1
6	$u_6(t)$	$i_6(t)$	U2	I2
7	$u_7(t)$	$i_7(t)$	U3	I3
12	$u_5(t)-u_6(t)$	$\dfrac{i_5(t)-i_6(t)}{3}$	U12	I12
13	$u_6(t)-u_7(t)$	$\dfrac{i_6(t)-i_7(t)}{3}$	U23	I23
14	$u_7(t)-u_5(t)$	$\dfrac{i_7(t)-i_5(t)}{3}$	U31	I31

Wiring '3+0, UΔI*-> UΔIΔ'

Display channel	Measuring channel numbers		Circuit numbers	
	u(t)	i(t)	U	I
5	$u_5(t)$	$i_5(t)$	U12	I1
6	$u_6(t)$	$i_6(t)$	U23	I2
7	$u_7(t)$	$i_7(t)$	U31	I3
12	$u_5(t)$	$\dfrac{i_5(t)-i_6(t)}{3}$	U12	I12
13	$u_6(t)$	$\dfrac{i_6(t)-i_7(t)}{3}$	U23	I23
14	$u_7(t)$	$\dfrac{i_7(t)-i_5(t)}{3}$	U31	I31

Wiring '3+0, UΔI*-> U*I*'

	Measuring channel numbers		Circuit numbers	
Display channel	u(t)	i(t)	U	I
5	$u_5(t)$	$i_5(t)$	U12	I1
6	$u_6(t)$	$i_6(t)$	U23	I2
7	$u_7(t)$	$i_7(t)$	U31	I3
12	$\dfrac{u_5(t)-u_7(t)}{3}$	$i_5(t)$	U1	I1
13	$\dfrac{u_6(t)-u_5(t)}{3}$	$i_6(t)$	U2	I2
14	$\dfrac{u_7(t)-u_6(t)}{3}$	$i_7(t)$	U3	I3

Wiring '3+1, U*I*-> UΔIΔ'

	Measuring channel numbers		Circuit numbers	
Display channel	u(t)	i(t)	U	I
5	$u_5(t)$	$i_5(t)$	U1	I1
6	$u_6(t)$	$i_6(t)$	U2	I2
7	$u_7(t)$	$i_7(t)$	U3	I3
8	$u_8(t)$	$i_8(t)$	U4	I4
12	$u_5(t)-u_6(t)$	$\dfrac{i_5(t)-i_6(t)}{3}$	U12	I12
13	$u_6(t)-u_7(t)$	$\dfrac{i_6(t)-i_7(t)}{3}$	U23	I23
14	$u_7(t)-u_5(t)$	$\dfrac{i_7(t)-i_5(t)}{3}$	U31	I31

Wiring '3+1, UΔI*-> UΔIΔ'

	Measuring channel numbers		Circuit numbers	
Display channel	u(t)	i(t)	U	I
5	$u_5(t)$	$i_5(t)$	U12	I1
6	$u_6(t)$	$i_6(t)$	U23	I2
7	$u_7(t)$	$i_7(t)$	U31	I3
8	$u_8(t)$	$i_8(t)$	U4	I4
12	$u_5(t)$	$\dfrac{i_5(t)-i_6(t)}{3}$	U12	I12

	Measuring channel numbers		Circuit numbers	
Display channel	u(t)	i(t)	U	I
13	$u_6(t)$	$\dfrac{i_6(t) - i_7(t)}{3}$	U23	I23
14	$u_7(t)$	$\dfrac{i_7(t) - i_5(t)}{3}$	U31	I31

Wiring '3+1, U∆I*-> U*I*'

	Measuring channel numbers		Circuit numbers	
Display channel	u(t)	i(t)	U	I
5	$u_5(t)$	$i_5(t)$	U12	I1
6	$u_6(t)$	$i_6(t)$	U23	I2
7	$u_7(t)$	$i_7(t)$	U31	I3
8	$u_8(t)$	$i_8(t)$	U4	I4
12	$\dfrac{u_5(t) - u_7(t)}{3}$	$i_5(t)$	U1	I1
13	$\dfrac{u_6(t) - u_5(t)}{3}$	$i_6(t)$	U2	I2
14	$\dfrac{u_7(t) - u_6(t)}{3}$	$i_7(t)$	U3	I3

5.3.2   Values from single measuring

Voltage and current

true root mean square: $Utrms = \sqrt{\dfrac{1}{T} \int_{t=0}^{T} u(t)^2\, dt}$ $Itrms = \sqrt{\dfrac{1}{T} \int_{t=0}^{T} i(t)^2\, dt}$

DCn negative DC component:

$$Udcn = \frac{1}{T} \int_{t=0}^{T} \left\{ \begin{array}{l} u(t)\ for\ u(t) < 0 \\ 0\ for\ u(t) \geq 0 \end{array} \right\} dt \qquad Idcn = \frac{1}{T} \int_{t=0}^{T} \left\{ \begin{array}{l} i(t)\ for\ i(t) < 0 \\ 0\ for\ i(t) \geq 0 \end{array} \right\} dt$$

DCp positive DC component:

$$Udcn = \frac{1}{T} \int_{t=0}^{T} \left\{ \begin{array}{l} u(t)\ for\ u(t) \geq 0 \\ 0\ for\ u(t) < 0 \end{array} \right\} dt \qquad Idcn = \frac{1}{T} \int_{t=0}^{T} \left\{ \begin{array}{l} i(t)\ for\ i(t) \geq 0 \\ 0\ for\ i(t) < 0 \end{array} \right\} dt$$

DC component: $Udc = \dfrac{1}{T} \int_{t=0}^{T} u(t)dt$ $Idc = \dfrac{1}{T} \int_{t=0}^{T} i(t)dt$

AC component: $Uac = \sqrt{Utrms^2 - Udc^2}$ $Iac = \sqrt{Itrms^2 - Idc^2}$

peak-peak value: $\qquad Upp = \max(u(t)) - \min(u(t)) \qquad Ipp = \max(i(t)) - \min(i(t))$

rectified value: $\qquad Urect = \dfrac{1}{T}\displaystyle\int_{t=0}^{T}|u(t)|dt \qquad Irect = \dfrac{1}{T}\displaystyle\int_{t=0}^{T}|i(t)|dt$

crest factor: $\qquad Ucf = \dfrac{Upk}{Utrms} \qquad Icf = \dfrac{Ipk}{Itrms}$

form factor: $\qquad Uff = \dfrac{Utrms}{Urect} \qquad Iff = \dfrac{Itrms}{Irect}$

Inrush current: $\qquad Iinr = \max(|i(t)|)$

Power

active power: $\qquad P = \dfrac{1}{T}\displaystyle\int_{t=0}^{T}u(t)i(t)dt$

reactive power $\qquad Q = \sqrt{S^2 - P^2}$

apparent power: $\qquad S = Utrms * Itrms$

power factor: $\qquad PF = \lambda = \dfrac{|P|}{S}$

Behind the power factor might be a 'i' or 'c' showing, that the load is inductive or capacitive. This decision is only done under following conditions:

$\lambda < 0.999\, and\, 1.05 < Uff < 1.2\, and\, 1.05 < Iff < 1.2\, and\, f < 30kHz$

This means, that voltage and current are nearly sinusoidal. In all other cases there is neither 'i' nor 'c'.

Please note: The i/c indication was developed for usual line applications. When the usage of the channels is very low or you work with very high frequencies you should take care, if the i/c indication is correct or not.

angle: $\qquad \varphi = \arccos\lambda \quad with \quad \varphi = \varphi_{ui} = \varphi_u - \varphi_i$

The sign of the angle is derived from the i/c indication, '+' for an inductive load, '-' for a capacitive one. Here the current is the reference. This value is only valid at sinusoidal wave forms! The value can be in the range ±180°, values outside ±90° usually indicate negative active power.

Impedances

apparent impedance: $Z = \dfrac{Utrms}{Itrms}$

active impedance: $Rser = \dfrac{P}{Itrms^2}$

reactive impedance $Xser = \dfrac{Q}{Itrms^2}$

5.3.3   Integrated values

The following basic definitions are used:

n   The value from the measuring cycle number n.

N   Is the number of measuring cycles for the integration. This number depends on the real measuring times and on the desired integration time.

Energy

active energy: $EP = \sum_{n=0}^{N} P_n * T_n$

reactive energy: $EQ = \sum_{n=0}^{N} Q_n * T_n$

apparent energy $ES = \sum_{n=0}^{N} S_n * T_n$

Average values

average active power: $Pm = \dfrac{EP}{\sum_{n=0}^{N} T_n}$

average reactive power: $Qm = \dfrac{EQ}{\sum_{n=0}^{N} T_n}$

average apparent power $Sm = \dfrac{ES}{\sum_{n=0}^{N} T_n}$

Miscellaneous

charge: $q = \sum_{n=0}^{N} Idc_n * T_n$

integration time: $t = \sum_{n=0}^{N} T_n$

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5.3.4   Total values

This are values which are calculated over several channels of one group. Following symbols are used:

f   first channel of the group

l   last channel of the group

s   number of the display channel for the total values

These three symbols depend on the wiring. Please refer to 2.4, 'The group concept' and 2.5, 'Linked values' for details

Following values are calculated for the total values display channels (all other values are invalid):

collective sum voltage: $U_{s_{TRMS}} = \sqrt{\sum_{n=f}^{l} U_{n_{TRMS}}^2}$

collective sum current: $I_{s_{TRMS}} = \sqrt{\sum_{n=f}^{l} I_{n_{TRMS}}^2}$

active power: $P_s = \sum_{n=f}^{l} P_n$

apparent power: $S_s = U_s * I_s$

reactive power: $Q_s = \sqrt{S_s^2 - P_s^2}$

power factor: $\lambda_s = \dfrac{|P_s|}{S_s}$

frequency: $f_s = f_f$

active energy: $EP_s = \sum_{n=0}^{N} P_s T_n$

reactive energy: $EQ_s = \sum_{n=0}^{N} Q_s T_n$

apparent energy: $ES_s = \sum_{n=0}^{N} S_s T_n$

average active power: $Pm_s = \dfrac{EP_s}{\sum_{n=0}^{N} T_n}$

average reactive power: $Qm_s = \dfrac{EQ_s}{\sum_{n=0}^{N} T_n}$

average apparent power: $Sm_s = \dfrac{ES_s}{\sum_{n=0}^{N} T_n}$

All this calculation are in accordance with DIN40110.

5.4   Display of values

For the display of the values you can choose several menus. Also in this menus we have the group concept. With the rotary knob you can select the desired group. Now you can have four softkeys (maybe not all appear, depending on the selected wiring, the group and installed options):

Chns   By this you can select, which channel you want to see. A second softkey bar appears, where you can select the channel.

Link   Here you can select which linked channel you want to see (only if option L50-O6 star to delta conversion is installed).

Sum   Here you can select the total values of the group (over several channels).

Displ   Here you can setup if you want to see few values in a big font or more values in a smaller font. This softkey may be inactive, if you watch several channels.

Above the displayed values you see a header which describes in several fields, what you see:

Chnx   You see the values from the measuring channel x. This is always a measuring channel from the rear side of the instrument.

Linkxy   You see the values of a linked channel. xy are the channels which are used to calculate the value.

SUM(x-y)   You see the values of a sum channel. x and y are the first and last channels which are used to calculate the value

(x,y)   This field is optional. It shows you, which values of your circuit are displayed on this channel.

n:x   It belongs to group n. x is the number of the display channel. You have to use this number (together with the ':'!) for example in the script editor or in the computer interface.

The following examples exit if you have the wiring 'A:1+2 B:3+4' and the Aron field is switched on in the measuring menu.

Example: Chn2 (U23,I2) A:2

This is the <u>measuring channel</u> 2. It should be <u>connected</u> to U23 and I2 of your circuit. It belongs to group A and has the display channel number 2.

Example: Link34 (U12,I3) B:6

This is a <u>linked channel</u>, which is calculated from values of channel 1 and 2. The displayed values <u>represent</u> U12 and I3 of your circuit. It belongs to group B and has the display channel number 6.

Example: Sum(1-2) A:13

This is the sum channel which is calculated over the display channels 1 to 2. It belongs to group A and has the display channel number 13.

For further information please refer also 2.4, 'The group concept' and 2.5, 'Linked values'.

5.4.1   Default

With *Default* you see the most important values of the instrument. For the handling please see the general description in chapter 5.4, 'Display of values'.
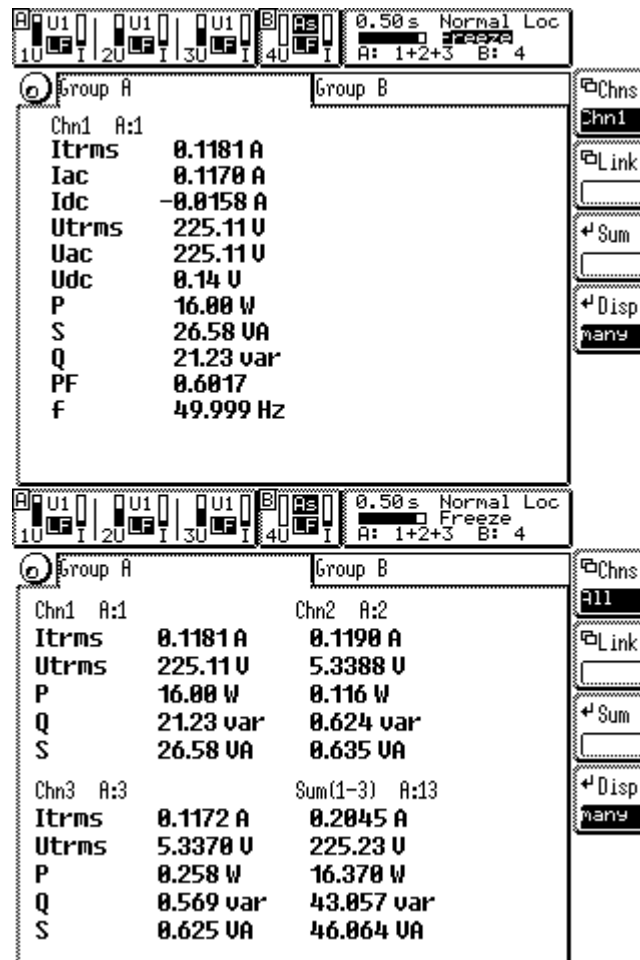
Figure 27: Default display with one and four channels

5.4.2   Voltage

With *Voltage* you see the most important voltage values of the instrument. For the handling please see the general description in chapter 5.4, 'Display of values'.

5.4.3   Current

With *Current* you see the most important current values of the instrument. For the handling please see the general description in chapter 5.4, 'Display of values'. With the **Inrsh** key you can reset the last measured inrush current to 0. This softkey is only available when the manual measuring range is selected for the current and the voltage! The average in the measuring menu has to be set to 1! If the inrush current is too big for the measuring range, a dashed line is displayed.

5.4.4   Power

With *Power* you see the most important power values of the instrument. For the handling please see the general description in chapter 5.4, 'Display of values'. Further on you get the

following resistor values: Z, X and R. **<u>Please note that the values of X and R are only</u>**
<u>correct, if the voltage and current have a sinusoidal waveform!</u>

5.4.5   Energy

In this menu (you reach it by *Int. Val)* you see the most important energy values as well as
derived values which also depend on time. For the handling please see the general description
in chapter 5.4, 'Display of values'.

5.4.5.1   Integration menu

In this menu (you reach it by *Int. Time*) you defines the measuring conditions for time
depending signals. **Reset** sets the display values to their default state (i.e. 0 for all energy
values). This is only possible if the state is 'Hold'.

Mode Defines the integration mode. You can only change the mode, if the state is 'RESET'.

off	No integration can be done.
continuous	After the integration is started it measures continuously until *Stop* is pressed. With the start of this measurement the values are automatically reset to 0.
interval	After the integration is started it measures continuously until the interval **DUR** is over. With the start of this measurement the values are automatically reset to 0.
periodic	Same like 'interval', but with two differences: - At the end of one interval a new one is started. - The display is only updated at the end of an interval and not after every cycle.
summing	After the integration is started it measures continuously until *Stop* is pressed. With the start of the integration the values are NOT reset to 0!

Start Time,
Start Date This are the start time and date of an integration. You <u>have to</u> press *Start* to
change the state of the integration changes to 'wait'. If the entered time is
reached, the integration starts.

DUR This is the time of the time interval in interval and periodic integration mode.

Runtime is the running integration time. Please note, that this time can be smaller than the real
time, for example because of invalid measuring cycles while a change in the measuring ranges.

Start of integration

In general there are three ways to start an integration. You can either enter a start time with **Start Time, Start Date**, or you can simply press the *Start* button or you can start via the external sync jack of the LMG. The first cycle which is taken into account is the cycle which follows the actual cycle.

The integration time should be an integer number of times the cycle time.

Stop of integration

The last cycle which is taken into account is the cycle when the *Stop* button or any other stop signal appear.

State of integration

The integration can be in 6 different states:

Reset	The energy measurement is stopped, the values are reset to 0
Wait	If the start time is later than the actual time and you have started the integration this state appears until the start time is reached.
Start	This state is displayed from the logical start of integration (e.g. pressing the *Start* button) until the physical start of integration which is always the begin of the next cycle.
Run	This is displayed while the physical integration is running
Stop	This state is displayed from the logical end of integration (e.g. pressing the *Stop* button) until the physical end of integration which is always the end of the actual cycle.
Hold	This is displayed if the integration has finished. The integrated values are hold, until the integration continuous (only summing mode) or the values are reset by **RESET** or *Start*.

The logical integration is running, if the state is displayed inverse.

5.4.6   Graphical display

With *Graph* you see the graphical display of the normal measuring mode. Also in this menu we have the group concept. With the rotary knob you can select different tabs ('Scope A', 'Scope B', 'Vec.A' and 'Vec.B').

5.4.6.1   Scope A/B

The settings in group A and B are identical, so they are just described once.

Left of this graph you see the Y scaling (ydiv), the Y scaling factor (yzoom) and the four selected signals. Under the graph you see the start position of the graph in seconds, the X

scaling factor (xzoom) and the X scaling (x/div). By pressing the rotary knob you can do the following settings:

Graph Here you can select one of the four scope channels 'A' to 'D'.

Signal Here you can choose the signal to be displayed. The possible values depend on the chosen wiring. In principle you have:
ix: The current of channel x after all activated filters.
ux: The voltage of channel x after all activated filters.
px: The power of channel x after all activated filters.

Div. By pressing this softkey, you get a small symbol for the rotary knob in the softkey. This means, that from now the rotary knob is used for changeing the x/y divisions. By pressing this softkey several times you can choose if you want to change the x/division or y/division.
You have to confirm your selection with *Enter*.

move By pressing this softkey, you get a small symbol for the rotary knob in the softkey. This means, that from now the rotary knob is used for the moving. By pressing this softkey several times you can choose if you want to change the following setting:

x-pos The signal is moved if you use the rotary knob. So it is possible to see other parts of the wave form.
c1 The first cursor is moved when using the rotary knob. In the second line below the graph you see the X position in seconds and the value of the wave form at this position. The selected cursor position is constant. That means if you scroll the wave form the cursor can move out of the displayed window. If the cursor is outside the visible screen and you move the cursor, it will be set to the border of the visible screen.
c2 Same as c1
c1&c2 Both cursors are moved at the same time. In the second line under the graph you see the time difference and the Y value distance between the two cursors.

Split You can have all graphs in the same screen (good for relations between different signals) or you can have one graph for each signal (good if you have many signals)

Grid You can switch the background grid on or off.
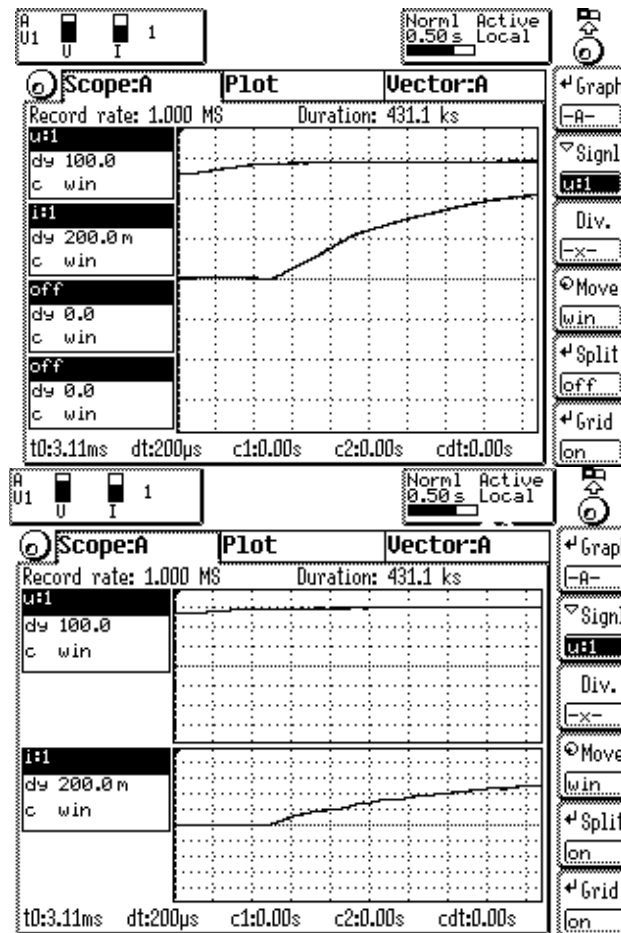
Figure 28: Scope display with split off/on

5.4.6.2   Plot function
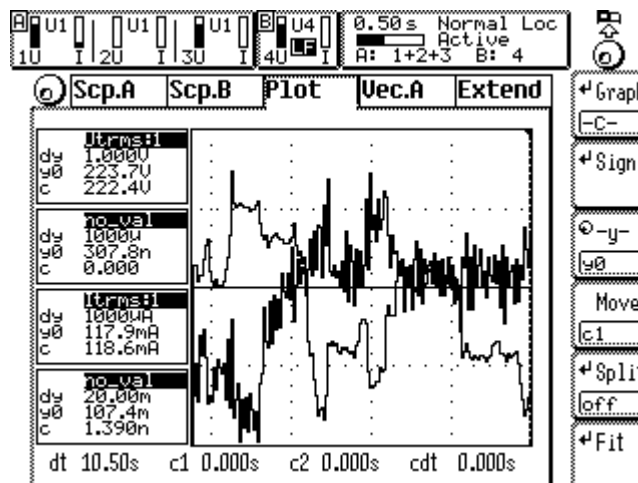
Figure 29: The plot display; split off

In this menu all measured values can be displayed over the time in one or four plots. On the left side, the information segment, the following settings are displayed:

The plotted signal is shown in the colour in which the graph is drawn.

dy   scaling of the y axis per division

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y0   offset of the y axis (value of the centre line)

c   value of the function at the cursor position

Below the graphs the time depending values are displayed:

dt   scaling of the x axis per division

c1   x value of the first cursor

c2   x values of the second cursor

cdt   time difference between the cursors

The following settings can be done with the softkeys on the right side:

Chn   changes the displayed channel (A-D)

Signl Pressing this softkey a list will open, in which you can adjust the following parameters (refer chapter 4.5):

    Signl   here you can select the signal to be plot

    y/div   here you can select the scaling factor of the Y axis

    y0   here you can select the offset of the y axis (value of the centre line). Example: If you select y0 = 200V and y/div = 10V the you will see a window from 180V to 220V on the screen.

    Auto Scale If you check this box, the signal will be fitted, if it is outside the display range.

Each setting is confirmed with *Enter* and rejected with *Esc*.

y-   pressing this softkey - the rotary knob symbol appears in the upper left corner - the adjustments of the y axis can be changed while the plot is running. Each pressing of the button toggles between the parameters dy and y0. The adjusted values can be changed with the rotary knob. The adjustments will be confirmed by pressing the rotary knob or with the *Enter* key.

Move here the cursors are selected. With the rotary knob the cursors will scroll through the plot. For easy reading of the values the plot should be frozen. The scrolling of the cursors can be done for each cursor separately or for both together.

    c1   the first cursor is moved. below the graphs the values for the x position in seconds and the value of the function are shown.

c2   same as c1

c1&c2 both cursors are moved at the same time.

Split   after pressing this button the display will be split in four separated graphs, refer the
following picture:
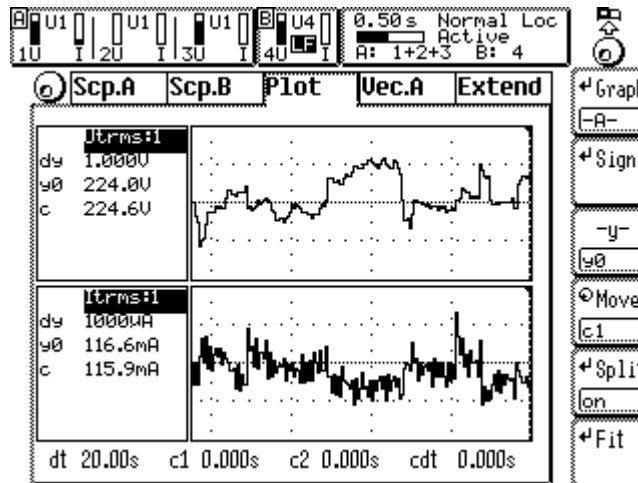
Figure 30: The plot display; split on

Hint: the settings of the cursor are the same for all four to get accurate readings at the selected
moment for all channels.

Fit   By this the actual selected graph (A to D) is rescaled to fit into the screen.

5.4.6.3   Vec. A/B

The settings in group A and B are identical, so they are just described once.

On this tabs you see the vectors of voltage and current (Fresnel diagramm). In the lower left
corner you see the amplitude and the phase angle of the selected signal. In the upper right
corner you see the rotating direction of the vectors and the phase counting of the voltages.
'1,2,3' means that the zero crossings are in the order 1st, 2nd, 3rd phase. '3,2,1' means that you
have the opposite order. By pressing the rotary knob you can do the following settings:

Signl   Here you can choose the signal to be displayed. The possible values are voltage or
current.

Ref.   Here you can choose the reference for the angles:
U   U1 is set to 0°
I   I1 is set to 0°
None   The sync. signal is used as 0° reference.
All angles which are displayed in this menu are relative to this reference angle.

Zoom   You can zoom the selected signal to get longer vectors.
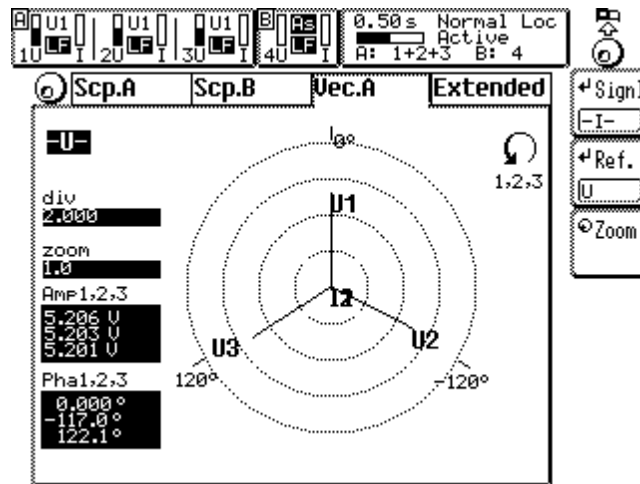
Figure 31: Vector (Fresnel) diagramm

Please note following

1. The angels between the voltages are calculated from the time of the zero crossing in each phase. If you have big distortions on the voltage, this values might be wrong. You can use all possible filter to smooth the voltage.

   When using the 'HARM100' measuring mode, this problems will not occur!

2. The angels of the currents are calculated from the power factor. If voltage and current are sinusoidal this value is identical to the cosφ and the calculated angels are correct. If you have distortions in the voltage or current signal, this values might be wrong! You can use all possible filters to smooth the voltage and current. Then you can see the phase shift between the fundamentals.

   When using the 'HARM100' measuring mode, this problems will not occur!

3. In Aron circuit the calculation of the power factors is in general wrong (this is a disadvantage of this circuit!). So also the current angles are wrong (see above). But you can get valid power factors (and angles) if you use the star to delta conversion (option).

For interface access or other usage inside the instrument please refer to following chapters:
9.2.4.1.1.9   Phase angle of current
9.2.4.1.1.13   Amplitude of current
9.2.4.1.14.9   Phase angle of voltage
9.2.4.1.14.13   Amplitude of voltage
9.2.10.8.3   Reference setting for angles

5.4.7   Custom menu

With *Custom* you see the custom menu. Here you can setup your own menus, calculate formulas and execute programs. See 4.4.3, 'Custom menu' and 4.4.4, 'Script/Formula editor'.

5.5   Storage of values

First you have to change to the menu you want to print out or to store and press *Print/Log* (exact handling see 10, 'Logging of values to drives, printer and interfaces'). All the values you see in this menu are printed out.

6   CE-Harmonic measuring mode (option L50-O9)

In the CE-Harmonic measuring mode the LMG500 works as an high precision harmonic analyser. The number of settings have been reduced to the needed ones to avoid fail handling.

Note!
The synchronisation is fixed to U. For this reason it is important to have a valid signal for synchronisation to get measuring results. **The valid frequency range is from 45 to 65Hz!**

6.1   Measuring configuration (Measuring)

The synchronisation is fixed to the voltage channel. With the rotary knob you can select three tabs ('Globals', 'Group A' and 'Group B').

6.1.1   Global tab

Here the general settings are done.

Eval   Selects how the measuring results have to be evaluated:

Class A	The signal is judged according class A of EN61000-3-2:1995 or EN61000-3-2:2006
Class B	The signal is judged according class B of EN61000-3-2:1995 or EN61000-3-2:2006
Class C-1	The signal is judged according class C, Table 1 of EN61000-3-2:1995 or EN61000-3-2:2006
Class C-2	The signal is judged according class C, Table 2 of EN61000-3-2:1995 or EN61000-3-2:2006
Class C-3	The signal is judged according class C, Table 3 of EN61000-3-2:1995 or EN61000-3-2:2006
Class C-W	The signal is judged according class C, special waveform according 7.3 b) of EN61000-3-2:2006
Class D	The signal is judged according class D of EN61000-3-2:1995 or EN61000-3-2:2006
Table 2	The signal is judged according table 2 of EN61000-3-12:2005
Table 3	The signal is judged according table 3 of EN61000-3-12:2005
Table 4	The signal is judged according table 4 of EN61000-3-12:2005

EN...   This selects the standard which defines the exact measuring mode of the harmonic analyser:

2:95/-4-7:93   The combination EN61000-3-2:1995 and EN61000-4-7:1993 is active

2:95/-4-7:02   The combination EN61000-3-2:1995 and EN61000-4-7:2008 is active

2:00/-4-7:93   The combination EN61000-3-2:2006 and EN61000-4-7:1993 is active

2:00/-4-7:02   The combination EN61000-3-2:2006 and EN61000-4-7:2008 is active

12:05/-4-7:02   The combination EN61000-3-12:2005 and EN61000-4-7:2008 is active

Systm   This selects the system which is used for the measurement. There are four possible values:
220V/50Hz, 230V/50Hz, 240V/50Hz
220V/60Hz, 230V/60Hz, 240V/60Hz
120V/50Hz
120V/60Hz
The system is required for example for checking the correct frequency of the measuring setup.

Intv   This selects the measuring time for a long time evaluation, for example if you have devices with fluctuation harmonics. The result you can see in the *Int-Value* menu.

Smooth Here you can switch the 1.5s low pass filters for smoothing the fluctuating harmonics on or off. With EN61000-3-2:2006 this point is always on!
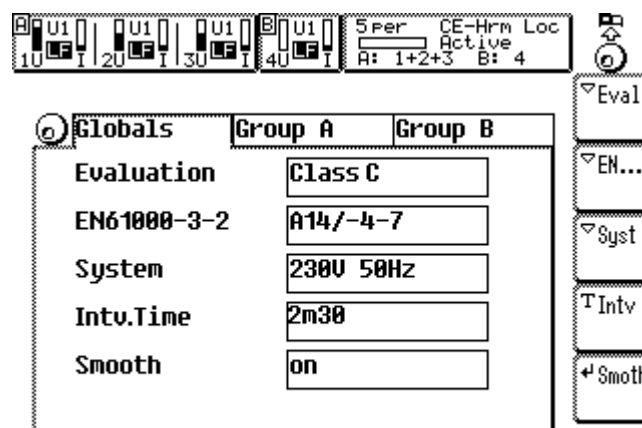
Figure 32: Measuring menu in CE-Harm mode

6.1.2   Group A/B tab

The settings in group A and B are identical, so they are just described once.

This tab is only accessible if you have chosen EN61000-3-2:2006 with Class C or D or EN61000-3-12!

Here you have to setup the setting which are required for EN61000-3-2:2006. For class C you have to enter the fundamental current and the power factor or your device. For class D you have to enter the active power.

This values are used to calculate the limits. For each value the average measured one is compared to the entered one. If there is a difference of more than 10% all the limits are calculated again with the measured values. In this case it might be, that you have to compare all the measuring results again against the new limits. For this purpose we recommend to use a special test and evaluation software (like for the SYS61K system).

Class C

With **PF** and **Curr** you can enter the power factor and the fundamental current.

Class D

With **Pow** you can enter the active power.

EN61000-3-12

With **Rsce** you enter the R_{sce} value of the system.

6.2   Measuring ranges (Range)

The settings are the same like in 5.2, 'Measuring ranges (Range)'. Please note that the standards require a continuous measuring without gaps. For that reason the auto range function should be deactivated to prevent a range change, because this will cause a short measurement with invalid values.

6.3   Definition of measuring values

The following basic definitions are used:

n The harmonic order.

T The time of an integer number of the periods of the synchronisation signal

Voltage and current

true root mean square: $Utrms = \sqrt{\dfrac{1}{T} \int_{t=0}^{T} u(t)^2 \, dt}$ $Itrms = \sqrt{\dfrac{1}{T} \int_{t=0}^{T} i(t)^2 \, dt}$

DC component:
$$Udc = \frac{1}{T}\int_{t=0}^{T} u(t)dt$$
$$Idc = \frac{1}{T}\int_{t=0}^{T} i(t)dt$$

AC component:
$$Uac = \sqrt{Utrms^2 - Udc^2}$$
$$Iac = \sqrt{Itrms^2 - Idc^2}$$

crest factor:
$$Ucf = \frac{Upk}{Utrms}$$
$$Icf = \frac{Ipk}{Itrms}$$

total harmonic distortion:
$$Uthd = \sqrt{\sum_{n=2}^{40}\left(\frac{U_n}{U_1}\right)^2}$$
$$Ithd = \sqrt{\sum_{n=2}^{40}\left(\frac{I_n}{I_1}\right)^2}$$

The harmonic values 'I(n)' and 'U(n)' are calculated by using a DFT algorithm. The limit values 'Limit (n)' are calculated according to EN61000-3-2.

Power

active power:
$$P = \left(\frac{1}{T}\int_{t=0}^{T} u(t)i(t)dt\right) - U(0)*I(0) \ if \ EN61000-4-7:2008$$
$$P = \frac{1}{T}\int_{t=0}^{T} u(t)i(t)dt \ \ in \ other \ cases$$

reactive power:
$$Q = \sqrt{S^2 - P^2}$$

apparent power:
$$S = Utrms * Itrms$$

power factor:
$$\lambda = \frac{|P|}{S}$$

Impedances

apparent impedance:
$$Z = \frac{Utrms}{Itrms}$$

active impedance:
$$Rser = \frac{P}{Itrms^2}$$

reactive impedance:
$$Xser = \frac{Q}{Itrms^2}$$

6.4   Display of values

For the display of the values we have the same rules like in the normal measuring mode (see 5.4, 'Display of values').

6.4.1   Default

With *Default* you see the most important values of the instrument. For the handling please see the general description in chapter 5.4, 'Display of values'.

6.4.2   Voltage

With *Voltage* you see the harmonic values of the measured voltage and in the second row the allowed limits in this voltage (if you see a single channel). A '!' between the two rows shows that the measuring value is bigger than the limit. In this menu you see always the evaluation of the actual measured window!

With the arrow keys or with the shuttle knob you can scroll through the list to see all harmonics.

In the top line you see the total trms value of the signal and the frequency of the synchronisation source.

Below the softkeys you see the result of the complete voltage judgement: a '✓' indicates that all requirements of the standard are met. A '✗' indicates a fault measuring result. This result is only the result of the actual measuring and not influenced by earlier measurements.
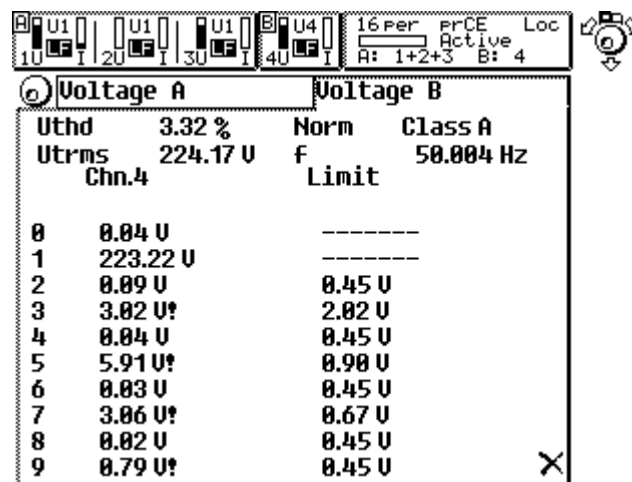
Figure 33: Display of voltages in CE-Harm-Harm mode

6.4.3   Current

With *Current* you see the harmonic values of the measured current and in the second row the allowed limits in this current. A '!' between the two rows shows that the measuring value is bigger than the limit. A '?' between the two rows shows that the measuring value is bigger than 100%, but smaller than 150% of the limit (which is important for fluctuating harmonics!). This special evaluation is only valid for the harmonics of order 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13, 15, 17 and 19. The '?' indicates that the harmonic might be outside the standard if the '?' appears for more than 10% of a any 2.5min windows.

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If the current is <5mA or <0.6% of I_{trms} there is no judgement of the current. For this reason '------' is displayed for the limit.

With the arrow keys or with the shuttle knob you can scroll through the list to see all harmonics.

In the top line you see the total trms value of the signal and the frequency of the synchronisation source.

Below the softkeys you see the result of the complete current judgement: a '✓' indicates that all requirements of the standard are met. A '✗' indicates a fault measuring result. This result is only the result of the actual measuring and not influenced by earlier measurements.

Please note:
If only '?' appear and no '!' then the result will be '✓', because this is only the short term result, which might be correct.

6.4.4   Power

With *Power* you see the most important power values of the instrument. For the handling please see the general description in chapter 5.4, 'Display of values'

6.4.5   Long time evaluation

In this menu you see the result of the long time evaluation. This is started with *Start* and can be cancelled with the *Stop* button. You see in the first row the order of the harmonics, followed by the maximum measured current.

The third row shows the evaluation for fluctuating harmonics. According to the standard it is allowed that some defined harmonics have values up to 1.5 times the limit for maximum 10% of a 2.5 minute window. The maximum percentage out of this window is displayed here. If the value is bigger than 10% you have a '!' behind this value.

In the fourth row you see if the current harmonics have violated any point of the standard anytime while the complete long time measuring. If you have here a '!' the device under test does not fulfil the standard!

In the last row you see if the test voltage has ever violated the harmonic limits.
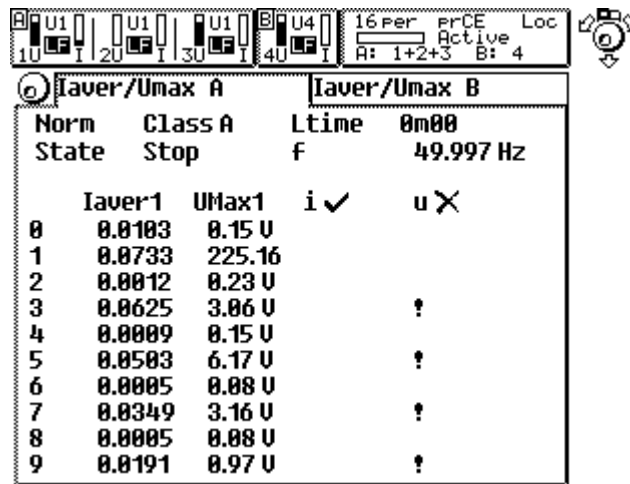
Figure 34: Long time evaluation of harmonics

Below the softkeys you see the total evaluation of the measurement. If any current harmonic has violated the standard at any time or the differences between control and measured values of power (class D) or of current and power factor (class C) were more then 10% (only for A14) you have 'Test I ✘'. If any voltage harmonic or the amplitude or the frequency have violated the standard you have 'Test U ✘'. The printing and logging of this menu is only possible in single mode (see 4.4.2.1, 'Interfaces for remote control') and with ASCII format.

6.4.6 Graphical display

With *Graph* you see the graphical display of the CE-Harm measuring mode. Also in this menu we have the group concept. With the rotary knob you can select different tabs ('Spectrum A' and 'Spectrum B').

6.4.6.1 Spectrum A/B

The settings in group A and B are identical, so they are just described once.

The graphical display of the voltage, the current and the limits of the harmonics. On the left side you see for each graph signal value (yn), the limit value (yl) at cursor position, the scaling of the y-axis (dy) and the zoom of the y-axis (zm).

If you have logarithmic display, the dy value specifies the signal level at the top line. The lower lines have each a tenth of the upper ones.

Graph   Here you can select one of the four possible display channels.

Signl   Defines the signal for this display channel. Possible values are (for each channel):
   U   The voltage harmonics
   LU   The limits of the voltage harmonics and the voltage harmonics
   I   The current harmonics
   LI   The limits of the current harmonics and the current harmonics

For the displays with limits and harmonics you have always one thin bar with the limit, one thin bar with the measuring value and again one thin bar with the limit. So the value is covered by the limits.

You can imagine that the limits are displayed like a cup filled with water (which represents the values). If you have too much in the cup you have a problem.

Zoom Allows you to zoom the signals in y direction

Move Allows you to move the cursor to another position.

Split You can have one graph in one big screen or you can have several graphs in several screens (see pictures below)

Log changes between linear scaling (=off) and logarithmic scaling (=on) for the y-axis.
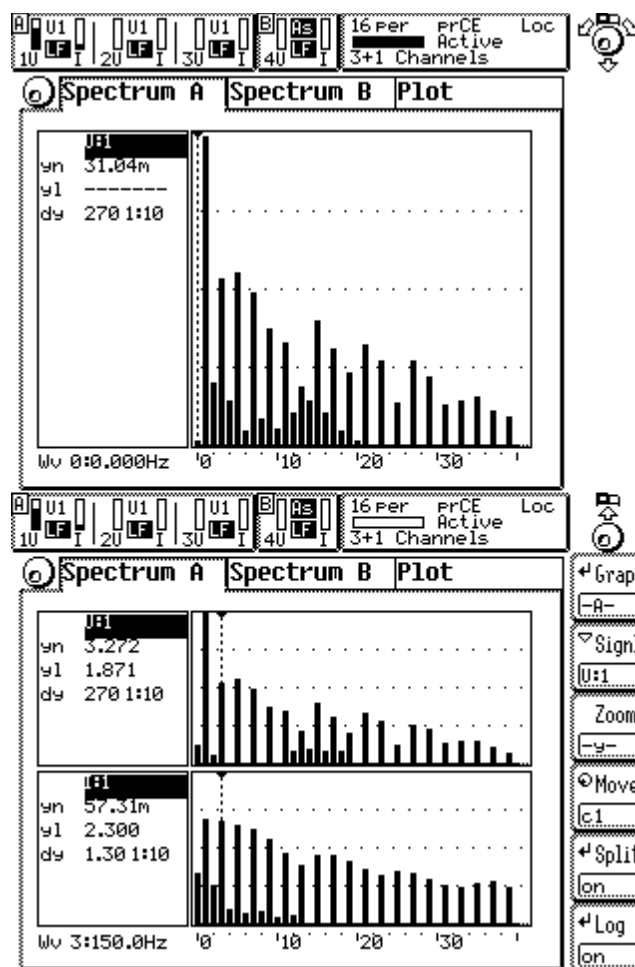
Figure 35: Graphical display of harmonics

6.4.6.2 Plot function

For the plot function we have the same rules like in the normal measuring mode (see '5.4.6.2, Plot function')

6.4.7   Custom menu

With *Custom* you see the custom menu. Here you can setup your own menus, calculate formulas and execute programs. See 4.4.3, 'Custom menu' and 4.4.4, 'Script/Formula editor'.

6.5   Storage of values

First you have to change to the menu you want to print out or to store and press *Print/Log* (exact handling see 10, 'Logging of values to drives, printer and interfaces'). All the values you see in this menu are printed out. In the menues with harmonic values you get all harmonics (not only the ones you see!).

6.6   Compliance tests according EN61000-3-2

For tests according to this standard you first have to change the *Range* to 'Manual' mode. This is necessary because the test has to be done without any gaps.

Now you go to the *Measuring* menu, change the version with **EN** to '61000-3-2:1995' or '61000-3-2:2006' and select with **Eval** the class you want to test.

Now you can switch on the voltage. When the LMG is synchronised you can switch on the equipment under test (EUT).

If you want to make long time evaluations you can start them with *Start*.

7   CE-Flicker measuring mode (option L50-O4)

In the CE-Flicker measuring mode the LMG500 works as an high precision flicker analyser according to EN61000-4-15. The number of settings has been reduced to the needed ones to avoid fail handling.

Note!
In this measuring mode the valid frequency range is from **45 to 65Hz!**

7.1   Measuring configuration (Measuring)

The synchronisation is fixed to the voltage channel. With the rotary knob you can only select 'Globals' tab.

7.1.1   Globals tab

Here the general settings are done.

dMax   This selects the dmax limit for the measuring. This value has to be taken out of the standard, depending on the measuring requirements.

EN   Defines the standard which should be used:

3:95/-4-15	EN61000-3-3:1995 with EN61000-4-15:1998/A1:2003
3:08/-4-15	EN61000-3-3:2008 with EN61000-4-15:1998/A1:2003
3:08B2/-4-15	EN61000-3-3:2008 with EN61000-4-15:1998/A1:2003
	This one is especially for tests according annex B.2
-11:2000	EN61000-3-11:2000 with EN61000-4-15:1998/A1:2003

Syst   This selects the system which is used for the measurement. There are four possible values:
230V/50Hz
230V/60Hz
120V/50Hz
120V/60Hz
The system is required for example for checking the correct frequency of the measuring setup.

Intv   This is the interval time of the short term flicker measuring. The standard value is 10min.

Per.   This is the number of short term periods for the long term measurement. The standard value is 12 periods for a long term time of 2 hours.
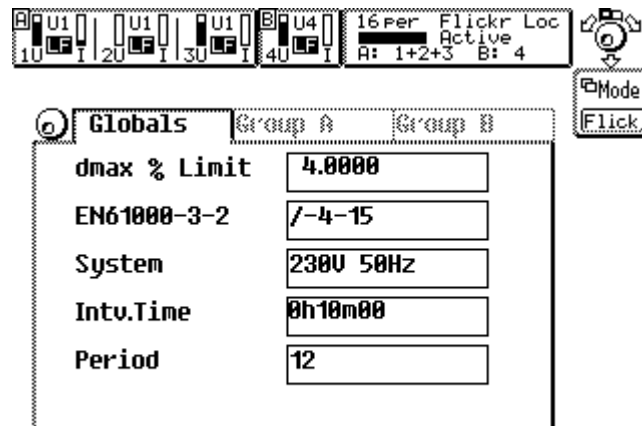
Figure 36: Measuring menu in CE-Flicker mode

7.1.2   Ztest/Zref tab

This is only available when EN61000-3-11 is selected.

With **Ztest** you have to enter your actual used test impedance in Ω.

With **Zref** you have to choose, if your reference impedance is $(0.24+j0.15)\Omega$ or $(0.4+j0.25)\Omega$.

The values for d_c, d_{max}, P_{st} and P_{lt} are recalculated as described in EN61000-3-11:2000

7.2   Measuring ranges (Range)

The settings are the same like in 5.2, 'Measuring ranges (Range)'. Please note that the standards require a continuous measuring without gaps. For that reason the auto range function should be deactivated to prevent a range change, because this will cause a short measurement with invalid values.

7.3   Definition of measuring values

The following basic definitions are used:

n The harmonic order.

T   The time of an integer number of the periods of the synchronisation signal. The integer factor depends on the standard EN61000-4-7. Actually 16 periods are measured.

Voltage and current

true root mean square: $$Utrms = \sqrt{\frac{1}{T} \int_{t=0}^{T} u(t)^2\, dt} \qquad\qquad Itrms = \sqrt{\frac{1}{T} \int_{t=0}^{T} i(t)^2\, dt}$$

total harmonic distortion: $$Uthd = \sqrt{\sum_{n=2}^{40} \left(\frac{U_n}{U_1}\right)^2} \qquad\qquad Ithd = \sqrt{\sum_{n=2}^{40} \left(\frac{I_n}{I_1}\right)^2}$$

The harmonic values 'I(n)' and 'U(n)' are calculated by using a DFT algorithm.

The values 'Pmom', 'Pst' and 'Plt' are calculated using a flickermeter according to EN61000-4-15. 'dc' and 'dmax' are calculated according to EN61000-3-3.

Power

active power: $$P = \frac{1}{T} \int_{t=0}^{T} u(t)i(t)dt$$

reactive power: $$Q = \sqrt{S^2 - P^2}$$

apparent power: $$S = Utrms * Itrms$$

power factor: $$\lambda = \frac{|P|}{S}$$

Impedances

apparent impedance: $$Z = \frac{Utrms}{Itrms}$$

active impedance: $$Rser = \frac{P}{Itrms^2}$$

reactive impedance: $$Xser = \frac{Q}{Itrms^2}$$

7.4   Display of values

For the display of the values you can choose several menues.

7.4.1   Default

For the display of the values we have the same rules like in the normal measuring mode (see 5.4, 'Display of values')

7.4.2   Voltage

Here you see the TRMS value, the THD and the frequency.

7.4.3   Current

Here you see the TRMS value, the THD and the frequency.

7.4.4   Power

For the display of the values we have the same rules like in the normal measuring mode (see 5.4, 'Display of values')

7.4.5   Flicker (Int. Val)

In this menu you see the flicker values of the equipment under test (EUT). You see the short term flicker level P_{st}, the long term flicker level P_{lt}, the actual flicker level P_{mom}, the relative steady-state voltage change d_c, the maximum relative voltage change d_{max}, the remaining long term time, the remaining short term time and the state of the flicker measuring.

The state can be 'starting' (8s from pressing *START*), 'running' (while the long term interval) and 'stooped' after the measuring.
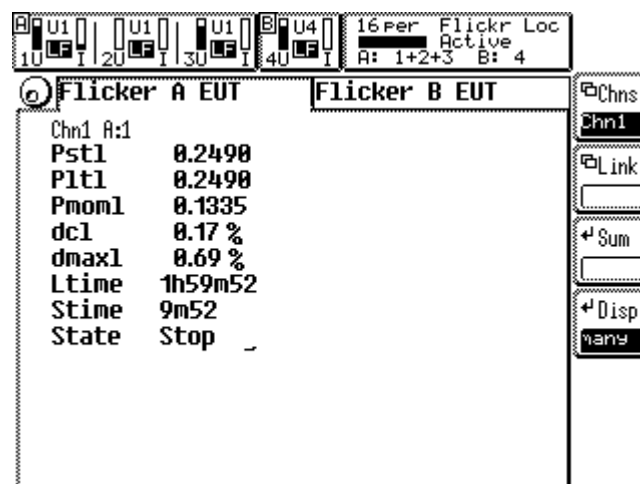
Figure 37: Evaluation of flicker measurement

d_{max} is measured over the long term time.

d_c is the relative voltage change between two 'constant' voltages. Therefore it can have different values:

d_c=------- means that there was no constant voltage.
d_c=0.000% means that there was exactly one constant voltage.
Any other value is the biggest difference between two constant voltages.

P_{lt} is calculated at the end of the long term measuring. Until then it is displayed as '-------'.

7.4.6   Graphical display

 Here just the plot function is available. The handling is the same like described in 5.4.6, 'Graphical display'

But there are some things to know concerning the displayed values:

In the other modes, all values are measured in the same time interval. In the flicker mode there are two main time intervals: 10ms and 320ms. Most values are updated every 320ms, but some come every 10ms: They are the momentary flicker level (ID is Pml) and the half wave trms value (ID is Uhwl). As said above, this values come every 10ms. The Pmoml and Utrms values are the average values of Pml and Uhwl. So you can see Pmoml and Pml in one graph as function 'A' and 'B'. Because Pmoml has a slower time base, it is plotted with 32 same values.

7.4.7   Custom menu

With *Custom* you see the custom menu. Here you can setup your own menus, calculate formulas and execute programs. See 4.4.3, 'Custom menu' and 4.4.4, 'Script/Formula editor'.

7.5   Storage of values

First you have to change to the menu you want to print out or to store and press *Print/Log* (exact handling see 10, 'Logging of values to drives, printer and interfaces'). All the values you see in this menu are printed out.

7.6   Tests according EN61000-3-3

For tests according to this standard you first have to change the *Range* to 'Manual' mode. This is necessary because the test has to be done without any gaps.

Switch on the <u>voltage</u> of the EUT. Start the flicker process with *Start*. After a delay of 8s the real measuring is started. Now you can switch on the EUT to get the different values. If you want to stop the measuring before the end of the long term time just press *Stop*.

Annex B.2

Usually the values d_c and d_{max} run for the whole observation period (Plt-time). To simplify tests according annex B.2 of EN61000-3-3:2008, you can choose, that these values are reset after each short term observation periode. To do this, please select the B2 item in measuring menu, softkey **EN**.

8   100 Harmonics measuring mode (option L50-O8)

In the 100 Harmonics measuring mode the LMG500 works as a high precision harmonic analyser. The difference to the CE mode is, that 100 harmonics, the phase angles and the power harmonics are measured. The frequency range is much wider. There is no check against any limits.

8.1   Measuring configuration (Measuring)

When you came to this menu by pressing *Measure* you first have to choose **MODE** and then **HARM** to enter this mode. The well known setting menu with the three tabs („Globals", „Group A" and „Group B") opens:

Globals   Here you can set up the wiring in which is measured.

Group A/B   For the settings in this menu refer 5.1.2 Group A/B/C/D tab. Additional settings are possible:

> **FDiv**   This defines a frequency divider for the basic wave. With a value of 1 the measured frequency is identical to the basic wave. With a value of 2 the fundamental has only the half frequency of the measured frequency (e.g. A 50Hz signal with **FDiv** = 4 is analysed on a 12.5Hz base. So you get 3 interharmonic between the 50Hz Harmonics)
> Only with **FDIV** set to 1 you get the THD values of the signals

> **Filt**   Defines the active filter:
> Auto: A sufficient anti aliasing filter will be selected.
> other values: The chosen filter will be activated. CAUTION: with a wrong filter setting you might get aliasing!

Pressing the rotary knob you will get to the main menu.
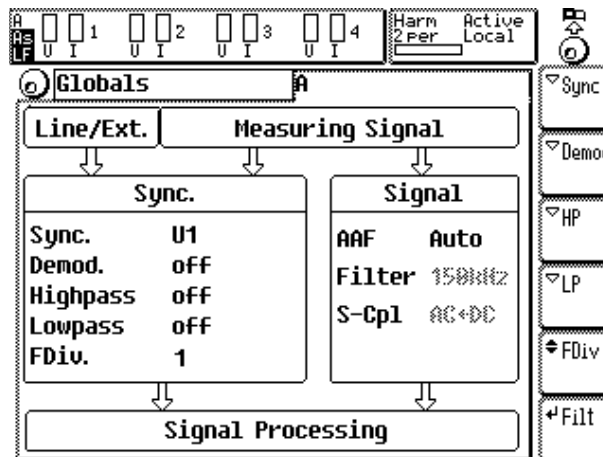
Figure 38: Measuring menu in Harm100 mode

8.2   Measuring ranges (Range)

The settings are the same like in 5.2, 'Measuring ranges (Range)5.2', but in this mode you have no autorange function.

8.3   Definition of measuring values

The following basic definitions are used:

n The harmonic order.

T   The time of an integer number of the periods of the synchronisation signal. The integer factor depends on the frequency of the basic wave:

Basic wave range / Hz	Number of measured periods	Sample frequency divider	Automatically selected filter
640-1280	32	1	HF-Rejection
320-640	16	1	HF-Rejection
160-320	8	1	HF-Rejection
80-160	4	1	HF-Rejection
40-80	4	2	18kHz
20-40	4	4	6kHz
10-20	4	8	2.8kHz
5-10	4	16	1.4kHz
2.5-5	4	32	700Hz
1.25-2.5	4	64	350Hz
0.625-1.25	4	128	175Hz
0.3125-0.625	4	256	87.5Hz
0.15625-0.3125	2	256	87.5Hz
0.078125-0.15625	1	256	87.5Hz

The 'sample frequency divider' defines, how the sampling frequency of about 100kHz is divided for this measuring.

Voltage and current

true root mean square:
$$Utrms = \sqrt{\frac{1}{T}\int_{t=0}^{T} u(t)^2\,dt} \quad Itrms = \sqrt{\frac{1}{T}\int_{t=0}^{T} i(t)^2\,dt}$$

total harmonic distortion:
$$Uthd = \sqrt{\sum_{n=2}^{99}\left(\frac{U_n}{U_1}\right)^2} \qquad Ithd = \sqrt{\sum_{n=2}^{99}\left(\frac{I_n}{I_1}\right)^2}$$

Only with **FDIV** set to 1 you get the THD values of the signals.

The harmonic components are calculated to meet the following:

$$u(t) = \sum_{n=0}^{99} \sqrt{2}U_n \sin(n\omega t + \varphi_{un}) \qquad i(t) = \sum_{n=0}^{99} \sqrt{2}I_n \sin(n\omega t + \varphi_{in})$$

The harmonic values 'I(n)', 'U(n)' and 'Phase(n)' are calculated by using a DFT algorithm. With this values also the values of 'P(n)', 'S(n)' and 'Q(n)' are calculated. This 'Q(n)' is only the reactive power, caused by a phase shift of a voltage and current component with the same frequency. Therefore it is in this mode possible to calculate also the reactive power which is caused by voltage and current components with different frequencies. This value is called D:

$$D = \sqrt{S^2 - P^2 - Qshift^2} \text{ with } Qshift = \sum_{n=0}^{99} Q(n), \text{ P and S see below.}$$

Power

active power:
$$P = \frac{1}{T} \int_{t=0}^{T} u(t)i(t)dt$$

reactive power:
$$Q = \sqrt{S^2 - P^2}$$

apparent power:
$$S = Utrms * Itrms$$

power factor:
$$\lambda = \frac{|P|}{S}$$

Impedances

apparent impedance:
$$Z = \frac{Utrms}{Itrms}$$

active impedance:
$$Rser = \frac{P}{Itrms^2}$$

reactive impedance:
$$Xser = \frac{Q}{Itrms^2}$$

8.4   Display of values

For the display of the values you can choose several menues.

Harmonic values (amplitude, phase, frequency, ...) can just be displayed constant in steady state condition due to the nature of FFT. While signal changes (frequency and/or amplitude) you will get unexpected signals (they are not wrong, but due to the special calculation method 'FFT' they might look different than you expect).

The influence of the HF-Rejection filter is compensated for the amplitudes of the harmonics. The values for U, I and P are <u>not</u> recalculated from the harmonics, but are calculated from the sampling values to get for example interharmonics and components with higher frequencies which are not captured by the harmonics. So it is not possible to compensate the influence of the filters for this values! For the same reason this values can also be much bigger than the values which can be derived from the harmonics (depending on the signal).

8.4.1   Default

With *Default* you see the most important values of the instrument. The available settings are described in „5.4 Display of values".

8.4.2   Voltage

With *Voltage* you see the harmonic values of the measured voltage and in the second row the phase of the harmonic component.

With the softkey **Chns** you can choose the channel.

With the softkey **Href** you can select the reference signal (voltage, current or none). The fundamental of this signal is always set to 0°. When selected 'none', the time window is the reference.

With the softkey **Link** the harmonics of the linked values will be shown.

Using the rotary knob you can scroll through the list to see all harmonics.

8.4.3   Current

With *Current* you see the harmonic values of the measured current and in the second row the phase of the harmonic component.

With the softkey **Chns** you can choose the channel.

With the softkey **Href** you can select the reference signal (voltage, current or none). The fundamental of this signal is always set to 0°. When selected 'none', the time window is the reference.

With the softkey **Link** the harmonics of the linked values will be shown.

Using the rotary knob you can scroll through the list to see all harmonics.

8.4.4   Power

With *Power* you see the harmonic values of the measured powers. The synchronisation frequency is shown in the first row, displaying all channels.

With the softkey **Chns** you can choose the channel.

With **List** you can choose several lists with the different combinations of the different powers.

Using the rotary knob you can scroll through the list to see all harmonics.

8.4.5   Graphical display

Here just the plot function, the spectrum and the vector diagram is available. The handling is the same like described in 5.4.6, 'Graphical display' and 6.4.6.1, 'Spectrum A/B'.
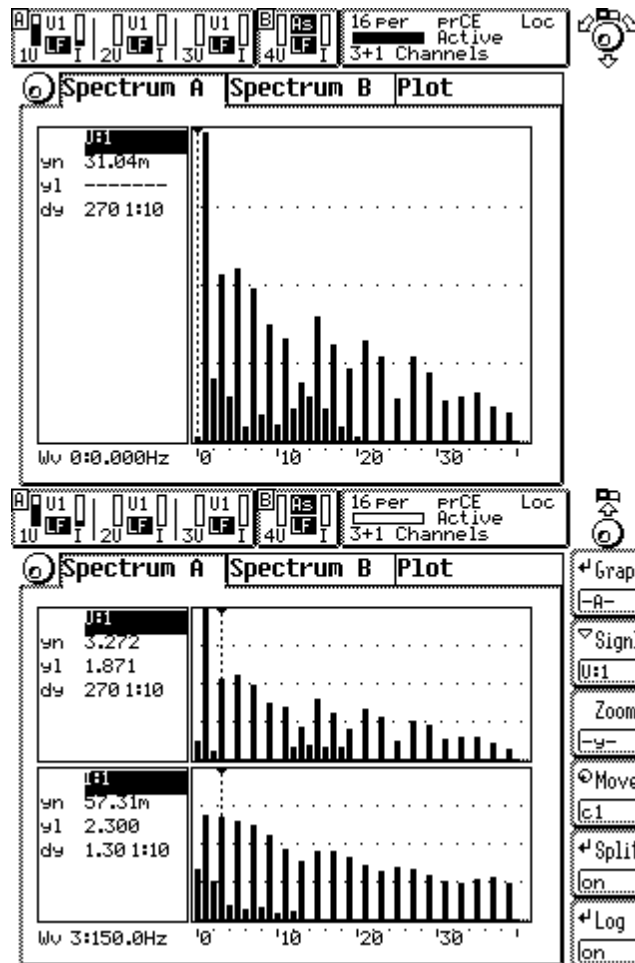
Figure 39: Graphical display of harmonics

8.4.6   Custom menu

With *Custom* you see the custom menu. Here you can setup your own menus, calculate formulas and execute programs. See 4.4.3, 'Custom menu' and 4.4.4, 'Script/Formula editor'.

8.5   Storage of values

First you have to change to the menu you want to print out or to store and press *Print/Log* (exact handling see 10, 'Logging of values to drives, printer and interfaces'). All the values you see in this menu are printed out. In the menues with harmonic values you get all harmonics (not only the ones you see!).

9   Interfaces (IEEE option L50-O1)

With exception of the IEEE interface all interfaces could also be used for data logging (see 10, 'Logging of values to drives, printer and interfaces'). To remote control the LMG please reserve first the wished interface for this job (see 4.4.2.1, 'Interfaces for remote control').

This chapter includes all commands and a short general syntax description. A much more detailed syntax description with a lot of examples and further programming explanations can be found in our ***Programmer's Guide*** on the CD which is included in the printed version of this manual. If this is missing or you have just a PDF version of this manual you can request the ***Programmer's Guide*** by email from 'sales@zes.com'.

9.1   Short syntax description

There are two implemented languages: SCPI and SHORT. When switching on the instrument SCPI is selected. To change to SHORT you have to send:

SYST:LANG SHORT

For further differences between SCPI and SHORT command set see also 9.2.4, ':FETCh and :READ commands'

The general syntax for both command sets is identical. The most important syntax rules are:

- A message to the instrument has to be terminated with an EOS character.
- brackets [..] are showing optional part of commands. There is no need to send them to the device, but you can do it, if you need this function. The brackets are just informative and should not be sent.
- The number of the measuring channel (further on called 'suffix') follows directly (without any space) after the identifier. If you don't specify one, '1' is assumed.
- If you request a value you have to add a '?' directly behind the suffix (or the identifier, if no suffix is specified), without any space.
- All parameters following the commands have to be separated from the command with at least one space character.
- The group number is usually an optional parameter in the format [,<NRi>]. If you don't specify it, group A (=0) is assumed as default value.
- '/qonly/' indicates, that this is a value which can only be demanded, but not set. Do not send the '/qonly/' string to the device, it is just written in this manual to explain the command. For example you can't send a measuring value.

- '/nquery/' indicates that this value can only be set, and not demanded. Do not send the '/nquery/' string to the device, it is just written in this manual to explain the command. For example you can't request a trigger command.

- All commands without '/qonly/' and '/nquery/' can be read and set.

- <NRf> are float numbers

- <NRi> are integer numbers

- <list> stands for <(<NRf>:<NRf>)>. With this construct you can request several values which are stored in an array, for example harmonic values. To get the 3rd to 11th harmonic of the voltage of the second measuring channel you have to write in SHORT command set: HUAM2? (3:11)

For the complete syntax rules please take a look at the ***Programmer's Guide***!

Examples showing the syntax

Equivalent SCPI commands for reading the TRMS value of the 1st measuring channel:
:FETCh:CURRent:TRMS?
:FETC:CURR:TRMS?
:FETC:CURR:TRMS1?
As SHORT command it would be
ITRMS? or ITRMS1?
Please note that there is <u>no</u> space before the '1' and <u>no</u> space before the '?'!

Command for reading the harmonic voltages from the 2nd to the 4th harmonic (3 values):
:FETC:HARM:VOLT:AMPL? (2:4)
Please notice that there is <u>at least one</u> space between the question mark and the parameters!

Command for setting the 250V range:
:SENS:VOLT:RANG 250
Please notice that there is <u>at least one</u> space before the parameter 250!

Command for setting the 250V range in the 3rd channel:
:SENS:VOLT:RANG3 250
Please notice that there is <u>no</u> space before the suffix and <u>at least one</u> space before the 250!

Commands for setting and reading a filter in group B (short language):
FILT 5,1
FILT? 1
For group A you can write:
FILT 5,0 or FILT 5
FILT? 0   or FILT?

For more examples please take a look at the ***Programmer's Guide***!

9.2   Commands

Here you find all commands the instrument can handle. The commands are ordered like in the SCPI tree structure. The description is always the same:

SCPI: *The SCPI syntax of the command*
SHORT: *The SHORT syntax of the command*

ID:	*The ID for script editor and similar*	Mode:	*The valid measuring modes*
Type:	*The data type*	Suffix:	*The valid suffix range*
Value:	*The value range*	List:	*The valid list range*
Unit:	*The physical unit*	Group:	*The valid group range*

An 'n/a' means 'not applicable'. If you for example see an 'n/a' in the 'Value:' field, then this command has no value at all. Or it is a float number with all valid codes according IEEE754.

The titles of the useable commands are in a box. There you find from left to right: SCPI command, SHORT command and the ID if existing.

Please see also 9.1, 'Short syntax description'.

For all this commands there is a separated index. See chapter 16, 'Interface command index'.

9.2.1   IEEE488.2 common commands

9.2.1.1   *CLS   *CLS

SCPI: *CLS/nquery/
SHORT: *CLS/nquery/

ID:	n/a	Mode:	all
Type:	n/a	Suffix:	n/a
Value:	n/a	List:	n/a
Unit:	n/a	Group:	n/a

Clears the event registers of all status data structures in a device and the error/event queue.

9.2.1.2   *ESE   *ESE

SCPI: *ESE <NRi>
SHORT: *ESE <NRi>

ID:	n/a	Mode:	n/a
Type:	long int	Suffix:	n/a
Value:	0...255	List:	n/a
Unit:	n/a	Group:	n/a

Used to set up or read out the Event Status Enable Register.

9.2.1.3 *ESR?   *ESR?

SCPI: *ESR? /qonly/
SHORT: *ESR? /qonly/

ID:	n/a	Mode:	all
Type:	long int	Suffix:	n/a
Value:	0...255	List:	n/a
Unit:	n/a	Group:	n/a

Reads out and clears the Event Status Register.

9.2.1.4 *IDN?   *IDN?

SCPI: *IDN? /qonly/
SHORT: *IDN? /qonly/

ID:	n/a	Mode:	all
Type:	n/a	Suffix:	n/a
Value:	n/a	List:	n/a
Unit:	n/a	Group:	n/a

Reads out the identification of the device. There are 4 fields separated by commas:

Field 1 Manufacturer

Field 2 Model

Field 3 Serial number

Field 4 Firmware level

9.2.1.5 *IST?   *IST?

SCPI: *IST? /qonly/
SHORT: *IST? /qonly/

ID:	n/a	Mode:	all
Type:	long int	Suffix:	n/a
Value:	0, 1	List:	n/a
Unit:	n/a	Group:	n/a

Individual Status Query. This returns the status of the 'ist' local message in the device.

9.2.1.6 *OPC   *OPC

SCPI: *OPC/nquery/
SHORT: *OPC/nquery/

ID:	n/a	Mode:	all
Type:	n/a	Suffix:	n/a
Value:	n/a	List:	n/a
Unit:	n/a	Group:	n/a

Causes the device to set the operation complete bit in the Standard Event Status Register,

when all pending selected device operations have been finished.

9.2.1.7   *OPC?   *OPC?

SCPI: *OPC? /qonly/
SHORT: *OPC?/qonly/

ID:	n/a		Mode:	all
Type:	char		Suffix:	n/a
Value:	'1'		List:	n/a
Unit:	n/a		Group:	n/a

Causes the device to place a „1" (=31h) in the output queue, when all pending selected device actions have been finished (=operation complete). This is independent from the output format!

9.2.1.8   *PRE   *PRE

SCPI: *PRE <NRi>
SHORT: *PRE <NRi>

ID:	n/a		Mode:	all
Type:	long int		Suffix:	n/a
Value:	0...65535		List:	n/a
Unit:	n/a		Group:	n/a

Used to set up or read out the Parallel Poll Enable Register

9.2.1.9   *RST   *RST

SCPI: *RST/nquery/
SHORT: *RST/nquery/

ID:	n/a		Mode:	all
Type:	n/a		Suffix:	n/a
Value:	n/a		List:	n/a
Unit:	n/a		Group:	n/a

This performs a device reset. A lot of internal settings (like measuring mode, ranges, ...) are set to their default values. In this chapters the default value is indicated by '[*RST Default value]'. All time dependent measurements are stopped (energy, flicker, harmonics).

The interface and it's parameters are not reset! If you want to reset it, please use a BREAK with RS232 interface or a 'device clear' with IEEE interface.

Hint

The execution of this command can take up to several seconds. The LMG works internally with a watchdog protection. To prevent that the watchdog becomes active, the '*RST' command should be send as the only command in a message. Just the '*OPC?' can be added to get a feedback, if the command has finished ('*RST;*OPC?'). In this case wait until the '1' returns before sending the next commands!

9.2.1.10 *SRE   *SRE

SCPI: *SRE <NRi>
SHORT: *SRE <NRi>

ID:	n/a	Mode:	all
Type:	long int	Suffix:	n/a
Value:	0...255	List:	n/a
Unit:	n/a	Group:	n/a

Sets or queries the Service Request Enable Register

9.2.1.11 *STB?   *STB?

SCPI: *STB? /qonly/
SHORT: *STB? /qonly/

ID:	n/a	Mode:	all
Type:	long int	Suffix:	n/a
Value:	0...255	List:	n/a
Unit:	n/a	Group:	n/a

Queries the Status Byte Register.

9.2.1.12 *TRG   *TRG

SCPI: *TRG/nquery/
SHORT: *TRG/nquery/

ID:	n/a	Mode:	all
Type:	n/a	Suffix:	n/a
Value:	n/a	List:	n/a
Unit:	n/a	Group:	n/a

Triggers the same action that happens when programmer sends DT1 via IEEE488.1 interface or '&TRG<cr><lf>' via RS232 interface. Actually nothing is performed.

9.2.1.13 *TST?   *TST?

SCPI: *TST? /qonly/ <NRi>
SHORT: *TST?/qonly/ <NRi>

ID:	n/a	Mode:	all
Type:	long int	Suffix:	n/a
Value:	n/a	List:	n/a
Unit:	n/a	Group:	n/a

Initiates a self test. Returns a value depending on <NRi>. This command should only be used by ZES and not by customers.

9.2.1.14 *WAI   *WAI

SCPI: *WAI/nquery/
SHORT: *WAI/nquery/

ID:	n/a	Mode:	all
Type:	n/a	Suffix:	n/a
Value:	n/a	List:	n/a
Unit:	n/a	Group:	n/a

<u>Waits</u> until all pending selected device operations have been finished. Note: The instrument
handles commands in a queue, so when executing the *WAI all previous commands have been
executed. Thus the instrument is doing nothing when receiving the *WAI command. It has
been implemented to follow the standard IEEE488.2.

9.2.2   :CALCulate commands

Here you find commands which influence the script editor (formulas) or limits.

:CALCulate	→	**:ENVironment**
:DISPlay		:FORMula
:FETCh		:LIMit
:FORMat		
:INITiate		
:INPut		
:INSTrument		
:MEMory		
:READ		
:SENSe		
:SOURce		
:STATus		
:SYSTem		
:TRIGger		

9.2.2.1.1 ENVironment   ENV   Env

SCPI: :CALCulate:ENVironment <NRf>[,<NRi>]
SHORT: ENV <NRf>[,<NRi>]

ID:	Env	Mode:	all
Type:	float	Suffix:	n/a
Value:	n/a	List:	n/a
Unit:	n/a	Group:	optional [,<NRi>]: 0=Env0, ... ,7=Env7

Sets or queries an <u>environment</u> variable.

9.2.2.2   :FORMula

:CALCulate	→	:ENVironment		
:DISPlay		**:FORMula**	→	[:DEFine]
:FETCh		:LIMit		
:FORMat				
:INITiate				
:INPut				
:INSTrument				
:MEMory				

:READ
:SENSe
:SOURce
:STATus
:SYSTem
:TRIGger

9.2.2.2.1 [:DEFine]   FORM

SCPI: :CALCulate:FORMula[:DEFine] <string program data>
SHORT: FORM<string program data>

ID:	n/a	Mode:	all
Type:	string	Suffix:	n/a
Value:	n/a	List:	n/a
Unit:	n/a	Group:	n/a

Sets or reads the script of the script editor. There is no *RST default value.

For example 'FORM „a=1;"<lf>' sets the internal variable a to 1.

9.2.2.3   :LIMit:

:CALCulate	→	:ENVironment	
:DISPlay		:FORMula	
:FETCh		:LIMit	→	:CLASs
:FORMat			:DMAX
:INITiate			:FCURrent
:INPut			:PFACtor
:INSTrument			:POWer
:MEMory			:SYSTem
:READ			:VERSion
:SENSe			
:SOURce			
:STATus			
:SYSTem			
:TRIGger			

9.2.2.3.1 :CLASs   EVAL

SCPI: :CALCulate:LIMit:CLASs <NRi>
SHORT: EVAL <NRi>

ID:	n/a	Mode:	CE
Type:	long int	Suffix:	n/a
Value:	0...6, 10...12	List:	n/a
Unit:	n/a	Group:	n/a

Sets the evaluation of the harmonics in the CE-Harm mode:

0: Class A (EN61000-3-2) [*RST default value]

1: Class B (EN61000-3-2)

2: Class C-2 (EN61000-3-2)

3: Class D (EN61000-3-2)

4: Class C-3 (EN61000-3-2)

5: Class C-W (EN61000-3-2)

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6:    Class C-1 (EN61000-3-2)

10: Table 2 (EN61000-3-12)

11: Table 3 (EN61000-3-12)

12: Table 4 (EN61000-3-12)

9.2.2.3.2 :DMAX   FLDL

SCPI: :CALCulate:LIMit:DMAX <NRf>
SHORT: FLDL <NRf>

ID:	n/a	Mode:	Flicker
Type:	float	Suffix:	n/a
Value:	in %	List:	n/a
Unit:	n/a	Group:	n/a

Sets the allowed limit for d_{max} for the device under test according to the standard in the flicker mode.

9.2.2.3.3 :FCURrent   ISO

SCPI: :CALCulate:LIMit:FCURrent <NRf>
SHORT: ISO <NRf>

ID:	n/a	Mode:	CE-Harm
Type:	float	Suffix:	1...8
Value:	n/a, [*RST default value] = 1.0	List:	n/a
Unit:	A	Group:	n/a

Sets or reads the fundamental current for the EN61000-3-2:2006 limit calculation in the CE mode.

9.2.2.3.4 :FVERsion   FNRM

SCPI: :CALCulate:LIMit:FVERsion <NRi>
SHORT: FNRM <NRi>

ID:	n/a	Mode:	Flicker
Type:	long int	Suffix:	n/a
Value:	0...3	List:	n/a
Unit:	n/a	Group:	n/a

Sets or reads the edition of the flicker standard:

0: EN61000-3-3:1995 [*RST default value]

1: EN61000-3-3:2008

2: EN61000-3-3:2008 Annex B.2

3: EN61000-3-11:2000

9.2.2.3.5 :PFACtor   PFSO

SCPI: :CALCulate:LIMit:PFACtor <NRf>
SHORT: PFSO <NRf>

ID:	n/a	Mode:	CE-Harm
Type:	float	Suffix:	1...8
Value:	n/a, [*RST default value] = 1.0	List:	n/a
Unit:	n/a	Group:	n/a

Sets or reads the power factor for the EN61000-3-2:2006 limit calculation in the CE mode.

9.2.2.3.6 :POWer   PSO

SCPI: :CALCulate:LIMit:POWer <NRf>
SHORT: PSO <NRf>

ID:	n/a	Mode:	CE-Harm
Type:	float	Suffix:	1...8
Value:	n/a, [*RST default value] = 1.0	List:	n/a
Unit:	W	Group:	n/a

Sets or reads the power for the EN61000-3-2:2006 limit calculation in the CE mode.

9.2.2.3.7 :RSCE   RSCE

SCPI: :CALCulate:LIMit:RSCE <NRf>
SHORT: RSCE <NRf>

ID:	n/a	Mode:	CE
Type:	float	Suffix:	n/a
Value:	33...10000, [*RST default value] = 33	List:	n/a
Unit:	n/a	Group:	n/a

Sets or reads the R_{sce} for the EN61000-3-12:2005 limit calculation in the CE-Harm mode.

9.2.2.3.8 :SYSTem   SYSD

SCPI: :CALCulate:LIMit:SYSTem <NRi>
SHORT: SYSD <NRi>

ID:	n/a	Mode:	CE-Harm
Type:	long int	Suffix:	n/a
Value:	0...3	List:	n/a
Unit:	n/a	Group:	n/a

Sets or reads the supply system for the CE-harmonics and flicker:

0: 230V/50Hz [*RST default value]

1: 230V/60Hz

2: 120V/50Hz

3: 120V/60Hz

4: 220V/50Hz

5: 220V/60Hz

6: 240V/50Hz

7: 240V/60Hz

9.2.2.3.9 :VERSion	EDIT

SCPI: :CALCulate:LIMit:VERSion <NRi>
SHORT: EDIT <NRi>

ID:	n/a	Mode:	CE
Type:	long int	Suffix:	n/a
Value:	0...4	List:	n/a
Unit:	n/a	Group:	n/a

Sets or reads the edition of the harmonic standard:

0: EN61000-3-2:1995 and EN61000-4-7:1993 [*RST default value]

1: EN61000-3-2:1995 and EN61000-4-7:2008

2: EN61000-3-2:2006 and EN61000-4-7:1993

3: EN61000-3-2:2006 and EN61000-4-7:2008

4: EN61000-3-12:2005 and EN61000-4-7:2008

9.2.2.3.10 :ZREF	ZREF

SCPI: :CALCulate:LIMit:ZREF <NRf>
SHORT: ZREF <NRf>

ID:	n/a	Mode:	Flicker
Type:	int	Suffix:	n/a
Value:	0, 1	List:	n/a
Unit:	n/a	Group:	n/a

Sets or reads the Z_{ref} for the EN61000-3-11:2000 limit calculation.

0: $(0.24+j0.15)\Omega$ [*RST default value]

1: $(0.40+j0.25)\Omega$

9.2.2.3.11 :ZTESt	ZTST

SCPI: :CALCulate:LIMit:ZTESt <NRf>
SHORT: ZTST <NRf>

ID:	n/a	Mode:	Flicker
Type:	float	Suffix:	n/a
Value:	0.05...1, [*RST default value] = 0.283	List:	n/a
Unit:	Ω	Group:	n/a

Sets or reads the Z_{test} for the EN61000-3-11:2000 limit calculation.

9.2.3   :DISPlay commands

:CALCulate
:DISPlay →   :CONTrast
:FETCh   :RESet
:FORMat
:INITiate
:INPut
:INSTrument
:MEMory
:READ
:SENSe
:SOURce
:STATus
:SYSTem
:TRIGger

9.2.3.1 :CONTrast	DISC

SCPI: :DISPlay:CONTrast <NRf>
SHORT: DISC <NRf>

ID:	n/a	Mode:	all
Type:	float	Suffix:	n/a
Value:	0...100 in %, [*RST default value] = 65	List:	n/a
Unit:	n/a	Group:	n/a

Sets or reads the <u>contrast</u> of the display.

9.2.3.2 :RESet	DISR

SCPI: :DISPlay:RESet
SHORT: DISR

ID:	n/a	Mode:	all
Type:	n/a	Suffix:	n/a
Value:	n/a	List:	n/a
Unit:	n/a	Group:	n/a

<u>Resets</u> the <u>display</u> to the default values. (e.g. small fonts...).

9.2.4   :FETCh and :READ commands

These both commands are used to get measuring values from the instrument. With :FETCh you get the values which are actually in the copied buffer for the interface. With :READ there are internally two commands executed: :INITiate:IMMediate and :FETCh (see also 9.2.6.3, ':IMMediate   INIM' for further details).

If you request the same value twice with two :READ commands (e.g. :READ:DC?;:READ:DC?) you get two different values of two different cycles. This can cause problems for example with following request:
:READ:VOLTAGE:DC?;:READ:CURRENT:DC?
The two values you get for Udc and Idc are measured in different cycles!

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If you request the same value twice with two :FETCh commands you get the same values of the same cycle. For example :FETC:DC?;:FETC:DC? would not make any sense, because you will get the same value.

A usual request looks like this:
:READ:VOLTAGE:DC?;:FETC:CURRENT:DC?
In this case the instrument finishes the actual cycle, copies the values for the interface and returns the two requested values. This two values are measured in the same cycle!

The SHORT commands perform equal to the :FETCh commands (which means there is no INIM performed!). So if you want to perform the last example with SHORT commands you have to enter
INIM;UDC?;IDC?

9.2.4.1 [:SCALar]

9.2.4.1.1 :CURRent

:CALCulate			
:DISPlay			
:FETCh →	**[:SCALar]** →	**:CURRent** →	:AC
:FORMat		:CYCLe	:CFACtor
:INITiate		:DINPut	:DC
:INPut		:ENERgy	:FFACtor
:INSTrument		:FLICker	:INRush
:MEMory		:FREQuency	:MAXPk
:READ →		:HARMonics	:MINPk
:SENSe		:POWer	:PPEak
:SOURce		:RESistance	:RECTify
:STATus		:SSYStem	:RUSed
:SYSTem		:VARiable	[:TRMS]
:TRIGger		[:VOLTage]	

9.2.4.1.1.1 :AC?   IAC?   Iac

SCPI: :FETCh[:SCALar]:CURRent:AC? /qonly/ | :READ[:SCALar]:CURRent:AC? /qonly/
SHORT: IAC? /qonly/

ID:	Iac		Mode:	Normal, CE-Harm
Type:	float		Suffix:	1...14
Value:	n/a		List:	n/a
Unit:	A		Group:	n/a

Reads the AC value of the current.

9.2.4.1.1.2 :CFACtor?   ICF?   Icf

SCPI: :FETCh[:SCALar]:CURRent:CFACtor? /qonly/ | :READ[:SCALar]:CURRent:CFACtor? /qonly/
SHORT: ICF?/qonly/

ID:	Icf		Mode:	Normal

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Type:	float	Suffix:	1...14
Value:	n/a	List:	n/a
Unit:	n/a	Group:	n/a

Reads the crest factor of the current.

9.2.4.1.1.3   :DC?   IDC?   Idc

SCPI: :FETCh[:SCALar]:CURRent:DC? /qonly/ | :READ[:SCALar]:CURRent:DC? /qonly/
SHORT: IDC? /qonly/

ID:	Idc	Mode:	Normal, CE-Harm
Type:	float	Suffix:	1...14
Value:	n/a	List:	n/a
Unit:	A	Group:	n/a

Reads the DC value of the current.

9.2.4.1.1.4   :FFACtor?   IFF?   Iff

SCPI: :FETCh[:SCALar]:CURRent:FFACtor? /qonly/ | :READ[:SCALar]:CURRent:FFACtor? /qonly/
SHORT: IFF? /qonly/

ID:	Iff	Mode:	Normal
Type:	float	Suffix:	1...14
Value:	n/a	List:	n/a
Unit:	n/a	Group:	n/a

Reads the form factor of the current.

9.2.4.1.1.5   :FSCale?   FSI?

SCPI: :FETCh[:SCALar]:CURRent:FSCale? /qonly/ | :READ[:SCALar]:CURRent:FSCale? /qonly/
SHORT: FSI? /qonly/

ID:	n/a	Mode:	All
Type:	float	Suffix:	1...14
Value:	n/a	List:	n/a
Unit:	A	Group:	n/a

Reads the full scale value of the current.

9.2.4.1.1.6   :INRush?   IINR?   Iinr

SCPI: :FETCh[:SCALar]:CURRent:INRush? /qonly/ | :READ[:SCALar]:CURRent:INRush? /qonly/
SHORT: IINR? /qonly/

ID:	Iinr	Mode:	Normal
Type:	float	Suffix:	1...14
Value:	n/a	List:	n/a
Unit:	A	Group:	n/a

Reads the value of the inrush current. For reset see 9.2.14.2

9.2.4.1.1.7   :MAXPk?   IMAX?   Ipkp

SCPI: :FETCh[:SCALar]:CURRent:MAXPk? /qonly/ | :READ[:SCALar]:CURRent:MAXPk? /qonly/
SHORT: IMAX? /qonly/

ID:	Ipkp	Mode:	Normal
Type:	float	Suffix:	1...14
Value:	n/a	List:	n/a
Unit:	A	Group:	n/a

Reads the biggest sample value of the current.

9.2.4.1.1.8   :MINPk?   IMIN?   Ipkn

SCPI: :FETCh[:SCALar]:CURRent:MINPk? /qonly/ | :READ[:SCALar]:CURRent:MINPk? /qonly/
SHORT: IMIN? /qonly/

ID:	Ipkn	Mode:	Normal
Type:	float	Suffix:	1...14
Value:	n/a	List:	n/a
Unit:	A	Group:	n/a

Reads the smallest sample value of the current.

9.2.4.1.1.9   :PHASe?   IPHI?   Iphi

SCPI: :FETCh[:SCALar]:CURRent:PHASe? /qonly/ | :READ[:SCALar]:CURRent:MINPk? /qonly/
SHORT: IPHI? /qonly/

ID:	n/a	Mode:	Normal
Type:	float	Suffix:	1...8
Value:	n/a	List:	n/a
Unit:	°	Group:	n/a

Reads the phase angle of the current like displayed in the Fresnel diagram.

9.2.4.1.1.10 :PPEak?   IPP?   Ipp

SCPI: :FETCh[:SCALar]:CURRent:PPEak? /qonly/ | :READ[:SCALar]:CURRent:PPEak? /qonly/
SHORT: IPP? /qonly/

ID:	Ipp	Mode:	Normal
Type:	float	Suffix:	1...14
Value:	n/a	List:	n/a
Unit:	A	Group:	n/a

Reads the peak peak value of the current.

9.2.4.1.1.11 :RECTify?   IREC?   Irect

SCPI: :FETCh[:SCALar]:CURRent:RECTify? /qonly/ | :READ[:SCALar]:CURRent:RECTify? /qonly/
SHORT: IREC? /qonly/

ID:	Irect	Mode:	Normal
Type:	float	Suffix:	1...14
Value:	n/a	List:	n/a
Unit:	A	Group:	n/a

Reads the <u>rectified</u> value of the <u>current</u>.

9.2.4.1.1.12 :RUSed?   OVRI?   Ovrl

SCPI: :FETCh[:SCALar]:CURRent:RUSed? /qonly/ | :READ[:SCALar]:CURRent:RUSed? /qonly/
SHORT: OVRI? /qonly/

ID:	Ovrl	Mode:	All
Type:	float	Suffix:	1...14
Value:	0...100 in %	List:	n/a
Unit:	n/a	Group:	n/a

Reads the <u>usage</u> of the <u>current range</u>.

9.2.4.1.1.13 [:TRMS?]   ITRMS?   Itrms

SCPI: :FETCh[:SCALar]:CURRent[:TRMS]? /qonly/ | :READ[:SCALar]:CURRent[:TRMS]? /qonly/
SHORT: ITRMS? /qonly/

ID:	Itrms	Mode:	All
Type:	float	Suffix:	1...18
Value:	n/a	List:	n/a
Unit:	A	Group:	n/a

Reads the TRMS value of the current.

9.2.4.1.2 :CYCLe

:CALCulate		
:DISPlay		
:FETCh →	**[:SCALar]** →	:CURRent
:FORMat	**:CYCLe** →	:COUNt
:INITiate	:DINPut	:TIME
:INPut	:ENERgy	
:INSTrument	:FLICker	
:MEMory	:FREQuency	
:READ →	:HARMonics	
:SENSe	:POWer	
:SOURce	:RESistance	
:STATus	:SSYStem	
:SYSTem	:VARiable	
:TRIGger	[:VOLTage]	

9.2.4.1.2.1   :COUNt?   COUNT?   Cnr

SCPI: :FETCh[:SCALar]:CYCLe:COUNt? /qonly/ | :READ[:SCALar]:CYCLe:COUNt? /qonly/
SHORT: COUNT? /qonly/

ID:	Cnr	Mode:	All
Type:	float	Suffix:	n/a

Value:	0...65535	List:	n/a
Unit:	n/a	Group:	n/a

Reads an individual number of the <u>measuring cycle counter</u> which is copied into memory. This value runs up to 65535 and starts then again at 0.

9.2.4.1.2.2   :SNUMber?   SCTC?

SCPI: :FETCh[:SCALar]:CYCLe:SNUMber? /qonly/ | :READ[:SCALar]:CYCLe:SNUMber? /qonly/
SHORT: SCTC? /qonly/

ID:	n/a	Mode:	All
Type:	long int	Suffix:	n/a
Value:	$0...2^{31}-1$	List:	n/a
Unit:	n/a	Group:	n/a

Reads the <u>number</u> of the <u>last sample</u> value <u>of a cycle</u>. The sample values of the instrument are counted. At the end of each cycle this counter is stored and can be read by this command. The counter runs up to $2^{31}-1$ and starts then again at 0. See also 9.2.10.14.5, ':SCTRigger?
      SCTT?'

9.2.4.1.2.3   :TIME?   CYCR?   Mtime

SCPI: :FETCh[:SCALar]:CYCLe:TIME? /qonly/ | :READ[:SCALar]:CYCLe:TIME? /qonly/
SHORT: CYCR? /qonly/

ID:	Mtime	Mode:	Normal, CE-Harm, Flicker, HARM100
Type:	float	Suffix:	1...14
Value:	n/a	List:	n/a
Unit:	s	Group:	n/a

Reads the <u>real measuring time</u> of the <u>measuring cycle</u>. This is the time for an integer number of periods of the measured signal (in average this is the cycle time, but it depends on the signal!).

9.2.4.1.3 :DINPut?   DIST?

SCPI: :FETCh[:SCALar]:DINPut? /qonly/ | :READ[:SCALar]:DINPut? /qonly/
SHORT: DIST? /qonly/

ID:	digin(), see 4.4.4.2.7, 'Functions'	Mode:	All
Type:	long int	Suffix:	1,2
Value:	0...64	List:	n/a
Unit:	n/a	Group:	n/a

Reads the status of the <u>digital inputs</u>. The bits in the answer have following meanings:

Bit 0: Input 1

Bit 1: Input 2

Bit 2: Input 3

Bit 3: Input 4

Bit 4:   Input 5

Bit 5:   Input 6

9.2.4.1.4 :ENERgy

:CALCulate		
:DISPlay		
:FETCh →	**[:SCALar]** →	:CURRent
:FORMat		:CYCLe
:INITiate		:DINPut
:INPut	**:ENERgy** →	[:ACTive]
:INSTrument	:FLICker	:APPArent
:MEMory	:FREQuency	:CHARge
:READ →	:HARMonics	:REACtive
:SENSe	:POWer	:TIME
:SOURce	:RESistance	
:STATus	:SSYStem	
:SYSTem	:VARiable	
:TRIGger	[:VOLTage]	

9.2.4.1.4.1   [:ACTive]?   EP?   EP

SCPI: :FETCh[:SCALar]:ENERgy[:ACTive]? /qonly/ | :READ[:SCALar]:ENERgy[:ACTive]? /qonly/
SHORT: EP? /qonly/

ID:	EP	Mode:	Normal
Type:	float	Suffix:	1...14
Value:	n/a	List:	n/a
Unit:	Wh	Group:	n/a

Reads the <u>active energy</u> (integrated active power).

9.2.4.1.4.2   :APParent?   ES?   ES

SCPI: :FETCh[:SCALar]:ENERgy:APPArent? /qonly/ | :READ[:SCALar]:ENERgy:APPArent?
/qonly/
SHORT: ES? /qonly/

ID:	ES	Mode:	Normal
Type:	float	Suffix:	1...14
Value:	n/a	List:	n/a
Unit:	VAh	Group:	n/a

Reads the <u>apparent energy</u> (integrated apparent power).

9.2.4.1.4.3   :CHARge?   EI?   q

SCPI: :FETCh[:SCALar]:ENERgy:CHARge? /qonly/ | :READ[:SCALar]:ENERgy:CHARge? /qonly/
SHORT: EI? /qonly/

ID:	q	Mode:	Normal
Type:	float	Suffix:	1...14
Value:	n/a	List:	n/a
Unit:	Ah	Group:	n/a

Reads the <u>charge</u> (integrated DC current).

9.2.4.1.4.4	**:REACtive?**	**EQ?**	**EQ**

SCPI: :FETCh[:SCALar]:ENERgy:REACtive? /qonly/ |
          :READ[:SCALar]:ENERgy:REACtive? /qonly/
SHORT: EQ? /qonly/

ID:	EQ	Mode:	Normal
Type:	float	Suffix:	1...14
Value:	n/a	List:	n/a
Unit:	varh	Group:	n/a

Reads the <u>reactive energy</u> (integrated reactive power).

9.2.4.1.4.5	**:TIME?**	**INTR?**

SCPI: :FETCh[:SCALar]:ENERgy:TIME? /qonly/ | :READ[:SCALar]:ENERgy:TIME? /qonly/
SHORT: INTR? /qonly/

ID:	LoadOK	Mode:	Normal
Type:	long int	Suffix:	1...14
Value:	$0...2^{31}-1$	List:	n/a
Unit:	ms	Group:	n/a

Reads the <u>time</u> of the <u>running integration</u>.

9.2.4.1.5 :FLICker

9.2.4.1.5.1 [:EUTest]

Selects the equipment under test measuring results. They are measured at the voltage input jacks.

:CALCulate			
:DISPlay			
:FETCh →	**[:SCALar]** →	:CURRent	
:FORMat		:CYCLe	
:INITiate		:DINPut	
:INPut		:ENERgy	
:INSTrument		**:FLICker** →	**[:EUTest]** →	:APMoment
:MEMory		:FREQuency	:LTRemain	:DC
:READ →		:HARMonics	:PHWave	:DELTat
:SENSe		:POWer	:SOURce	:DMAX
:SOURce		:RESistance	:STATe	:HWTRms
:STATus		:SSYStem	:STRemain	:PLT
:SYSTem		:VARiable		:PMOMentary
:TRIGger		[:VOLTage]		:PST
				:RESult

9.2.4.1.5.1.1	**:APMoment?**	**FLMO?**	**Pmoml**

SCPI: :FETCh[:SCALar]:FLICker[:EUTest]:APMoment? /qonly/ |
          :READ[:SCALar]:FLICker[:EUTest]:APMoment? /qonly/

SHORT: FLMO? /qonly/

ID:	Pmoml		Mode:	Flicker
Type:	float		Suffix:	1...8
Value:	n/a		List:	n/a
Unit:	n/a		Group:	n/a

Reads the <u>averaged momentary flicker level</u> of the equipment under test. It is averaged over 16 periods.

9.2.4.1.5.1.2 :DC?   FLDC?   dcl

SCPI: :FETCh[:SCALar]:FLICker[:EUTest]:DC? /qonly/ |
         :READ[:SCALar]:FLICker[:EUTest]:DC? /qonly/
SHORT: FLDC? /qonly/

ID:	dcl		Mode:	Flicker
Type:	float		Suffix:	1...8
Value:	in %		List:	n/a
Unit:	n/a		Group:	n/a

Reads the d_c value of the equipment under test.

9.2.4.1.5.1.3 :DELTat?   FLDT?   dtl

SCPI: :FETCh[:SCALar]:FLICker[:EUTest]:DELTat? /qonly/ <list>|
         :READ[:SCALar]:FLICker[:EUTest]:DELTat? /qonly/ <list>
SHORT: FLDT? /qonly/ <list>

ID:	dtl		Mode:	Flicker
Type:	float		Suffix:	1...8
Value:	in %		List:	0...31
Unit:	n/a		Group:	n/a

Reads the $d(t)$ values of the equipment under test. After each measuring cycle over 16 periods you can get 32 values.

9.2.4.1.5.1.4 :DMAX?   FLDX?   dmaxl

SCPI: :FETCh[:SCALar]:FLICker[:EUTest]:DMAX? /qonly/ |
         :READ[:SCALar]:FLICker[:EUTest]:DMAX? /qonly/
SHORT: FLDX? /qonly/

ID:	dmaxl		Mode:	Flicker
Type:	float		Suffix:	1...8
Value:	in %		List:	n/a
Unit:	n/a		Group:	n/a

Reads the d_{max} value of the equipment under test.

9.2.4.1.5.1.5   :DTMViolation?   FLMV?

SCPI: :FETCh[:SCALar]:FLICker[:EUTest]:DTMViolation? /qonly/ |
         :READ[:SCALar]:FLICker[:EUTest]:DTMViolation? /qonly/
SHORT: FLMV? /qonly/

ID:	n/a	Mode:	Flicker
Type:	long int	Suffix:	1...8
Value:	n/a	List:	n/a
Unit:	n/a	Group:	n/a

Reads the <u>maximum number</u> of <u>half waves</u> for which the d(t) of the equipment under test was <u>bigger than allowed</u> in the standard.

9.2.4.1.5.1.6   :HWTRms?   FLRM?   Uhwl

SCPI: :FETCh[:SCALar]:FLICker[:EUTest]:HWTRms? /qonly/ <list> |
         :READ[:SCALar]:FLICker[:EUTest]:HWTRms? /qonly/ <list>
SHORT: FLRM? /qonly/ <list>

ID:	Uhwl	Mode:	Flicker
Type:	float	Suffix:	1...8
Value:	n/a	List:	0...31
Unit:	V	Group:	n/a

Reads the <u>half wave TRMS</u> values of the equipment under test. After each measuring cycle over 16 periods you can get 32 values.

9.2.4.1.5.1.7   :PLT?   FLLT?   Pltl

SCPI: :FETCh[:SCALar]:FLICker[:EUTest]:PLT? /qonly/ |
         :READ[:SCALar]:FLICker[:EUTest]:PLT? /qonly/
SHORT: FLLT? /qonly/

ID:	Pltl	Mode:	Flicker
Type:	float	Suffix:	1...8
Value:	n/a	List:	n/a
Unit:	n/a	Group:	n/a

Reads the P_{lt} value of the equipment under test.

9.2.4.1.5.1.8   :PMOMentary?   FLMS?   Pml

SCPI: :FETCh[:SCALar]:FLICker[:EUTest]:PMOMentary?/qonly/ <list> |
         :READ[:SCALar]:FLICker[:EUTest]:PMOMentary? /qonly/ <list>
SHORT: FLMS? /qonly/ <list>

ID:	Pml	Mode:	Flicker
Type:	float	Suffix:	1...8
Value:	n/a	List:	0...31
Unit:	n/a	Group:	n/a

Reads the <u>momentary flicker level</u> of the equipment under test. After each measuring cycle over 16 periods you can get 32 values.

9.2.4.1.5.1.9   :PST?   FLST?   Pstl

SCPI: :FETCh[:SCALar]:FLICker[:EUTest]:PST? /qonly/ |
         :READ[:SCALar]:FLICker[:EUTest]:PST? /qonly/
SHORT: FLST? /qonly/

ID:	Pstl	Mode:	Flicker
Type:	float	Suffix:	1...8
Value:	n/a	List:	n/a
Unit:	n/a	Group:	n/a

Reads the P_{st} value of the equipment under test.

9.2.4.1.5.1.10   :RESult?   FLRE?   LoadOK

SCPI: :FETCh[:SCALar]:FLICker[:EUTest]:RESult? /qonly/ |
         :READ[:SCALar]:FLICker[:EUTest]:RESult? /qonly/
SHORT: FLRE? /qonly/

ID:	n/a	Mode:	Flicker
Type:	long int	Suffix:	1...8
Value:	n/a	List:	n/a
Unit:	n/a	Group:	n/a

Reads the <u>result</u> of the <u>flicker measuring</u> at the equipment under test.

Bit 0: Set if the total evaluation of the flicker fails (=if any of the sub evaluation fails). Cleared otherwise.
Bit 1: Set if at least one P_{st} value was >1.0, cleared otherwise.
Bit 2: Set if the P_{lt} value was >0.65 at the END of the measuring interval, cleared otherwise.
Bit 3: Set if d_{max} was bigger than limit, cleared otherwise.
Bit 4: Set if d(t) was >3% for more than allowed time, cleared otherwise.
Bit 5: Set if d_c was > 3%, cleared otherwise.

9.2.4.1.5.2   :LTRemain?   FLTR?

SCPI: :FETCh[:SCALar]:FLICker:LTRemain? /qonly/ |
         :READ[:SCALar]:FLICker:LTRemain? /qonly/
SHORT: FLTR? /qonly/

ID:	n/a	Mode:	Flicker
Type:	long int	Suffix:	n/a
Value:	n/a	List:	n/a
Unit:	s	Group:	n/a

Reads the <u>remaining long time</u> for the <u>flicker measurement</u>.

9.2.4.1.5.3   :PHWave?   FLPH?   Phw

SCPI: :FETCh[:SCALar]:FLICker:PHWave? /qonly/ <list> |
           :READ[:SCALar]:FLICker:PHWave? /qonly/ <list>
SHORT: FLPH? /qonly/ <list>

ID:	Phw		Mode:	Flicker
Type:	float		Suffix:	1...8
Value:	n/a		List:	0...31
Unit:	W		Group:	n/a

Reads the <u>half wave power</u> values. After each measuring cycle over 16 periods you can get 32 values. To get a correct value it is necessary to measure the current with the current channel and not the voltage of a source!

9.2.4.1.5.4   :SOURce

Selects the source's measuring results. They are measured at the current input jacks.

:CALCulate				
:DISPlay				
:FETCh →	**[:SCALar]** →	:CURRent		
:FORMat		:CYCLe		
:INITiate		:DINPut		
:INPut		:ENERgy		
:INSTrument		**:FLICker** →	[:EUTest]	
:MEMory		:FREQuency	:LTRemain	
:READ →		:HARMonics	:PHWave	
:SENSe		:POWer	**:SOURce** →	:APMoment
:SOURce		:RESistance	:STATe	:DC
:STATus		:SSYStem	:STRemain	:DELTat
:SYSTem		:VARiable		:DMAX
:TRIGger		[:VOLTage]		:HWTRms
				:PLT
				:PMOMentary
				:PST
				:RESult

9.2.4.1.5.4.1   :APMoment?   FSMO?   Pmoms

SCPI: :FETCh[:SCALar]:FLICker:SOURce:APMoment? /qonly/ |
           :READ[:SCALar]:FLICker:SOURce:APMoment? /qonly/
SHORT: FSMO? /qonly/

ID:	Pmoms		Mode:	Flicker
Type:	float		Suffix:	1...8
Value:	n/a		List:	n/a
Unit:	n/a		Group:	n/a

Reads the <u>averaged momentary flicker level</u> of the source. It is averaged over 16 periods.

9.2.4.1.5.4.2   :DC?   FSDC?   dcs

SCPI: :FETCh[:SCALar]:FLICker:SOURce:DC? /qonly/ |
           :READ[:SCALar]:FLICker:SOURce:DC? /qonly/
SHORT: FSDC? /qonly/

ID:	dcs		Mode:	Flicker
Type:	float		Suffix:	1...8
Value:	in %		List:	n/a
Unit:	n/a		Group:	n/a

Reads the d_c value of the source.

9.2.4.1.5.4.3   :DELTat?   FSDT?   dts

SCPI: :FETCh[:SCALar]:FLICker:SOURce:DELTat? /qonly/ <list>|
         :READ[:SCALar]:FLICker:SOURce:DELTat? /qonly/ <list>
SHORT: FSDT? /qonly/ <list>

ID:	dts		Mode:	Flicker
Type:	float		Suffix:	1...8
Value:	in %		List:	0...31
Unit:	n/a		Group:	n/a

Reads the $d(t)$ values of the source. After each measuring cycle over 16 periods you can get 32 values.

9.2.4.1.5.4.4   :DMAX?   FSDX?   dmaxs

SCPI: :FETCh[:SCALar]:FLICker:SOURce:DMAX? /qonly/ |
         :READ[:SCALar]:FLICker:SOURce:DMAX? /qonly/
SHORT: FSDX? /qonly/

ID:	dmaxs		Mode:	Flicker
Type:	float		Suffix:	1...8
Value:	in %		List:	n/a
Unit:	n/a		Group:	n/a

Reads the d_{max} value of the source.

9.2.4.1.5.4.5   :DTMViolation?   FSMV?

SCPI: :FETCh[:SCALar]:FLICker:SOURce:DTMViolation? /qonly/ |
         :READ[:SCALar]:FLICker:SOURce:DTMViolation? /qonly/
SHORT: FSMV? /qonly/

ID:	n/a		Mode:	Flicker
Type:	long int		Suffix:	1...8
Value:	n/a		List:	n/a
Unit:	n/a		Group:	n/a

Reads the maximum number of half waves for which the d(t) of the source was bigger than allowed in the standard.

9.2.4.1.5.4.6   :HWTRms?   FSRM?   Uhws

SCPI: :FETCh[:SCALar]:FLICker:SOURce:HWTRms? /qonly/ <list> |

:READ[:SCALar]:FLICker:SOURce:HWTRms? /qonly/ <list>
SHORT: FSRM? /qonly/ <list>

ID:	Uhws	Mode:	Flicker
Type:	float	Suffix:	1...8
Value:	n/a	List:	0...31
Unit:	V or A depending on measured signal	Group:	n/a

Reads the <u>half wave TRMS</u> values of the source. After each measuring cycle over 16 periods you can get 32 values.

9.2.4.1.5.4.7   :PLT?   FSLT?   Plts

SCPI: :FETCh[:SCALar]:FLICker:SOURce:PLT? /qonly/ |
         :READ[:SCALar]:FLICker:SOURce:PLT? /qonly/
SHORT: FSLT? /qonly/

ID:	Plts	Mode:	Flicker
Type:	float	Suffix:	n/a
Value:	n/a	List:	n/a
Unit:	n/a	Group:	n/a

Reads the P_{lt} value of the source.

9.2.4.1.5.4.8   :PMOMentary?   FSMS?   Pms

SCPI: :FETCh[:SCALar]:FLICker:SOURce:PMOMentary? /qonly/ <list>|
         :READ[:SCALar]:FLICker:SOURce:PMOMentary? /qonly/ <list>
SHORT: FSMS? /qonly/ <list>

ID:	Pms	Mode:	Flicker
Type:	float	Suffix:	1...8
Value:	n/a	List:	0...31
Unit:	n/a	Group:	n/a

Reads the <u>momentary flicker level</u> of the source. After each measuring cycle over 16 periods you can get 32 values.

9.2.4.1.5.4.9   :PST?   FSST?   Psts

SCPI: :FETCh[:SCALar]:FLICker:SOURce:PST? /qonly/ |
         :READ[:SCALar]:FLICker:SOURce:PST? /qonly/
SHORT: FSST? /qonly/

ID:	Psts	Mode:	Flicker
Type:	float	Suffix:	n/a
Value:	n/a	List:	n/a
Unit:	n/a	Group:	n/a

Reads the P_{st} value of the source.

9.2.4.1.5.4.10   :RESult?   FSRE?   SrcOK

SCPI: :FETCh[:SCALar]:FLICker:SOURce:RESult? /qonly/ |
         :READ[:SCALar]:FLICker:SOURce:RESult? /qonly/
SHORT: FSRE? /qonly/

ID:	n/a	Mode:	Flicker
Type:	long int	Suffix:	1...8
Value:	n/a	List:	n/a
Unit:	n/a	Group:	n/a

Reads the result of the flicker measuring at the source.

Bit 0: Set if the total evaluation of the flicker fails (=if any of the sub evaluation fails). Cleared otherwise.

Bit 1: Set if at least one P_{st} value was >1.0, cleared otherwise.

Bit 2: Set if the P_{lt} value was >0.65 at the END of the measuring interval, cleared otherwise.

Bit 3: Set if d_{max} was bigger than limit, cleared otherwise.

Bit 4: Set if d(t) was >3% for more than allowed time, cleared otherwise.

Bit 5: Set if d_c was > 3%, cleared otherwise.

9.2.4.1.5.5   :STATe?   FSTA?

SCPI: :FETCh[:SCALar]:FLICker:STATe? /qonly/ | :READ[:SCALar]:FLICker:STATe? /qonly/
SHORT: FSTA? /qonly/

ID:	n/a	Mode:	Flicker
Type:	long int	Suffix:	n/a
Value:	n/a	List:	n/a
Unit:	n/a	Group:	n/a

Reads the state of the flicker measuring.

0:     Reset

1:     Wait

2:     Run

3:     Stop

9.2.4.1.5.6   :STRemain?   FSTR?

SCPI: :FETCh[:SCALar]:FLICker:STRemain? /qonly/ |
         :READ[:SCALar]:FLICker:STRemain? /qonly/
SHORT: FSTR? /qonly/

ID:	n/a	Mode:	Flicker
Type:	long int	Suffix:	n/a
Value:	n/a	List:	n/a
Unit:	s	Group:	n/a

Reads the remaining short time for the actual short term measurement.

9.2.4.1.6 FREQuency

:CALCulate		
:DISPlay		
:FETCh →	**[:SCALar]** →	:CURRent
:FORMat		:CYCLe
:INITiate		:DINPut
:INPut		:ENERgy
:INSTrument		:FLICker
:MEMory		**:FREQuency** → : FINPut
:READ →	:HARMonics	:SAMPle
:SENSe	:POWer	[:SSOurce]
:SOURce	:RESistance	
:STATus	:SSYStem	
:SYSTem	:VARiable	
:TRIGger	[:VOLTage]	

9.2.4.1.6.1 :FINPut?   DIFQ?   DigFrq

SCPI: :FETCh[:SCALar]:FREQuency:FINPut? /qonly/ |
         :READ[:SCALar]:FREQuency:FINPut? /qonly/
SHORT: DIFQ?/qonly/

ID:	DigFrq		Mode:	All
Type:	float		Suffix:	1, 2
Value:	n/a		List:	n/a
Unit:	Hz		Group:	n/a

Reads the value of <u>frequency</u> input of the <u>processing signal interface</u>.

9.2.4.1.6.2 :SAMPle?   SMPL?

SCPI: :FETCh[:SCALar]:FREQuency:SAMPle? /qonly/ |
         :READ[:SCALar]:FREQuency:SAMPle? /qonly/
SHORT: SMPL? /qonly/

ID:	n/a		Mode:	All
Type:	float		Suffix:	n/a
Value:	n/a		List:	n/a
Unit:	Hz		Group:	optional [,<NRi>], 0=A, 1=B, ...

Reads the <u>sampling frequency</u> of the LMG.

9.2.4.1.6.3 :SSOurce?   FREQ?   f

SCPI: :FETCh[:SCALar]:FREQuency[:SSOurce]? /qonly/ |
         :READ[:SCALar]:FREQuency[:SSOurce]? /qonly/
SHORT: FREQ? /qonly/

ID:	f		Mode:	All
Type:	float		Suffix:	1...18
Value:	n/a		List:	n/a
Unit:	Hz		Group:	n/a

Reads the <u>frequency</u> of the <u>synchronisation source</u>

9.2.4.1.7 :HARMonics

:CALCulate		
:DISPlay		
:FETCh →	**[:SCALar]** →	:CURRent
:FORMat		:CYCLe
:INITiate		:DINPut
:INPut		:ENERgy
:INSTrument		:FLICker
:MEMory		:FREQuency
:READ →	**:HARMonics** →	:AMPFactor
:SENSe	:POWer	:AMPower
:SOURce	:RESistance	:APFactor
:STATus	:VARiable	:APower
:SYSTem	[:VOLTage]	:CDResult
:TRIGger		:CURRent
		:LTRemain
		:POWer
		[:VOLTage]

9.2.4.1.7.1 :AMPFactor?   HPFM?

SCPI: :FETCh[:SCALar]:HARMonics:AMPFactor? /qonly/ |
         :READ[:SCALar]:HARMonics:AMPFactor? /qonly/
SHORT: HPFM? /qonly/

ID:	n/a	Mode:	CE
Type:	float	Suffix:	1...8
Value:	n/a	List:	n/a
Unit:	n/a	Group:	n/a

Reads the <u>maximum smoothed power factor</u> of the harmonic measuring.

9.2.4.1.7.2 :AMPower?   HPM?

SCPI: :FETCh[:SCALar]:HARMonics:AMPower? /qonly/ |
         :READ[:SCALar]:HARMonics:AMPower? /qonly/
SHORT: HPM? /qonly/

ID:	n/a	Mode:	CE
Type:	float	Suffix:	1...8
Value:	n/a	List:	n/a
Unit:	W	Group:	n/a

Reads the <u>maximum smoothed power</u> of the harmonic measuring.

9.2.4.1.7.3 :APFactor?   HPFA?

SCPI: :FETCh[:SCALar]:HARMonics:APFactor? /qonly/ |
         :READ[:SCALar]:HARMonics:APFactor? /qonly/
SHORT: HPFA? /qonly/

ID:	n/a	Mode:	CE
Type:	float	Suffix:	1...8
Value:	n/a	List:	n/a
Unit:	n/a	Group:	n/a

Reads the <u>smoothed power factor</u> of the harmonic measuring.

9.2.4.1.7.4   :APOWer?   HPAV?

SCPI: :FETCh[:SCALar]:HARMonics:APOWer? /qonly/ |
         :READ[:SCALar]:HARMonics:APOWer? /qonly/
SHORT: HPAV? /qonly/

ID:	n/a	Mode:	CE
Type:	float	Suffix:	1...8
Value:	n/a	List:	n/a
Unit:	W	Group:	n/a

Reads the <u>smoothed power</u> of the harmonic measuring.

9.2.4.1.7.5   :CDResult?   HENS?

SCPI: :FETCh[:SCALar]:HARMonics:CDResult? /qonly/ |
         :READ[:SCALar]:HARMonics:CDResult? /qonly/
SHORT: HENS? /qonly/

ID:	n/a	Mode:	CE
Type:	long int	Suffix:	1...8
Value:	n/a	List:	n/a
Unit:	n/a	Group:	n/a

Reads the <u>class D result</u> of the harmonic measuring:

Bit 0: Set if the total class D evaluation failed (=if any of the sub evaluation failed). Cleared otherwise.

Bit 1: Set if the current was for <95% of time under the positive special envelop, cleared otherwise.

Bit 2: Set if the current was for <95% of time under the negative special envelop, cleared otherwise.

Bit 3: Set if P>600W, cleared otherwise.

Bit 4: Set if the total class C evaluation failed (=if any of the sub evaluation failed). Cleared otherwise.

Bit 5: Set if the 60° condition failed in first halfwave. Cleared otherwise.

Bit 6: Set if the 65° condition failed in first halfwave. Cleared otherwise.

Bit 7: Set if the 90° condition failed in first halfwave. Cleared otherwise.

Bit 8: Set if the peak value in first halfwave is negative. Cleared otherwise.

Bit 9: Set if the 60° condition failed in second halfwave. Cleared otherwise.

Bit 10: Set if the 65° condition failed in second halfwave. Cleared otherwise.

Bit 11: Set if the 90° condition failed in second halfwave. Cleared otherwise.

Bit 12: Set if the peak value in second halfwave is negative. Cleared otherwise.

9.2.4.1.7.6   :CURRent

:CALCulate
:DISPlay

```
:FETCh   →        [:SCALar]  →      :CURRent
:FORMat                            :CYCLe
:INITiate                          :DINPut
:INPut                             :ENERgy
:INSTrument                        :FLICker
:MEMory                            :FREQuency
:READ   →                         :HARMonics  →   :AMPower
:SENSe                             :POWer           :APFactor
:SOURce                            :RESistance      :CDResult
:STATus                            :SSYStem         :CURRent  →    :AAMPlitude
:SYSTem                            :VARiable        :LTRemain      :AFUNdamental
:TRIGger                           [:VOLTage]       :POWer         :AMPLitude
                                                    [:VOLTage]     :FPRotz
                                                                   :FRESult
                                                                   :GFResult
                                                                   :LIMit
                                                                   :LTResult
                                                                   :OLIMit
                                                                   :PHASe
                                                                   :POHarmonics
                                                                   :POLimit
                                                                   :SAVerage
                                                                   :SMOothed
                                                                   :STATe
                                                                   :THARmonic
                                                                   :THDistortion
```

9.2.4.1.7.6.1   :AAMPlitude?   HIAV?   Iaver

SCPI: :FETCh[:SCALar]:HARMonics:CURRent:AAMPlitude? /qonly/ <list> |
         :READ[:SCALar]:HARMonics:CURRent:AAMPlitude? /qonly/ <list>
SHORT: HIAV? /qonly/ <list>

ID:	Iaver	Mode:	CE-Harm
Type:	float	Suffix:	1...8
Value:	n/a	List:	0...40 for harmonic order
Unit:	A	Group:	n/a

Reads the average amplitude of the harmonics of the current.

9.2.4.1.7.6.2   :AFUNdamental?   HIFM?

SCPI: :FETCh[:SCALar]:HARMonics:CURRent:AFUNdamental? /qonly/ |
         :READ[:SCALar]:HARMonics:CURRent:AFUNdamental? /qonly/
SHORT: HIFM? /qonly/

ID:	n/a	Mode:	CE-Harm
Type:	float	Suffix:	1...8
Value:	n/a	List:	n/a
Unit:	A	Group:	n/a

Reads the maximum averaged fundamental current of the harmonics.

9.2.4.1.7.6.3   :AMPLitude?   HIAM?   Ih

SCPI: :FETCh[:SCALar]:HARMonics:CURRent:AMPLitude? /qonly/ <list> |
         :READ[:SCALar]:HARMonics:CURRent:AMPLitude? /qonly/ <list>

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SHORT: HIAM? /qonly/ <list>

ID:	Ih		Mode:	CE-Harm, HARM100
Type:	float		Suffix:	1...8(CE-Harm), 1...14(HARM100)
Value:	n/a		List:	0...40/99 (CE-Harm/HARM100) for order
Unit:	A		Group:	n/a

Reads the amplitude of the harmonics of the current.

9.2.4.1.7.6.4   :FPRotz?   HFMX?

SCPI: :FETCh[:SCALar]:HARMonics:CURRent:FPRotz? /qonly/ <list> |
         :READ[:SCALar]:HARMonics:CURRent:FPRotz? /qonly/ <list>
SHORT: HFMX? /qonly/ <list>

ID:	n/a		Mode:	CE-Harm
Type:	float		Suffix:	1...8
Value:	in %		List:	0...40 for harmonic order
Unit:	n/a		Group:	n/a

Reads the maximum duration in percent of a 2.5 minute window while each harmonic was over the 100% limit.

9.2.4.1.7.6.5   :FRESult?   HIFL?

SCPI: :FETCh[:SCALar]:HARMonics:CURRent:FRESult? /qonly/ <list> |
         :READ[:SCALar]:HARMonics:CURRent:FRESult? /qonly/ <list>
SHORT: HIFL? /qonly/ <list>

ID:	n/a		Mode:	CE-Harm
Type:	long int		Suffix:	1...8
Value:	$0...2^{41}-1$		List:	0, 1 for array element
Unit:	n/a		Group:	n/a

Reads the long time result of the fluctuating harmonics of the current. This is an array of 2 long numbers, so that you get a 64 bit result, if you read out both elements. Each bit from 0 to 40 indicates, if the corresponding harmonic has at least one time while the measuring violated the limit for more than 10% of a 2.5 minute window.

9.2.4.1.7.6.6   :GFResult?   HIGF?

SCPI: :FETCh[:SCALar]:HARMonics:CURRent:GFResult? /qonly/ |
         :READ[:SCALar]:HARMonics:CURRent:GFResult? /qonly/
SHORT: HIGF? /qonly/

ID:	n/a		Mode:	CE-Harm
Type:	long int		Suffix:	1...8
Value:	n/a		List:	n/a
Unit:	n/a		Group:	n/a

Reads the global final result of the current check.

Bit 0:   Set if the total current evaluation failed (=if any of the sub evaluation failed). Cleared otherwise.

Bit 1:   Set if any of the harmonics was > 100% of the allowed limit, cleared otherwise.

Bit 2:   Set if the fluctuating harmonics were for more than 10% of the 2.5 minute window between 100% and 150% of the limit. Cleared otherwise.

Bit 3:   Set if questionable vales (with '?') have occurred. Cleared otherwise.

Bit 4:   Set if measured power was > 110% of defined power. Cleared otherwise. This is only a warning, not an error.

Bit 5:   Set if measured power factor was > 110% of defined power factor. Cleared otherwise. This is only a warning, not an error.

Bit 6:   Set if measured fundamental current was > 110% of defined fundamental current. Cleared otherwise. This is only a warning, not an error.

Bit 7:   Set if measured power was < 90% of defined power. Cleared otherwise.

Bit 8:   Set if measured power factor was < 90% of defined power factor. Cleared otherwise.

Bit 9:   Set if measured fundamental current was < 90% of defined fundamental current. Cleared otherwise.

Bit 10: Set if any harmonic is > 150% of limits. Cleared otherwise.

Bit 11: Set if the THD condition of EN61000-3-12 failed. Cleared otherwise.

9.2.4.1.7.6.7	:IAMPlitude?	HIZA?	

SCPI: :FETCh[:SCALar]:HARMonics:CURRent:IAMPlitude? /qonly/ <list>|
        :READ[:SCALar]:HARMonics:CURRent:IAMPlitude? /qonly/ <list>
SHORT: HIZA? /qonly/ <list>

ID:	n/a	Mode:	CE-Harm
Type:	float	Suffix:	1...8
Value:	n/a	List:	0...5 for interharmonics number relative to start position
Unit:	A	Group:	n/a

Reads the interharmonics of the current in CE-HRM mode. To define the analysis area see command 9.2.10.8.2, ':ISTart   HNRZ'

9.2.4.1.7.6.8	:LIMit?	HILM?	IL

SCPI: :FETCh[:SCALar]:HARMonics:CURRent:LIMit? /qonly/ <list> |
        :READ[:SCALar]:HARMonics:CURRent:LIMit? /qonly/ <list>
SHORT: HILM? /qonly/ <list>

ID:	IL	Mode:	CE-Harm
Type:	float	Suffix:	1...8
Value:	n/a	List:	0...40 for order
Unit:	A	Group:	n/a

Reads the limits of the harmonics of the current.

9.2.4.1.7.6.9   :LTResult?   HILT?

SCPI: :FETCh[:SCALar]:HARMonics:CURRent:LTResult? /qonly/ <list> |
         :READ[:SCALar]:HARMonics:CURRent:LTResult? /qonly/ <list>
SHORT: HILT? /qonly/ <list>

ID:	n/a	Mode:	CE-Harm
Type:	long int	Suffix:	1...8
Value:	$0...2^{41}-1$	List:	0, 1 for array element
Unit:	n/a	Group:	n/a

Reads the <u>long time result</u> of the <u>harmonics</u> of the <u>current</u>. This is an array of 2 long numbers, so that you get a 64 bit result, if you read out both elements. Each bit from 0 to 40 indicates, if the corresponding harmonic has at least one time while the measuring violated the limit.

9.2.4.1.7.6.10   :OLIMit?   HIOV?

SCPI: :FETCh[:SCALar]:HARMonics:CURRent:OLIMit? /qonly/ <list> |
         :READ[:SCALar]:HARMonics:CURRent:OLIMit? /qonly/ <list>
SHORT: HIOV? /qonly/ <list>

ID:	n/a	Mode:	CE-Harm
Type:	long int	Suffix:	1...8
Value:	$0...2^{41}-1$	List:	0...3 for array element
Unit:	n/a	Group:	n/a

Reads the <u>over limit status</u> of the <u>harmonics</u> of the <u>current</u>. This is an array of 4 long numbers, so that you get two 64 bit results, if you read out the elements 0/1 or 2/3.
For array element 2/3 each bit from 0 to 40 indicates, if the corresponding harmonic has violated the limit in the actual frame ('!' on LMG display).
For array element 0/1 each bit from 0 to 40 indicates, if the corresponding harmonic has violated the 100% limit but is within the 150% limit in the actual frame ('?' on LMG display).

9.2.4.1.7.6.11   :PHASe?   HIPH?   IP

SCPI: :FETCh[:SCALar]:HARMonics:CURRent:PHASe? /qonly/ <list> |
         :READ[:SCALar]:HARMonics:CURRent:PHASe? /qonly/ <list>
SHORT: HIPH? /qonly/ <list>

ID:	IP	Mode:	HARM100
Type:	float	Suffix:	1...14
Value:	n/a	List:	0...99 for order
Unit:	°	Group:	n/a

Reads the <u>phase</u> of the <u>harmonics</u> of the <u>current</u>.

9.2.4.1.7.6.12   :POHarmonic?   HPOC?   Ipohc

SCPI: :FETCh[:SCALar]:HARMonics:CURRent:POHarmonic? /qonly/ |
         :READ[:SCALar]:HARMonics:CURRent:POHarmonic? /qonly/
SHORT: HPOC? /qonly/

ID:	lpohc		Mode:	CE-Harm
Type:	float		Suffix:	1...8
Value:	n/a		List:	n/a
Unit:	A		Group:	n/a

Reads the <u>Partial Odd Harmonic Current</u>.

9.2.4.1.7.6.13   :POLimit?   HLIP?

SCPI: :FETCh[:SCALar]:HARMonics:CURRent:POLimit? /qonly/ |
         :READ[:SCALar]:HARMonics:CURRent:POLimit? /qonly/
SHORT: HLIP? /qonly/

ID:	n/a		Mode:	CE-Harm
Type:	float		Suffix:	1...8
Value:	n/a		List:	n/a
Unit:	A		Group:	n/a

Reads the <u>partial odd harmonic current</u> which is calculated from the <u>limits</u> at the end of a
measuring.

9.2.4.1.7.6.14   :SAVerage?   HIAS?

SCPI: :FETCh[:SCALar]:HARMonics:CURRent:SAVerage? /qonly/ |
         :READ[:SCALar]:HARMonics:CURRent:SAVerage? /qonly/
SHORT: HIAS? /qonly/

ID:	n/a		Mode:	CE-Harm
Type:	float		Suffix:	1...8
Value:	n/a		List:	n/a
Unit:	A		Group:	n/a

Reads the <u>smoothed averaged TRMS current.</u>

9.2.4.1.7.6.15   :SMOothed?   HIMA?

SCPI: :FETCh[:SCALar]:HARMonics:CURRent:SMOothed? /qonly/ |
         :READ[:SCALar]:HARMonics:CURRent:SMOothed? /qonly/
SHORT: HIMA? /qonly/

ID:	n/a		Mode:	CE-Harm
Type:	float		Suffix:	1...8
Value:	n/a		List:	n/a
Unit:	A		Group:	n/a

Reads the <u>smoothed TRMS current</u> in this measuring mode.

9.2.4.1.7.6.16   :STATe?   HIST?

SCPI: :FETCh[:SCALar]:HARMonics:CURRent:STATe? /qonly/ |
         :READ[:SCALar]:HARMonics:CURRent:STATe? /qonly/
SHORT: HIST? /qonly/

ID:	n/a		Mode:	CE-Harm
Type:	long int		Suffix:	1...8
Value:	n/a		List:	n/a
Unit:	n/a		Group:	n/a

Reads the <u>actual result</u> of the <u>current check</u>:

Bit 0: Set if the total current evaluation failed (=if any of the sub evaluation failed). Cleared otherwise.

Bit 1: Set if any of the harmonics was > 100% of the allowed limit, cleared otherwise.

Bit 2: Set if the fluctuating harmonics were for more than 10% of the 2.5 minute window between 100% and 150% of the limit. Cleared otherwise.

Bit 3: Set if questionable vales (with '?') have occurred. Cleared otherwise.

Bit 10: Set if any harmonic is > 150% of limits. Cleared otherwise.

9.2.4.1.7.6.17   :THARmonic?   HTHC?   Ithc

SCPI: :FETCh[:SCALar]:HARMonics:CURRent:THARmonic? /qonly/ |
         :READ[:SCALar]:HARMonics:CURRent:THARmonic? /qonly/
SHORT: HTHC? /qonly/

ID:	Ithc		Mode:	CE-Harm
Type:	float		Suffix:	1...8
Value:	n/a		List:	n/a
Unit:	A		Group:	n/a

Reads the <u>Total Harmonic Current</u>.

9.2.4.1.7.6.18   :THDistort?   HIHD?   Ithd

SCPI: :FETCh[:SCALar]:HARMonics:CURRent:THDistort? /qonly/ |
         :READ[:SCALar]:HARMonics:CURRent:THDistort? /qonly/
SHORT: HIHD? /qonly/

ID:	Ithd		Mode:	CE-Harm, Flicker, HARM100
Type:	float		Suffix:	1...8/12
Value:	in %		List:	n/a
Unit:	n/a		Group:	n/a

Reads the <u>THD</u> of the <u>current</u>.

9.2.4.1.7.7   :LTRemain?   HLTR?

SCPI: :FETCh[:SCALar]:HARMonics:LTRemain? /qonly/ |
         :READ[:SCALar]: HARMonics:LTRemain? /qonly/
SHORT: HLTR? /qonly/

ID:	n/a		Mode:	CE-Harm
Type:	long int		Suffix:	n/a
Value:	n/a		List:	n/a
Unit:	s		Group:	n/a

Reads the remaining long time for the harmonic measurement.

9.2.4.1.7.8   :POWer

```
:CALCulate
:DISPlay
:FETCh      →      [:SCALar]   →      :CURRent
:FORMat                              :CYCLe
:INITiate                            :DINPut
:INPut                               :ENERgy
:INSTrument                          :FLICker
:MEMory                              :FREQuency
:READ       →                       :HARMonics   →   :AMPower
:SENSe                               :POWer            :APFactor
:SOURce                              :RESistance       :CDResult
:STATus                              SSYStem           :CURRent
:SYSTem                              :VARiable         :LTRemain
:TRIGger                             [:VOLTage]        :POWer   →   :ACTive
                                                       [:VOLTage]    :APParent
                                                                     :REACtive
```

9.2.4.1.7.8.1   :ACTive?   HPAM?   Ph

SCPI: :FETCh[:SCALar]:HARMonics:POWer:ACTive? /qonly/ <list> |
        :READ[:SCALar]:HARMonics:POWer:ACTive? /qonly/ <list>
SHORT: HPAM? /qonly/ <list>

ID:	Ph	Mode:	HARM100
Type:	float	Suffix:	1...14
Value:	n/a	List:	0...99 for order
Unit:	W	Group:	n/a

Reads the <u>harmonics</u> of the <u>active power</u>.

9.2.4.1.7.8.2   :APParent?   HSAM?   Sh

SCPI: :FETCh[:SCALar]:HARMonics:POWer:APParent?/qonly/ <list> |
        :READ[:SCALar]:HARMonics:POWer:APParent? /qonly/ <list>
SHORT: HSAM? /qonly/ <list>
.

ID:	Sh	Mode:	HARM100
Type:	float	Suffix:	1...14
Value:	n/a	List:	0...99 for order
Unit:	VA	Group:	n/a

Reads the <u>harmonics</u> of the <u>apparent power</u>.

9.2.4.1.7.8.3   :REACtive?   HQAM?   Qh

SCPI: :FETCh[:SCALar]:HARMonics:POWer:REACtive? /qonly/ <list> |
        :READ[:SCALar]:HARMonics:POWer:REACtive? /qonly/ <list>
SHORT: HQAM? /qonly/ <list>

ID:	Qh	Mode:	HARM100
Type:	float	Suffix:	1...14
Value:	n/a	List:	0...99 for order
Unit:	var	Group:	n/a

Reads the <u>harmonics</u> of the <u>reactive power</u>.

9.2.4.1.7.9   [:VOLTage]

```
:CALCulate
:DISPlay
:FETCh  →        [:SCALar]  →      :CURRent
:FORMat                            :CYCLe
:INITiate                          :DINPut
:INPut                             :ENERgy
:INSTrument                        :FLICker
:MEMory                            :FREQuency
:READ   →                          :HARMonics  →    :AMPower
:SENSe                             :POWer           :APFactor
:SOURce                            :RESistance      :CDResult
:STATus                            :SSYStem         :CURRent
:SYSTem                            :VARiable        :LTRemain
:TRIGger                           [:VOLTage]       :Power
                                   [:VOLTage]  →          :AMPLitude
                                                          :GFResult
                                                          :LIMit
                                                          :LTResult
                                                          :MAMPlitude
                                                          :OLIMit
                                                          :PHASe
                                                          :STATe
                                                          :THDistortion
```

9.2.4.1.7.9.1   :AMPLitude?   HUAM?   Uh

SCPI: :FETCh[:SCALar]:HARMonics[:VOLTage]:AMPLitude? /qonly/ <list> |
        :READ[:SCALar]:HARMonics[:VOLTage]:AMPLitude? /qonly/ <list>
SHORT: HUAM? /qonly/ <list>

ID:	Uh	Mode:	CE-Harm, HARM100
Type:	float	Suffix:	1...8(CE-Harm), 1...14(HARM100)
Value:	n/a	List:	0...40/99 (CE-Harm/HARM100) for order
Unit:	V	Group:	n/a

Reads the <u>amplitude</u> of the <u>harmonics</u> of the <u>voltage</u>.

9.2.4.1.7.9.2   :GFResult?   HUGF?

SCPI: :FETCh[:SCALar]:HARMonics[:VOLTage]:GFResult? /qonly/ |
        :READ[:SCALar]:HARMonics[:VOLTage]:GFResult? /qonly/
SHORT: HUGF? /qonly/

ID:	n/a	Mode:	CE-Harm
Type:	long int	Suffix:	1...8
Value:	n/a	List:	n/a
Unit:	n/a	Group:	n/a

Reads the <u>global final result</u> of the <u>voltage check.</u>

Bit 0: Set if the total voltage evaluation failed (=if any of the sub evaluation failed). Cleared
        otherwise.

Bit 1: Set if any of the harmonics was > 100% of the allowed limit, cleared otherwise.

Bit 2: Set if the voltage amplitude was not within the limit, cleared otherwise.

Bit 3: Set if the frequency was not within the limit, cleared otherwise.

Bit 4: Set if the crest factor was not within the limit, cleared otherwise.

Bit 5: Set, if the peak value is not within $90°\pm3°$

9.2.4.1.7.9.3   :HWCFactor?   FLCF?

SCPI: :FETCh[:SCALar]:HARMonics[:VOLTage]: HWCFactor? /qonly/ <list>|
         :READ[:SCALar]:HARMonics[:VOLTage]: HWCFactor? /qonly/ <list>
SHORT: FLCF? /qonly/ <list>

ID:	n/a	Mode:	CE-Harm
Type:	float	Suffix:	1...8
Value:	n/a	List:	0...31 for half wave number
Unit:	n/a	Group:	n/a

Reads the voltage <u>crest factor of the half waves</u>. After each measuring cycle over 16 periods you can get 32 values.

9.2.4.1.7.9.4   :IAMPlitude?   HUZA?

SCPI: :FETCh[:SCALar]:HARMonics:VOLTage:IAMPlitude? /qonly/ |
         :READ[:SCALar]:HARMonics:VOLTage:IAMPlitude? /qonly/
SHORT: HUZA? /qonly/

ID:	n/a	Mode:	CE-Harm
Type:	float	Suffix:	0...8
Value:	n/a	List:	0...5 for interharmonics number relative to start position
Unit:	V	Group:	n/a

Reads the <u>interharmonics</u> of the <u>voltage</u>. To define the analysis area see command 9.2.10.8.2, ':IST art   HNRZ'

9.2.4.1.7.9.5   :LIMit?   HULM?   UL

SCPI: :FETCh[:SCALar]:HARMonics[:VOLTage]:LIMit? /qonly/ <list> |
         :READ[:SCALar]:HARMonics[:VOLTage]:LIMit? /qonly/ <list>
SHORT: HULM? /qonly/ <list>

ID:	UL	Mode:	CE-Harm
Type:	float	Suffix:	1...8
Value:	n/a	List:	0...40 for order
Unit:	V	Group:	n/a

Reads the <u>limits</u> of the <u>harmonics</u> of the <u>voltage.</u>

9.2.4.1.7.9.6   :LTResult?   HULT?

SCPI: :FETCh[:SCALar]:HARMonics[:VOLTage]:LTResult? /qonly/ <list> |
         :READ[:SCALar]:HARMonics[:VOLTage]:LTResult? /qonly/ <list>
SHORT: HULT? /qonly/ <list>

ID:	n/a	Mode:	CE-Harm
Type:	long int	Suffix:	1...8
Value:	$0...2^{41}-1$	List:	0, 1 for array element
Unit:	n/a	Group:	n/a

Reads the long time result of the harmonics of the voltage. This is an array of 2 long numbers, so that you get a 64 bit result, if you read out both elements. Each bit from 0 to 40 indicates, if the corresponding harmonic has at least one time while the measuring violated the limit.

9.2.4.1.7.9.7   :MAMPlitude?   HUMX?   UMax

SCPI: :FETCh[:SCALar]:HARMonics[:VOLTage]:MAMPlitude? /qonly/ <list> |
         :READ[:SCALar]:HARMonics[:VOLTage]:MAMPlitude? /qonly/ <list>
SHORT: HUMX? /qonly/ <list>

ID:	UMax	Mode:	CE-Harm
Type:	float	Suffix:	1...8
Value:	n/a	List:	0...40 for order
Unit:	V	Group:	n/a

Reads the maximum amplitude of the harmonics of the voltage.

9.2.4.1.7.9.8   :MAXCfactor?   FLCX?

SCPI: :FETCh[:SCALar]:HARMonics[:VOLTage]: MAXCfactor? /qonly/ |
         :READ[:SCALar]:HARMonics[:VOLTage]: MAXCfactor? /qonly/
SHORT: FLCX? /qonly/

ID:	n/a	Mode:	CE-Harm
Type:	float	Suffix:	1...8
Value:	n/a	List:	n/a
Unit:	n/a	Group:	n/a

Reads the maximum crest factor of the voltage.

9.2.4.1.7.9.9   :MAXPhi?   FLPX?

SCPI: :FETCh[:SCALar]:HARMonics[:VOLTage]: MAXPhi? /qonly/ |
         :READ[:SCALar]:HARMonics[:VOLTage]: MAXPhi? /qonly/
SHORT: FLPX? /qonly/

ID:	n/a	Mode:	CE-Harm
Type:	float	Suffix:	1...8
Value:	n/a	List:	n/a
Unit:	°	Group:	n/a

Reads the maximum phase of peak value of the voltage.

9.2.4.1.7.9.10   :MINCfactor?   FLCN?

SCPI: :FETCh[:SCALar]:HARMonics[:VOLTage]: MINCfactor? /qonly/ |
         :READ[:SCALar]:HARMonics[:VOLTage]: MINCfactor? /qonly/
SHORT: FLCN? /qonly/

ID: n/a   Mode: CE-Harm
Type: float   Suffix: 1...8
Value: n/a   List: n/a
Unit: n/a   Group: n/a

Reads the minimum crestfactor of the voltage.

9.2.4.1.7.9.11   :MINPhi?   FLPN?

SCPI: :FETCh[:SCALar]:HARMonics[:VOLTage]: MINPhi? /qonly/ |
         :READ[:SCALar]:HARMonics[:VOLTage]: MINPhi? /qonly/
SHORT: FLPN? /qonly/

ID: n/a   Mode: CE-Harm
Type: float   Suffix: 1...8
Value: n/a   List: n/a
Unit: °   Group: n/a

Reads the minimum phase of peak value of the voltage.

9.2.4.1.7.9.12   :OLIMit?   HUOV?

SCPI: :FETCh[:SCALar]:HARMonics[:VOLTage]:OLIMit? /qonly/ <list> |
         :READ[:SCALar]:HARMonics[:VOLTage]:OLIMit? /qonly/ <list>
SHORT: HUOV? /qonly/ <list>

ID: n/a   Mode: CE-Harm
Type: long int   Suffix: 1...8
Value: 0...2^{41}-1   List: 0...3 for array element
Unit: n/a   Group: n/a

Reads the over limit status of the harmonics of the voltage. This is an array of 4 long numbers,
so that you get two 64 bit results, if you read out the elements 0/1 or 2/3.
For array element 2/3 each bit from 0 to 40 indicates, if the corresponding harmonic has
violated the limit in the actual frame ('!' on LMG display).
Array elements 0/1 are not used.

9.2.4.1.7.9.13   :PHASe?   HUPH?   UP

SCPI: :FETCh[:SCALar]:HARMonics[:VOLTage]:PHASe? /qonly/ <list> |
         :READ[:SCALar]:HARMonics[:VOLTage]:PHASe? /qonly/ <list>
SHORT: HUPH? /qonly/ <list>

ID: UP   Mode: HARM100
Type: float   Suffix: 1...14
Value: n/a   List: 0...99 for order
Unit: °   Group: n/a

Reads the <u>phase</u> of the <u>harmonics</u> of the <u>voltage</u>.

9.2.4.1.7.9.14   :PPHase?   FLUP?

SCPI: :FETCh[:SCALar]:HARMonics[:VOLTage]: PPHase? /qonly/ <list>|
        :READ[:SCALar]:HARMonics[:VOLTage]: PPHase? /qonly/ <list>
SHORT: FLUP? /qonly/ <list>

ID: n/a   Mode: CE-Harm
Type: float   Suffix: 1...8
Value: n/a   List: 0...31 for half wave number
Unit: °   Group: n/a

Reads the <u>phase angle of the voltage peak value of the half waves</u>. After each measuring cycle over 16 periods you can get 32 values.

9.2.4.1.7.9.15   :STATe?   HUST?

SCPI: :FETCh[:SCALar]:HARMonics[:VOLTage]:STATe? /qonly/ |
        :READ[:SCALar]:HARMonics[:VOLTage]:STATe? /qonly/
SHORT: HUST? /qonly/

ID: n/a   Mode: CE-Harm
Type: long int   Suffix: 1...8
Value: $0...2^5-1$ List: n/a
Unit: n/a   Group: n/a

Reads the <u>actual result</u> of the <u>voltage check</u>

Bit 0: Set if the total voltage evaluation failed (=if any of the sub evaluation failed). Cleared otherwise.
Bit 1: Set if any of the harmonics was > 100% of the allowed limit, cleared otherwise.
Bit 2: Set if the voltage amplitude was not within the limit, cleared otherwise.
Bit 3: Set if the frequency was not within the limit, cleared otherwise.
Bit 4: Set if the crest factor was not within the limit, cleared otherwise.
Bit 5: Set, if the peak value is not within 90°±3°

9.2.4.1.7.9.16   :THDistort?   HUHD?   Uthd

SCPI: :FETCh[:SCALar]:HARMonics[:VOLTage]:THDistort? /qonly/ |
        :READ[:SCALar]:HARMonics[:VOLTage]:THDistort? /qonly/
SHORT: HUHD? /qonly/

ID: Uthd   Mode: CE-Harm, Flicker, HARM100
Type: float   Suffix: 1...8/12
Value: n/a   List: n/a
Unit: n/a   Group: n/a

Reads the <u>THD</u> of the <u>voltage</u>.

9.2.4.1.8 :POWer

```
:CALCulate
:DISPlay
:FETCh  →      [:SCALar]  →      :CURRent
:FORMat                          :CYCLe
:INITiate                        :DINPut
:INPut                           :ENERgy
:INSTrument                      :FLICker
:MEMory                          :FREQuency
:READ  →                         :HARMonics
:SENSe                           :POWer  →      :AACTive
:SOURce                          :RESistance    :AAPParent
:STATus                          :SSYStem       [:ACTive]
:SYSTem                          :VARiable      :APParent
:TRIGger                         [:VOLTage]     :AREactive
                                                :FSCale
                                                :ICAPacity
                                                :PFACtor
                                                :PHASe
                                                :REACtive
```

9.2.4.1.8.1 :AACTive?   PM?   Pm

SCPI: :FETCh[:SCALar]:POWer:AACTive? /qonly/ | :READ[:SCALar]:POWer:AACTive? /qonly/
SHORT: PM? /qonly/

ID:	Pm	Mode:	Normal
Type:	float	Suffix:	1...14
Value:	n/a	List:	n/a
Unit:	W	Group:	n/a

Reads the <u>average active power</u>.

9.2.4.1.8.2 :AAPParent?   SM?   Sm

SCPI: :FETCh[:SCALar]:POWer:AAPParent? /qonly/ |
         :READ[:SCALar]:POWer:AAPParent? /qonly/
SHORT: SM? /qonly/

ID:	Sm	Mode:	Normal
Type:	float	Suffix:	1...14
Value:	n/a	List:	n/a
Unit:	VA	Group:	n/a

Reads the <u>average apparent power</u>.

9.2.4.1.8.3 [:ACTive]?   P?   P

SCPI: :FETCh[:SCALar]:POWer[:ACTive]? /qonly/ | :READ[:SCALar]:POWer[:ACTive]? /qonly/
SHORT: P? /qonly/

ID:	P	Mode:	All
Type:	float	Suffix:	1...18
Value:	n/a	List:	n/a
Unit:	W	Group:	n/a

Reads the <u>active power</u>.

9.2.4.1.8.4   :APParent?   S?   S

SCPI: :FETCh[:SCALar]:POWer:APParent? /qonly/ | :READ[:SCALar]:POWer:APParent? /qonly/
SHORT: S? /qonly/

ID:	S	Mode:	All
Type:	float	Suffix:	1...18
Value:	n/a	List:	n/a
Unit:	VA	Group:	n/a

Reads the <u>apparent power</u>.

9.2.4.1.8.5   :AREactive?   QM?   Qm

SCPI: :FETCh[:SCALar]:POWer:AREactive? /qonly/ |
         :READ[:SCALar]:POWer:AREactive? /qonly/
SHORT: QM? /qonly/

ID:	Qm	Mode:	Normal
Type:	float	Suffix:	1...14
Value:	n/a	List:	n/a
Unit:	var	Group:	n/a

Reads the <u>average reactive power</u>.

9.2.4.1.8.6   :FSCale?   FSP?

SCPI: :FETCh[:SCALar]:POWer:FSCale? /qonly/ | :READ[:SCALar]:POWer:FSCale? /qonly/
SHORT: FSP? /qonly/

ID:	n/a	Mode:	All
Type:	float	Suffix:	1...14
Value:	n/a	List:	n/a
Unit:	W	Group:	n/a

Reads the <u>full scale</u> value of the <u>power</u>.

9.2.4.1.8.7   :ICAPacity?   INCA?   Inca

SCPI: :FETCh[:SCALar]:POWer:ICAPacity? /qonly/ | :READ[:SCALar]:POWer:ICAPacity? /qonly/
SHORT: INCA? /qonly/

ID:	Inca	Mode:	Normal
Type:	long int	Suffix:	1...14
Value:	-1, 0, +1	List:	n/a
Unit:	n/a	Group:	n/a

Reads the status of the inca flag. It shows, if the system is <u>inductive</u> or <u>capacitive</u>:

+1   inductive

0   undefined

-1   capacitive

9.2.4.1.8.8   :PFACtor?   PF?   PF

SCPI: :FETCh[:SCALar]:POWer:PFACtor? /qonly/ | :READ[:SCALar]:POWer:PFACtor? /qonly/
SHORT: PF? /qonly/

ID:	PF	Mode:	All
Type:	float	Suffix:	1...18
Value:	n/a	List:	n/a
Unit:	n/a	Group:	n/a

Reads the power factor.

9.2.4.1.8.9   :PHASe?   PHI?   PHI

SCPI: :FETCh[:SCALar]:POWer:PHASe? /qonly/ | :READ[:SCALar]:POWer:PHASe? /qonly/
SHORT: PHI? /qonly/

ID:	PHI	Mode:	Normal
Type:	float	Suffix:	1...14
Value:	n/a	List:	n/a
Unit:	°	Group:	n/a

Reads the phase angle in degree between current and voltage.

9.2.4.1.8.10 :REACtive?   Q?   Q

SCPI: :FETCh[:SCALar]:POWer:REACtive? /qonly/ | :READ[:SCALar]:POWer:REACtive? /qonly/
SHORT: Q? /qonly/

ID:	Q	Mode:	All
Type:	float	Suffix:	1...18
Value:	n/a	List:	n/a
Unit:	var	Group:	n/a

Reads the reactive power.

9.2.4.1.9 :RESistance

```
:CALCulate
:DISPlay
:FETCh   →      [:SCALar]  →      :CURRent
:FORMat                          :CYCLe
:INITiate                        :DINPut
:INPut                           :ENERgy
:INSTrument                      :FLICker
:MEMory                          :FREQuency
:READ    →                       :HARMonics
:SENSe                           :POWer
:SOURce                          :RESistance  →   :ASResist
:STATus                          :SSYStem         :IMPedance
```

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:SYSTem	:VARiable	:RSIMpedance
:TRIGger	[:VOLTage]	

9.2.4.1.9.1   :ASResist?   RSER?   Rser

SCPI: :FETCh[:SCALar]:RESistance:ASResist? /qonly/ |
         :READ[:SCALar]:RESistance:ASResist? /qonly/
SHORT: RSER? /qonly/

ID:	Rser	Mode:	Normal, CE-Harm, Flicker
Type:	float	Suffix:	1...14
Value:	n/a	List:	n/a
Unit:	Ω	Group:	n/a

Reads the active serial resistance.

9.2.4.1.9.2   :IMPedance?   Z?   Z

SCPI: :FETCh[:SCALar]:RESistance:IMPedance? /qonly/ |
         :READ[:SCALar]:RESistance:IMPedance? /qonly/
SHORT: Z? /qonly/

ID:	Z	Mode:	Normal, CE-Harm, Flicker
Type:	float	Suffix:	1...14
Value:	n/a	List:	n/a
Unit:	Ω	Group:	n/a

Reads the impedance (apparent resistance).

9.2.4.1.9.3   :RSIMpedance?   XSER?   Xser

SCPI: :FETCh[:SCALar]:RESistance:RSIMpedance? /qonly/ |
         :READ[:SCALar]:RESistance:RSIMpedance? /qonly/
SHORT: XSER? /qonly/

ID:	Xser	Mode:	Normal, CE-Harm, Flicker
Type:	float	Suffix:	1...14
Value:	n/a	List:	n/a
Unit:	Ω	Group:	n/a

Reads the reactive serial impedance.

9.2.4.1.10 :SSYStem?   RLS?

SCPI: :FETCh[:SCALar]:SSYStem? /qonly/ [<NRi>] | :READ[:SCALar]:SSYStem? /qonly/ [<NRi>]
SHORT: RLS? /qonly/

ID:	n/a	Mode:	Normal
Type:	long int	Suffix:	n/a
Value:	-1, 0, +1	List:	n/a
Unit:	n/a	Group:	optional [<NRi>], 0=A, 1=B, ...

Reads the supply system:

0   undefined system

+1   right rotating system (phase order 1, 2, 3)

-1   left rotating system (phase order 3, 2, 1)

9.2.4.1.11 :STATe?   TSTA?

SCPI: :FETCh[:SCALar]:TRANsient:STATe? /qonly/ | :READ[:SCALar]: TRANsient:STATe? /qonly/
SHORT: TSTA? /qonly/

ID:	n/a	Mode:	Normal
Type:	long int	Suffix:	n/a
Value:	0...2	List:	n/a
Unit:	n/a	Group:	n/a

Reads the state of the transient search:

0   off

1   Search

2   found, fetching posttrigger

3   Finish

9.2.4.1.12 :VARiable?   VAR?

SCPI: :FETCh[:SCALar]:VARiable? /qonly/ <list> | :READ[:SCALar]:VARiable? /qonly/ <list>
SHORT: VAR? /qonly/ <list>

ID:	The name a user has defined. With script 'abc=Utrms*2;' then ID would be 'abc'	Mode:	All
Type:	float	Suffix:	n/a
Value:	n/a	List:	0...11 for array element
Unit:	n/a	Group:	n/a

Reads value of the user defined <u>variables</u>. They are stored as an array.

9.2.4.1.13 :VNAMe?   NVAR?

SCPI: :FETCh[:SCALar]:VNAMe? /qonly/ <string program data> | :READ[:SCALar]:VNAMe? /qonly/ <string program data>
SHORT: NVAR? /qonly/ <string program data>

ID:		Mode:	All
Type:	float	Suffix:	n/a
Value:	n/a	List:	n/a
Unit:	n/a	Group:	n/a

Reads the value of the user defined <u>variable</u> whose name was sent as <string program data>.

Example: You have a variable 'abc'. This can be read by NVAR? „abc".

9.2.4.1.14 [:VOLTage]

:CALCulate

:DISPlay		
:FETCh →	**[:SCALar]** →	:CURRent
:FORMat		:CYCLe
:INITiate		:DINPut
:INPut		:ENERgy
:INSTrument		:FLICker
:MEMory		:FREQuency
:READ →		:HARMonics
:SENSe		:POWer
:SOURce		:RESistance
:STATus		:SSYStem
:SYSTem		:VARiable
:TRIGger		**[:VOLTage]** →

		:AC
		:AINPut
		:CFACtor
		:DC
		:FFACtor
		:INRush
		:MAXPk
		:MINPk
		:PPEak
		:RECTify
		:RUSed
		[:TRMS]

9.2.4.1.14.1 :AC?   UAC?   Uac

SCPI: :FETCh[:SCALar][:VOLTage]:AC? /qonly/ | :READ[:SCALar][:VOLTage]:AC? /qonly/
SHORT: UAC? /qonly/

ID:	Uac		Mode:	Normal, CE-Harm
Type:	float		Suffix:	1...14
Value:	n/a		List:	n/a
Unit:	V		Group:	n/a

Reads the AC value of the voltage.

9.2.4.1.14.2 :AINPut?   AIVA?   Ain

SCPI: :FETCh[:SCALar][:VOLTage]:AINPut? /qonly/ | :READ[:SCALar][:VOLTage]:AINPut? /qonly/
SHORT: AIVA? /qonly/

ID:	Ain		Mode:	All
Type:	float		Suffix:	1...8
Value:	n/a		List:	n/a
Unit:	V		Group:	n/a

Reads the voltage of the analogue input of the processing signal interface.

9.2.4.1.14.3 :CFACtor?   UCF?   Ucf

SCPI: :FETCh[:SCALar][:VOLTage]:CFACtor? /qonly/ |
         :READ[:SCALar][:VOLTage]:CFACtor? /qonly/
SHORT: UCF? /qonly/

ID:	Ucf		Mode:	Normal
Type:	float		Suffix:	1...14
Value:	n/a		List:	n/a

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Unit: n/a   Group: n/a

Reads the <u>crest factor</u> of the <u>voltage</u>.

9.2.4.1.14.4 :DC?   UDC?   Udc

SCPI: :FETCh[:SCALar][:VOLTage]:DC? /qonly/ | :READ[:SCALar][:VOLTage]:DC? /qonly/
SHORT: UDC? /qonly/

ID: Udc   Mode: Normal, CE-Harm
Type: float   Suffix: 1...14
Value: n/a   List: n/a
Unit: V   Group: n/a

Reads the <u>DC</u> value of the <u>voltage</u>.

9.2.4.1.14.5 :FFACtor?   UFF?   Uff

SCPI: :FETCh[:SCALar][:VOLTage]:FFACtor? /qonly/ |
          :READ[:SCALar][:VOLTage]:FFACtor? /qonly/
SHORT: UFF? /qonly/

ID: Uff   Mode: Normal
Type: float   Suffix: 1...14
Value: n/a   List: n/a
Unit: n/a   Group: n/a

Reads the <u>form factor</u> of the <u>voltage</u>.

9.2.4.1.14.6 :FSCale?   FSU?

SCPI: :FETCh[:SCALar][:VOLTage]:FSCale? /qonly/ |
          :READ[:SCALar][:VOLTage]:FSCale? /qonly/
SHORT: FSU? /qonly/

ID: n/a   Mode: All
Type: float   Suffix: 1...14
Value: n/a   List: n/a
Unit: V   Group: n/a

Reads the <u>full scale</u> value of the <u>voltage</u>.

9.2.4.1.14.7 :MAXPk?   UMAX?   Upkp

SCPI: :FETCh[:SCALar][:VOLTage]:MAXPk? /qonly/ |
          :READ[:SCALar][:VOLTage]:MAXPk? /qonly/
SHORT: UMAX? /qonly/

ID: Upkp   Mode: Normal
Type: float   Suffix: 1...14
Value: n/a   List: n/a
Unit: V   Group: n/a

Reads the biggest sample value of the voltage.

9.2.4.1.14.8 :MINPk?   UMIN?   Upkn

SCPI: :FETCh[:SCALar][:VOLTage]:MINPk? /qonly/ | :READ[:SCALar][:VOLTage]:MINPk? /qonly/
SHORT: UMIN? /qonly/

ID:	Upkn		Mode:	Normal
Type:	float		Suffix:	1...14
Value:	n/a		List:	n/a
Unit:	V		Group:	n/a

Reads the smallest sample value of the voltage.

9.2.4.1.14.9 :PHASe?   UPHI?   Uphi

SCPI: :FETCh[:SCALar][:VOLTage]:PHASe? /qonly/ | :READ[:SCALar][:VOLTage]:MINPk? /qonly/
SHORT: UPHI? /qonly/

ID:	n/a		Mode:	Normal
Type:	float		Suffix:	1...14
Value:	n/a		List:	n/a
Unit:	°		Group:	n/a

Reads the phase angle of the voltage like displayed in the Fresnel diagram.

9.2.4.1.14.10 :PPEak?   UPP?   Upp

SCPI: :FETCh[:SCALar][:VOLTage]:PPEak? /qonly/ | :READ[:SCALar][:VOLTage]:PPEak? /qonly/
SHORT: UPP? /qonly/

ID:	Upp		Mode:	Normal
Type:	float		Suffix:	1...14
Value:	n/a		List:	n/a
Unit:	V		Group:	n/a

Reads the peak peak value of the voltage.

9.2.4.1.14.11 :RECTify?   UREC?   Urect

SCPI: :FETCh[:SCALar][:VOLTage]:RECTify? /qonly/ |
          :READ[:SCALar][:VOLTage]:RECTify? /qonly/
SHORT: UREC? /qonly/

ID:	Urect		Mode:	Normal
Type:	float		Suffix:	1...14
Value:	n/a		List:	n/a
Unit:	V		Group:	n/a

Reads the rectified value of the voltage.

9.2.4.1.14.12 :RUSed?   OVRU?   OvrU

SCPI: :FETCh[:SCALar][:VOLTage]:RUSed? /qonly/ |
         :READ[:SCALar][:VOLTage]:RUSed? /qonly/
SHORT: OVRU? /qonly/

ID:	OvrU	Mode:	All
Type:	float	Suffix:	1...14
Value:	in %	List:	n/a
Unit:	n/a	Group:	n/a

Reads the usage of the range in percent.

9.2.4.1.14.13 [:TRMS?]   UTRMS?   Utrms

SCPI: :FETCh[:SCALar][:VOLTage][:TRMS]? /qonly/ |
         :READ[:SCALar][:VOLTage][:TRMS]? /qonly/
SHORT: UTRMS? /qonly/

ID:	Utrms	Mode:	All
Type:	float	Suffix:	1...18
Value:	n/a	List:	n/a
Unit:	V	Group:	n/a

Reads the TRMS value of the voltage.

9.2.5   :FORMat commands

Here you can setup the output format.

```
:CALCulate
:DISPlay
:FETCh
:FORMat  →        :DATA
:INITiate
:INPut
:INSTrument
:MEMory
:READ
:SENSe
:SOURce
:STATus
:SYSTem
:TRIGger
```

9.2.5.1   :DATA   FRMT

SCPI: :FORMat:DATA/nquery/ <NRi>
SHORT: FRMT/nquery/ <NRi>

ID:	n/a	Mode:	All
Type:	long int	Suffix:	n/a
Value:	0, 1	List:	n/a
Unit:	n/a	Group:	n/a

Defines the <u>data output format</u>. Parameter is:

'0' or 'ASCII' for ASCII output [*RST default value]

'1' or 'PACKED' for a packed output.

In the packed output format the data are transmitted as 'defined length arbitrary block response data'. If the available buffer memory size is too small for the amount of data the LMG wants to send, the data flow will be split in several sequential blocks of data. There are three kinds of data in the blocks: ASCII data, long data (4 Byte) and float data (4 Byte). The numeric data are transferred, so that the receiving PC program can store the data directly in memory. The number 0x11223344 is arranged inside the block as 0x44 0x33 0x22 0x11. This is the order Intel based computers store the number. So if you want to read the number you can simply use a pointer to the input buffer and read the contents of the pointer.

The output changes after the end of the actual program message.

9.2.6   :INITiate commands

Here you can start or stop special actions.

```
:CALCulate
:DISPlay
:FETCh
:FORMat
:INITiate   →        :CONTinuous
:INPut               :COPY
:INSTrument          :IMMediate
:MEMory
:READ
:SENSe
:SOURce
:STATus
:SYSTem
:TRIGger
```

9.2.6.1   :CONTinuous   CONT

SCPI: :INITiate:CONTinuous <NRi>
SHORT: CONT <NRi>

ID:	n/a	Mode:	All
Type:	long int	Suffix:	n/a
Value:	0, 1	List:	n/a
Unit:	n/a	Group:	n/a

This activates or deactivates the <u>continuous execution</u> of the string defined with :TRIGger:ACTion or ACTN. The programmer should only use :FETCh commands, because when CONT is switched to 'ON', automatically an :INITiate:IMMediate is executed at the end of each cycle.

Parameter:
'ON' or '1' activates this mode
'OFF' or '0' deactivates this mode [*RST default value]

The standard defines, that instruments with sequential commands can only exit the 'ON' state
by the device clear command of the interface. This works also with this instrument. But
additionally you can exit the 'ON' state by setting it to 'OFF' with :INITiate:CONTinuouse or
CONT.

9.2.6.2 :COPY	COPY

SCPI: :INITiate:COPY/nquery/
SHORT: COPY/nquery/

ID:	n/a	Mode:	All
Type:	n/a	Suffix:	n/a
Value:	n/a	List:	n/a
Unit:	n/a	Group:	n/a

This forces an <u>actualisation of the values</u> to be read with the :FETCh commands. The copying
of the data is done immediately and not at the end of the measuring cycle (see also 9.2.6.3,
':IMMediate   INIM').

9.2.6.3 :IMMediate	INIM

SCPI: :INITiate:IMMediate/nquery/
SHORT: INIM/nquery/

ID:	n/a	Mode:	All
Type:	n/a	Suffix:	n/a
Value:	n/a	List:	n/a
Unit:	n/a	Group:	n/a

This forces an <u>actualisation of the values</u> to be read with the :FETCh commands. In general the
instrument measures continuous. After each cycle the measured values are copied into the
display memory. The values read by the :FETCh commands are taken from another copy of the
values. This copy is updated, whenever the :INITiate:IMMediate or INIM command is
executed. By this it is sure, that all values read with sequential :FETCh commands are from
one measuring cycle and belong together.

Please note, that the execution of this command lasts until the end of the cycle. This can take
up to one complete cycle. Please keep this in mind when setting any time-out for expecting the
answer of a following command.

Please take care to follow this rules:
1. Use just one INIM in one command string to the instrument.

2. Send a second INIM just when the request of the first INIM is answered.

9.2.7   :INPut commands

```
:CALCulate
:DISPlay
:FETCh
:FORMat
:INITiate
:INPut   →          :COUPling
:INSTrument
:MEMory
:READ
:SENSe
:SOURce
:STATus
:SYSTem
:TRIGger
```

9.2.7.1   :COUPling   SCPL

SCPI: :INPut:COUPling <NRi>[,<NRi>]
SHORT: SCPL <NRi>[,<NRi>]

ID:	n/a	Mode:	Normal, HARM100
Type:	long int	Suffix:	n/a
Value:	0, 1	List:	n/a
Unit:	n/a	Group:	optional [,<NRi>]; 0=A, 1=B

Sets or queries the setting of the signal coupling. Allowed values are:

'0' or 'ACDC' for AC+DC coupling [*RST default value]
'1' for AC coupling

9.2.8   :INSTrument commands

Here general set-ups of the instrument are done.

```
:CALCulate
:DISPlay
:FETCh
:FORMat
:INITiate
:INPut
:INSTrument   →   :SELect
:MEMory
:READ
:SENSe
:SOURce
:STATus
:SYSTem
:TRIGger
```

9.2.8.1   :SELect   MODE

SCPI: :INSTrument:SELect <NRi>

SHORT: MODE <NRi>

ID:	n/a	Mode:	All
Type:	long int	Suffix:	n/a
Value:	0...3	List:	n/a
Unit:	n/a	Group:	n/a

Sets or reads the <u>measuring mode</u>:

'0' or 'NORML' for normal measuring mode [*RST default value]

'1' or 'CEHRM' for CE harmonic measuring mode

'2' or 'CEFLK' for CE flicker measuring mode

'3' or 'HRMHUN' for 100 harmonics measuring mode

Hint

The execution of this command can take up to few seconds. The LMG works internally with a watchdog protection. To prevent that the watchdog becomes active, the 'MODE' command should be send as the only command in a message. Just the '*OPC?' can be added to get a feedback, if the command has finished ('MODE x;*OPC?').

9.2.9   :MEMory commands

```
:CALCulate
:DISPlay
:FETCh
:FORMat
:INITiate
:INPut
:INSTrument
:MEMory  →      :FREeze
:READ           :SSIZe
:SENSe
:SOURce
:STATus
:SYSTem
:TRIGger
```

9.2.9.1   :FREeze   FRZ

SCPI: :MEMory:FREeze <NRi>
SHORT: FRZ <NRi>

ID:	n/a	Mode:	All
Type:	long int	Suffix:	n/a
Value:	0, 1	List:	n/a
Unit:	n/a	Group:	n/a

<u>Freezes</u> the scope <u>RAM</u>. The scope has too much memory so it can't be copied each cycle into a separate buffer. For this reason you should set FRZ to ON when you want to readout the sample values of the scope. Parameter:

'ON' or '1' activates the freeze mode

'OFF' or '0' deactivates the freeze mode [*RST default value]

9.2.9.2   :SSIZe   GMEM

SCPI: :MEMory:SSIZe? /qonly/
SHORT: GMEM? /qonly/

ID: n/a   Mode: All
Type: long int   Suffix: n/a
Value: $0, 2^{16}, 2^{22}, 2^{23}$ List: n/a
Unit: n/a   Group: n/a

Reads the <u>size</u> of the sample value <u>memory</u> in number of sample values.

9.2.10   :SENSe commands

9.2.10.1   :AINPut

```
:CALCulate
:DISPlay
:FETCh
:FORMat
:INITiate
:INPut
:INSTrument
:MEMory
:READ
:SENSe   →      :AINPut  →       :FSCale
:SOURce          :ARON             :ZERO
:STATus          :AVERage
:SYSTem          :CURRent
:TRIGger         :FILTer
                 :FINPut
                 :FLICker
                 :HARMonics
                 :INTegral
                 :SWEep
                 :TRANsient
                 :VOLTage
                 :WAVeform
                 :WIRing
                 :ZPReject
```

9.2.10.1.1 :DIFFerential   AIDI

SCPI: :SENSe:AINPut:DIFFerential <NRi>
SHORT: AIDI <NRi>

ID: n/a   Mode: All
Type: long int   Suffix: n/a
Value: 0, 1 [*RST default value] = 1   List: n/a
Unit: n/a   Group: n/a

Sets or queries if the <u>analogue inputs</u> work as 8 <u>single ended</u> or as 4 <u>differential</u> inputs.

0:      Differential inputs

1:      Single ended inputs, [*RST default value]

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9.2.10.1.2 :FSCale   AIHI

SCPI: :SENSe:AINPut:FSCale <NRf>
SHORT: AIHI <NRf>

ID:	n/a	Mode:	All
Type:	float	Suffix:	1...8
Value:	n/a, [*RST default value] = 10	List:	n/a
Unit:	n/a	Group:	n/a

Sets or queries the setting of the <u>full scale</u> of the <u>analogue inputs</u>.

9.2.10.1.3 :ZERO   AILO

SCPI: :SENSe:AINPut:ZERO <NRf>
SHORT: AILO <NRf>

ID:	n/a	Mode:	All
Type:	float	Suffix:	1...8
Value:	n/a, [*RST default value] = 0	List:	n/a
Unit:	n/a	Group:	n/a

Sets or queries the setting of the <u>zero position</u> of the <u>analogue inputs</u>.

9.2.10.2 :ARON   ARON

SCPI: :SENSe:ARON <NRi>[,<NRi>]
SHORT: ARON <NRi>[,<NRi>]

ID:	n/a	Mode:	Normal
Type:	long int	Suffix:	n/a
Value:	0, 1	List:	n/a
Unit:	n/a	Group:	n/a

Sets or queries if the aron circuit should be used. Following values are allowed:

0:      No aron circuit is used

1:      Aron circuit is used, [*RST default value]

The optional [,<NRi>] specifies, if the master instrument (=0, default) or slave instrument (=1) should be setup.

9.2.10.3 :AVERage

:CALCulate
:DISPlay
:FETCh
:FORMat
:INITiate
:INPut
:INSTrument
:MEMory
:READ
:SENSe →   :AINPut
:SOURce   :ARON

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:STATus	**:AVERage** →	:COUNt
:SYSTem	:CURRent	
:TRIGger	:FILTer	
	:FINPut	
	:FLICker	
	:HARMonics	
	:INTegral	
	:SWEep	
	:TRANsient	
	:VOLTage	
	:WAVeform	
	:WIRing	
	:ZPReject	

9.2.10.3.1 :COUNt   AVER   Aver

SCPI: :SENSe:AVERage:COUNt <NRf>
SHORT: AVER <NRf>

ID:	Aver	Mode:	Normal
Type:	float	Suffix:	n/a
Value:	1...999, [*RST default value] = 1	List:	n/a
Unit:	n/a	Group:	n/a

Sets or queries the setting of the average parameter.

9.2.10.4 :CURRent

:CALCulate		
:DISPlay		
:FETCh		
:FORMat		
:INITiate		
:INPut		
:INSTrument		
:MEMory		
:READ		
:SENSe →	:AINPut	
:SOURce	:ARON	
:STATus	:AVERage	
:SYSTem	**:CURRent** →	:DETector
:TRIGger	:FILTer	:IDENtify
	:FINPut	:RANGe
	:FLICker	:SCALe
	:HARMonics	
	:INTegral	
	:SWEep	
	:TRANsient	
	:VOLTage	
	:WAVeform	
	:WIRing	
	:ZPReject	

9.2.10.4.1 :DELay   IDLY

SCPI: :SENSe:CURRent:DELay <NRi>
SHORT: IDLY <NRi>

ID:	n/a	Mode:	All
Type:	long int	Suffix:	1...8

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Value:	-2666...+2666, [*RST default value] = 0	List:	n/a
Unit:	ns	Group:	n/a

Reads and sets the <u>delay</u> of the <u>current input</u> in ns. Positive values symbolize a delay, negative values a negative delay!

Example: You have a current sensor with a group delay of +100ns. If you want to correct this group delay, you have to set the current delay to -100ns.

9.2.10.4.2 :DETector   IEXT

SCPI: :SENSe:CURRent:DETector <NRi>
SHORT: IEXT <NRi>

ID:	n/a	Mode:	All
Type:	long int	Suffix:	1...8
Value:	0...2	List:	n/a
Unit:	n/a	Group:	n/a

Reads and sets <u>internal</u> or <u>external</u> shunt <u>input</u>:

'0' or 'INT' for internal shunt at I* jack (current input) [*RST default value]

'1' or 'EXT' for external shunt input (voltage input, sensor input)

'2' for for internal shunt at I_{HF} jack (current input)

9.2.10.4.3 :IDENtify?   IDNI?

SCPI: :SENSe:CURRent:IDENtify? /qonly/
SHORT: IDNI? /qonly/

ID:	n/a	Mode:	All
Type:	string	Suffix:	1...8
Value:	n/a	List:	n/a
Unit:	n/a	Group:	n/a

Reads the <u>type</u> of the external <u>current sensor</u>.

9.2.10.4.4 :RANGe

:CALCulate			
:DISPlay			
:FETCh			
:FORMat			
:INITiate			
:INPut			
:INSTrument			
:MEMory			
:READ			
:SENSe →	:AINPut		
:SOURce	:ARON		
:STATus	:AVERage		
:SYSTem	**:CURRent** →	:DETector	
:TRIGger	:FILTer	**:RANGe** →	:AUTO
	:FINPut	:SCALe	:LINTern
	:FLICker		[:UPPer]

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```
                    :HARMonics
                    :INTegral
                    :SWEep
                    :TRANsient
                    :VOLTage
                    :WAVeform
                    :WIRing
                    :ZPReject
```

9.2.10.4.4.1 :AUTO   IAM

SCPI: :SENSe:CURRent:RANGe:AUTO <NRi>
SHORT: IAM <NRi>

ID:	n/a	Mode:	All
Type:	long int	Suffix:	1...8
Value:	0, 1	List:	n/a
Unit:	n/a	Group:	n/a

Reads and sets the status of the <u>autorange</u> function:

'0' or 'MANUAL' for manual range selection

'1' or 'AUTO' for automatic range selection [*RST default value]

9.2.10.4.4.2 :LINTern?   IILS?

SCPI: :SENSe:CURRent:RANGe:LINTern?/qonly/
SHORT: IILS/qonly/

ID:	n/a	Mode:	All
Type:	float	Suffix:	1...8
Value:	n/a	List:	n/a
Unit:	A	Group:	n/a

Reads a list with the <u>available ranges</u>. You get several numbers which are separated by colons ',’. The first number defines the number of following numbers. If you have selected external sensors, you get the list of their ranges.

9.2.10.4.4.3 [:UPPer]   IRNG   RngI

SCPI: :SENSe:CURRent:RANGe[:UPPer] <NRf>
SHORT: IRNG <NRf>

ID:	RngI	Mode:	All
Type:	float	Suffix:	1...8
Value:	n/a	List:	n/a
Unit:	A	Group:	n/a

Reads and sets the <u>range</u> for the <u>current</u> measurement. The parameter is the nominal value of the range.

9.2.10.4.5 :SCALe   ISCA   Iscal

SCPI: :SENSe:CURRent:SCALe <NRf>

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SHORT: ISCA <NRf>

ID:	Iscal	Mode:	All
Type:	float	Suffix:	1...8
Value:	n/a, [*RST default value] = 1.0	List:	n/a
Unit:	n/a	Group:	n/a

Reads and sets the <u>scaling</u> of the <u>current range</u>.

9.2.10.5 :FILTer

9.2.10.5.1 :AFILter   FAAF

SCPI: :SENSe:FILTer:AFILter <NRi>[,<NRi>]
SHORT: FAAF <NRi>[,<NRi>]

ID:	n/a	Mode:	HARM100
Type:	long int	Suffix:	n/a
Value:	0, 1	List:	n/a
Unit:	n/a	Group:	optional [,<NRi>]; 0=A, 1=B, ...

Reads and sets the <u>anti-aliasing-filter</u> settings:

0:       Anti aliasing filter manual setable (via FILT)

1:       Anti aliasing filter selection automaticaly [*RST default value]

9.2.10.5.2 [:LPASs]

```
:CALCulate
:DISPlay
:FETCh
:FORMat
:INITiate
:INPut
:INSTrument
:MEMory
:READ
:SENSe    →      :AINPut
:SOURce          :ARON
:STATus          :AVERage
:SYSTem          :CURRent
:TRIGger         :FILTer  →      [:LPASs]  →      [:STATe]
                 :FINPut
                 :FLICker
                 :HARMonics
                 :INTegral
                 :SWEep
                 :TRANsient
                 :VOLTage
                 :WAVeform
                 :WIRing
                 :ZPReject
```

9.2.10.5.2.1 [:STATe]   FILT

SCPI: :SENSe:FILTer[:LPASS][:STATe] <NRi>[,<NRi>]

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SHORT: FILT <NRi>[,<NRi>]

ID:	n/a	Mode:	Normal
Type:	long int	Suffix:	n/a
Value:	n/a	List:	n/a
Unit:	n/a	Group:	optional [,<NRi>]; 0=A, 1=B, ...

Reads and sets the <u>filter</u> settings:

0:	Filter off [*RST default value]
1:	Low pass 270kHz
2:	Low pass 150kHz
3:	Low pass 138kHz
4:	Low pass 90kHz
5:	Low pass 42kHz
6:	Low pass 30kHz
7:	Low pass 21kHz
9:	Low pass 11kHz
10:	Low pass 10kHz
11:	Low pass 9.2kHz
12:	Low pass 6kHz
14:	Low pass 2.8kHz
16:	Low pass 2kHz
17:	Low pass 1.4kHz
20:	Low pass 700Hz
22:	Low pass 350Hz
23:	Low pass 175Hz
24:	Low pass 87.5Hz
25:	Low pass 60Hz
26:	Low pass 30Hz

9.2.10.6 :FINPut

```
:CALCulate
:DISPlay
:FETCh
:FORMat
:INITiate
:INPut
:INSTrument
:MEMory
:READ
:SENSe  →        :AINPut
:SOURce          :ARON
:STATus          :AVERage
:SYSTem          :CURRent
:TRIGger         :FILTer
                 :FINPut  →        :SCALe
                 :FLICker
                 :HARMonics
                 :INTegral
```

```
                         :SWEep
                         :TRANsient
                         :VOLTage
                         :WAVeform
                         :WIRing
                         :ZPReject
```

9.2.10.6.1 :SCALe   DIFS

SCPI: :SENSe:FINPut:SCALe <NRf>
SHORT: DIFS <NRf>

ID:	n/a	Mode:	All
Type:	float	Suffix:	1, 2
Value:	n/a, [*RST default value] is 1.0	List:	n/a
Unit:	n/a	Group:	n/a

Sets or queries the setting of the scale of the frequency input.

9.2.10.7 :FLICker

```
:CALCulate
:DISPlay
:FETCh
:FORMat
:INITiate
:INPut
:INSTrument
:MEMory
:READ
:SENSe  →        :AINPut
:SOURce          :ARON
:STATus          :AVERage
:SYSTem          :CURRent
:TRIGger         :FILTer
                 :FINPut
                 :FLICker  →        :PERiods
                 :HARMonics         :STIMe
                 :INTegral
                 :SWEep
                 :TRANsient
                 :VOLTage
                 :WAVeform
                 :WIRing
                 :ZPReject
```

9.2.10.7.1 :PERiods   FLPS   FlkPer

SCPI: :SENSe:FLICker:PERiods <NRf>
SHORT: FLPS <NRf>

ID:	FlkPer	Mode:	Flicker
Type:	float	Suffix:	n/a
Value:	n/a, [*RST default value] = 12	List:	n/a
Unit:	n/a	Group:	n/a

Reads and sets the number of periods for flicker measuring.

9.2.10.7.2 :STIMe   FTIM

SCPI: :SENSe:FLICker:STIMe <NRi>
SHORT: FTIM <NRi>

ID:	n/a	Mode:	Flicker
Type:	long int	Suffix:	n/a
Value:	n/a, [*RST default value] = 600	List:	n/a
Unit:	s	Group:	n/a

Reads and sets the <u>short term flicker</u> measuring <u>time</u>.

9.2.10.8 :HARMonics

:CALCulate		
:DISPlay		
:FETCh		
:FORMat		
:INITiate		
:INPut		
:INSTrument		
:MEMory		
:READ		
:SENSe →	:AINPut	
:SOURce	:ARON	
:STATus	:AVERage	
:SYSTem	:CURRent	
:TRIGger	:FILTer	
	:FINPut	
	:FLICker	
	:HARMonics →	:FDIV
	:INTegral	:REFerence
	:SWEep	:SMOoth
	:TRANsient	:TIME
	:VOLTage	
	:WAVeform	
	:WIRing	
	:ZPReject	

9.2.10.8.1 :FDIV   FDIV

SCPI: :SENSe:HARMonics:FDIV <NRf>[,<NRi>]
SHORT: FDIV <NRf>[,<NRi>]

ID:	n/a	Mode:	HARM100
Type:	float	Suffix:	n/a
Value:	1...50, [*RST default value] = 1	List:	n/a
Unit:	n/a	Group:	optional [,<NRi>]; 0=A, 1=B, ...

Reads and sets the <u>frequency divider ratio</u>.

9.2.10.8.2 :ISTart   HNRZ

SCPI: :SENSe:HARMonics:ISTart <NRi>[,<NRi>]
SHORT: HNRZ <NRi>[,<NRi>]

ID:	n/a	Mode:	CE-Harm
Type:	long int	Suffix:	n/a

Value:	0...1000		List:	n/a
Unit:	n/a		Group:	optional [,<NRi>]; 0=A, 1=B, ...

Reads and sets the number of the <u>interharmonic</u> where the <u>analysis range</u> of the interharmonics starts.

9.2.10.8.3 :REFerence   HREF

SCPI: :SENSe:HARMonics:REFerence <NRi>[,<NRi>]
SHORT: HREF <NRi>[,<NRi>]

ID:	n/a		Mode:	HARM100
Type:	long int		Suffix:	n/a
Value:	0, 1, 20		List:	n/a
Unit:	n/a		Group:	optional [,<NRi>]; 0=A, 1=B, ...

Reads and sets the state of the <u>phase reference</u> for the harmonics and the Fresnel diagram. That defines if the basic wave of U, I or the synchronisation source is set to 0° as reference for the system:

‘0’   for U as reference [*RST default value]

‘1’   for I as reference

‘20’   for none (=synchronisation source) as reference

9.2.10.8.4 :SMOoth   SMOO

SCPI: :SENSe:HARMonics:SMOoth <NRi>
SHORT: SMOO <NRi>

ID:	n/a		Mode:	CE-Harm
Type:	long int		Suffix:	n/a
Value:	0, 1		List:	n/a
Unit:	n/a		Group:	n/a

Reads and sets the state of the <u>smoothing</u>:

‘0’ or ‘OFF’ for direct measuring [*RST default value]

‘1’ or ‘ON’ for smoothed measuring

9.2.10.8.5 :TIME   HTIM

SCPI: :SENSe:HARMonics:TIME <NRi>
SHORT: HTIM <NRi>

ID:	n/a		Mode:	CE-Harm
Type:	long int		Suffix:	n/a
Value:	n/a, [*RST default value] = 150		List:	n/a
Unit:	s		Group:	n/a

Reads and sets the <u>harmonics measuring time</u>.

9.2.10.9 :INTegral

```
:CALCulate
:DISPlay
:FETCh
:FORMat
:INITiate
:INPut
:INSTrument
:MEMory
:READ
:SENSe   →         :AINPut
:SOURce            :ARON
:STATus            :AVERage
:SYSTem            :CURRent
:TRIGger           :FILTer
                   :FINPut
                   :FLICker
                   :HARMonics
                   :INTegral   →      :DATE
                   :SWEep             :INTerval
                   :TRANsient         :MODE
                   :VOLTage           :STATe
                   :WAVeform          :TIME
                   :WIRing
                   :ZPReject
```

9.2.10.9.1 :DATE   INTD

SCPI: :SENSe:INTegral:DATE <NRf>,<NRf>,<NRf>
SHORT: INTD <NRf>,<NRf>,<NRf>

ID:	n/a	Mode:	Normal
Type:	n/a	Suffix:	n/a
Value:	n/a	List:	n/a
Unit:	n/a	Group:	n/a

Reads and sets the start date for an energy measurement. Example: INTD 2003,02,09 sets the date to the 9th February, 2003.

9.2.10.9.2 :INTerval   INTI

SCPI: :SENSe:INTegral:INTerval <NRi>
SHORT: INTI <NRi>

ID:	n/a	Mode:	Normal
Type:	long int	Suffix:	n/a
Value:	n/a	List:	n/a
Unit:	s	Group:	n/a

Reads and sets the time interval for an energy measurement.

9.2.10.9.3 :MODE   INTM

SCPI: :SENSe:INTegral:MODE <NRi>
SHORT: INTM <NRi>

ID:	n/a		Mode:	Normal
Type:	long int		Suffix:	n/a
Value:	0...4		List:	n/a
Unit:	n/a		Group:	n/a

Reads and sets the <u>integration mode</u>:

0=off [*RST default value]

1=continuous

2=interval

3=periodic

4=summing

9.2.10.9.4 :STATe?   INTS?

SCPI: :SENSe:INTegral:STATe? /qonly/
SHORT: INTS? /qonly/

ID:	n/a		Mode:	Normal
Type:	long int		Suffix:	n/a
Value:	0...5		List:	n/a
Unit:	n/a		Group:	n/a

Reads the <u>state</u> of the <u>energy</u> measurement:

0=Reset

1=Wait

2=Start

3=Run

4=Stop

5=Hold

9.2.10.9.5 :TIME   INTT

SCPI: :SENSe:INTegral:TIME <NRf>,<NRf>,<NRf>
SHORT: INTT <NRf>,<NRf>,<NRf>

ID:	n/a		Mode:	Normal
Type:	n/a		Suffix:	n/a
Value:	n/a		List:	n/a
Unit:	n/a		Group:	n/a

Reads and sets the <u>start time</u> for an <u>energy measurement</u>. Example: INTT 19,26,49 sets the time to 19:26:49.

9.2.10.10 :RPValues   RPHV

SCPI: :SENSe:RPValues <NRi>
SHORT: RPHV <NRi>

ID:	n/a		Mode:	All

Type:	long int		Suffix:	n/a
Value:	0, 1		List:	n/a
Unit:	n/a		Group:	n/a

By this you can deactivate the rejection of phantom values:

0:      Phantom values are displayed

1:      Phantom values are not displayed [*RST default value]

9.2.10.11 :SWEep

```
:CALCulate
:DISPlay
:FETCh
:FORMat
:INITiate
:INPut
:INSTrument
:MEMory
:READ
:SENSe  →      :AINPut
:SOURce        :ARON
:STATus        :AVERage
:SYSTem        :CURRent
:TRIGger       :FILTer
               :FINPut
               :FLICker
               :HARMonics
               :INTegral
               :SWEep  →      :TIME
               :TRANsient
               :VOLTage
               :WAVeform
               :WIRing
               :ZPReject
```

9.2.10.11.1 :TIME	**CYCL**	**Cycle**

SCPI: :SENSe:SWEep:TIME <NRf>
SHORT: CYCL <NRf>

ID:	Cycle		Mode:	Normal
Type:	float		Suffix:	n/a
Value:	0, 0.05...60, [*RST default value] = 0.5	List:	n/a
Unit:	s		Group:	n/a

Reads and sets the cycle time.

9.2.10.12 :TRANsient

```
:CALCulate
:DISPlay
:FETCh
:FORMat
:INITiate
:INPut
:INSTrument
```

```
:MEMory
:READ
:SENSe  →        :AINPut
:SOURce          :ARON
:STATus          :AVERage
:SYSTem          :CURRent
:TRIGger         :FILTer
                 :FINPut
                 :FLICker
                 :HARMonics
                 :INTegral
                 :SWEep
                 :TRANsient  →    :ACRegister
                 :VOLTage         :LIMita
                 :WAVeform        :LIMitb
                 :WIRing          :DURation
                 :ZPReject        :OCRegister
                                  :RTIMe
                                  :SIGNal
```

9.2.10.12.1 :ACRegister   TACR

SCPI: :SENSe:TRANsient:ACRegister <NRi>
SHORT: TACR <NRi>

ID:	n/a	Mode:	Normal
Type:	long int	Suffix:	1...8
Value:	0, 1	List:	n/a
Unit:	n/a	Group:	n/a

Reads and sets the <u>AND Condition:</u>

0:      No AND condition for this Trigger-Event [*RST default value]

1:      AND condition for this Trigger-Event

9.2.10.12.2 :ALIMit   TLIA

SCPI: :SENSe:TRANsient:ALIMit <NRf>
SHORT: TLIA <NRf>

ID:	n/a	Mode:	Normal
Type:	float	Suffix:	1...8
Value:	±1e9, [*RST default value] = 0	List:	n/a
Unit:	n/a	Group:	n/a

Reads and sets the <u>lower limit</u>.

9.2.10.12.3 :BLIMit   TLIB

SCPI: :SENSe:TRANsient:BLIMit <NRf>
SHORT: TLIB <NRf>

ID:	n/a	Mode:	Normal
Type:	float	Suffix:	1...8
Value:	±1e9, [*RST default value] = 0	List:	n/a
Unit:	n/a	Group:	n/a

Reads and sets the <u>upper limit</u>.

9.2.10.12.4 :FUNCtion   TFUN

SCPI: :SENSe:TRANsient:FUNCtion <NRi>
SHORT: TFUN <NRi>

ID:	n/a	Mode:	Normal
Type:	long int	Suffix:	1...8
Value:	0...3	List:	n/a
Unit:	n/a	Group:	n/a

Reads and sets the <u>function</u> of the <u>trigger events</u>:

0:      < lower limit [*RST default value]

1:      > upper limit

2:      Window out (which is < lower limit or > upper limit)

3:      Window in (which is > lower limit and < upper limit)

9.2.10.12.5 :DURation   TDUR

SCPI: :SENSe:TRANsient:DURation <NRf>
SHORT: TDUR <NRf>

ID:	n/a	Mode:	Normal
Type:	float	Suffix:	1...8
Value:	$1*10^{-6}$...9.9, [*RST default value]=$1*10^{-6}$	List:	n/a
Unit:	s	Group:	n/a

Reads and sets the <u>duration</u> of the event.

9.2.10.12.6 :OCRegister   TOCR

SCPI: :SENSe:TRANsient:OCRegister <NRi>
SHORT: TOCR <NRi>

ID:	n/a	Mode:	Normal
Type:	long int	Suffix:	1...8
Value:	0, 1; [*RST default value] = 0	List:	n/a
Unit:	n/a	Group:	n/a

Reads and sets the <u>OR Condition</u>:

0:      No OR condition for this Trigger-Event [*RST default value]

1:      OR condition for this Trigger-Event

9.2.10.12.7 :SIGNal   TSRC

SCPI: :SENSe:TRANsient:SIGNal <NRi>
SHORT: TSRC <NRi>

ID:	n/a	Mode:	Normal

Type:	long int	Suffix:	1...8
Value:	see below	List:	n/a
Unit:	n/a	Group:	n/a

Reads and sets the <u>trigger signal source</u>:

Channels 1 to 4		Channels 5 to 8	
u1:	100	u5:	104
u2:	101	u6:	105
u3:	102	u7:	106
u4:	103	u8:	107
u9:	110	u12:	113
u10:	111	u13:	114
u11:	112	u14:	115
i1:	200	i5:	204
i2:	201	i6:	205
i3:	202	i7:	206
i4:	203	i8:	207
i9:	210	i12:	213
i10:	211	i13:	214
i11:	212	i14:	215
p1:	300	p5:	304
p2:	301	p6:	305
p3:	302	p7:	306
p4:	303	p8:	307
p9:	310	p12:	313
p10:	311	p13:	314
p11:	312	p14:	315

9.2.10.13 :VOLTage

9.2.10.13.1 :DELay   UDLY

SCPI: :SENSe:VOLTage:DELay <NRi>
SHORT: UDLY <NRi>

ID:	n/a	Mode:	All
Type:	long int	Suffix:	1...8
Value:	-2666...+2666, [*RST default value] = 0	List:	n/a
Unit:	ns	Group:	n/a

Reads and sets the <u>delay</u> of the <u>voltage input</u> in ns. Positive values symbolize a delay, negative values a negative delay!

Example: You have a voltage sensor with a group delay of +150ns. If you want to correct this group delay, you have to set the voltage delay to -150ns.

9.2.10.13.2 :DETector   UEXT

SCPI: :SENSe:VOLTage:DETector <NRi>
SHORT: UEXT <NRi>

ID:	n/a	Mode:	All
Type:	long int	Suffix:	1...8
Value:	0, 1	List:	n/a
Unit:	n/a	Group:	n/a

Reads and sets the jack for the voltage input:

'0' or 'INT' for voltage at U* jack [*RST default value]

'1' or 'EXT' for voltage at U_{Sensor} (sensor input)

9.2.10.13.3 :IDENtify   IDNU

SCPI: :SENSe:VOLTage:IDENtify? /qonly/
SHORT: IDNU? /qonly/

ID:	n/a	Mode:	All
Type:	string	Suffix:	1...8
Value:	n/a	List:	n/a
Unit:	n/a	Group:	n/a

Reads the type of an external voltage sensor. The LMG will always return „No sensor input".

9.2.10.13.4 :RANGe

```
:CALCulate
:DISPlay
:FETCh
:FORMat
:INITiate
:INPut
:INSTrument
:MEMory
:READ
:SENSe      →     :AINPut
:SOURce           :ARON
:STATus           :AVERage
:SYSTem           :CURRent
:TRIGger          :FILTer
                  :FINPut
                  :FLICker
                  :HARMonics
                  :INTegral
                  :SWEep
                  :TRANsient
                  :VOLTage   →     :RANGe   →     :AUTO
                  :WAVeform        :SCALe         :LINTern
                  :WIRing                         [:UPPer]
                  :ZPReject
```

9.2.10.13.4.1 :AUTO   UAM

SCPI: :SENSe:VOLTage:RANGe:AUTO <NRi>
SHORT: UAM <NRi>

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ID:	n/a	Mode:	All
Type:	long int	Suffix:	1...8
Value:	0, 1	List:	n/a
Unit:	n/a	Group:	n/a

Reads and sets the status of the <u>autorange</u> function:

'0' or 'MANUAL' for manual range selection.

'1' or 'AUTO' for automatic range selection [*RST default value].

9.2.10.13.4.2 :LINTern?   UILS?

SCPI: :SENSe:VOLTage:RANGe:LINTern?/qonly/
SHORT: UILS?/qonly/

ID:	n/a	Mode:	All
Type:	float	Suffix:	1...8
Value:	n/a	List:	n/a
Unit:	V	Group:	n/a

Reads a list with the <u>available ranges</u>. You get several float numbers which are separated by colons ','. The first number defines the number of following numbers.

9.2.10.13.4.3 [:UPPer]   URNG   RngU

SCPI: :SENSe:VOLTage:RANGe[:UPPer] <NRf>
SHORT: URNG <NRf>

ID:	RngU	Mode:	All
Type:	float	Suffix:	1...8
Value:	n/a	List:	n/a
Unit:	V	Group:	n/a

Reads and sets the <u>range</u> for the <u>voltage</u> measurement. The parameter is the nominal value of the range.

9.2.10.13.5 :SCALe   USCA   Uscal

SCPI: :SENSe:VOLTage:SCALe <NRf>
SHORT: USCA <NRf>

ID:	Uscal	Mode:	All
Type:	float	Suffix:	1...8
Value:	n/a, [*RST default value] = 1	List:	n/a
Unit:	n/a	Group:	n/a

Reads and sets the <u>scaling</u> of the <u>voltage range</u>.

9.2.10.14 :WAVeform

:CALCulate
:DISPlay

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```
:FETCh
:FORMat
:INITiate
:INPut
:INSTrument
:MEMory
:READ
:SENSe    →        :AINPut
:SOURce            :ARON
:STATus            :AVERage
:SYSTem            :CURRent
:TRIGger           :FILTer
                   :FINPut
                   :FLICker
                   :HARMonics
                   :INTegral
                   :SWEep
                   :TRANsient
                   :VOLTage
                   :WAVeform   →    :CYCLes
                   :WIRing          :IUPDate
                   :ZPReject        :SATRigger
                                    :SBTRigger
                                    :SCTRigger
                                    :SRATe
                                    :WAVE
```

9.2.10.14.1 :DIVision   GBAS

SCPI: :SENSe:WAVeform:DIVision <NRf>
SHORT: GBAS <NRf>

ID:	n/a	Mode:	Normal
Type:	float	Suffix:	n/a
Value:	10e-6...1	List:	n/a
Unit:	s	Group:	n/a

Reads or sets the timebase of the scope display (1-2-5 division). By this the record rate will be changed (requestable via GFRQ command). The smalles possible timebase depends on the following circumstances:

- cycle time
- chosen filter
- number of channels.

See also 11.1.3, 'Hints for setting up the record rate of the scope'

9.2.10.14.2 :IUPDate   SACT

SCPI: :SENSe:WAVeform:IUPDate/nquery/ [<NRi>]
SHORT: SACT/nquery/ [<NRi>]

ID:	n/a	Mode:	All
Type:	n/a	Suffix:	n/a
Value:	n/a	List:	n/a
Unit:	n/a	Group:	optional [<NRi>], 0=A, 1=B, ...

Requests to update <u>the the information</u> about the scope data. Before this command you should set ':MEMory:FREeze ON'. After this command you can use ':SENS:WAV:SATR', ':SENS:WAV:SBTR' and ':SENS:WAV:SCTT'. This command itself doesn't return any values!

9.2.10.14.3 :SATRigger?   SATR?

SCPI: :SENSe:WAVeform:SATRigger? /qonly/ [<NRi>]
SHORT: SATR? /qonly/ [<NRi>]

ID:	n/a	Mode:	All
Type:	long int	Suffix:	n/a
Value:	n/a	List:	n/a
Unit:	n/a	Group:	optional [<NRi>], 0=A, 1=B, ...

Reads how many <u>sample</u> values are available <u>after</u> the <u>trigger</u> event. See also ':SENS:WAV:IUPD' for further information.

9.2.10.14.4 :SBTRigger?   SBTR?

SCPI: :SENSe:WAVeform:SBTRigger? /qonly/ [<NRi>]
SHORT: SBTR? /qonly/ [<NRi>]

ID:	n/a	Mode:	All
Type:	long int	Suffix:	n/a
Value:	n/a	List:	n/a
Unit:	n/a	Group:	optional [<NRi>], 0=A, 1=B, ...

Reads how many <u>sample</u> values are available <u>before</u> the <u>trigger</u> event. See also ':SENS:WAV:IUPD' for further information.

9.2.10.14.5 :SCTRigger?   SCTT?

SCPI: :SENSe:WAVeform:SCTRigger? /qonly/
SHORT: SCTT? /qonly/

ID:	n/a	Mode:	All
Type:	long int	Suffix:	n/a
Value:	$0...2^{31}-1$	List:	n/a
Unit:	n/a	Group:	n/a

Reads the <u>number</u> of the <u>sample</u> value <u>at the trigger</u>. See also ':SENS:WAV:IUPD' for further information. The sample values of the instrument are counted. At the end of each cycle this counter is stored and can be read by this command. The counter runs up to $2^{31}-1$ and starts then again at 0. See also 9.2.4.1.2.2, ':SNUMber?   SCTC?'

You always get the value of group A.

9.2.10.14.6 :SRATe?   GFRQ?

SCPI: :SENSe:WAVeform:SRATe? [<NRi>]/qonly/
SHORT: GFRQ? [<NRi>]/qonly/

ID:	n/a	Mode:	All
Type:	float	Suffix:	n/a
Value:	n/a	List:	n/a
Unit:	n/a	Group:	optional [<NRi>], 0=A, 1=B, ...

Reads the <u>record rate</u> of the sampled values.

9.2.10.14.7 :WAVE?   WAVE?

SCPI: :SENSe:WAVeform:WAVE? /qonly/ <NRi>,<list>
SHORT: WAVE? /qonly/ <NRi>,<list>

ID:	n/a	Mode:	All
Type:	float	Suffix:	1...14
Value:	n/a	List:	see below
Unit:	n/a	Group:	n/a

Before using this command you should freeze the memory with :MEMory:FREeze, to avoid
data losses at long transfer duration. Reads out <u>sample values</u> specified with <NRi>:

4:      i

5:      u

6:      p

The first allowed value in <list> is the value read by :SENSe:WAVeform:SBTRigger?, the last
allowed value that read by :SENSe:WAVeform:SATRigger?

9.2.10.15 :WIRing   WIRE

SCPI: :SENSe:WIRing <NRi>[,<NRi>]
SHORT: WIRE <NRi>[,<NRi>]

ID:	n/a	Mode:	Normal, HARM100
Type:	long int	Suffix:	n/a
Value:	0...5, 8...15	List:	n/a
Unit:	n/a	Group:	n/a

Sets or queries the <u>wiring</u> of the LMG. Following values are allowed (3 to 7 only with option
L45-O6 star to delta conversion!):

0:      Wiring '4+0'

1:      Wiring '3+1' [*RST default value with 4 installed channels]

2:      Wiring '2+2'

3:      Wiring '3+1, U*I*->UΔIΔ'

4:      Wiring '3+1, UΔI*->UΔIΔ'

5:      Wiring '3+1, UΔI*->U*I*'

6, 7:   not used

8:        Wiring '1+0' [*RST default value with 1 installed channel]

9:        Wiring '2+0'

10:       Wiring '1+1' [*RST default value with 2 installed channels]

11:       Wiring '3+0' [*RST default value with 3 installed channels]

12:       Wiring '3+0, U*I*->UΔIΔ'

13:       Wiring '3+0, UΔI*->UΔIΔ'

14:       Wiring '3+0, UΔI*->U*I*'

15:       Wiring '2+1'

The optional [,<NRi>] specifies, if the master instrument (=0, default) or slave instrument (=1) should be setup. If you request the wiring from the slave but there is no slave connected, the answer will be -1.

9.2.10.16 :ZPReject   ZSUP

SCPI: :SENSe:ZPReject <NRi>
SHORT: ZSUP <NRi>

ID:	n/a	Mode:	Normal
Type:	long int	Suffix:	n/a
Value:	0, 1	List:	n/a
Unit:	n/a	Group:	n/a

By this you can deactivate the zero point rejection. It is a long number with following meaning:

0:        Zero point rejection is switched off

1:        Zero point rejection is switched on [*RST default value]

9.2.11 :SOURce commands

:CALCulate
:DISPlay
:FETCh
:FORMat
:INITiate
:INPut
:INSTrument
:MEMory
:READ
:SENSe
:SOURce →   :DIGital
:STATus   :VOLTage
:SYSTem
:TRIGger

9.2.11.1 :DIGital

:CALCulate
:DISPlay
:FETCh
:FORMat
:INITiate
:INPut
:INSTrument

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```
:MEMory
:READ
:SENSe
:SOURce  →      :DIGital  →      :CONDition
:STATus          :VOLTage         :LIMit
:SYSTem                           :VALue
:TRIGger
```

9.2.11.1.1 :CONDition   DOCO

SCPI: :SOURce:DIGital:CONDition <NRi>
SHORT: DOCO <NRi>

ID: n/a   Mode: All
Type: long int   Suffix: 1...8
Value: 0...3   List: n/a
Unit: n/a   Group: n/a

Sets or queries the condition of the digital outputs. Possible parameters are:

0:       off [*RST default value]

1:       on

2:       >=

3:       <

9.2.11.1.2 :LIMit   DOLI

SCPI: :SOURce:DIGital:LIMit <NRf>
SHORT: DOLI <NRf>

ID: n/a   Mode: All
Type: float   Suffix: 1...8
Value: n/a, [*RST default value] = 0   List: n/a
Unit: n/a   Group: n/a

Sets or queries the setting of the limits of the digital outputs.

9.2.11.1.3 :VALue   DOIX

SCPI: :SOURce:DIGital:VALue <string>
SHORT: DOIX <string>

ID: n/a   Mode: All
Type: string   Suffix: 1...8
Value: n/a, [*RST default value] = 'Utrms'   List: n/a
Unit: n/a   Group: n/a

Sets or queries the setting of the value of the digital outputs. As <string> you have to enter the same string as you would enter when using the instrument without interface. So you have to sent a valid ID!

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9.2.11.2 :VOLTage

9.2.11.2.1 :SCALe

```
:CALCulate
:DISPlay
:FETCh
:FORMat
:INITiate
:INPut
:INSTrument
:MEMory
:READ
:SENSe
:SOURce   →        :DIGital
:STATus           :VOLTage  →     :SCALe  →        :FSCale
:SYSTem                           :VALue           :ZERO
:TRIGger
```

9.2.11.2.1.1 :FSCale   AOHI

SCPI: :SOURce:VOLTage:SCALe:FSCale <NRf>
SHORT: AOHI <NRf>

ID:	n/a	Mode:	All
Type:	float	Suffix:	1...8
Value:	n/a, [*RST default value] = 10	List:	n/a
Unit:	n/a	Group:	n/a

Sets or queries the setting of the <u>full scale</u> of the <u>analogue outputs</u>.

9.2.11.2.1.2 :ZERO   AOLO

SCPI: :SOURce:VOLTage:SCALe:ZERO <NRf>
SHORT: AOLO <NRf>

ID:	n/a	Mode:	All
Type:	float	Suffix:	1...8
Value:	n/a, [*RST default value] = 0	List:	n/a
Unit:	n/a	Group:	n/a

Sets or queries the setting of the <u>zero position</u> of the <u>analogue outputs</u>.

9.2.11.2.2 :VALue   AOIX

SCPI: :SOURce:VOLTage:VALue <string>
SHORT: AOIX <string>

ID:	n/a	Mode:	All
Type:	string	Suffix:	1...8
Value:	n/a, [*RST default value] = „Utrms"	List:	n/a
Unit:	n/a	Group:	n/a

Sets or queries the setting of the <u>value</u> of the <u>analogue outputs</u>. As <string> you have to enter the same string as you would enter when using the instrument without interface. So you have to send a valid ID!

9.2.12 :STATus commands

9.2.12.1 :OPERation

```
:CALCulate
:DISPlay
:FETCh
:FORMat
:INITiate
:INPut
:INSTrument
:MEMory
:READ
:SENSe
:SOURce
:STATus     →      :OPERation   →    :CONDition
:SYSTem            :PRESet            :ENABle
:TRIGger           :QUEStionable      [:EVENt]
                                      :NTRansition
                                      :PTRansition
```

9.2.12.1.1 :CONDition?   SOC?

SCPI: :STATus:OPERation:CONDition? /qonly/
SHORT: SOC? /qonly/

ID:	n/a	Mode:	All
Type:	long int	Suffix:	n/a
Value:	0...65535	List:	n/a
Unit:	n/a	Group:	n/a

Reads the <u>Operation Status Condition Register</u>.

9.2.12.1.2 :ENABle   SOEN

SCPI: :STATus:OPERation:ENABle <NRi>
SHORT: SOEN <NRi>

ID:	n/a	Mode:	All
Type:	long int	Suffix:	n/a
Value:	0...65535	List:	n/a
Unit:	n/a	Group:	n/a

Reads and sets the <u>Operation Status Enable Register</u>.

9.2.12.1.3 [:EVENt]?   SOE?

SCPI: :STATus:OPERation[:EVENt]? /qonly/
SHORT: SOE? /qonly/

ID:	n/a		Mode:	All
Type:	long int		Suffix:	n/a
Value:	0...65535		List:	n/a
Unit:	n/a		Group:	n/a

Reads the Operation Status Event Register and clears it.

9.2.12.1.4 :NTRansition   SONT

SCPI: :STATus:OPERation:NTRansition <NRi>
SHORT: SONT <NRi>

ID:	n/a		Mode:	All
Type:	long int		Suffix:	n/a
Value:	0...65535		List:	n/a
Unit:	n/a		Group:	n/a

Reads and sets the Operation Status Negative Transition Register.

9.2.12.1.5 :PTRansition   SOPT

SCPI: :STATus:OPERation:PTRansition <NRi>
SHORT: SOPT <NRi>

ID:	n/a		Mode:	All
Type:	long int		Suffix:	n/a
Value:	0...65535		List:	n/a
Unit:	n/a		Group:	n/a

Reads and sets the Operation Status Positive Transition Register.

9.2.12.2 PRESet   PRES

SCPI: :STATus:PRESet/nquery/
SHORT: PRES/nquery/

ID:	n/a		Mode:	All
Type:	n/a		Suffix:	n/a
Value:	n/a		List:	n/a
Unit:	n/a		Group:	n/a

Presets the operation and the query registers. The p-transition registers are filled with 0x7FFF, the n-transition registers with 0x0000 and the enable registers with 0x0000.

9.2.12.3 :QUEStionable

:CALCulate
:DISPlay
:FETCh
:FORMat
:INITiate
:INPut
:INSTrument

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```
:MEMory
:READ
:SENSe
:SOURce
:STATus    →        :OPERation
:SYSTem             :PRESet
:TRIGger            :QUEStionable →   :CONDition
                                      :ENABle
                                      [:EVENt]
                                      :NTRansition
                                      :PTRansition
```

9.2.12.3.1 :CONDition?   SQC?

SCPI: :STATus:QUEStionable:CONDition? /qonly/
SHORT: SQC? /qonly/

ID:	n/a	Mode:	All
Type:	long int	Suffix:	n/a
Value:	0...65535	List:	n/a
Unit:	n/a	Group:	n/a

Reads the Questionable Status Condition Register.

9.2.12.3.2 :ENABle   SQEN

SCPI: :STATus:QUEStionable:ENABle <NRi>
SHORT: SQEN <NRi>

ID:	n/a	Mode:	All
Type:	long int	Suffix:	n/a
Value:	0...65535	List:	n/a
Unit:	n/a	Group:	n/a

Reads and sets the Questionable Status Enable Register.

9.2.12.3.3 [:EVENt]?   SQE?

SCPI: :STATus:QUEStionable[:EVENt]? /qonly/
SHORT: SQE? /qonly/

ID:	n/a	Mode:	All
Type:	long int	Suffix:	n/a
Value:	0...65535	List:	n/a
Unit:	n/a	Group:	n/a

Reads the Questionable Status Event Register and clears it.

9.2.12.3.4 :NTRansition   SQNT

SCPI: :STATus:QUEStionable:NTRansition <NRi>
SHORT: SQNT <NRi>

ID:	n/a	Mode:	All
Type:	long int	Suffix:	n/a

Value:	0...65535		List:	n/a
Unit:	n/a		Group:	n/a

Reads and sets the <u>Questionable Status Negative Transition Register</u>.

9.2.12.3.5 :PTRansition   SQPT

SCPI: :STATus:QUEStionable:PTRansition <NRi>
SHORT: SQPT <NRi>

ID:	n/a		Mode:	All
Type:	long int		Suffix:	n/a
Value:	0...65535		List:	n/a
Unit:	n/a		Group:	n/a

Reads and sets the <u>Questionable Status Positive Transition Register</u>.

9.2.13 :SYSTem commands

9.2.13.1 :BEEPer

```
:CALCulate
:DISPlay
:FETCh
:FORMat
:INITiate
:INPut
:INSTrument
:MEMory
:READ
:SENSe
:SOURce
:STATus
:SYSTem   →     :BEEPer   →         :IMMediate
:TRIGger        :DATE
                :ERRor
                :HELP
                :KEY
                :LANGuage
                :OPTions
                :PHEADER
                :TIME
                :VERSion
```

9.2.13.1.1 :IMMediate   BEEP

SCPI: :SYSTem:BEEPer:IMMediate/nquery/
SHORT: BEEP/nquery/

ID:	n/a		Mode:	All
Type:	n/a		Suffix:	n/a
Value:	n/a		List:	n/a
Unit:	n/a		Group:	n/a

Forces the internal <u>beeper</u> to produce a short sound.

9.2.13.2 :DATE	DATE

SCPI: :SYSTem:DATE <NRf>,<NRf>,<NRf>
SHORT: DATE <NRf>,<NRf>,<NRf>

ID:	n/a	Mode:	All
Type:	n/a	Suffix:	n/a
Value:	n/a	List:	n/a
Unit:	n/a	Group:	n/a

Reads and sets the <u>system date</u>. Format is DATE yyyy,mm,dd. Example: DATE 2003,02,09 sets the date to the 9th February, 2003.

9.2.13.3 :ERRor

Following errors can occur:

No.	Name	Possible reason; what to do
8	Overrun error at CONT ON	Too many values were requested in a too short time
7	Nested TRIGger:ACTion not allowed	
6	Action Buffer Overrun	Too many commands after the TRIGger:ACTion command
5	Command header error; (or maybe wrong path before)	Not existing or misspelled command or wrong SCPI path
4	Formatter output has overrun	Internal error, please contact ZES
2	Parser output has overrun	Internal error, please contact ZES
1	Parser deadlocked	Internal error, please contact ZES
0	No error	-
-101	Invalid character	A '(' or ')' is missing in a <list>
-103	Invalid separator	A wrong character instead of the expected separator (',', ';', ':', '<EOS>', ...)
-110	Command header error	Not existing or misspelled command
-113	Undefined header	There are no default commands to complete the header automatically. You have to enter the complete command
-120	Numeric data error	A number was expected but not send
-123	Exponent too large	Exponent is > 37
-124	Too many digits	Number has more than 9 digits
-131	Invalid suffix	Suffix too big or small
-150	String data error	A'"' is missing
-221	Settings conflict	Setting at the moment impossible. For example to change a measuring range while autorange is active
-222	Data out of range	Happens for example at invalid <list> entries

No.	Name	Possible reason; what to do
-224	Illegal parameter value	Happens for example if you want to change to the (not existing) measuring mode 27
other	Illegal error, please inform your supplier	An error in the internal error handling. Please contact ZES

```
:CALCulate
:DISPlay
:FETCh
:FORMat
:INITiate
:INPut
:INSTrument
:MEMory
:READ
:SENSe
:SOURce
:STATus
:SYSTem  →       :BEEPer
:TRIGger         :DATE
                 :ERRor  →        :ALL
                 :HELP            :COUNt
                 :KEY             [:NEXT]
                 :LANGuage
                 :OPTions
                 :PHEADER
                 :TIME
                 :VERSion
```

9.2.13.3.1 :ALL?   ERRALL?

SCPI: :SYSTem:ERRor:ALL? /qonly/
SHORT: ERRALL? /qonly/

ID: n/a   Mode: All
Type: n/a   Suffix: n/a
Value: n/a   List: n/a
Unit: n/a   Group: n/a

Reads <u>all errors</u>, including error code and error description, separated by colons out of the error/event queue.

9.2.13.3.2 :COUNt?   ERRCNT?

SCPI: :SYSTem:ERRor:COUNt? /qonly/
SHORT: ERRCNT? /qonly/

ID: n/a   Mode: All
Type: long int   Suffix: n/a
Value: n/a   List: n/a
Unit: n/a   Group: n/a

Reads the <u>number of errors</u> in the error/event queue.

9.2.13.3.3 [:NEXT]?   ERR?

SCPI: :SYSTem:ERRor[:NEXT]? /qonly/
SHORT: ERR? /qonly/

ID:	n/a	Mode:	All
Type:	n/a	Suffix:	n/a
Value:	n/a	List:	n/a
Unit:	n/a	Group:	n/a

Reads the oldest entry from the error/event queue, including error code and error description, separated by colons (',').

9.2.13.4 :HELP

```
:CALCulate
:DISPlay
:FETCh
:FORMat
:INITiate
:INPut
:INSTrument
:MEMory
:READ
:SENSe
:SOURce
:STATus
:SYSTem  →      :BEEPer
:TRIGger        :DATE
                :ERRor
                :HELP     →      :HEADers
                :KEY             :SHEaders
                :LANGuage
                :OPTions
                :PHEADER
                :TIME
                :VERSion
```

9.2.13.4.1 :HEADers?   HEAD?

SCPI: :SYSTem:HELP:HEADers? /qonly/
SHORT: HEAD? /qonly/

ID:	n/a	Mode:	All
Type:	n/a	Suffix:	n/a
Value:	n/a	List:	n/a
Unit:	n/a	Group:	n/a

Returns a list of all SCPI headers. This list is a <defined length arbitrary block response data>. Because this command has a very special output format it should only be used stand alone.

9.2.13.4.2 :SHEaders?   SHEAD?

SCPI: :SYSTem:HELP:SHEaders? /qonly/ [<NRi>]
SHORT: SHEAD? /qonly/ [<NRi>]

ID:	n/a	Mode:	All

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Type:	n/a	Suffix:	n/a
Value:	n/a	List:	n/a
Unit:	n/a	Group:	n/a

Returns a <u>list</u> of all <u>SHORT headers</u>. This list is a <defined length arbitrary block response data>. Because this command has a very special output format it should only be used stand alone.

If the optional NRi is '0', then the output is according to SCPI standard. If it is '1' there are additional information in the format 'x;y t':

x, if specified, is the maximum suffix

;y, if specified, is the maximum index

t, if specified, is the data type

9.2.13.5 :KEY   KEY

SCPI: :SYSTem:KEY <NRi>
SHORT: KEY <NRi>

ID:	n/a	Mode:	All
Type:	long int	Suffix:	n/a
Value:	n/a	List:	n/a
Unit:	n/a	Group:	n/a

Queries the last pressed <u>key</u> or simulates the pressing of a key. Valid key numbers are:
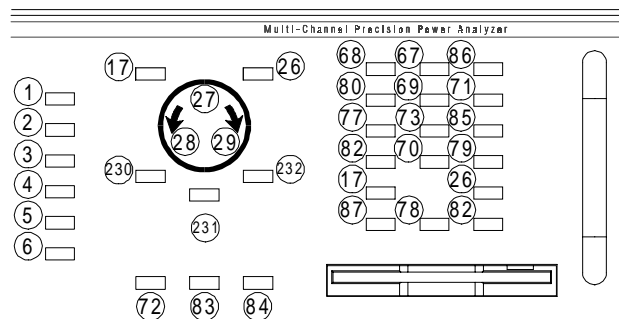
Figure 40: Keynumbers

Please note, that the rotary knob can just be set but not queried!

9.2.13.6 :LANGuage   LANG

SCPI: :SYSTem:LANGuage/nquery/ <NRi>
SHORT: LANG/nquery/ <NRi>

ID:	n/a	Mode:	All
Type:	long int	Suffix:	n/a
Value:	0, 1	List:	n/a
Unit:	n/a	Group:	n/a

Changes the command set to be used. Parameter can be:

'0' or 'SCPI' to go to the SCPI command set

'1' or 'SHORT' to go to the SHORT command set

The new language will be used beginning with the following command header.

There is no *RST default value! The language at power up will be SCPI. A 'device clear' or 'BREAK' will also select SCPI.

9.2.13.7 :OPTions?   OPTN?

SCPI: :SYSTem:OPTions? /qonly/
SHORT: OPTN/qonly/

ID:	n/a	Mode:	All
Type:	long int	Suffix:	n/a
Value:	$0...2^{23}-1$	List:	n/a
Unit:	n/a	Group:	n/a

Reads the installed options inside the LMG. The return value is a long parameter where the bits have following function (bit set = option installed):

Bit 0: COM A interface

Bit 1: COM B interface

Bit 2: Printer interface

Bit 3: IEEE488.2 interface

Bit 5: Floppy disk drive

Bit 6: Processing signal interface

Bit 8: Flicker

Bit 9: Harm100

Bit 16: Linked values

Bit 17: CE Harmonics

Bit 19: Ethernet LAN

Bit 24: USB interface

Bit 25-27: 3 bit with the number of installed power measuring channels

Bit 28-31: 4 bit with the number of installed DSP

9.2.13.8 :PHEader   PHDR

SCPI: :SYSTem:PHEader <string program data>
SHORT: PHDR <string program data>

ID:	n/a	Mode:	All
Type:	string	Suffix:	n/a
Value:	n/a	List:	n/a
Unit:	n/a	Group:	n/a

Sets or reads the printer header. At *RST this value is deleted.

For example
PHDR „HELLO"
would cause to output „HELLO" before each printing.

9.2.13.9 :TIME   TIME

SCPI: :SYSTem:TIME <NRf>,<NRf>,<NRf>
SHORT: TIME <NRf>,<NRf>,<NRf>

ID:	n/a	Mode:	All
Type:	n/a	Suffix:	n/a
Value:	n/a	List:	n/a
Unit:	n/a	Group:	n/a

Reads and sets the system time. Format is TIME hh,mm,ss. Example: TIME 10,26,46 sets the
time to 10:26:46.

9.2.13.10 :VERSion?   VER?

SCPI: :SYSTem:VERSion? /qonly/
SHORT: VER? /qonly/

ID:	n/a	Mode:	All
Type:	n/a	Suffix:	n/a
Value:	1999.0	List:	n/a
Unit:	n/a	Group:	n/a

Returns the version of the SCPI implementation. Returns always '1999.0'.

9.2.14 :TRIGger commands

```
:CALCulate
:DISPlay
:FETCh
:FORMat
:INITiate
:INPut
:INSTrument
:MEMory
:READ
:SENSe
:SOURce
:STATus
:SYSTem
:TRIGger   →      :ACTion
                  :ICURrent
                  :INTerval
                  [:SEQuence]
```

9.2.14.1 :ACTion   ACTN

SCPI: :TRIGger:ACTion/nquery/
SHORT: ACTN/nquery/

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ID:	n/a	Mode:	All
Type:	n/a	Suffix:	n/a
Value:	n/a	List:	n/a
Unit:	n/a	Group:	n/a

Defines an <u>action</u> which has to be performed, when :INIT:CONT is set to ON and a trigger event occurs. All program headers which follow behind the ';' after TRIG:ACT will be used, until the end of the program message.

Example: ACTN;UTRMS?;ITRMS?

This defines that each time a trigger event occurs in the INIT:CONT ON state, the TRMS values of voltage and current are returned. See also 9.2.6.1, ':CONTinuous   CONT'. The same example in SCPI syntax would be.

:TRIG:ACT;:FETC:TRMS?;:FETC:CURR:TRMS?

There is no *RST default value!

9.2.14.2 :ICURrent   IINC

SCPI: :TRIGger:ICURrent/nquery/
SHORT: IINC/nquery/

ID:	n/a	Mode:	All
Type:	n/a	Suffix:	n/a
Value:	n/a	List:	n/a
Unit:	n/a	Group:	n/a

Triggers the measuring of the inrush current. The value for the inrush current is reset to 0. See also 9.2.4.1.1.6

9.2.14.3 :INTerval

```
:CALCulate
:DISPlay
:FETCh
:FORMat
:INITiate
:INPut
:INSTrument
:MEMory
:READ
:SENSe
:SOURce
:STATus
:SYSTem
:TRIGger   →      :ACTion
                  :ICURrent
                  :INTerval   →      :RESet
                  [:SEQuence]        :STARt
                                     :STOP
```

9.2.14.3.1 :RESet   RESET

SCPI: :TRIGger:INTerval:RESet/nquery/
SHORT: RESET/nquery/

ID: n/a   Mode: Normal
Type: n/a   Suffix: n/a
Value: n/a   List: n/a
Unit: n/a   Group: n/a

Resets the energy measurement.

9.2.14.3.2 :STARt   START

SCPI: :TRIGger:INTerval:STARt/nquery/
SHORT: START/nquery/

ID: n/a   Mode: Normal, CE-Harm, Flicker
Type: n/a   Suffix: n/a
Value: n/a   List: n/a
Unit: n/a   Group: n/a

Starts a time dependent measuring (e.g. energy, flicker, ...)

9.2.14.3.3 :STOP   STOP

SCPI: :TRIGger:INTerval:STOP/nquery/
SHORT: STOP/nquery/

ID: n/a   Mode: Normal, CE-Harm, Flicker
Type: n/a   Suffix: n/a
Value: n/a   List: n/a
Unit: n/a   Group: n/a

Stops a time dependent measuring (e.g. energy, flicker, ...)

9.2.14.3.4 :TREStart   TRST

SCPI: :TRIGger:INTerval:TREStart/nquery/
SHORT: START/nquery/

ID: n/a   Mode: Normal
Type: n/a   Suffix: n/a
Value: n/a   List: n/a
Unit: n/a   Group: n/a

(Re)starts the transient search.

9.2.14.3.5 :TSTop   TSTP

SCPI: :TRIGger:INTerval:TSTop/nquery/
SHORT: TSTP/nquery/

ID:	n/a		Mode:	Normal
Type:	n/a		Suffix:	n/a
Value:	n/a		List:	n/a
Unit:	n/a		Group:	n/a

Stops a transient search.

9.2.14.4 [:SEQuence]

```
:CALCulate
:DISPlay
:FETCh
:FORMat
:INITiate
:INPut
:INSTrument
:MEMory
:READ
:SENSe
:SOURce
:STATus
:SYSTem
:TRIGger   →      :ACTion
                  :ICURrent
                  :INTerval
                  [:SEQuence]  →   :DEModulator
                                   :HPASs
                                   :LPASs
                                   :SOURce
```

9.2.14.4.1 :DEModulator   TRGA

SCPI: :TRIGger[:SEQuence]:DEModulator <NRi>[,<NRi>]
SHORT: TRGA <NRi>[,<NRi>]

ID:	n/a		Mode:	Normal, HARM100
Type:	long int		Suffix:	n/a
Value:	0...2		List:	n/a
Unit:	n/a		Group:	optional [,<NRi>], 0=A, 1=B, ...

Sets or reads the AM demodulator setting. Possible values are:

0 for demodulator switched off [*RST default value]

1 for AM-demodulator with carrier < 1kHz

2 for AM-demodulator with carrier > 1kHz

9.2.14.4.2 :HPASs   TRGP

SCPI: :TRIGger[:SEQuence]:HPASs <NRi>[,<NRi>]
SHORT: TRGP <NRi>[,<NRi>]

ID:	n/a		Mode:	Normal, HARM100
Type:	long int		Suffix:	n/a
Value:	0...2		List:	n/a
Unit:	n/a		Group:	optional [,<NRi>], 0=A, 1=B, ...

Sets or reads the <u>synchronisation highpass</u>. Possible values are:

0   switched off [*RST default value]

1   >0.5Hz

2   >30Hz

9.2.14.4.3 :LPASs   TRGT

SCPI: :TRIGger[:SEQuence]:LPASs <NRi>[,<NRi>]
SHORT: TRGT <NRi>[,<NRi>]

ID:	n/a	Mode:	Normal, HARM100
Type:	long int	Suffix:	n/a
Value:	see below	List:	n/a
Unit:	n/a	Group:	optional [,<NRi>], 0=A, 1=B, ...

Sets or reads the <u>synchronisation low pass</u>. Possible values are:

0   switched off [*RST default value]

5   5Hz

10   10Hz

20   20Hz

50   50Hz

100   100Hz

200   200Hz

500   500Hz

1000   1kHz

2000   2kHz

5000   5kHz

10000 10kHz

20000 20kHz

50000 50kHz

9.2.14.4.4 :SOURce   SYNC

SCPI: :TRIGger[:SEQuence]:SOURce <NRi>[,<NRi>]
SHORT: SYNC <NRi>[,<NRi>]

ID:	n/a	Mode:	Normal, HARM100
Type:	long int	Suffix:	n/a
Value:	0...4	List:	n/a
Unit:	n/a	Group:	optional [,<NRi>], 0=A, 1=B, ...

Sets or reads the <u>synchronisation source</u>. Possible values are:

'0' or 'LINE' for line synchronisation

'1' or 'EXTS' for external synchronisation

'2' for synchronisation to the voltage signal U1 [*RST default value]

'3' for synchronisation to the current signal I1

'4' for synchronisation to the voltage signal U2

'5' for synchronisation to the current signal I2

'6' for synchronisation to the voltage signal U3

'7' for synchronisation to the current signal I3

'8' for synchronisation to the voltage signal U4

'9' for synchronisation to the current signal I4

'10' for synchronisation to the voltage signal U5

'11' for synchronisation to the current signal I5

'12' for synchronisation to the voltage signal U6

'13' for synchronisation to the current signal I6

'14' for synchronisation to the voltage signal U7

'15' for synchronisation to the current signal I7

'16' for synchronisation to the voltage signal U8

'17' for synchronisation to the current signal I8

Note

Only values which are members of a group are valid. If you have a wiring 3+1, you can't select signal U4 for group A!

9.2.14.5 :CONTrol   TCTL

SCPI: :TRIGger:TRANsient:CONTrol <NRi>
SHORT: TCTL <NRi>

ID:	n/a	Mode:	Normal
Type:	long int	Suffix:	n/a
Value:	0, 1	List:	n/a
Unit:	n/a	Group:	n/a

Controls the <u>transient search</u>. Possible values are:

0: Stop

1: Start

9.2.15 Special commands

9.2.15.1 :GTL   GTL

SCPI: :GTL /nquery/
SHORT: GTL /nquery/

ID:	n/a	Mode:	All
Type:	n/a	Suffix:	n/a
Value:	n/a	List:	n/a
Unit:	n/a	Group:	n/a

Sets the instrument back to the local state (**go t**o **l**ocal). This should be the last command of a remote control sequence

9.2.15.2 :LEN	LEN

SCPI: :LEN/nquery/
SHORT: LEN/nquery/

ID:	n/a	Mode:	All
Type:	n/a	Suffix:	n/a
Value:	n/a	List:	n/a
Unit:	n/a	Group:	n/a

Initiates the LMG´s remote state but adjustments made via the front panel keyboard of the meter will also be accepted (**l**ocal **en**able). It depends on the applications if it is useful or not.

9.2.16 Example 1

Following you find a small example for periodic data exchange via RS232 interface:

```
' QBasic 1.1
' Example for reading data from a LMG95/450/500
' LMG should be set to following:
' MEASURING Menu
' Normal measuring mode, 500ms cycle time
' IF/IO (OPTIONS) Menu
' Rmote Device: COM1 RS232
' Dev.: COM1: 9600 Baud, EOS <lf>, Echo off, Protocol None
' Connect COM1 of your PC to COM1 of LMG with a 1:1 cable (all pins
' connected, no NULL modem).

DECLARE FUNCTION readans$ ()
OPEN "COM1:9600,N,8,1,ASC,CD0,CS0,DS0,OP0,RS,TB2048,RB4096" FOR RANDOM AS #1
PRINT #1, "syst:lang short" + CHR$(10);    ' Change command set
PRINT #1, "actn;utrms?;itrms?" + CHR$(10); ' Request Utrms and Itrms
PRINT #1, "cont on" + CHR$(10);            ' Continue output
DO
   answer$ = readans$                      ' Read answer from LMG
   val1 = VAL(answer$)                      ' Calculate values
   val2 = VAL(MID$(answer$, 1 + INSTR(1, answer$, ";")))
   PRINT USING "Answer:& Value1: ###.###V Value2: ##.#####A"; readans$; val1; val2
LOOP UNTIL INKEY$ = CHR$(32)                ' Loop, until SPACE bar pressed
PRINT #1, "cont off" + CHR$(10);            ' Stop continue output
SLEEP 1
PRINT #1, "gtl" + CHR$(10);                 ' Go back to local mode
CLOSE #1

FUNCTION readans$
   answer$ = ""
   DO
      a$ = INPUT$(1, 1)                      ' Read character from interface
      IF a$ <> CHR$(10) THEN                 ' If it is not the EOS character
         answer$ = answer$ + a$              ' add character to answer string
      END IF
   LOOP WHILE a$ <> CHR$(10)                 ' Loop until EOS is reached
   readans$ = answer$                        ' return answer
END FUNCTION
```

9.2.17 Example 2

Following you find a small example for one time data exchange via RS232 interface.
Additionally to the SCPI commands you find the same functionality in SHORT syntax.

```
' QBasic 1.1
' Example for reading data from a LMG95/450/500
' LMG should be set to following:
' MEASURING Menu
' Normal measuring mode, 500ms cycle time
' IF/IO (OPTIONS) Menu
' Rmote Device: COM1 RS232
' Dev.: COM1: 9600 Baud, EOS <lf>, Echo off, Protocol None
' Connect COM1 of your PC to COM1 of LMG with a 1:1 cable (all pins
' connected, no NULL modem).

DECLARE FUNCTION readans$ ()
OPEN "COM1:9600,N,8,1,ASC,CD0,CS0,DS0,OP0,RS,TB2048,RB4096" FOR RANDOM AS #1
PRINT #1, "READ:CURRENT:TRMS;::FETCH:VOLTAGE:TRMS" + CHR$(10); 'Request values
(SCPI)
'PRINT #1, "SYST:LANG SHORT" + CHR$(10);          'Change Language to SHORT
'PRINT #1, "INIM;ITRMS?;UTRMS?" + CHR$(10);    'Request values (SHORT)
DO
   answer$ = readans$                         ' Read answer from LMG
   val1 = VAL(answer$)                         ' Calculate values
   val2 = VAL(MID$(answer$, 1 + INSTR(1, answer$, ";")))
   PRINT USING "Answer:& Value1: ##.####A Value2: ###.###V"; readans$; val1; val2
LOOP UNTIL INKEY$ = CHR$(32)                    ' Loop, until SPACE bar pressed
PRINT #1, "gtl" + CHR$(10);                     ' Go back to local mode
CLOSE #1

FUNCTION readans$
   answer$ = ""
   DO
     a$ = INPUT$(1, 1)                        ' Read character from interface
     IF a$ <> CHR$(10) THEN                   ' If it is not the EOS character
        answer$ = answer$ + a$                ' add character to answer string
     END IF
   LOOP WHILE a$ <> CHR$(10)                  ' Loop until EOS is reached
   readans$ = answer$                         ' return answer
END FUNCTION
```

9.2.18 Testing the interface using a terminal program

For testing the interface, or how any commands work it is recommended to use a terminal
program (e.g. Hyperterminal under WINDOWS).

Setup the instrument pressing *IF/IO* several times until you reach the IF/IO menu. With **IF** you
reach the setup menu. If the instrument should be in the remote state switch it back to local by
Goto Local. Choose the profile 'ComA: Terminal' and connect the ComA jack with a 1:1
cable to your PC.

Now setup you computer. Start you terminal program and set it up to 9600Baud, 8Data Bit,
1Stop Bit, No Parity and No Protocol. Select the correct com port of your computer.

If you now type in '*IDN?' and press Return, the status bar of LMG should change from 'Active Local' to 'Active Remote'. If not, check if the characters you typed in are echoed on your screen or not.

If everything is ok, then you get an answer string with the manufacturer, the device, the serial number and the software version.

If all this fails, check all settings and cables and try again.

9.2.19 SCPI command Example

This shows you as an example (in SCPI language), what you could send, what the instrument should answer and some comments about this. Some of the responses like measuring values depend on measured signals, so they may be different, if you try this examples. This examples work with a new powered on instrument (no commands before!). For testing some functions we recommend to use the RS232 interface, because it is much more simple to use than the IEEE interface. In principal the example works with both interfaces. This should help you to program your requests and to understand how to communicate with the instrument.

Two comments on the syntax in the 'Sent' column: A '∪' stands for a space character, a '↵' for the <cr> (carriage return) character (which is the enter key, if you use for example a RS232 terminal-program on your PC).

No.	Sent	Received	Comments
1	*rst↵		Reset the instrument to it's default values. After this first command the instrument changes to the remote state.
2	*idn?↵	ZES ZIMMER Electronic Systems GmbH, LMG500, serial number, version	You ask the instrument for it's identification.
3a	fetc:volt:trms**n**?↵	0	Reads out the voltage of channel **n(=1,2,...)**. You don't get the actual value, because there has been no values copied to the interface buffer
3b	read:volt:trms**n**?↵	220.34	Waits until the end of the measuring cycle, copies the values of channel **n** to the interface buffer and outputs the actual voltage
3c	fetc:volt:trms**n**?↵	220.34	No values were copied to the interface buffer, so you get the same result!

No.	Sent	Received	Comments
4a	read:volt:trms**n**?;:read:curr:trms**n**?↵	220.21;0.6437	Waits until the end of the measuring cycle, copies the values of channel **n** to the interface buffer and outputs the actual voltage. Then the instrument waits until the end of the next measuring cycle, copies the values to the interface buffer and outputs the actual current. The voltage and current are from **different** measuring cycles!!
4b	read:volt:trms**n**?;:fetc:curr:trms**n**?↵	221.13;0.6432	Waits until the end of the measuring cycle, copies the values of channel **n** to the interface buffer and outputs the actual voltage and current. The voltage and current are from the **same** measuring cycle!!
4c	read:volt:trms**n**?↵ fetc:curr:trms**n**?↵	217.75;0.6135	Waits until the end of the measuring cycle, copies the values to the interface buffer and outputs the actual voltage and current of channel **n**. The voltage and current are also from the **same** measuring cycle!!
5a	calc:form∪„Bpk=Urect/(4*f*3*0.0000916);↵ Hpk=Ipp/2*3/0.085608;↵ Ua=Bpk/1.2566e-6/Hpk;"↵		Enters the script between the „" signs. This script is stored in the script editor and executed from the next measuring cycle.
5b	read:var?∪(0:1)↵	3.4567,2.8405	Waits until the end of the measuring cycle, copies the values to the interface buffer and outputs the variables 0 to 1 (Bpk and Hpk). Both are from the **same** measuring cycle!!
6a	fetc:volt:trm3?↵		You misspelled the request
6b	syst:err:all?↵	command header error:TRM3	You ask the error queue what happened and get the answer. If you have misspelled more than this command, you get more answers.
7a	inst:sel∪1; *opc?↵		Switch to the CE harmonics mode
7b	read:harm:curr:ampl **n**?∪(3:5)↵	1.2346,00034,0.9984	Waits until the end of the measuring cycle, copies the values of channel **n** to the interface buffer and outputs the amplitudes of the current harmonics of order 3 to 5. All are from the **same** measuring cycle!!
7c	inst:sel∪norml; *opc?↵		switch back to the normal measuring mode
8a	trig:act;:fetc:volt:trms?;:fetc:pow?↵		Defines that the voltage and the power should be output after every measuring cycle, without any further request.

No.	Sent	Received	Comments
8b	init:cont⌣on↵	220.34;15.345 220.19;15.217	Activates this continuous output of the values defined with 'actn'. (until the CONT OFF command!)
8c	init:cont⌣off↵		stops the continuous output.
9a	mem:fre⌣on		freezes the scope memory
9b	sens:wav:iupd;:sens:wav:sbtr?⌣1;::sens:wav:satr?⌣1↵	-3204, +4506	calculates new information to the sampled values of group B (0 = group A, 1 = group B), reads how much values are stored before and after the trigger
9c	sens:wav:wave?⌣5,(-100:100)↵	220.45, 221.36 ... (comma separated one dimensioned array with the size 201)	Reads out the sampled values of the voltage
9d	mem:fre⌣off↵		deactivates the scope memory
10	gtl		Changes from the remote to the local state. So the instrument can be controlled manually

9.2.20 SHORT command Example

This shows you as an example (in SHORT language), what you could send, what the instrument should answer and some comments about this. Some of the responses like measuring values depend on measured signals, so they may be different, if you try this examples. This examples work with a new powered on instrument (no commands before!). For testing some functions we recommend to use the RS232 interface, because it is much more simple to use than the IEEE interface. In principal the example works with both interfaces. This should help you to program your requests and to understand how to communicate with the instrument.

Two comments on the syntax in the 'Sent' column: A '⌣' stands for a space character, a '↵' for the <cr> (carriage return) character (which is the enter key, if you use for example a RS232 terminal-program on your PC).

No.	Sent	Received	Comments
1	*rst↵		Reset the instrument to it's default values. After this first command the instrument changes to the remote state.
2	*idn?↵	ZES ZIMMER Electronic Systems GmbH, LMG500, serial number, version	You ask the instrument for it's identification.
3	syst:lang short↵		Switch to the SHORT command set
4a	utrms**n**?↵	0	Reads out the voltage of channel **n(=1,2,...)**. You don't get the actual value, because there has been no values copied to the interface buffer

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No.	Sent	Received	Comments
4b	inim;utrms**n**?↵	220.34	Waits until the end of the measuring cycle, copies the values of channel **n** to the interface buffer and outputs the actual voltage
4c	utrms**n**?↵	220.34	No values of channel **n** were copied to the interface buffer, so you get the same result!
5a	inim;utrms**n**?;inim;i trms**n**?↵	220.21;0.6437	Waits until the end of the measuring cycle, copies the values of channel **n** to the interface buffer and outputs the actual voltage. Then the instrument waits until the end of the next measuring cycle, copies the values to the interface buffer and outputs the actual current. The voltage and current are from **different** measuring cycles!!
5b	inim;utrms**n**?;itrms**n** ?↵	221.13;0.6432	Waits until the end of the measuring cycle, copies the values of channel **n** to the interface buffer and outputs the actual voltage and current. The voltage and current are from the **same** measuring cycle!!
5c	inim;utrms**n**?↵ itrms**n**?↵	217.75;0.6135	Waits until the end of the measuring cycle, copies the values of channel **n** to the interface buffer and outputs the actual voltage and current. The voltage and current are also from the **same** measuring cycle!!
6a	form⌣„Bpk=Urect/(4*f*3*0.0000916); ↵ Hpk=Ipp/2*3/0.0856 08;↵ Ua=Bpk/1.2566e- 6/Hpk;"↵		Enters the script between the „" signs. This script is stored in the script editor and executed from the next measuring cycle.
6b	inim;var?⌣(0:1)↵	3.4567,2.8405	Waits until the end of the measuring cycle, copies the values to the interface buffer and outputs the variables 0 to 1 (Bpk and Hpk). Both are from the **same** measuring cycle!!
7a	utrm3?↵		You misspelled the request
7b	errall?↵	command header error:UTRM	You ask the error queue what happened and get the answer. If you have misspelled more than this command, you get more answers.
8a	mode⌣1; *opc?↵		Switch to the CE harmonics mode
8b	INIM;HIAM?⌣(3:5)↵	1.2346,00034,0.9984	Waits until the end of the measuring cycle, copies the values to the interface buffer and outputs the amplitudes of the current harmonics of order 3 to 5. All are from the **same** measuring cycle!!

No.	Sent	Received	Comments
8c	mode∪norml; *opc?↵		switch back to the normal measuring mode
9a	actn;utrms**n**?;p**n**?↵		Defines that the voltage and the power of channel **n** should be output after every measuring cycle, without any further request.
9b	cont∪on↵	220.34;15.345 220.19;15.217	Activates this continuous output of the values defined with 'actn'. (until the CONT OFF command!)
9c	cont∪off↵		stops the continuous output.
10a	frz∪on		freezes the scope memory
10b	sact1;sbtr?∪1;satr?∪1↵	-3204, +4506	calculates new information to the sampled values of group B (0 = group A, 1 = group B), reads how much values are stored before and after the trigger
10c	wave1?∪5,(-100:100)↵	220.45, 221.36 ... (comma separated one dimensioned array with the size 201)	Reads out the sampled values of the voltage of channel 1
10d	frz∪off↵		deactivates the scope memory
11	gtl		Changes from remote to the local state. So the instrument can be controlled manually

9.3   Physical devices

The physical devices are the jacks at the rear panel of the instrument.

9.3.1   The serial interfaces

The most simple but universal interface. The LMG has build in two of them in the standard instrument.

Both can be used for data logging as well as for remote control. The maximum transfer rate is 115200 Baud. That are about 10000 characters per second. By this you are able to transfer also the very many harmonic values in real time to your PC.

Together with the BMP2PC software (available from our homepage) you can also get screen shots via the serial interface onto your PC.

With the same speed you can also remote control the instrument, send commands and get answers.

9.3.1.1 ComA, RS232

In this female connector a null modem is implemented. That means if you want to connect ComA of the LMG to a PC you have to use a cable which connects 1:1 (<u>without</u> a null modem function).
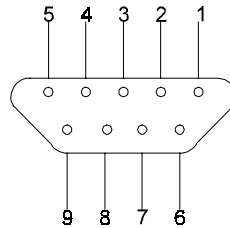
Figure 41: ComA connector

Pin	1	2	3	4	5	6	7	8	9
Comment	nc	TxD	RxD	nc	GND	nc	CTS	RTS	nc

9.3.1.2 ComB, RS232

In this male connector <u>no</u> null modem is implemented. That means if you want to connect ComB of the LMG to a PC you have to use a cable <u>with</u> null modem function.
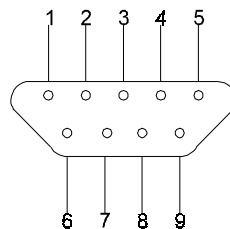
Figure 42: ComB connector

Pin	1	2	3	4	5	6	7	8	9
Comment	DCD	RxD	TxD	DTR	GND	DSR	RTS	CTS	RI

9.3.2 IEEE488.2

This interface is also known as IEC625 bus or GPIB. By it you can implement the LMG into an existing bus system.

The IEEE interface can just be used for remote control, not for logging. The maximum data transfer is about 1 Mbytes per second. This and the connection of several other devices makes this bus a standard for complex measuring systems

This port has the pinout defined in the standard IEEE488. You can use the standard cables.

9.3.3   Parallel Port

Whenever you want to print out data directly, this interface is used. In the LMG we have implemented drivers for the most popular printers. They are just needed, if you want to print out graphics.

Like with the serial interface you can print out cyclic values as tables.

Printers are not the fastest devices, so it can happen, that the printer gets more data than it can handle. In this case the printing is interrupted

This port has the same pinout like a PC parallel port. You can use the same cables.

10 Logging of values to drives, printer and interfaces

All menues you see can be stored to a memory card, floppy disk drives, interfaces or can be printed out. In principal you get what you see. Some exceptions are described in the individual chapters (e.g. you get all harmonics, not only the visible). If you want to record in single mode you get the values you see. That means when you have frozen the display you get the frozen values. If you are in a periodic mode then you get the actual values, also if you have frozen the display.

The data logging is handled in a way that you have to press as few keys as possible to get the result: To output the measured values periodically or one time to an interface or storage media.

There are no menus where you have to choose the values you want to output. Choose just one of the available menus and press *Print/Log*.

You get an dialog box where you can choose the destination of the logging (with **Dest.**). This can be a file, an interface or a printer.

Each single destination entry in this menu describes an output device and its most important setting. For storage media this is the file name, for the printer the printer type and for the interfaces the baud rate. This and other settings you can change at any time by pressing **Set.** Your changes are stored in so called 'profiles'. This profiles are stored in the memory. They are just valid in their environment: If you change the baud rate of ComA for <u>logging</u>, the baud rate of ComA for <u>remote control</u> is not changed!

In the dialog box you see further on the state of the chosen destination device. For storage media you see here also the available size and the number of stored files. For printers you can get 'printer ready', 'printer busy' or 'paper empty'.

10.1 Start of logging

The logging itself starts, if you close the dialog box with *Enter*. (if you press *Esc* you close the box without storing). In the status bar you get at the right side a red/green flashing log display while the logging is active.

If you want to output to a serial interface it could happen, that this interface is already reserved for remote control. In this case you are asked, if you want to change the usage of this interface from remote control to logging. If you say 'Yes' the usage is changed. Please make sure, that you don't have any remote controlled data transfer before you press *Enter*.

10.2   End of logging

To stop an periodic output (one time outputs are stopped automatically) you have to press *Print/Log* again. By pressing *Enter* you stop the logging, with *Esc* you leave the dialog box

10.3   Logging profiles (output devices)

Following profiles are accessible after pressing **Dest.**:

Disk(Data): filename

Writes the <u>data</u> of the actual menu to the file 'filename'. As default this is 'LOG', but you can choose any other name with up to 6 characters. This name is expanded by a two digit number which is incremented with each new logging. The extension is always '.AT'. Some examples for filenames are (the number is generated by the LMG):

LOG00.DAT
LOG01.DAT
MYDAT05.DAT
MOTOR_01.DAT
MOTOR_02.DAT

If you want to know, which files already exist on a media, how much space is available or if you want to setup anything press **Set.**

Here you can choose a new name for the next logging with **File**. By pressing **Mark*** you can mark/unmark files and delete them with **Del***. With **Clear Disk** you format a media.

Typ. lets you choose another output format (see 10.4, 'Output formats')

Caution

Do never remove the media, while a logging is in progress. This can corrupt the files and destroy your measuring results!

Disk(Scr): filename

Saves a <u>screen shot</u> of the displayed menu as a PCX file at the media. All settings are identical to 'Disk(Data)', except the **Typ.** is fixed to 'PCX'.

ComA: baudrate

The measuring values are transferred in the chosen 'Output as' format via ComA with the displayed baud rate. With **Set** you can change baud rate, protocol or the format. For the connection to the PC you have to use a 1:1 cable.

ComB: baudrate

Same like 'ComA: baudrate', but another jack and you have to use a null-modem cable.

ComA: BMP2PC

If you don't have a storage media but want to get screen shots, you can use this profile. Use our program BMP2PC (available on our homepage www.zes.com) and connect your PC with a 1:1 cable with ComA. Then you can transfer a screen shot to the PC and the receiving program stores it as a bitmap file.

Lpt: printer

On a connected printer you can output measuring values as well as hardcopies of the actual screen. The 'output as displayed' is pure text, so that you can connect almost every printer. For a graphical output you have to setup the correct printer type. Due to the growing number of printers it's not possible to write a driver for each type. So we implemented 5 generic drivers which can drive most available printers:
EPSON 9-Pin
EPSON ESP/P
EPSON ESP/P2
HP DeskJet
HP LaserJet

In case of any doubts please contact your local computer shop.

After pressing **Set** you can setup the model (**Prn**) and the output format (**Output as**). Further on you can create a comment (**Rem**) which is also printed (see10.5, 'Remarks, header lines').

Some models try to get a complete image of a page in their RAM before they start printing. Therefore you might think, the printer is not working, if you send it just some few lines.

It's not a good idea to output a page after just few lines. Therefore we send as default no form feed to the printer. But you can change this with **At end**: instead of 'None' setup 'paper out'. Or you can press **Page out** to do this manually, when you like.

10.3.1 Output intervals

With **Mode** you can setup how often the values should be output:

every cycle   The values are periodically output after each measuring cycle. Please make sure, that the output device is fast enough!

periodic   The values are output after the interval you set up. The minimum time is 10s. After you have chosen 'periodic' you get this time in a highlighted box. If the value is ok, you press just *Enter*. If not press **Per.** and change it. Leave the box with *Enter*.

every integral   The output interval depends on the settings of the *Int. Time* menu. The outputs starts, if you have started an integration. For the different integration modes you get:

        continuous   Output at end of measuring cycle
        interval   One time output after the integration time is over.
        periodic   Periodic after each integration time
        summing   Output at end of measuring cycle

by script   The output is done, when the `print()` function in the script editor is called (see 4.4.4.2.7, 'Functions').

10.4   Output formats

Output as displayed

As default the values are output in the same position like at the display. A one-time output of default menu, 1st channel could look like this:

```
Itrms:1= 0.0270 A
Utrms:1= 0.1414 V
P:1=-0.004 W
Q:1= 0.000 var
S:1= 0.004 VA
PF:1= 0.9992
```

Output as csv (Excel)

At periodic output it is an advantage, if the values are ordered by time. To do this choose the 'csv (Excel)' format.

```
dt/s,Itrms1/A,Utrms1/V,P1/W,Q1/var,S1/VA
216.00E-03, 289.94E-03, 221.61E+00, 41.313E+00, 49.210E+00, 64.253E+00
716.00E-03, 289.51E-03, 221.68E+00, 41.290E+00, 49.132E+00, 64.178E+00
1.2160E+00, 289.64E-03, 221.59E+00, 41.172E+00, 49.234E+00, 64.180E+00
1.7230E+00, 290.86E-03, 221.45E+00, 41.291E+00, 49.435E+00, 64.410E+00
2.2160E+00, 289.72E-03, 221.54E+00, 41.261E+00, 49.164E+00, 64.184E+00
2.7160E+00, 289.95E-03, 221.57E+00, 41.335E+00, 49.181E+00, 64.245E+00
3.2160E+00, 289.21E-03, 221.54E+00, 41.206E+00, 49.065E+00, 64.073E+00
3.7160E+00, 289.75E-03, 221.46E+00, 41.280E+00, 49.126E+00, 64.167E+00
4.2160E+00, 289.83E-03, 221.44E+00, 41.232E+00, 49.181E+00, 64.178E+00
4.7160E+00, 290.01E-03, 221.50E+00, 41.290E+00, 49.210E+00, 64.238E+00
```

```
5.2160E+00, 289.41E-03, 221.51E+00, 41.262E+00, 49.066E+00, 64.109E+00
```

The measuring values are written in scientific format without identifier or unit into a table. By this it is very easy to load such data into for example EXCEL. Invalid values are marked as '-------'. Each line ends with <CR><LF>.

The first column is always the time in seconds after the start of the logging. In general this is an integer multiple of the cycle time. In the harmonic and flicker modes you find here the number of signal periods which were used for analysis. So if you know the signal frequency you can calculate the real time (an exception is the Harm100 mode, because here the measuring has to be done with gaps!)

10.5   Remarks, header lines

At the start of each output (floppy disk, memory card, printer, ...) you can place several comment/header lines. When logging periodically, this header lines are just printed at the start of logging.

When editing this field (see 10.3, 'Logging profiles (output devices)') you can use a pre defined example with **Exmp**. You can modify and delete this example by **Edit**. If you have finished, press **End**.

You can see standard text and some special identifiers with a leading '$'. They will be replaced when logging the header by their real value. In the case of '$Cycle' the real cycle time will be inserted at this position. You can select every identifier. For a list of this identifiers please refer chapter 9.2, 'Commands'. The 'ID' field specifies the useable values. They are the same identifiers like for the script editor.

If you log the *Default* menu with the example header you get following result:

```
My Company
Printed at 22.04.2003 14:22:13
Cycletime 500.00 ms
Voltage at channel 2: 136.99mV

Itrms:1  0.0320 A
Utrms:1  212.01 V
P:1      -0.14 W
Q:1       6.78 var
S:1       6.78 VA
PF:1     20.646 m
```

Like in the script editor you can call the pre-defined lists (see chapter 4.5, 'Entering identifiers, characters and text'). Just remember to use the '$' in front of the identifier.

When „Output as table" in front of each comment line a 'REM' is written to simplify evaluation.

10.6   Storage media

Storage media are used to store single or periodic measuring data. The data format is equal to the data format of the serial or parallel interface. But this data are written immediately and evaluated later on.

Equivalent to a screen dump to a printer you can make a screen shot and store it in the popular PCX file format.

10.6.1   Floppy disk drive

The optional floppy disk drive is a PC compatible 3 1/2" drive for 1.44 Mbytes disks.

The file format is MSDOS (FAT) format. So you can read it with each PC with an Microsoft OS.

Floppy disk is a very good medium for data transfer to a PC if you want to evaluate the measured data afterwards. The disadvantage is the slow data transfer and the medium storage capacity. The medium transfer rate is just about 20kbyte per second, if you use a blank, formatted disk.

If you want to store harmonic values you get about 100 harmonics for 4 channels for each measuring cycle. That are 400 values which take about 5000 characters in storage. At 200ms cycle time you have about 25kbyte per second! In this case it might be better to use a memory card drive.

10.6.2   USB memory stick

The number of files and directories in the root directory must not be more than 150. Else you get the error message „File Table Overflow".

The stick must be formatted with FAT16. FAT32 will not work! The stick must not contain any own operating system (like e.g. Titanium Cruzer). Such an OS must be removed before the usage. The stick must not have more than one partition.

After calling the log dialog it can take several seconds until the structure of the memory stick is analysed. The time increases, if more files or stored on the stick. If the log dialog is opened, the stick must not be removed.

The stick implementation does not support a real formatting of the stick. So if you choose formatting, only the files in the root directory are delete. This can take several seconds. For a real formatting, please use a PC.

10.7   Import of data into PC programs

To get the measuring values into your PC you have two possibilities: You can store them on a storage media or you can send them via the serial interface.

10.7.1   Data exchange via storage media

If you are using a floppy disk it is no problem if you have a standard floppy disk drive.

10.7.2   Data exchange via serial interface

For this you just need a 1:1 cable (or a null modem cable if you are using ComB) and an installed terminal program. On each Windows PC you should have the program 'Hyperterm' already installed.

1. Start Hyperterm and enter any name for the new connection.
2. Choose the COM port which is connected to your PC.
3. Set up this port with following parameters:

Baud rate	115200
Databits	8
Parity	None
Stopbits	1
Protocol	None

4. Hyperterm is now ready to receive data. To test the connection press *Print/Log* at LMG, choose 'ComA: 115200' as destination. If the baud rate should not be 115200 please set it via **Set.** If you are using ComB do the same for it..
    The mode should be set to 'one-time' and 'output as table'.
5. Press *Enter* to start the transfer.
6. Hyperterm should now display the values. If not, check the correct ports, cable and all settings. Check also that Hyperterm is 'on-line'. If not, open the connection.
7. Hyperterm receives correct data. You can save the following data into a file via menu 'transfer' and 'save text'
8. Press at LMG *Print/Log* again and choose now 'every cycle'. Start logging with *Enter*.
    In Hyperterm you see now the received data which are stored in background.
9. To stop the logging press *Print/Log* and *Enter*.
10. Stop the recording of Hyperterm by closing the text file. If you open this file with any text editor you see the logged data.

10.7.3   Country dependent numbers

Float numbers are output with a dot '.' as decimal separator. This can cause problems, when your computer is set up to use ',' as separator (like for example in Germany). In this case set up your operating system to use the dot '.' as separator.

10.7.4 Reading data into EXCEL

First make sure, that the decimal separator is set up correctly. Then start Excel and load the file. Choose the number of lines Excel should skip to reject the header.

As column separator select a space.

Now the data from the file are read into Excel without any problems.

10.8   Error messages

Drive not ready

You have chosen a storage media as destination, but this media is not plugged in. Press *Esc* until the message vanishes. Choose another destination or insert the storage media

Operation not permitted

An error occurred while storing. For example the storage media was removed.

Output device too slow - stopped!

The chosen output device is too slow to handle the data in real time. In this case the logging is stopped. Press *Esc* until the message vanishes. Choose a faster output device or reduce the data volume for example by choosing a longer cycle time.

All values until this message are stored correctly.

11 Miscellaneous

11.1 Frequently asked questions

11.1.1 Accuracy of measured and computed values

The accuracy of the directly measured values I, U and P can be found in the tables in 12.3.3 'Accuracy'. The following calculations illustrate how to use these tables and how to calculate the error for other values (λ).

The read value of device should be:
U_{trms}=230.000V, range 250V, peak range 400V
I_{trms}=0.95000A, range 1.2A, peak range 3.75A
λ=0.25000
f=50.0000Hz
P=54.625W, range 300W, peak range 1500W
AC coupling mode for the signal

From the table for the general accuracies, the following errors for voltage and current can be determined (using the peak values of the respective measuring range):

$$\Delta U = \pm(\, 0.01\% \; of \; Rdg. + 0.02\% \; of \; Rng.) = \pm(\, 0.023V + 0.08V) = \pm 0.103V$$

$$\Delta I = \pm(\, 0.01\% \; of \; Rdg. + 0.02\% \; of \; Rng.) = \pm(\, 0.095mA + 0.75mA) = \pm 0.845mA$$

$$\Delta P = \pm(\, 0.015\% \; of \; Rdg. + 0.01\% \; of \; Rng.) = \pm(\, 8.194mW + 150mW) = \pm 0.158W$$

The power factor is computed as follows:

$$\lambda = \frac{P}{S} = \frac{P}{U * I}$$

The absolute maximum error for power factor is calculated corresponding to the rules of error computation using the total differential:

$$\Delta\lambda = \frac{\partial\lambda}{\partial P} * \Delta P + \frac{\partial\lambda}{\partial U} * \Delta U + \frac{\partial\lambda}{\partial I} * \Delta I$$

$$\Delta\lambda = \frac{\Delta P}{U * I} - \frac{P * \Delta U}{I * U^2} - \frac{P * \Delta I}{I^2 * U}$$

$$\Delta\lambda = \frac{0.158W}{230V*0.95A} + \frac{54.625W*0.103V}{0.95A*(230V)^2} + \frac{54.625W*0.845mA}{(0.95A)^2*230V}$$

$$\Delta\lambda = 0.00039$$

This is the absolute maximum error (worst case) that can occur in the calculation of the power factor. The typical error is two to five times better!

The relative measuring errors are:

$$U\%_{measure} = \frac{\Delta U}{U} = 0.045\%$$

$$I\%_{measure} = \frac{\Delta I}{I} = 0.089\%$$

$$P\%_{measure} = \frac{\Delta P}{P} = 0.289\%$$

$$\lambda\%_{measure} = \frac{\Delta\lambda}{\lambda} = 0.16\%$$

To get the real error, the inaccuracy of display (1 digit) has to be taken into account:

$$U\%_{display} = \frac{0.01V}{230.0V} = 0.004\%$$

$$I\%_{display} = \frac{0.00001A}{0.95A} = 0.001\%$$

$$P\%_{display} = \frac{0.001W}{54.625W} = 0.002\%$$

$$\lambda\%_{display} = \frac{0.00001}{0.25} = 0.004\%$$

This results in the following measuring values:

U_{trms} = (230.00 ± 0.103)V
I_{trms} = (0.9500 ± 0.00085)A
P = (54.625 ± 0.158)W
l = 0.25000 ± 0.00039

When using the AC+DC coupling instead of the AC coupling, you get different errors. In this case you might get an additional DC current of $\Delta I_{DC}=\pm(10\mu V/Ri)=\pm(10\mu V/2m\Omega)=\pm5mA$. This error influences the TRMS value in the following way:

$$I_{trms} = \sqrt{I_{ac}^2 + I_{dc}^2}$$

$$\Delta I_{trms} = \pm\left(\frac{\partial I_{trms}}{\partial I_{ac}} * \Delta I_{ac} + \frac{\partial I_{trms}}{\partial I_{dc}} * \Delta I_{dc}\right)$$

$$\Delta I_{trms} = \pm\left(\frac{I_{ac}}{I_{trms}} * \Delta I_{ac} + \frac{I_{dc}}{I_{trms}} * \Delta I_{dc}\right)$$

With an reading of I_{dc}=0.00112A you get:

$$\Delta I_{trms} = \pm\left(\frac{0.95A}{0.95A} * 0.845mA + \frac{1.12mA}{0.95A} * 5mA\right) = \pm0.851mA$$

For the active power you have an additional error of $\pm(10\mu V^2/Ri/V_{DC})=$ $\pm(10\mu V^2/2m\Omega/V_{DC})=\pm5mW/V_{dc}$. So with a reading of U_{DC}=0.013V you get a total error of

$$\Delta P_{tot} = \pm\left(\Delta P + 5\frac{mW}{V} * U_{DC}\right) = \pm\left(0.158W + 5\frac{mW}{V} * 13mV\right) = \pm0.158065W$$

For the apparent power you get:

$$\Delta S = \pm\left(\frac{\partial S}{\partial U} * \Delta U + \frac{\partial S}{\partial I} * \Delta I\right)$$

$$\Delta S = \pm(I * \Delta U + U * \Delta I) = \pm(0.95A * 0.103V + 230V * 0.845mA) = \pm0.292VA$$

Please note that in this case you have to use ΔI_{trms} for ΔI!

If you use external sensors please see the ZES Sensors and Accessories Manual for hints, how to calculate the total uncertainty under this circumstances.

11.1.2 Accuracy of non sinusoidal signals

The standard accuracies are just given for sinusoidal signals. The reason is, that the national standards usually work just with sinusoidal signals.

To estimate the error of non sinusoidal signals you can use the following system.

Let's assume you want to measure a square signal with 5V peak value, 50% duty cycle, no DC value and a frequency of 50Hz.

First the signal has to be divided into its frequency components. Then the errors of the rms-values of each frequency component have to be calculated. The used error is the standard error of reading at the specific frequency according to the technical specification. All these errors have to be added geometrically (because they are rms values with different frequencies). Further on you have to add the error of the measuring range of the fundamental once (once because it includes common errors like offset, ...). With this sum you can calculate the total error.

The values in the columns of the following table are:

Frequency (f / Hz)

rms value at this frequency (U / V)

Percentage error of frequency component according to technical data (% of value)

- Absolute error of frequency component (ΔU / mV)

f / Hz	U / V	Error in % of U	Error ΔU / mV
50	4.501	0.01	0.4501
150	1.500	0.02	0.3000
250	0.900	0.02	0.1800
350	0.636	0.02	0.1272
450	0.499	0.02	0.0998
550	0.408	0.02	0.0816
650	0.346	0.02	0.0692
750	0.300	0.02	0.0600

For this example only the harmonics from 1 (50Hz) to 15 (750Hz) have been used. Harmonics of a higher order cause just barely greater errors not affecting the total error very much like shown in the table.

The geometrical sum of all errors results in an error of 0.6051mV.

To that you have to add the error of the range (0.02% of 12V (peak-value) = 2.4mV).

The total error is 3.0051mV which is 0.06% of 5V.

11.1.3 Hints for setting up the record rate of the scope

The scope function defines the record rate of the sample values indirectly by changing the timebase. When transferring sample values over the interface it is more useful to setup a fix record rate instead of setting up a timebase. The relation between timebase and record rate is described here.

The CAPITAL words are not requestable via interface nor visible on the display. They are here locally introduced to explain the situation.

Scope settings

BASE   The only setting for the scope is the timebase, i.e. the time per division in seconds. There are 20 sample values per division used. The timebase can be set in a range from 10µs to 1s in a 1-2-5 stepping.

Software parameters

CYCLE   The cycle time in seconds.

DIV   This is the sample rate pre divider which depends on the selected filter. The following values are possible:

          1   without filter
          2   with filter > 10 kHz
          30 with filter ≤ 10 kHz

      For the calculation the biggest divider of all groups is used. Example: Group A without filter, group B with 270kHz Filter, group C with 10kHz filter. Then DIV=30 is used.

SMPL   sampling rate
          SMPL = 3MS/s / DIV

Hardware parameters

MEM   Memory depth: This is always 1048576. In master slave mode the memory is doubled, but there are also more channels, so this values is constant. See CHNS.

CHNS   Number of power measuring channels. In master slave mode, CHNS is the maximum number of channels in each single instrument. Example: Master has 4, slave 3 channels. Then CHNS=4 is used.

Internal parameters

ZOOM   The display of the values depends on the ZOOM factor. It defines, how many sample values are packed to one display value. The default value is 10. The parameter ZOOM is changed, if BASE becomes such small, that the requested display can only be reached by reducing ZOOM. In this case not 10 values are packed but less, down to 1. ZOOM can only be 50, 20, 10, 5, 2, 1. With ZOOM=1 every sampled value is stored and displayed. Over the interface you will get <u>every</u> stored value, independent of the ZOOM setting. For the calculation of this value, see below.

FREEZE If the memory is frozen, of course you can't change the sample rate any more. Changing BASE can now only influence the ZOOM value to zoom in or out. Due to the limited value range of ZOOM, the zooming is also limited. For the influence of this parameter see below.

Results

Following interim values are calculated

RATE   Storage rate
        RATE = 20 * ZOOM / BASE

DUR   Storage duration
        DUR = MEM / CHNS / RATE

If a special sampling rate is wished, it can be calculated in opposite order:

BASE =20 * ZOOM / RATE

Caution: Not every storage rate is possible. By rounding (dividers must always be integers!) and internal divider structures the resulting storage rate can be different from the requested one. It is always necessary to check the storage rate by the GFRQ interface command.

Example: 4 channels, BASE = 10ms/div, ZOOM = 10.
        RATE = 20000 samples/s
        DUR = 13.11s

Limits

MAXRATE The maximum storage rate. It is limited by the cycle time (CYCLE) and the number of channels (CHNS). Because at least one complete cycle of all channels has to fit into the memory. For administrative purposes the cycle time must be multiplied with a factor of 1.7!
        MAXRATE = MEM / (CYCLE * 1.7 * CHNS)
        If MAXRATE is bigger than SMPL then MAXRATE = SMPL!

Example 1: CYCLE = 0.5s, 4 CHNS
        MAXRATE = 308,457 kS/s (only 200kS/s settable, see MINBASE)

Example 2: CYCLE = 0.05s, 4 CHNS
        MAXRATE = 3.08MS/s (limited to 3MS/s!)
        This shows, that the maximum sample rate is possible with 4 channels at fastest cycle time.

From above calculation for BASE you get a minimum timebase MINBASE at ZOOM=1 and with the maximum storage rate MAXRATE:

MINBASE = 20 * ZOOM / MAXRATE = 20 / MAXRATE

Example: CYCLE = 0.5, 4 CHNS
          MINBASE = 64μs.
          The next bigger valid value is 100μs which results in a real RATE of
          RATE = 20 * ZOOM / BASE = 20kS/s (see above).

The third limit is a divider. The ration SMPL / RATE must be an integer. If it is not, the resulting number must be scaled <u>down</u> and SMPL must be divided by it to get the real RATE.

Determination of ZOOM

<u>Without Freeze</u>
If you reduce BASE, ZOOM stays at 10 as long as the storage RATE is much smaller than MAXRATE. If it becomes bigger, ZOOM must be reduced to reach a valid rate (see definition of RATE).

For MAXRATE / RATE ≥ 10 you get ZOOM = 10
For 5 < MAXRATE / RATE < 10 you get ZOOM = 5
For 2 < MAXRATE / RATE < 5 you get ZOOM = 2
For MAXRATE / RATE < 2 you get ZOOM = 1

<u>With Freeze</u>
If *Freeze* was pressed the actual BASE is stored as LASTBASE. In the same way ZOOM is stored as LASTZOOM.

The zoom factor is now:

ZOOM = BASE * LASTZOOM / LASTBASE

in the range from 1 to 50. In this case ZOOM has no 1-2-5 stepping, because this comes indirectly from the stepped input of BASE!

Validity of BASE

If the calculated value for ZOOM is outside the range 1-50, the setting of BASE becomes invalid. In this case there is an error message in the display or in the interface system.

Calculation of BASE for a requested sampling rate

ZOOM is always 1, because via interface you can't zoom, i.e. you always get all sample values!

Example 1
You have a 3 phase instrument and want a sampling rate of 150kS/s without any filter and a 1s cycle time. How to setup BASE?

BASE =20 * ZOOM / RATE. So you get BASE = 133µs/div, the next valid stepped neighbours are 100µs/div and 200µs/div. This results in a real rate of 100kS/s @ 200µs/div and 200kS/s @ 100µs/div.

Now we have to check the limits:

MAXRATE = MEM / (CYCLE * 1.7 * CHNS) = 205603kS/s
MINBASE = 20 / MAXRATE = 0.97ms/div
SMPL / RATE = 30 resp. 15

Both BASE settings would meet these conditions! You can't setup 150kS/s as sampling rate but 100kS/s or 200kS/s.

Example 2
You have a 3 phase instrument and want a sampling rate of 150kS/s with 9.2kHz filter and a 1s cycle time. How to setup BASE?

BASE =20 * ZOOM / RATE. So you get BASE = 133µs/div, the next valid stepped neighbours are 100µs/div and 200µs/div. This results in a real rate of 100kS/s @ 200µs/div and 200kS/s @ 100µs/div.

Now we have to check the limits:

MAXRATE = MEM / (CYCLE * 1.7 * CHNS) / DIV = 205603kS/s
MAXRATE is limited to 100kS/s due to the filter setting! So the 100µs/div is not possible to setup!
MINBASE = 20 / MAXRATE = 200µs/div
SMPL / RATE = 1

The 200µs/div BASE setting meets all conditions and is possible, so the best possible sampling rate is 100kS/s.

Example 3
You have a 3 phase instrument and want a sampling rate of 3MS/s without filter and a 0.05s cycle time. How to setup BASE?

BASE =20 * ZOOM / RATE. So you get BASE = 6.7µs/div, the next valid stepped neighbours are 5µs/div and 10µs/div. The smallest possible value is 10µs/div, so the other value doesn't matter. This results in a RATE of 2MS/s @ 10µs/div.

Now we have to check the limits:

MAXRATE = MEM / (CYCLE * 1.7 * CHNS) / DIV = 4112063S/s
MAXRATE is limited to 3MS/s due to the filter setting.
MINBASE = 20 / MAXRATE = 6.7µs/div
SMPL / RATE = 1.5, scaled down to 1.0, resulting in a new RATE = 3MS/s / 1 = 3MS/s.

The 10µs/div BASE setting meets all conditions and is possible, so the best possible sampling rate is 3MS/s.

11.2   Function fault

If you think you have found an error or function fault in a LMG500 please fill out the following page and send it to ZES. If you think the measuring result are wrong, please also fill out the second page. For this purpose connect the measuring circuit, freeze the screen with the values and fill out the paper with the frozen values.

On the attached CD you find a tool called 'LMG CONTROL'. One feature of this tool is, that it can store all measuring values and a complete configuration in a report file. You can also use this tool to generate a function fault report.

Function fault at a LMG500

To: From:

                                                             Name:

Z E S ZIMMER Electronic Systems GmbH   Company:

Tabaksmühlenweg 30   Street:

61440 Oberursel   City:

Germany   Country:

Tel. ++49 (0)6171 / 628750   Tel:

Fax ++49 (0)6171 / 52086   Fax:

Information about the instrument:

<u>Type Plate:</u>

Serial number: _____   Supply Voltage: _____

IF/IO Menu: **List** more

Version: _____

Interface: _____   ext. programs:

Process Signal: _____   Calibration: _____

Flicker: _____   PQA: _____

Harmonic 100:   _____   SYS61K: _____

extended memory: _____   TERM-L5:   _____

linked values: _____

Exact error description:

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

Measuring menu

Globals

Cycle: _____   Aver: _____   Wiring: _____

Group A

Filter: _____   S_Cpl: _____
Signal _____   Demod: _____
HP: _____   LP: _____

Group B

Filter: _____   S_Cpl: _____
Signal _____   Demod: _____
HP: _____   LP: _____

Channel 1

Range menu

U jack: _____   I jack: _____
U range: _____V   I range: _____A
U range: auto/manual   I range: auto/manual
U scale: _____   I scale: _____
Sensor-Types, SN: _____

Voltage menu   **Current menu**   **Power menu**

Utrms: _____   Itrms: _____ P: _____
Uac: _____   Iac: _____ Q: _____
Udc: _____   Idc: _____ S: _____
Upp: _____   Ipp: _____ PF: _____
Upkp: _____   Ipkp: _____ f: _____
Upkn: _____   Ipkn: _____ Z: _____
Urect: _____   Irect: _____ Rser: _____
Ucf: _____   Icf: _____ Xser: _____
Uff: _____   Iff: _____
                    Iinr: _____

Channel 2

Range menu

U jack: _____   I jack: _____
U range: _____V   I range: _____A
U range: auto/manual   I range: auto/manual
U scale: _____   I scale: _____
Sensor-Types, SN: _____

Voltage menu	**Current menu**	**Power menu**
Utrms: _____	Itrms: _____	P: _____
Uac: _____	Iac: _____	Q: _____
Udc: _____	Idc: _____	S: _____
Upp: _____	Ipp: _____	PF: _____
Upkp: _____	Ipkp: _____	f: _____
Upkn: _____	Ipkn: _____	Z: _____
Urect: _____	Irect: _____	Rser: _____
Ucf: _____	Icf: _____	Xser: _____
Uff: _____	Iff: _____	
	Iinr: _____	

Channel 3

Range menu

U jack: _____		I jack:	_____
U range: _____V		I range:	_____A
U range: auto/manual		I range:	auto/manual
U scale: _____		I scale:	_____
Sensor-Types, SN:		_____	

Voltage menu	**Current menu**	**Power menu**
Utrms: _____	Itrms: _____	P: _____
Uac: _____	Iac: _____	Q: _____
Udc: _____	Idc: _____	S: _____
Upp: _____	Ipp: _____	PF: _____
Upkp: _____	Ipkp: _____	f: _____
Upkn: _____	Ipkn: _____	Z: _____
Urect: _____	Irect: _____	Rser: _____
Ucf: _____	Icf: _____	Xser: _____
Uff: _____	Iff: _____	
	Iinr: _____	

Channel 4

Range menu

U jack: _____		I jack:	_____
U range: _____V		I range:	_____A
U range: auto/manual		I range:	auto/manual
U scale: _____		I scale:	_____
Sensor-Types, SN:		_____	

Voltage menu	**Current menu**	**Power menu**
Utrms: _____	Itrms: _____	P: _____
Uac: _____	Iac: _____	Q: _____
Udc: _____	Idc: _____	S: _____
Upp: _____	Ipp: _____	PF: _____

Upkp: _____   Ipkp: _____   f: _____
Upkn: _____   Ipkn: _____   Z: _____
Urect: _____   Irect: _____ Rser: _____
Ucf: _____   Icf: _____   Xser: _____
Uff: _____   Iff: _____
                   Iinr: _____

You can directly print out this menus.

Please sketch also the wiring of LMG500 and equipment under test / measuring signals:

11.3   Maintenance

11.3.1   Calibration

With this precision power meter you have a high end measuring instrument. But you can only take advantage of it's performance, if the instrument is well adjusted and calibrated. Especially with the calibration of third party labs there are very often unnecessary problems. If you let the calibration made by any third party calibration lab, please watch following points:

- The reference instruments might have not the required accuracy, especially for active AC power.
  A very common error is, that reference sources, which some companies call 'calibrator' have not the necessary accuracy to calibrate this instrument. The calibrators are very useful for many hand held multimeters, but are often worthless when calibrating active power. A common candidate for this error is the Fluke 5500A calibrator.
  Please keep in mind, that the reference instrument should be at least 3 times more accurate than the device under test. If not, the precision power meter calibrates the so called calibrator!
- The reference instrument may be traceable for voltage and current, but it is very rare, that it is traceable for active AC power with the required accuracy. Nevertheless it is common, that calibration labs calibrate active power if only voltage and current are traceable. This happens very often in the context of national calibration services like DKD, UKAS, …
  Here it happens regular, that voltage and current are accredited, but not the active power. So this protocols are worthless for active power!

If a calibration is performed by any third party lab, at least following points should be calibrated to ensure a proper function of the instrument:

- Voltage and current of all ranges at a frequency near to 50Hz.
- A representative selection of voltage/current range combinations to ensure a proper power reading

The ZES ZIMMER calibration service offers a traceable calibration of all relevant parameters and meets the requirements of IEC17025. Our active power calibration is directly traceable to PTB (Physikalisch Technische Bundesanstalt in Braunschweig).

A further advantage of our calibration service is, that for the case of a service there are no additional shipping costs and time delays.

11.3.1.1 Requirements for reference instruments

As generally known the references, calibration sources and/or reference power meters, have to be in an accuracy class, which is at least 3 time better than the LMG500. An optimal value is from 5 to 10 times better.

For the allowed error of the LMG to be calibrated please refer also to chapter 11.1.1, 'Accuracy of measured and computed values'

11.3.2 Adjustment

The adjustment has to be done at $(23\pm1)°C$.

ZES ZIMMER offers in principle a way to adjust the instruments outside our factory, if some technical preconditions are fulfilled. For further information, please contact sales@zes.com

11.3.3 Zero adjustment of the instrument

The zero settings of the LMG can be adjusted without sending the instrument back to the factory. For this purpose remove **<u>ALL</u>** measuring cables from the instrument and switch to the normal measuring mode. Activate the jack, you want to adjust, in the range menu. Now short circuit the voltage input (U* or U_{sensor} with U). If you have selected I_{sensor} also short circuit I_{sensor} with I. I* and I_{HF} stay open! Short circuit means, not to connect the inputs with any wire but to connect them as short as possible to get a minimised loop area!

If you want to adjust external sensors connect them, switch to external sensors in the range menu and don't enclose any measuring lead with the sensor.

Warm the instrument up for a minimum of 2h.

Now press **Z-Adj** in the *Misc.* menu (see 4.4.1, 'Misc.'.

Answer the warning with *Enter* if you have setup the instrument correctly. After about 1 minute the instrument is adjusted and a message appears.

If you are in doubt about any detail of this adjustment please contact the manufacturer.

This adjustment is active, while the instrument is switched on. If you switch off and on the instrument, the factory values are loaded.

11.3.4 Battery

In the instrument is a lithium battery for holding several data. It should be checked after 8 years or when any problems occur. In some instruments the battery is plugged, so it can be

exchanged very easy. In other instruments it is soldered, so here it is recommended to exchange the battery in our service department.

11.3.5 Software update

The software of the LMG can be updated by the customer. You get the actual software from our homepage http://www.zes.com or directly by ZES. You need a PC and a serial cable to connect COM1 of your PC to ComA of the LMG. It has to be a 1:1 cable without any crossings or null modem functions, where all wires are connected.

If you start the update software on your PC you will get detailed information how to handle.

11.4 Use with an inverter

The power meters of the e LMG series accord to the protection class 1. A use without an earthed protective conductor is not permitted. Inverters (e.g. 12Vdc to 230Vac) mostly have no protective conductor. In this case the LMG has to be wired with a protective conductor at the rear panel. Refer the safety rules of the working area.

12 Technical data

12.1 General

Display: Colour display, resolution 320x240 Pixel

Mains supply: 100...240V, 50...60Hz, max. 150W (depending on options), 2 fuses
                            5x20mm T3.15A/250V IEC127-2/3

Storage temperature: -20°C to +50°C

Safety: EN61010-1:2001

                            Normal environmental condition:
                            Indoor use, altitude up to 2000m, temperature 5°C to 40°C, maximum
                            relative humidity 80% for temperatures up to 31°C decreasing linearly
                            to 50% relative humidity at 40°C

                            Mains supply:
                            Measurement category II, pollution degree 2

                            Measuring inputs:
                            Up to 1000V: Measurement category III, pollution degree 2
                            Up to 600V: Measurement category IV, pollution degree 2

                            IP20 according EN60529

EMC: EN61326-1:2006
                            EN61000-3-2:2006
                            EN61000-3-3:1995+A1:2001+A5:2005

Dimensions: Desktop: 433mm (W) x 148mm (H) x 506mm (D)
                            19" rack: 84HP x 3U x 506mm

Weight: depending on options, about 12.5kg with 4 channels
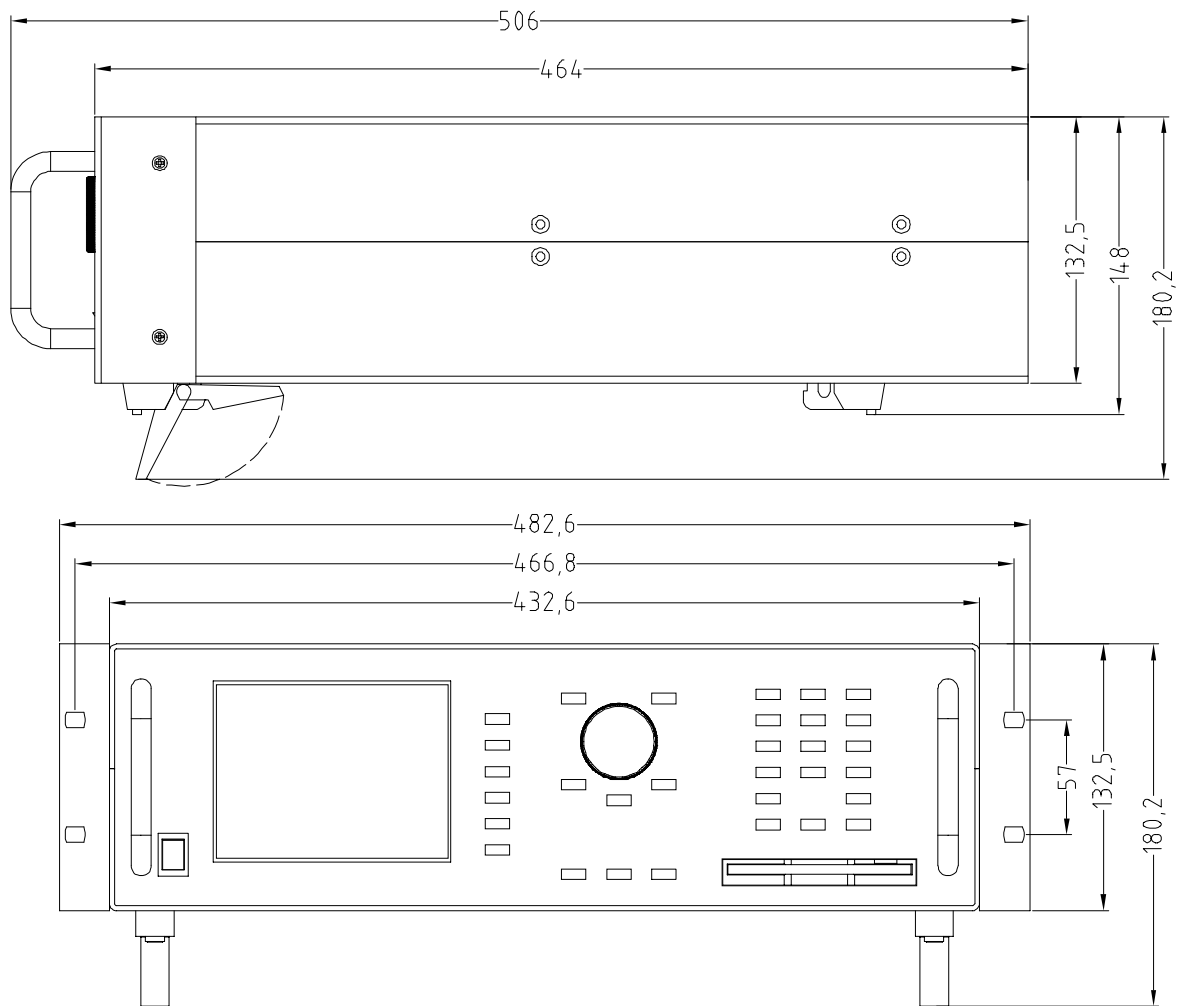
Figure 43: Dimensions of LMG500

In the above picture you see the desktop instrument in combination with the rack mounting kit.

12.2   Display of values

The measured values are displayed with 6 digits. The position of the decimal point is set to the position which is required to display the maximum allowed TRMS value.

If the TRMS value of a measuring channel is lower than 1.5% of the measurable TRMS value of the range, all channel values are displayed as 0.0. For example in the 0.6A current range you get values from 0.018750A...1.87500A and 0.000A. This zero rejection can be switched off, see 4.4.1, 'Misc.'Misc.

12.3   Measuring channels

12.3.1   Sampling

The sampling is done synchronously at all channels with about 3MHz per channel.

12.3.2 Ranges

Capacitance between voltage and current channel: 13pF

12.3.2.1 Voltage channel

Voltage ranges

Rated range value / V	3	6	12.5	25	60	130	250	400	600	1000
Measurable TRMS value / V	3.6	7.2	14.4	30	66	136	270	560	999	1001
Permissible peak value / V	6	12	25	50	100	200	400	800	1600	3200

Overload capability   1000V continuously, 1500V for 1s

Input resistance   4.59MΩ, 3pF

Capacitance against earth   31pF

⚠ **Note!**
The 'Measurable TRMS value' is the biggest TRMS value which can be measured. That does not mean that it is allowed to measure with that value, if any security standards define other values!

Inputs for voltage sensors with voltage output

Rated range value / V	0.03	0.06	0.12	0.25	0.5	1	2	4
Measurable TRMS value / V	0.037	0.075	0.15	0.3	0.6	1.2	2.5	5
Permissible peak value / V	0.062	0.125	0.25	0.5	1	2	4	8

Overload capability   100V continuously, 250V for 1s

Input resistance   100kΩ, 34pF

Capacitance against earth   31pF

12.3.2.2 Current channel

Current ranges wide dynamic, I*

Rated range value / A	0.02	0.04	0.08	0.15	0.3	0.6	1.2	2.5	5	10	20	32
Measurable TRMS value / A	0.037	0.075	0.15	0.3	0.6	1.25	2.5	5	10	20	32	32
Permissible peak value / A	0.056	0.112	0.224	0.469	0.938	1.875	3.75	7.5	15	30	60	120
Resistance incl. Jacks / mΩ	710	710	710	84	84	84	27	27	27	8.4	8.4	8.4
Continuously overload / A	5	5	5	5	5	5	15	15	15	32	32	32
Short time overload	150A for 10ms											

Capacitance against earth   31pF

Current ranges high frequent, I_{HF}

Rated range value / A	0.15	0.3	0.6	1.2
Measurable TRMS value / A	0.225	0.45	0.9	1.8
Permissible peak value / A	0.313	0.625	1.25	2.5

Overload capability   5A continuously

Input resistance Ri   100mΩ

Capacitance against earth   31pF

Inputs for current sensors with voltage output

Rated range value / V	0.03	0.06	0.12	0.25	0.5	1	2	4
Measurable TRMS value / V	0.037	0.075	0.15	0.3	0.6	1.2	2.5	5
Permissible peak value / V	0.062	0.125	0.25	0.5	1	2	4	8

Overload capability   100V continuously, 250V for 1s

Input resistance   100kΩ, 34pF

Capacitance against earth   31pF

12.3.3 Accuracy

An example, how to handle this values, you find in 11.1.1, 'Accuracy of measured and computed values'

Measuring accuracy

The values are in ±(% of measuring value + % of measuring range)

Frequency	DC	0.05Hz..45Hz, 65Hz..3kHz	45Hz..65Hz	3kHz..15kHz	15kHz..100kHz
Voltage U*	0.02+0.06	0.02+0.03	0.01+0.02	0.03+0.06	0.1+0.2
Voltage U_{Sensor}	0.02+0.06	0.015+0.03	0.01+0.02	0.03+0.06	0.2+0.4
Current I*, 20mA...5A range	0.02+0.06	0.015+0.03	0.01+0.02	0.03+0.06	0.2+0.4
Current I*, 10A...32A range (1)	0.02+0.06	0.015+0.03	0.01+0.02	0.10+0.20	0.3+0.6
Current I_{HF}	0.02+0.06	0.015+0.03	0.01+0.02	0.03+0.06	0.2+0.4
Current I_{Sensor}	0.02+0.06	0.015+0.03	0.01+0.02	0.03+0.06	0.2+0.4
Active power U*/I* (20mA..5A)	0.032+0.06	0.028+0.03	0.015+0.01	0.048+0.06	0.24+0.3
Active power U*/I* (10A..32A)	0.032+0.06	0.028+0.03	0.015+0.01	0.104+0.13	0.32+0.4
Active power U*/I_{HF}	0.032+0.06	0.028+0.03	0.015+0.01	0.048+0.06	0.24+0.3
Active power U*/I_{Sensor}	0.032+0.06	0.028+0.03	0.015+0.01	0.048+0.06	0.24+0.3
Active power U_{Sensor}/I* (20mA..5A)	0.032+0.06	0.024+0.03	0.015+0.01	0.048+0.06	0.32+0.4
Active power U_{Sensor}/I* (10A..32A)	0.032+0.06	0.024+0.03	0.015+0.01	0.104+0.13	0.4+0.5
Active power U_{Sensor}/I_{HF}	0.032+0.06	0.024+0.03	0.015+0.01	0.048+0.06	0.32+0.4
Active power U_{Sensor}/I_{Sensor}	0.032+0.06	0.024+0.03	0.015+0.01	0.048+0.06	0.32+0.4

Frequency/Hz	100kHz..500kHz	500kHz.. 1MHz	1MHz..3MHz	3MHz..10MHz
Voltage U*	0.5+1.0	0.5+1.0	3+3	f/1MHz*1.2 + f/1MHz*1.2
Voltage U_{Sensor}	0.4+0.8	0.4+0.8	f/1MHz*0.7 + f/1MHz*1.5	f/1MHz*0.7 + f/1MHz*1.5
Current I*, 20mA...5A range	0.5+1.0	0.5+1.0	f/1MHz*1 + f/1MHz*2	-
Current I*, 10A...32A range (1)	f/100kHz*0.8 + f/100kHz*1.2	-	-	-
Current I_{HF}	0.5+1.0	0.5+1.0	f/1MHz*1 + f/1MHz*2	-
Current I_{Sensor}	0.4+0.8	0.4+0.8	f/1MHz*0.7 + f/1MHz*1.5	f/1MHz*0.7 + f/1MHz*1.5
Active power U*/I* (20mA..5A)	0.8+1.0	0.8+1.0	f/1MHz*3.2 + f/1MHz*2.5	-
Active power U*/I* (10A..32A)	f/100kHz*1 + f/100kHz*1.1	-	-	-
Active power U*/I_{HF}	0.8+1.0	0.8+1.0	f/1MHz*3.2 + f/1MHz*2.5	-
Active power U*/I_{Sensor}	0.72+0.9	0.72+0.9	f/1MHz*3 + f/1MHz*2.3	f/1MHz*1.5 + f/1MHz*1.4
Active power U_{Sensor}/I* (20mA..5A)	0.72+0.9	0.72+0.9	f/1MHz*1.4 + f/1MHz*1.8	-
Active power U_{Sensor}/I* (10A..32A)	f/100kHz*1 + f/100kHz*1	-	-	-
Active power U_{Sensor}/I_{HF}	0.72+0.9	0.72+0.9	f/1MHz*1.4 + f/1MHz*2	-
Active power U_{Sensor}/I_{Sensor}	0.64+0.8	0.64+0.8	f/1MHz*1.12 + f/1MHz*1.5	f/1MHz*1.12 + f/1MHz*1.5

(1)   additional error $\pm I^2 \dfrac{30\mu A}{A^2}$

Accuracies based on:

1. sinusoidal voltages and currents
2. ambient temperature $(23\pm3)°C$, no additional heating or cooling (i.e. by sunlight or current of air)
3. warm up time 1h
4. power range is the product of current and voltage range, $0\leq|\lambda|\leq1$
5. Voltage and current are $\geq 10\%$ and $\leq110\%$ of rated range
6. calibration interval 1 year
7. Adjustment was done at 23°C.

Temperature effect: 0.01% of measuring value / K

12.3.4 Common mode rejection

The common mode rejection was measured with a sinusoidal voltage of 100V against PE. For the voltages ranges the signal was fed into the short circuit U and U* resp. U and U_{sensor}. For the current channel the signal was fed into I resp. I and I_{sensor} (short circuit).

Common mode frequency	10kHz Filter	U 3V range	U_{sensor} 4V range	I* 32A range	I_{HF} 0.15A range	I_{sensor} 4A range
50Hz	off	>120dB	>140dB	>170dB	>180dB	>140dB
100kHz	on	>100dB	>140dB	>140dB	>160dB	>140dB
100kHz	off	>80dB	>110dB	>130dB	>130dB	>110dB

12.4   ZES sensors

Most ZES sensors have an EEPROM implemented in which we have stored the name, scaling, ranges, adjustment and delay time of the sensor. The LMG500 recognises automatically, which ZES sensor is connected and sets up the range menu. Further on we correct some of the errors the sensor produces (transfer error, delay time, ...). So you get the best measuring results with each sensor.

Due to the EEPROM this sensors offer a plug & play solution for your measuring. The usage of the LMG sensor input offers several measuring ranges which increase the dynamic of the connected sensors.

There is a very wide range of sensors available:
- Current clamps, transformers, hall sensors, flux compensated types, flexible Rogowski sensors, shunts, ...
- Accuracies up to <0.01%
- Frequency range from DC to several hundred kHz
- Current range from <<1A up to several kA

For the exact specifications of all this sensors you find a detailed manual on the CD which is delivered together with this manual. If this CD is missing or you have this manual only as PDF file you can request it via email from 'sales@zes.com'.

To adapt this sensors to a LMG500 you need a special adaptor, L50-Z14:
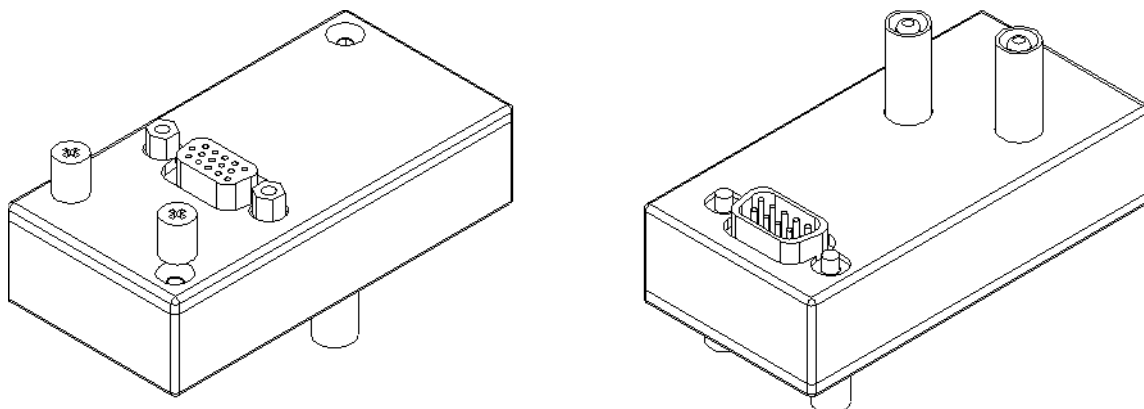
Figure 44: L50-Z14 adaptor

The sensor is connectet to the 15pin jack. With the other side the adaptor is connected to the LMG500. The two long pins are placed into the U_{sensor}/U resp. I_{sensor}/I jacks, the 9pin SUB-D connector to the proper sensor ID jack and locked with the two knurled screws.

12.4.1 Several external sensors in a test bench

A common situation in test benches is, that different sensors have to be connected, controlled by a program. In this case the relevant signals have to be redirected, e.g. by a relais. Relevant are **all** 10 signals of the pins 6 to 15 of the 15 pin jack in the L50-Z14!

Important!

First you have to disconnect an existing sensor.

Secondly you have to wait for at least 3s.

Now you can connect the new sensor.

12.5 Filter

12.5.1 10kHz filter

This analogue filter has the following characteristic:

Frequency / Hz	Rejection / dB
10	0.0019
20	0.0005
50	0
100	-0.0004
200	-0.0014
500	-0.0086
1000	-0.0319
2000	-0.1459
5000	-0.8350
10000	-3.16
20000	-14.45
50000	-49.45

12.6 CE Harmonics

Relative deviation between f_1 and frequency f_{syn}, to which the sampling rate is synchronised is <0.015% of f_1 under steady-state conditions.

This instrument is a class I instrument according EN61000-4-7.

Accuracy

According EN61000-4-7 Ed. 2.0:

U: $U_m \geq 1\% U_{nom}$: $\pm 5\% U_m$

      $U_m < 1\% U_{nom}$: $\pm 0.05\% U_{nom}$

I: $I_m \geq 3\% I_{nom}$: $\pm 5\% I_m$

      $I_m < 3\% I_{nom}$: $\pm 0.15\% I_{nom}$

With

$_m$ = measuring value

$_{nom}$ = nominal value of the range

Please note

The influence of the HF-Rejection filter is compensated for the amplitudes of the harmonics. The values for U, I and P are <u>not</u> recalculated from the harmonics, but are calculated from the sampling values to get for example interharmonics and components with higher frequencies which are not captured by the harmonics. So it is not possible to compensate the influence of the filters for this values! For the same reason this values can also be much bigger than the values which can be derived from the harmonics (depending on the signal).

12.7   CE Flicker

Accuracy

Flickermeter: $\pm 5\%$ acording to EN61000-4-15

d-meter: $\pm 0.15\%$ of nominal voltage according to EN61000-3-3

12.8   HARM100 Mode

Amplitude error

The error of the harmonic with the biggest amount H_{max} (usually the fundamental) and of the DC part (H_{00}) is calculated as if each part is measured alone (refer error specifications of the normal measuring mode).

The errors of the harmonics (H_{01}, H_{02}, ...) except H_{max} is calculated as follows:

$\pm(0.5 * error_{Hmax} + 0.02\%$ from $H_{max}/kHz)$

This errors are valid if the amplitude of the harmonics are higher than 0.1% of the full scale peak value.

Phase error

$\pm(0.15° + 0.25° / kHz)$

This errors are valid if the amplitude of the harmonics are higher than 0.1% of the full scale peak value.

12.9   Processing signal interface (option L50-O3)

The 8 functional groups are isolated against each other (for details please refer 13.6, 'Functional block diagram processing signal interface'). The allowed working voltage is 25V between the groups. The testing voltage is 500V.

The analogue inputs and outputs have nominal ±10V signal range, but in fact they are able to handle ±20V resp. ±11V.

The processing signal interface has two connectors (Analogue/Digital I/O A and B) with the following inputs and outputs. Each connector is compatible to LMG95 and LMG450.

- 8 analogue outputs with ±10V. The outputs are updated with each measuring cycle for normal values. All analogue outputs have one common ground (AOut_GND) which is isolated from all other grounds.
- 8 analogue inputs with ±20V. This values are displayed after each measuring cycle. All analogue inputs have one common ground (AIn_GND) which is isolated from all other grounds.
- 4 digital outputs A (open collector outputs). They are updated with each measuring cycle. They have one common ground (DOut_GND_A) which is isolated from all other grounds.
- 4 digital outputs B (open collector outputs). They are updated with each measuring cycle. They have one common ground (DOut_GND_B) which is isolated from all other grounds.
- 4 digital inputs A. They have one common ground (DIn_GND_A) which is isolated from all other grounds.
- 4 digital inputs B. They have one common ground (DIn_GND_B) which is isolated from all other grounds.
- 1 frequency input A with sensor supply. It can measure frequency and direction of a rotation speed converter. This frequency input and it's supply have a common ground (Aux_F_GND_A) which is isolated from all other grounds. Via FIn_5 you can apply the frequency, FIn_6 gives the direction information. If not used as a frequency input, the state of FIn_5 and FIn_6 are displayed like a usual digital input.
- 1 frequency input B with sensor supply. It can measure frequency and direction of a rotation speed converter. This frequency input and it's supply have a common ground (Aux_F_GND_B) which is isolated from all other grounds. Via FIn_11 you can apply the frequency, FIn_12 gives the direction information. If not used as a frequency input, the state of FIn_11 and FIn_12 are displayed like a usual digital input.

The connectors have the following pinout:
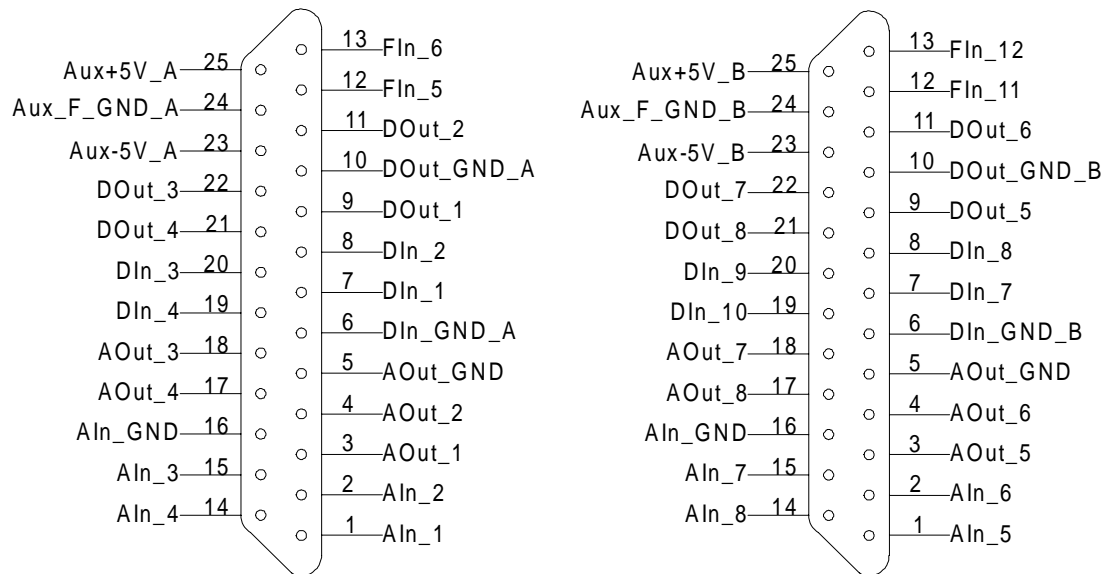
Figure 45: Processing Signal Interface Connector A and B

For information how to setup this values see 4.4.2.2, 'Processing signal interface'

12.9.1 Analogue inputs

Pins: AIn_1 to AIn_8 with AIn_GND

Resolution: 24Bit

Accuracy: $\pm$(0.05% of measuring value + 0.05% of full scale)

Input signal: $\pm$20V

Overload capability: -30...+30V

Input resistance: 100k$\Omega\pm$0.1%

12.9.2 Analogue outputs

Pins   AOut_1 to AOut_8 with AOut_GND

Resolution: 14Bit

Accuracy: $\pm$(0.05% of measuring value + 0.05% of full scale)

Output signal: $\pm$11V

Output load: <10mA

Impedance: <1Ω

12.9.3 Digital outputs A

They are open collector outputs (see 13.6, 'Functional block diagram processing signal interface').

Pins: DOut_1 to DOut_4 with DOut_GND_A

Output high impedance: max 60V@100µA

Output low impedance: max. 0.9V@100mA

Reverse polarity: max. -1V@-100mA

12.9.4 Digital outputs B

They are open collector outputs (see 13.6, 'Functional block diagram processing signal interface').

Pins: DOut_5 to DOut_8 with DOut_GND_B

Output high impedance: max 60V@100µA

Output low impedance: max. 0.9V@100mA

Reverse polarity: max. -1V@-100mA

12.9.5 Digital inputs A

Pins: DIn_1 to DIn_4 with DIn_GND_A

Input signal: $U_{low}min = -60V@0.001mA$, $U_{low}max = 1.3V@0.03mA$
$U_{high}min = 3V@1mA$, $U_{high}max = 60V@1.5mA$

12.9.6 Digital inputs B

Pins: DIn_7 to DIn_10 with DIn_GND_B

Input signal: $U_{low}min=-60V@0.001mA$, $U_{low}max=1.3V@0.03mA$
$U_{high}min=3V@1mA$, $U_{high}max=60V@1.5mA$

12.9.7 Frequency input A with sensor supply

Pins: Frequncy input FIn_5
                           Direction input FIn_6
                           +5V supply Aux+5V_A

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-5V supply Aux-5V_A
Ground Aux_F_GND_A

Input signal:	U_{low}min=-30V@-3mA, U_{low}max=0.6V@0.001mA, U_{high}min=2V@0.002mA, U_{high}max=30V@2.5mA
Input resistance:	1MΩ@0V<Uin<5V 10kΩ@-30V<Uin<30V
Frequency range:	0.05Hz (depending and cycle time) to 6MHz
Accuracy:	±100ppm of reading
Auxiliary supply:	±5V, 10% @ 100mA

12.9.8 Frequency input B with sensor supply

Pins:	Frequncy input FIn_11 Direction input FIn_12 +5V supply Aux+5V_B -5V supply Aux-5V_B Ground Aux_F_GND_B
Input signal:	U_{low}min=-30V@-3mA, U_{low}max=0.6V@0.001mA, U_{high}min=2V@0.002mA, U_{high}max=30V@2.5mA
Input resistance:	1MΩ@0V<Uin<5V 10kΩ@-30V<Uin<30V
Frequency range:	0.05Hz (depending and cycle time) to 6MHz
Accuracy:	±100ppm of reading
Auxiliary supply:	±5V, 10% @ 100mA

12.9.9 Sensor supply

The functional group 'frequency input with sensor supply' can be connected directly to usual incremental sensors:

HTL version

(Supply 8...30V, max. 100mA, differential output):
Aux+5V to: +Ub

Aux-5V to: 0V
Shield of Sub-D to: Shield of cable

TTL version
(Supply 5V, max. 100mA, TTL output):
Aux+5V to: +Ub
Aux_F_GND to: 0V
Shield of Sub-D to: Shield of cable

12.9.10 Frequency/direction input

Incremental sensors without direction information
Connect them to FIn_5 resp. FIn_11 only. Let FIn_6 resp. FIn_12 open!

Incremental sensors with direction information
Connect the frequency track (usually track A) to FIn_5 resp. FIn_11.

Connect the direction track (usually track B) to FIn_6 resp. FIn_12.

A <u>positive</u> frequency is displayed, if the direction signal is high at the rising edge of the frequency signal.

A <u>negative</u> frequency is displayed, if the direction signal is low at the rising edge of the frequency signal.

If this is opposite to what you want, change the tracks or use a negative frequency scaling.

12.10 Timebase

The timebase which controls the energy measuring and the internal clock has an accuracy of ±25ppm @ 23°C

12.11 Frequency measuring

0.05Hz...3MHz, ±100ppm

12.12 Scope memory

Size: 1048576 words for u,
        1048576 words for i,
        1048576 words for p,
        together for all channels of one instrument resp. one master or one slave.

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13 System design

13.1 Further connectors

13.1.1 External Synchronisation (Sync.)

13.1.1.1 Sync. connector
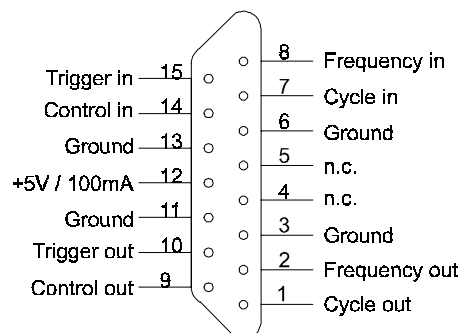
Figure 46: Sync. connector

13.1.1.2 Pin configuration of the „Sync. connector"

For the connection a 15 pole D-Sub plug with the following pin configuration is necessary:

Pin	Meaning	Pin	Meaning
1	Cycle out	9	Control out
2	Frequency out	10	Trigger out
3	Ground	11	Ground
4	Do not connect!	12	+5V / 100mA
5	Do not connect!	13	Ground
6	Ground	14	Control in
7	Cycle in	15	Trigger in
8	Frequency in		

13.1.1.3 Signal Level

All in- and outputs have CMOS - Drivers with 5V level. The supply of external sensors / drivers is provided at pin 12 with 5V and an Imax of 100mA. All in - and outputs are low active (0V), what means the idle level is high (+5V).

13.1.1.4 Function of the signals

Frequency in

Maximum 100kHz frequency synchronous to the frequency of the measured signal. If the LMG is set to Ext. Sync. this frequency is used for synchronisation. The rising edge of this signal replaces the positive zero crossing of the usual sync detector.

Frequency out

Measured frequency of group A, depending on the synchronisation source of the group.

Control in

Control of the energy measurement. With the next high low transition the integration is reset (if summing mode is inactive) and started. The integration stops only at transitions from low to high. The functionality of the transitions:

high   →   low   start key
low   →   high   stop key

Control out

Status of the energy measurement high level if the integration is stopped, low level if the integration is running.

Cycle in

Control of the measurement cycle. The period must be longer than 50ms and shorter than 60 seconds and longer than the period of the measured signal. The pulse duty factor can be 50%. Example: To measure a 5Hz signal the measurement cycle must be bigger than 200ms. Attention: Use only with valid control periods otherwise there can be a system fault of the meters. This input is normally not used.

The rising edge of this signal finishes one cycle and starts a new one.

Cycle out

Pulse for about 10μs per measurement cycle.

Trigger in/out

not used.

13.1.1.5 Synchronised measurements of two LMG500

Following a possibility is described, how two LMG500 can perform synchronized measurements. Please don't mix up this posibility with the combining of two LMG500 to a real 8 channel instrument. For a real 8 channel instrument you need a connection cable L50-Z13 and have to bring one instrument into the slave mode (see chapter 4.4.1, 'Misc.' and chapter 3.4, 'Coupling of two LMG500 (L50-Z13) for a 8 channel instrument').

13.1.1.5.1 General

Two LMG500 (or also LMG450) may measure synchronous if they are connected with the option L45-Z13 „Master-Slave cable". Because of this the measurement of even 8 phases in four groups is possible. In the following documentation the groups are named: group A1 and B1 are the groups of the first LMG500. Group A2 and B2 are the groups of the second meter.

13.1.1.5.2 Connection of the meters

The Master-Slave cable must be fitted to the „Sync"-sockets of both meters. The cable is symmetric, so there is no wiring direction.

13.1.1.5.3 Pin configuration of the Master-Slave cable L45-Z13:

Plug 1	Plug 2	Signal	ST1	ST2
1	7	Cycle	Out	In
2	8	Frequency	Out	In
9	14	Control	Out	In
10	15	Trigger	Out	In
7	1	Cycle	In	Out
8	2	Frequency	In	Out
14	9	Control	In	Out
15	10	Trigger	In	Out

Ground and Screen are connected to pin 3 of both plugs.

Synchronisation stages, Set-up of the Meters

The synchronisation of the measurement can be done in different stages. Each stage is independent to all others.

A) Synchronisation of the measurement signal

This stage has no master-slave functionality. The inputs „Frequency in" are connected with the synchronisation frequency of group A of the other power meter. The adjustments of this parameter can be set separately for each group in every meter in the *Measure* menu with *Sync*.

Because of this all groups can synchronise the measuring of one common signal.
Example for the settings:

Group A1 of the first meter is set to U1.
Group A2 of the second meter is set to Ext., by this the synchronisation is set to U1 of the first meter.
Group B1 is set to Ext., by this it gets the synchronisation frequency via A2 what means U1.
Group B2 is set to Ext., by this it gets the synchronisation frequency of A1 what means U1.

If the groups A of both meters are set to Ext. there is no common synchronisation frequency and the measuring is asynchronous.

B) Synchronisation of the measuring cycle

This stage has a master-slave functionality!
For a simultaneous generation of the measuring values of two LMG the measuring cycle of the meters has to be exactly the same. Therefore the cycle time of the slave meter can be set to 0ms in the *Measure* (refer 5.1.1 Globals tab) menu.
In the status bar „0 Ext" is shown and the green bar flashes every second.
The measuring values of both meters are now generated at exactly the same moment and a comparison of the values is possible.
Because of the master-slave meaning this adjustment can only be set in one meter. If both meters are set to 0ms the measurement stops!

C) Synchronisation of the energy measurement

This stage has no master-slave functionality but a control of a master LMG is recommended (if existing from the last top).
The energy measurement of both meters has to be set to the same mode and should be reset (refer 5.4.5.1 Integration menu).
The measurement can be started and stopped mutual with the keys „Start" and „Stop". A remote controlled measurement is also possible (see the following section)

D) External synchronisation signal

If the measurement should be synchronised to an additional external signal, this signal has to be connected to the pins of the D-Sub plug. The plug fitted to the meter which should be synchronised external has to be opened and the „Freq" and „Control" inputs must be disconnected. After this the external signal can be connected to this inputs.
If the signals are connected to the master LMG also the slave LMG can use them, because the master outputs are still connected to slave inputs:

Pin   8   Input for the external synchronisation frequency
Pin   7   Input for the cycle

Pin   14   Input for the control signal for energy metering
The connections at this pins of the master plug can be unsoldered and own signals can be
connected.
Ground should be connected to Pin 6, 11 or 13.

13.2   Functional block diagram LMG500
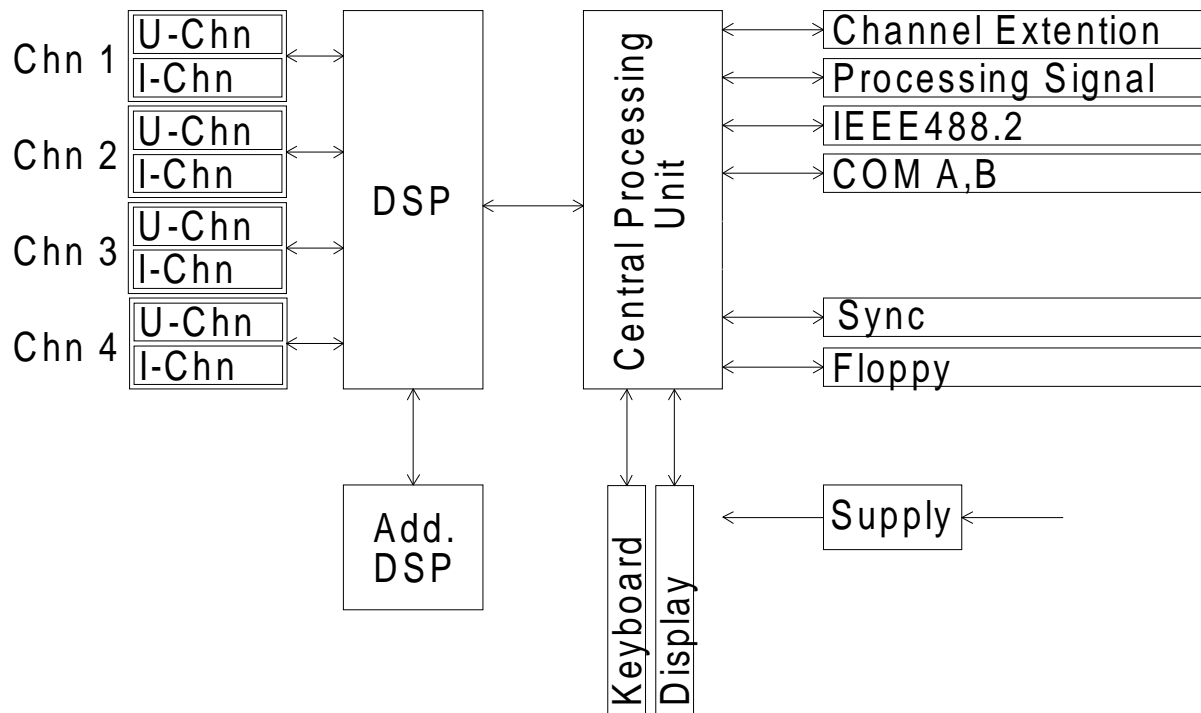
Figure 47: Functional block diagram LMG500

13.3   Functional block diagram voltage channels
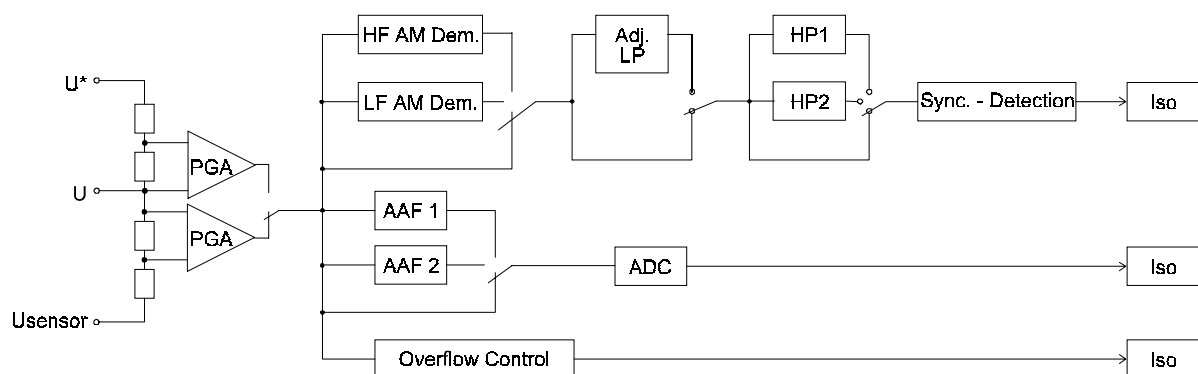
Figure 48: Functional block diagram voltage channels

13.4   Functional block diagram current channels
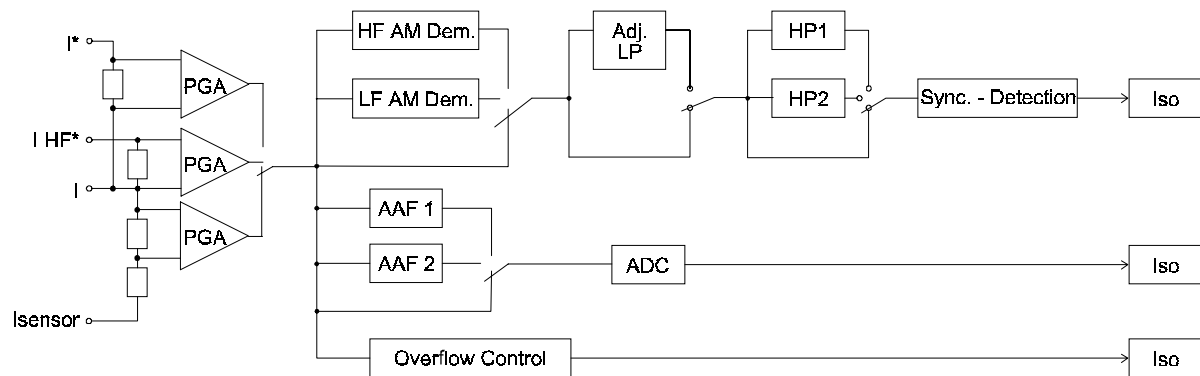
Figure 49: Functional block diagram current channels

13.5   Functional block diagram computing unit
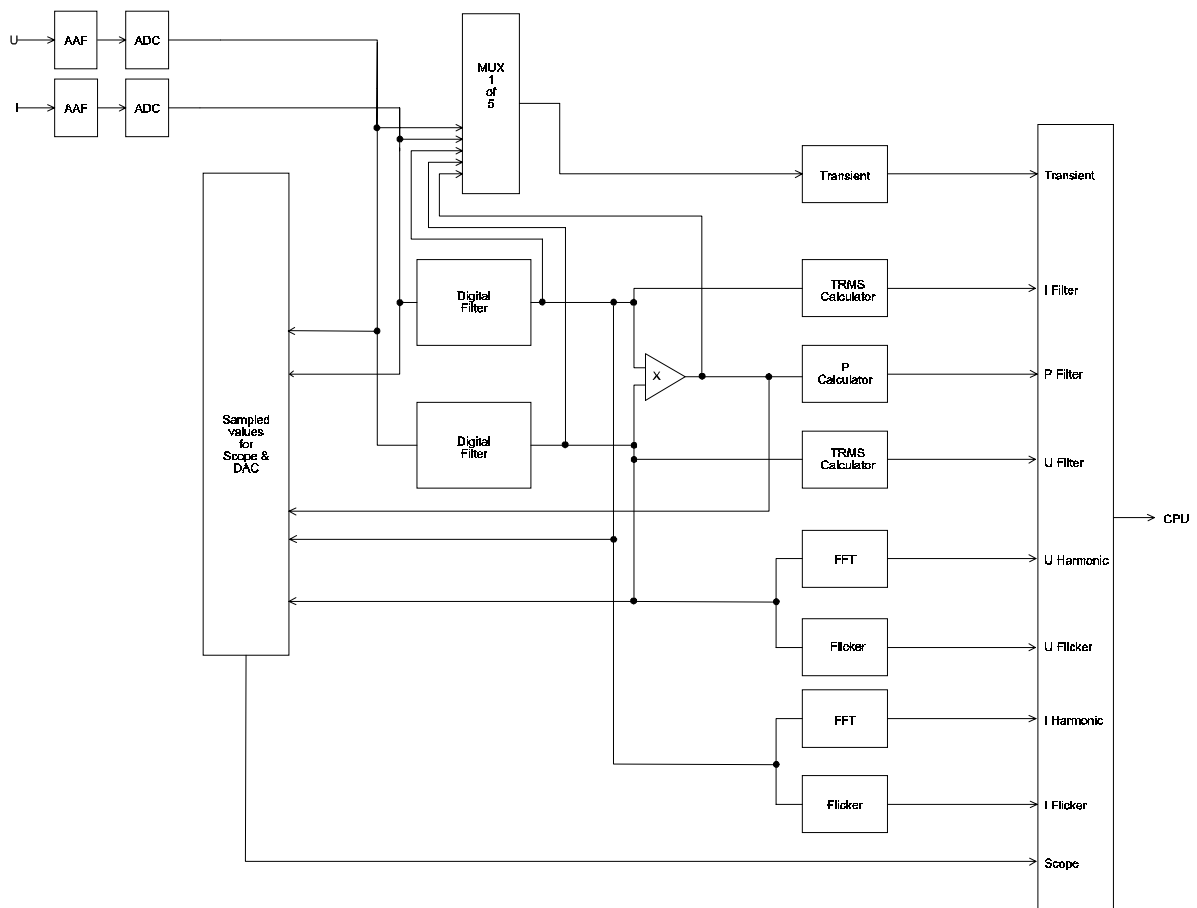
Figure 50: Functional block diagram computing unit

13.6   Functional block diagram processing signal interface
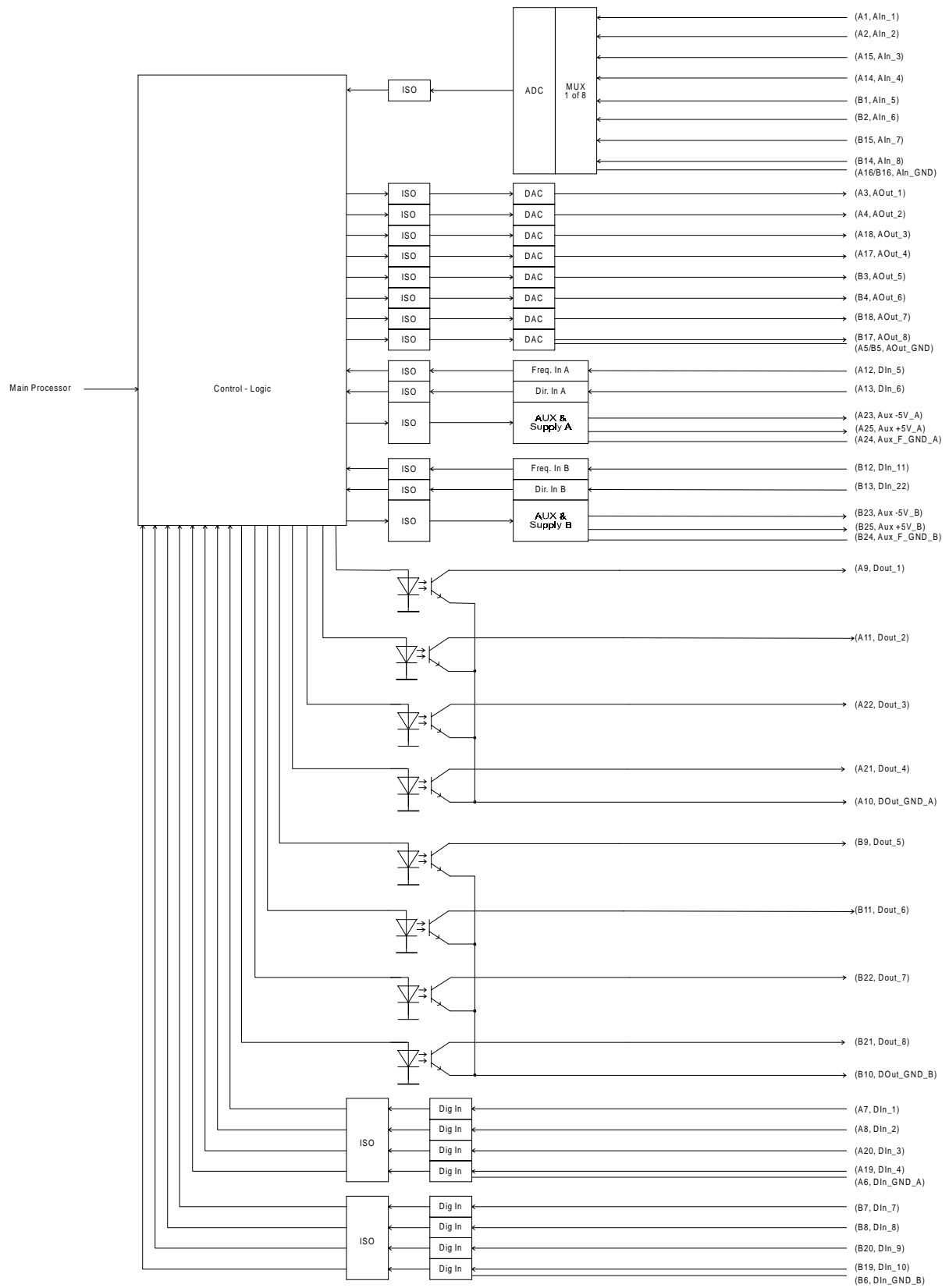
Figure 51: Functional block diagram processing signal interface

14 Glossary

Catchword	Meaning
100 Harmonics	Mode in which 99 harmonics of U, I and P are calculated.
A	
AAF	$\Rightarrow$ Anti Aliasing Filter.
AC	Alternating current; instantaneous values of voltage and current are time depending signals which have positive and negative values.
AC coupling	Used to remove the DC parts of a signal by using a high pass filter.
AC+DC coupling	Couples the complete signal without rejecting any parts.
Accuracy	Declaration of the errors which will be made in measuring.
Active energy	Energy which is consumed by the (usually ohmic) load.
Active power	Power which is consumed in the (usually ohmic) load.
Actual flicker level Pmom	$\Rightarrow$ Instantaneous flicker level.
Aliasing	Distortion caused by signal parts, which are created through the violation of the sampling (Nyquist, Shannon) theorem (bandwidth $\geq$ ½ sampling frequency). This can be prevented by using $\Rightarrow$ Anti Aliasing Filter.
Allowed limits	Limits which are declared in standards.
AM	Amplitude modulation; one signal is multiplied with another one; A typical example is a rapid fire control, where a 50Hz sine wave is modulated with a slower rectangular signal.
Amplitude error	Error in the modulus of a measuring result.
Amplitude modulation	$\Rightarrow$ AM.
Analogue I/O	Analogue input and output, the LMG series supplies four separated inputs and outputs for analogue signals: 0-10V.
Analogue Input	$\Rightarrow$ Analogue I/O.
Analogue Output	$\Rightarrow$ Analogue I/O.
AND Condition Register	Register in which a flag is set, if two conditions are true.
Anti-Aliasing-Filter	Filter which cuts off signal parts which might produce aliasing.
Apparent energy	Energy which seems to be consumed by the load; $\Rightarrow$ Apparent power. It is the integration of the apparent power.
Apparent power	Power which seems to be consumed; it is calculated by $U_{TRMS} * I_{TRMS}$ without taking care on the phase angle

Catchword	Meaning
	between them.
Application note	Several measuring or wiring problems are described in application notes of ZES ZIMMER; available also at the ZES homepage: www.zes.com.
Arbitrary block response data	⇒ Defined length arbitrary block response data.
ASCII format	Format which bases on the American standard code of information interchange with 128 symbols.
Autorange	Function which changes the ranges of the current and voltage inputs automatically, depending on the signal.
Auxiliary transducer supply	Some transducers need a separate supply. The LMG can provide this supply.
Averaged values	This values are averaged over a constant number of measuring cycles.
B	
Bandwidth	Frequency range from the lowest to the highest frequency, which can be measured or used.
Bargraph	Display of the values symbolised by bars; A typical bargraph is the spectrum display.
Basic wave	The signal part with the lowest frequency in the signal (except DC part).
Baud rate	Transfer speed of the bits in a serial data stream.
Binary	Numerical system based only on to values: 0 and 1, the data is represented only by this two binary values.
Bitmap	Format of drawing or photos.
Burden	Total load of a current transducer including wiring and input resistance.
C	
Calibration according to ISO9000	Testing of the meter accuracy traceable to national or international standards.
Capacitance against earth	Each channel has a capacitance against the earth ; this can cause systematically measuring errors which can be corrected.
CAT II	Overvoltage class for usage in normal building nets.
CAT III	Overvoltage class for usage at the PCC (point of common coupling)
CE harmonics	Harmonics measured according to EN61000-3-2; this test is requested for the CE sign.
CE-Flicker	Flicker measured according to EN61000-3-3; this test is

Catchword	Meaning
	requested for the CE sign.
Channel	Hardware which acts as an interface between the test circuit and the instrument, these are U, I and P channels (P=U*I).
Charge	The integration of the current over the time; this charge can be stored for example in an accumulator the unit is Ah.
Class A, B, C, D	Different kinds of equipment under test for EN61000-3-2 tests are assigned to this test classes.
COM interfaces	Serial Interface, mostly 9 pole SUB-D socket or 25 pole SUB-D socket.
Comma separated	Data format in which each value is separated by a ','.
Command set	A couple of commands to remote control the instrument
Common mode rejection	Relation of the displayed value to a common floating signal on all inputs of a measuring channel; a high common mode rejection is necessary for high accuracy.
Condition instruction	Instruction which will only be executed if a condition has been fulfilled.
Constant	Value which will not change over time.
Continuous measuring	Measuring without any gaps.
Core parameter measuring circuit	The core parameters, like hysteresis and magnetic flux, can be determined through power measuring.
Correct current Correct voltage measuring	You can only measure one of these parameters in the correct way, because the impedance of the voltage / current channel has an influence on the measuring channel. This is a systematically measuring error, which can be corrected.
Coupling	This defines which parts of a signal are fed into the next stage. $\Rightarrow$ AC coupling.
Crest factor	Ratio of peak value to TRMS value; very important when using analogue instruments.
Current clamp	Tool to measure currents; work like a removable transformer.
Current transducer	Similar to current clamps, but placed unremovable in the measurement circuit.
Cursor	Representation of the place on which the next text input will follow; in graphics the cursor marks a special point of the waveform.
Custom menu	Menu defined by the customer himself.
Cycle time	Time which defines a measuring cycle must be higher than the period time of the basic wave.
D	

Catchword	Meaning
D. U. T.	'Device under test': equipment which should be measured.
Data output format	Format which is used to transfer data from the meter to a PC or data logger.
DC value	'Direct current'; signal without alternating components. This signal is constant over the time.
Default parameters	Parameters defined by the manufacturer; the instrument is set to this parameters when it leaves the factory.
Defined length arbitrary block response data	Data transfer in blocks with a defined length and random contents inside the blocks; there can be for example the $\Rightarrow$ EOS character which will be interpreted as data instead of EOS. The fastest way to get data.
Demodulation	Inverse function to $\Rightarrow$ modulation; remove the carrier and you get the signal you want.
Desired integration time	Time in which the power is integrated, set by the user.
Device	Every meter or equipment take place in the measurement (Printer, PC ...).
Device under test	$\Rightarrow$ D. U. T.
DFT algorithm	Discrete Fourier transformation; operation with discrete values using the Fourier integral to get the harmonics of a signal.
Digital filter	Filter built up with digital components and software.
Digital Input	Like $\Rightarrow$ Analogue inputs the LMG series provides digital inputs, to read external states.
Digital Output	Like $\Rightarrow$ Analogue outputs the LMG series provides digital outputs, which can be used to signalise states (e.g. alarm outputs).
DIP switches	Small hardware switches to set up a meter parameter, like communication speed.
Direction input	Input for motor testing to measure the rotary direction of the motor.
Dot joiner	Connects the dots of the measured graph; it improves the look of a graph.
E	
E. U. T.	$\Rightarrow$ D. U. T.
Echo	Repetition of characters sent via the RS232 to the instrument.
Edit line	Line in which you can change a value or text.
Efficiency measurement	Efficiency is the relation between the output power and the

Catchword	Meaning
	input power of an E. U. T.
EN61000-3-2, EN61000-4-7 EN61000-3-3, EN61000-4-15	Standards which describe the harmonic measuring Standards which describe the flicker measuring.
End of string character	'<lf>', '<cr>, <cr><lf>' are examples for EOS characters.
Energy	Integration of the power which is consumpted by a consumer or a device in a defined time.
envelope	It is the curve which covers a mixed frequency signal connecting the peak values of the fast frequency; a curve defined by EN61000-3-2 to define if a device belongs to Class D or not.
EOS	⇒ End of string.
Equipment under test	⇒ D. U. T.
ESC key	Key used to cancel an entering mode and to quit an error message.
Extended Trigger	Mode in which the trigger conditions can be set up very differentiated to measure even modulated signal.
External current transformer	Device to transform high currents to lower ones.
External shunt	Changes currents into voltage with defined ratio.
External synchronisation jack	Input for an external synchronisation source.
F	
Falling edge	Opposite of rising edge; the logic signal turns from the high potential to the lower one.
FIFO	First in first out; method how the in- and output of memory is handled.
Filter	Device which cuts off frequencies which are not useful; e.g. high pass filter cuts off low frequencies.
Flicker meter	Device to measure flicker levels.
Fluctuating harmonics	Harmonics not constant over time.
Form factor	Ratio of TRMS value to rectified value; older meters could only measure the rectified value and multiply it with the form factor to get the TRMS value. The problem is, that the form factor depends on the wave form. So with other wave form you get an error. Modern instruments like the LMGs measure independent to the form factor, so you measure always correct.
Formula editor	Here you can set up formulas which will calculate different parameters from the measured values.
Freeze	The display values are not updated any more.

Catchword	Meaning
Frequency	Speed in which the period of an alternating signal repeats.
Frequency divider	Changes a high frequency into lower frequency by division with an <u>integer</u> number.
Frequency domain view	The signal is shown as spectrum over the frequency.
Frequency range	⇒ Bandwidth.
Full scale value	Highest measurable instantaneous value in the chosen range.
Fundamental	⇒ Basic wave.
G	
GPIB interface	General Purpose Interface Bus socket to transfer data from meter to PC and opposite.
Graphical display	Representation of the measured values via time or frequency.
H	
Half wave value	Values measured over the half time of the signals period.
Harm100	⇒ 100 Harmonics.
Harmonic analyser	Device to measure harmonics.
Harmonic order	Describes which order the harmonic has; e.g. of a 50Hz signal the order of the 100Hz harmonic is 2, its the second harmonic.
High impedance state	The digital output has a high impedance; the transistor is in blocking mode.
Hyperterminal	Software to exchange data between a PC and a device; included in Microsoft Windows.
Hysteresis	Difference between the switching level of the rising signal to the switching level of the falling signal.
I	
I/C indication	Indication if the load is inductive or capacitive.
Identifier	Text string representing a measuring value.
IEC61000-3-2, 2-3	⇒ EN61000-3-2.
IEC61000-4-7, -4-15	⇒ EN61000.
IEEE488.2 interface	⇒ GPIB interface.
IF/IO	Key for the set - up menus of interface and processing signal interface.
Inaccuracy of display	Because of the limited numbers on the display the displayed values have an error caused by the display (this is always ± 1 digit).
InCa flag	Flag which is set depending if the load is inductive or

Catchword	Meaning
	capacitive.
Input resistance Ri	Resistance of the input of the measuring channel.
Inrush current	Very high current at the start of a device or appliance; this can be 5 ... 100 times bigger than the current at normal operation.
Instantaneous flicker level	Time-dependent output signal of a flickermeter (output 5), which simulates an actual reaction of men's brain to the variations of light brightness caused by fluctuation of the supply voltage.
Instantaneous value	The value of a signal at one point of time.
Int. Time	Interval time; for example for integration.
Int. Value	Interval value; they are measured while the ⇒ Int. Time.
Integer number	Number without decimal position.
Integration mode	Mode in which the energy is calculated.
Interface	Adapter for the connection between two devices.
Interharmonic	Sinusoidal components with a frequency which is not an integer time of the fundamental.
Internal beeper	Like the PC speaker; to signalise errors.
Interval	Fixed time period.
ISO9000	Standard to guarantee the quality of devices or appliances.
L	
Level	Height of a value.
Logical devices	Log or remote; if log printer, RS232 or MCM is meant, is the question of the physical device.
Limit	Border of a value.
Linefeed	<lf>, hex0A, dec10; jump to the next line; historical from a typewriter, is the most common ⇒ EOS character.
Local	In this mode the LMG can be controlled directly by the user at its keyboard; ⇒ Remote control.
Logarithmic display	Display scaled with logarithmic axis.
Logging	Store data to memory, printer or any other storage device.
Long number	4 Bytes.
Long term flicker level Plt	A result of weighted averaging of short term flicker levels over a time period which typically equals to 2h.
Loop area	Inner area of a circle is a loop area.
Low-Pass Filter	Cuts off high frequencies.
M	
Mains	Line supply.

Catchword	Meaning
Mains switch	Switch to start up the instrument.
Manual range	The range settings have to be done by the user.
Measuring converter	Adapter to connect a meter to the $\Rightarrow$ D. U. T.
Measuring cycle	Cycle set up from the user. After this time the meter calculates new values. The exact time depends on the synchronisation frequency.
Measuring settings	All parameters of the meter which influence the measurement.
Memory card	Random access memory card to store data.
Menu	The whole measurement settings are divided in menus to get a better survey.
Miscellaneous	In this menu you can set up several parameters which have no direct influence on the power measurement, like contrast time and date.
Multimeter	Meter which can measure several values like voltage, current and resistance.
N	
Nibble	Half of a byte; upper or lower 4bit.
Noise	Usually random signals with a high bandwidth which are superposed to the useful signal.
Nondecimal numeric program data	Data which can be represented as string instead of a number; e. g. 'Cont on' instead of 'Cont 1'.
Non-linear component losses	Losses caused by non linear loads like inductivities or capacitors or amplifier circuits.
Null modem	Type of serial connection between a PC and another device; the connection cable has two crossed conductor pairs.
O	
Open collector outputs	Passive outputs where the user has access to the collector of the output transistor. You have to connect an external voltage supply to this collector to use the output.
Operator	Instruction which is taken into the calculation: +, -, *, /.
Option Key	A string which can be used to implement software options when the LMG is at the customer.
OR Condition Register	Register which becomes true if an or condition is fulfilled.
Order	$\Rightarrow$ Harmonic order.
Overload capability	A value how far a channel can be overloaded for a special time.
Overload condition	The instrument is in overload condition while the applied

Catchword	Meaning
	signal is too big for the selected range.
P	
Packed	Data are transferred binary instead of ASCII format
Parallel interface	⇒ Serial interface; here the data is transferred in parallel.
Parity	Even or odd number of 1's in a binary data block; The LMG works without parity.
Parsing	The LMG tries to interpret a formula or interface string and to react correctly.
Partial odd harmonic current	The harmonic content of order 21, 23 ...
PCMCIA memory cards	⇒ Memory card; PCMCIA is the old name for the PC - Card standard.
Peak current ranges	Ranges with quiet small allowed TRMS values (because of the heating up of the shunt) but very big allowed peak values; very useful to measure ⇒ Inrush currents.
Peak value	Value measured from the zero line to the highest peak of the signal.
Peak-peak value	Measured from the lowest to the highest peak of a signal.
Periodic integration mode	In this mode the integration interval is repeated periodically.
Phase	Conductor of the high potential; typically marked with L.
Phase angles	Usually the angle between current and voltage.
Phase error	The error in power caused by an additional phase shift in the measuring equipment, for example the additional phase shift of a current clamp.
Physical device	Hardware, device (RS232, printer, GPIB...).
Plot function	Mode in which cycle values (e.g. voltage, frequency, ...) are displayed over time.
Power	The energy of a time interval divided by the internal time (e.g. cycle time); so the power is always an averaged value!!
Power factor	Relation between active and apparent power.
Power measuring channel	⇒ Channel.
Power supply	Source which provides the necessary voltage.
Pretrigger	Time before the trigger condition, while which sample values are stored.
Printer header	Upper line of the printer like a title or headline.
Printer output	Socket to connect a printer.
Processing signal interface	Board with Analogue or Digital outputs.
Protocol	Arrangements for communication between devices.
Pulse controlled currents	A modulated current controls the device's power; like in a

Catchword	Meaning
	hot air fan the rapid fire control.
R	
RAM	Random access memory; you can read and write to this memory.
Range	The measuring range defines the biggest measurable signal. For best accuracy the range should be used for at least 66%.
Reactive energy	Energy which oscillates between source and load without being consumpted.
Reactive power	Average $\Rightarrow$ Reactive energy.
Real measuring time	Time in which the measuring is made, depends on $\Rightarrow$ cycle time and $\Rightarrow$ synchronisation frequency.
Record rate	Ratio in which the sampled values are stored in memory.
Rectified value	The average value of a rectified signal; measured by many analogue instruments $\Rightarrow$ form factor.
Remote control	You can control the LMG via a connection to a PC.
Resolution	Resolution is <u>not</u> $\Rightarrow$ Accuracy!!! In the LMG are two resolutions important: the analogue to digital converter has 16bit resolution, the display has 5 or 6 digit resolution.
Rise time	Time in which the signal rises from zero to the maximum (in practice from 10% to 90%).
Rotary knob	Knob used to set up parameters in the meter or move the $\Rightarrow$ Cursor.
Rotation speed	Speed of the shaft of a motor; rpm.
RS232 interface	$\Rightarrow$ Serial interface.
RTS/CTS	$\Rightarrow$ Protocol to control the data flow of a $\Rightarrow$ Serial interface.
S	
Safety socket	Connection with high safety against electric shock.
Sample memory	Memory to store the sampled measurement values.
Sample value	Value of a signal measured at a defined time $\Rightarrow$ Instantaneous Value.
Sampling frequency	Frequency with which the samples of a signal are taken.
Scaling	Resolution of an axis or factor which has an influence on the measured value.
Scope function	In this mode the LMG works like an oscilloscope and displays $\Rightarrow$ Sample values.
SCPI commands	A standardised set of commands to remote control the LMG.

Catchword	Meaning
Sensors	A small external device which converts a current or voltage to a signal the LMG can measure.
Serial poll	A PC program can ask every connected instrument in series if it has data to send. Used by $\Rightarrow$ GPIB.
SHORT headers	Shorter set of commands, equivalent to $\Rightarrow$ SCPI.
Short term flicker level	A result of statistical processing of instantaneous flicker level quantities over a time period, which typically equals to 10 min.
Shunt input	Special socket to connect the small voltages of an external shunt to the correct channel.
Shuttle knob	$\Rightarrow$ Rotary knob.
Signal coupling	$\Rightarrow$ AC coupling; This coupling affects the measured values.
Signal source	Where you get a signal from; e.g. frequency generator.
Slewrate	Relation between the voltage rise and the used time.
Softkey	This keys change the meaning depending on the menu.
Software options	Options which can be installed with software.
Software update	Updates your software of the LMG. Available on the homepage: www.zes.com.
Status byte register	Register in which several flags are set according to the status of the LMG.
String	Characters lined up in a row.
Sub menu	A subdivision of a menu.
Synchronisation	Periodic signals have to be measured for an integer number of periods. So the LMG must synchronise it's measuring to the signal to get stable values.
System time	Main time of the meter.
T	
Table	Special format for output of measuring values in a table.
Terminal	Each device which takes an account on a data transfer.
Terminal program	$\Rightarrow$ Hyperterminal.
THD values	Total harmonic distortion, relation of the harmonics of a signal to the fundamental.
Time depended signals	Signal of which the values change depending on the time.
Time domain views	Values are displayed over time.
Total Harmonic Current	Sum of all harmonics starting with 2nd order.
Total harmonic distortion	$\Rightarrow$ THD.
Total harmonic distortion factor including noise (THD+N)	$\Rightarrow$ THD with included noise.

Catchword	Meaning
Transient	A short, unusual event on a signal.
Transient mode	Mode in which events can be recorded.
Trigger condition	The trigger starts depending on this condition.
Trigger level	Level on which the trigger starts.
Trigger signal	Signal which gives the trigger event.
TRMS	$\Rightarrow$ True root mean square.
True root mean square	The average of a squared signal.
V	
Variables	Values calculated by $\Rightarrow$ Formula Editor.
Visual display	Display what you can see in the moment.
Voltage transformers	Changes voltage levels.
Z	
Zero crossing	When the signal passes the zero axis. The positive zero crossing is usually used for $\Rightarrow$ Synchronisation.
Zoom	Zoom in: enlarge the display Zoom out: reduce the visual display.

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