ZES ZIMMER
Electronic Systems

# 1-Phase- Precision Power Meter

# LMG95

# User manual

Status: 23. May 2000

© Copyright 2000
ZES ZIMMER Electronic Systems GmbH
Tabaksmühlenweg 30
D-61440 Oberursel (Taunus), FRG
pho ++49 (0)6171 628750
fax ++49 (0)6171 52086
e-mail: sales@zes.com
Internet: http:://www.zes.com

No part of this document may be reproduced, in any form or by any means, without the permission in writing from ZES ZIMMER Electronic Systems GmbH.

Regard DIN 34!

We reserve the right to implement technical changes at any time, particularly where these changes will improve the performance of the instrument.

# 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

Tabaksmühlenweg 30
D-61440 Oberursel

Date

Quality Control

## List of figures

# 1 Instructions and Warnings

## 1.1 Safety Instructions

This instrument conforms to the IEC61010-1 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**. 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 possible 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 personnel. 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 against voltages up to 600V according to protection class I.

Opening the instrument exposes components 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 exposed and energised instrument.

Fuses may only be replaced with the correctly rated and recommended 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<br>0°C...40°C, humidity max. 85%, annual average 65%, no dewing |

# 2 General

The 1-Phase Precision Power Meter LMG95 extends the ZES multimeter product range for power measurement. It benefits from experience and know-how gained from the successful ZES LMG90 and LMG310 series.

Due to the very high sampling rate which is used in this instrument, it is now possible to make extremely accurate power and efficiency measurements in 1-phase system configurations with a choice of load and signal components containing frequencies in the precision range from DC to 50kHz.

Transient observation and storage, harmonic analysis as well as time domain views of signals on the visual display (oscilloscope mode) are all available with this instrument.

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

## 2.1 Features and application areas

Voltages and currents can be measured over a wide dynamic range. This makes the LMG95 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 (option). This makes it possible to take only the fundamental harmonics into account, which are responsible for torque production.

Due to the exceptionally good common mode rejection of the individual channels it is possible to measure currents and voltages which float up to 600V and at high frequencies with respect to earth. This is particularly important for measurements in invertor- and rectifier circuitry and in switched mode power supply applications.

The harmonics option permits the measurement of high frequency harmonic reflections in networks conforming to IEC61000-3-2 standards and is therefore indispensable for tests according to these standards. The user can also obtain the energy distribution over different frequency ranges and can thus investigate their relative contribution to the total consumption of energy.

The LMG95 is suitable for measurements in electromagnetically noisy environments to IEC61000-4. 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.

## 2.2 Usage of the manual

The LMG95 is controlled either by depressing buttons with hard-wired functions (in the following characterised by *italic* style), or by using soft keys (**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 her or 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, Voltage, Current, Power, Energy and Graph*) enable the standard display of the 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, Range, Integral, Option, Function, User*). 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 LMG95 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 channel.

- CE harmonics mode: In this mode the LMG95 works as an harmonic analyzer. All measurements are judged according to the standards. There is only a minimum of settings to prevent setup errors.

- CE flicker mode: In this mode the LMG95 works as a flicker meter. All measurements are judged according to the standards. There is only a minimum of settings to prevent setup errors.

- Harm100 mode: In this mode the LMG95 works as an harmonic analyzer for 100 harmonic components. You get many values like phase angles and the power at each frequency.

- Transient mode: In this mode the LMG95 works as a transient recorder. You can define special events when the storage of values should be stopped.

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.

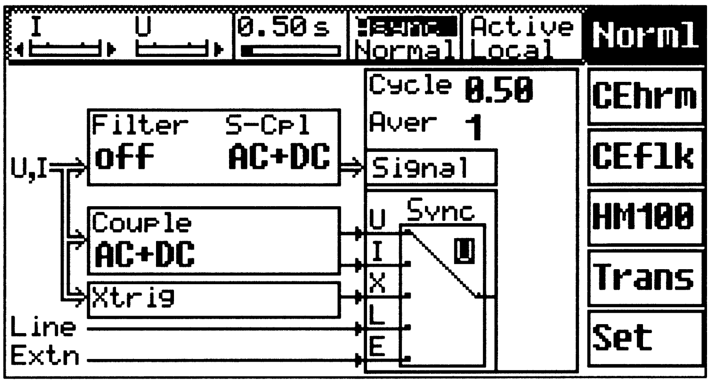


**Figure 1: Measuring menu**

# 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 not possible 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 LMG95 1-phase precision measuring instrument
- 1 User manual
- 4 Safety type grey and violet laboratory cables, 2.5mm², 1m
- 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 only be operated in a horizontal position or tilted by means 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.

## 3.3 Connection of the LMG95

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 black terminals 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 currrents, the instrument have to be connected to a suitable earth point via an adequately rated cable. If reliable earthing cannot be realized, 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 21A (short-time 160A)

Shunt Input: maximum 10V signal voltage

When the instrument has a BNC connector for the shunt input you have maximum 600V@CAT III or 1000V@CAT II operating voltage against earth or instrument casing. When the shunt input uses a safety jack you have maximum 1000V@CAT III or 1500V@CAT II operating voltage against earth, instrument casing or voltage channel. See also 14.2, 'Operating voltages'

U*,U: maximum 600V (short-time 1500V) between U and U*, maximum 1000V@CAT III or 1500V@CAT II operating voltage against earth, instrument casing or current channel.

⚠ **Attention!** The jacks for I, I* and Shunt Input are internally connected. If you measure a current, the Shunt Input jack has the same voltage against earth like the I jacks! The shield of the Shunt-/Transformer Input (protection BNC connector) is internally directly connected to the I jack. For this purpose do not connect the I/I* jack and the shunt input at the same time!

⚠ **Attention!** Use only cables with **safety** connectors and sufficient cross section (obtainable from the equipment manufacturer). This is also recommended for the protection BNC connectors!

⚠ **Attention!** Do not use unisolated BNC cables

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* and I*.

When working with DC voltages/currents, note that the terminals marked with the '*' are the positive connections.

The following diagrams are some examples for typical connections of the LMG95. But all other measuring circuits are also possible (eg. circuits which measure the correct current instead of the correct voltage).

### 3.3.1 Measuring circuit using the internal current path

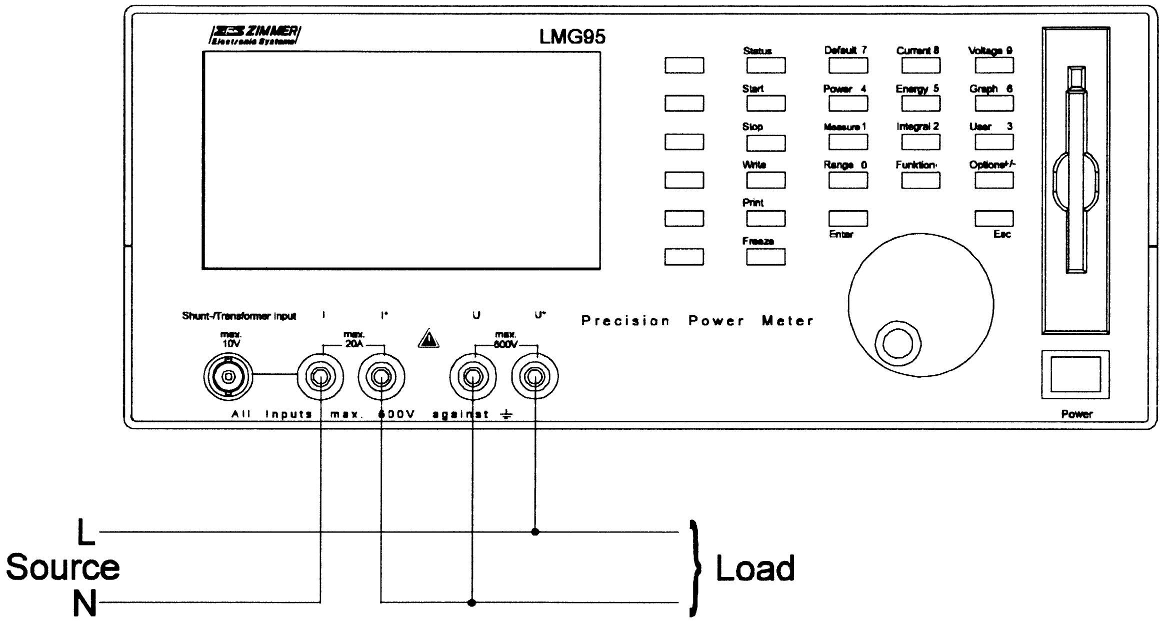


**Figure 2: Standard measuring circuit**

### 3.3.2 Measuring circuit using an external current transformer

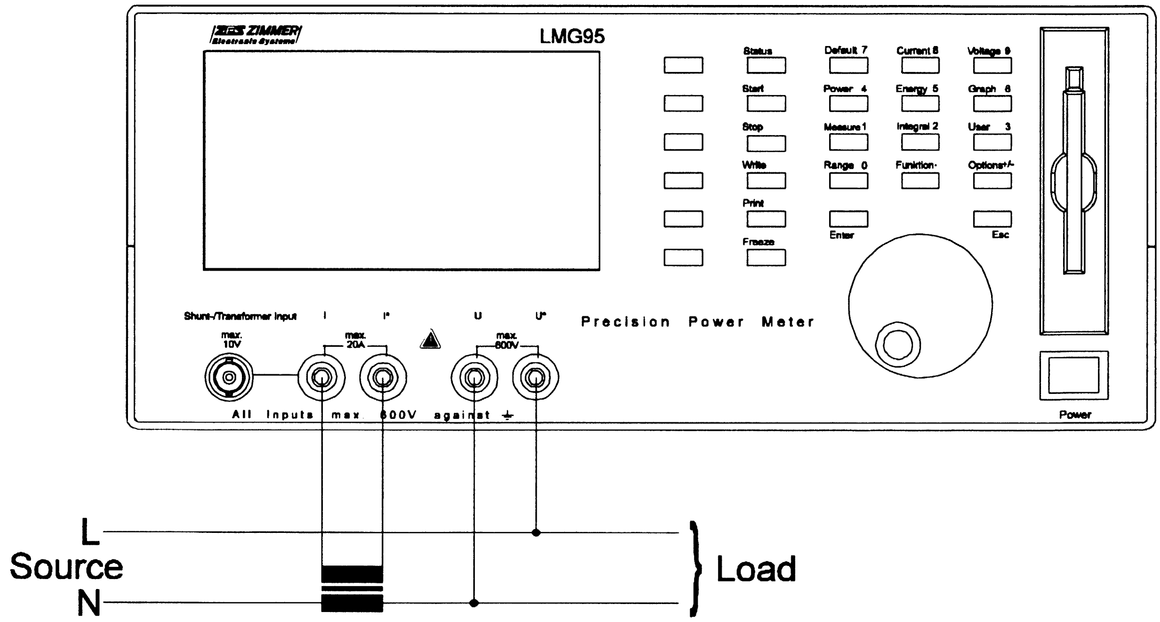


**Figure 3: Measuring circuit with external current transformer**

### 3.3.3 Measuring circuit using an external shunt

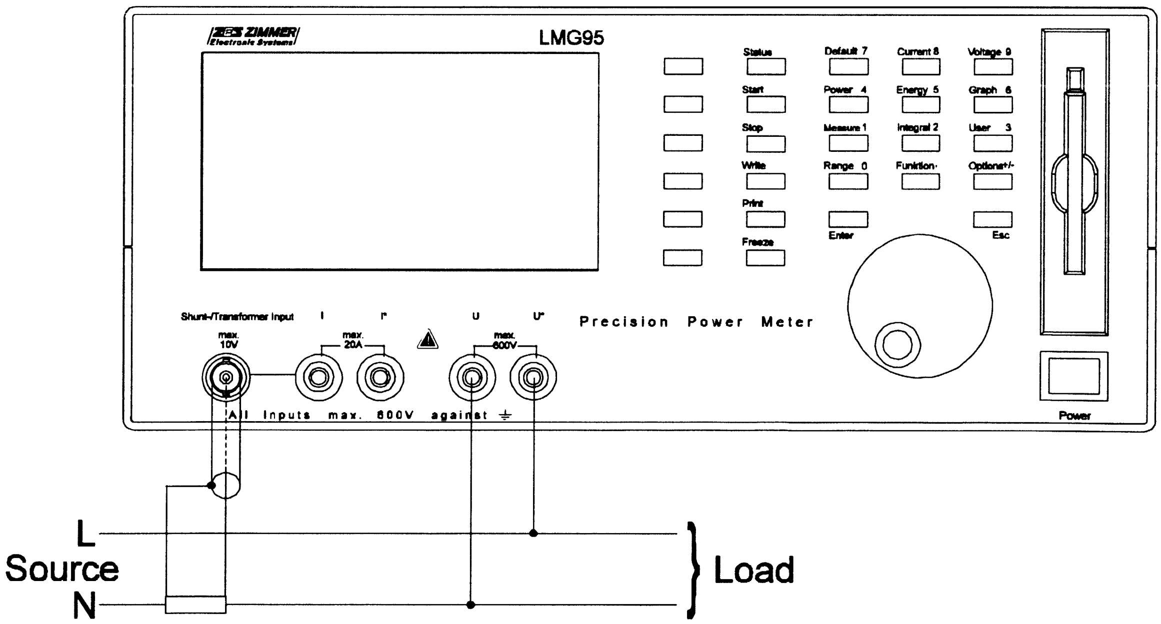


**Figure 4: Measuring circuit with external shunt**

### 3.3.4 Measuring circuit using an external current transducer

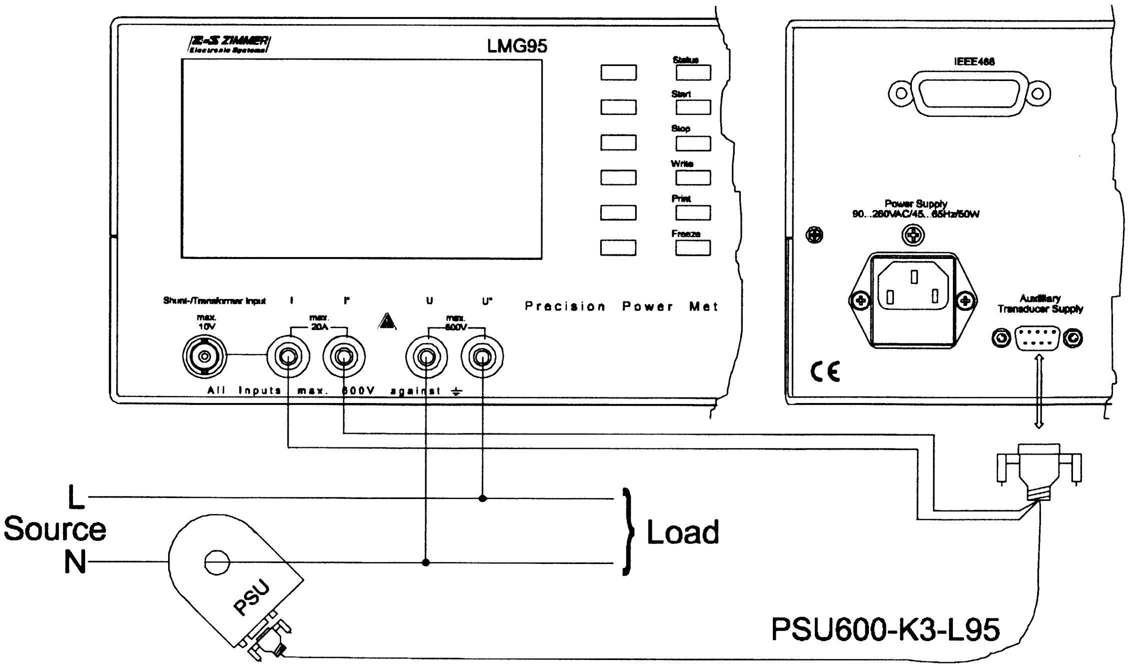


**Figure 5: Measuring circuit with external transducer**

This special current transducers of the PSU series can measure currents up to 2000Apk in the frequency range from DC to >100kHz. The auxiliary supply for the transducer is taken from a 9 pin SUB-D jack from the rear of the instrument. The setup of the range menu should look like this (for PSU600): Current scaling 1500, Shunt intern, current range 0.4Apk or smaller.

# 4 Instrument controls

## 4.1 Front panel

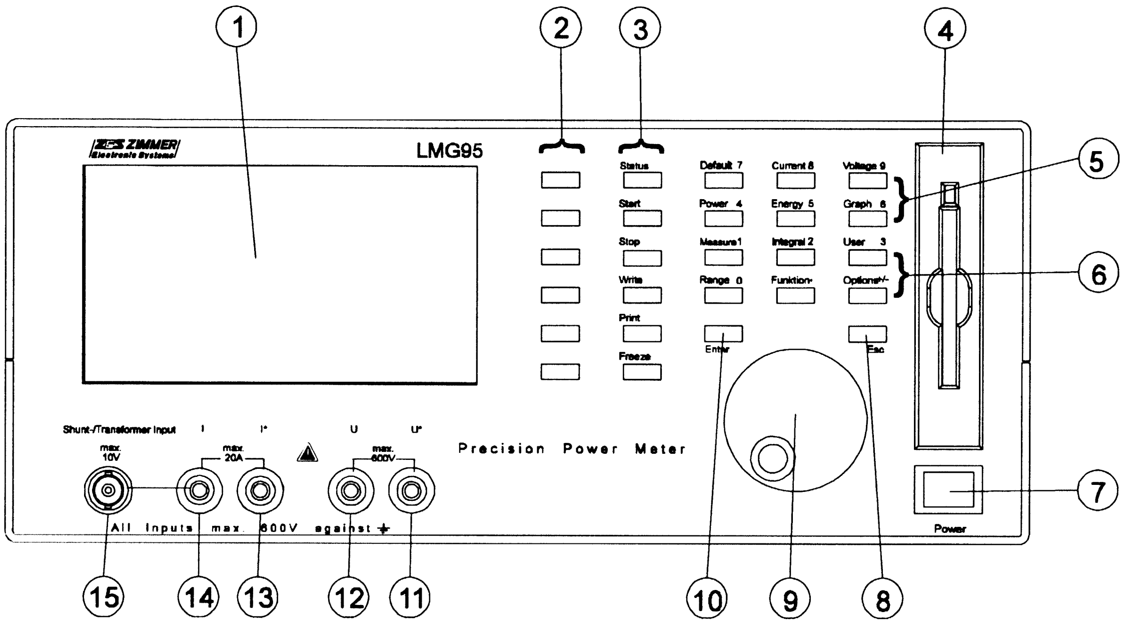


**Figure 6: Front panel of the instrument**

1 Graphical Display

2 6 Softkeys.
Their function depends on the indicated function in the display.

3 Special function keys:

Status: Here you get status information about the LMG95
Start: This key is used to start time dependent measurements
Stop: This key is used to stop time dependent measurments
Save/Recall: (Write on older instruments) The actual menu is stored to the memory card
Print/Log: The actual menu is send to the printer output
Freeze: Holds or enables the visual display

4 Memory Card Slot
Here the PCMCIA memory cards are inserted.

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

6 Purple menu selection keys

With this keys you can call several menus for setting up the instrument:

Measure: The main measuring parameters

Int.Time: (Integral on older instruments) The parameters for time dependent measuring

Custom: (User on older instruments) The setup of the custom defined menus

Ranges: The range selection of the mesuring channels

Misc.: (Function on older instruments) Setup of date, time and display brightness.

IF/IO: (Options on older instruments) 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.

7 Mains switch

8 ESC key

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

9 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.

10 ENTER key

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

11 U*

Voltage input (high), 4mm purple safety socket

12 U

Voltage input (low), 4mm grey safety socket

13 I*

Current input (high), 4mm purple safety socket

14 I

Current input (high), 4mm grey safety socket

15 Shunt-/Transformer Input

Input for voltages from external shunts and transformers. Safety BNC jack

## 4.2 Rear panel

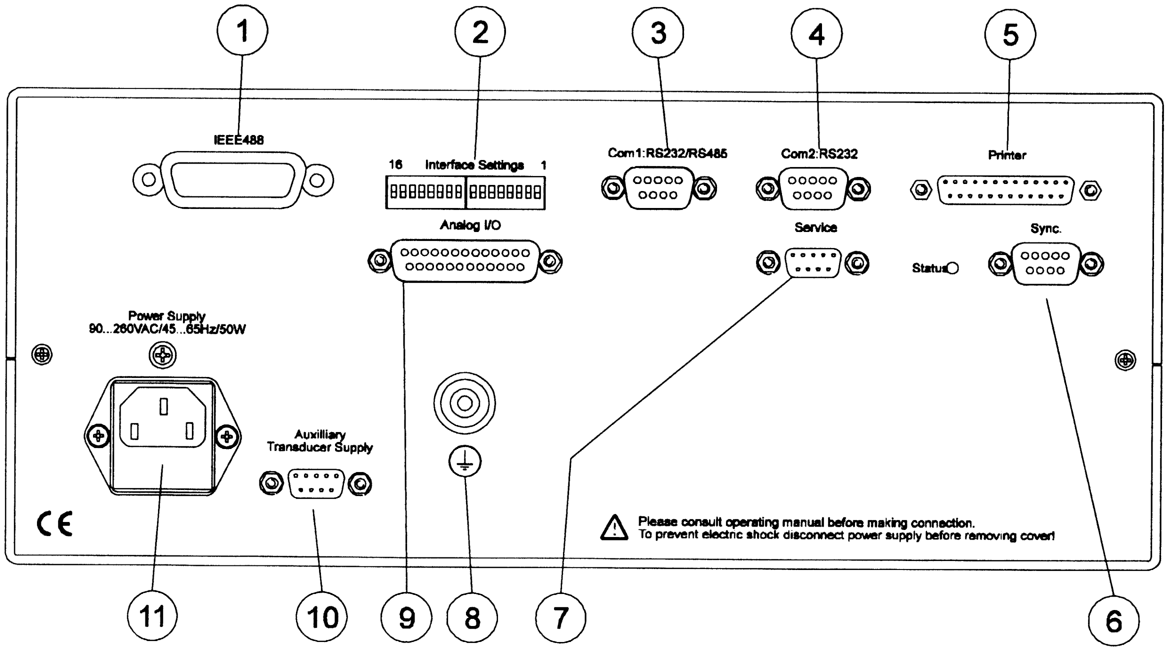


**Figure 7: Rear panel of the instrument**

1 IEEE488
Parallel interface, 24-pin micro-ribbon socket

2 DIP-Switches
This switches are used for external configuration of the interface parameters

3 Com1: Serial RS232/RS485 interface
This is the standard serial interface for remote control of the LMG95.
9-pin SUB-D socket

4 Com2: Serial RS232 interface
This is a serial interface which is reserved for further usage
9-pin SUB-D socket

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

6 Sync.
Socket for external synchronisation and measuring time control of the LMG95.
9-pin SUB-D socket

7 Service
Socket for service purposes such like software-update.

8 PE
Connector for additional earthing, pole terminal

9 Analogue I/O
Additional analogue and digital inputs and outputs for auxiliary signals.

10 Auxiliary transducer supply
Here a voltage of ±15V is available. It is used for extenal sensors.

11 Mains
Fused chassis plug with holder for microfuses. Mains voltage 90...250V, 45...65Hz, about 30W
Microfuse T1A/250V, 5x20mm, IEC127-2/3

## 4.3 Display

The display is divided into 3 regions:

- The softkeys at the right border change their meaning depending on the actual menu. A softkey with a black background is a 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 informations of the instrument. This line is always visible.

- In the main display the different menues are displayed. This can be measuring values or set up menues.
  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

The status line has the following 5 sub regions (from left to right):

- The current signal level indicator. Here you can see how much of the actual current range has been used. This display is important for the selection of the measuring range. An inverse displayed 'LF' indicates that signal of the channel is filtered. If the arrow to the left is blinking you should use next next lower range. If the arrow to the richt is blinking you should use the next bigger range.

- The voltage signal level indicator. Here you can see how much of the actual voltage range has been used. This display is important for the selection of the measuring range. An inverse displayed 'LF' indicates that signal of the channel is filtered. If the arrow to the left is blinking you should use next next lower range. If the arrow to the richt is blinking you should use the next bigger range.

- The time base indicator shows the actual choosen cycle time. The bar below this number shows how much of the cycle time is over.

- The synchronisation and mode indicator. In the first line you see the choosen synchronisation source. Possible values are ‘Line’, ‘Extern’, ‘Sync U’ and ‘Sync I’. If this display is written on a white background, a valid synchronisation signal is found. Else the instrument could not found a valid signal.
  In the second line you see the choosen measuring mode. Possible values are ‘Normal’, ‘CE-Hrm’, ‘CE-Flk’, ‘HRM100’ and ‘Trans’.

- The freeze and remote indicator. In the first line ‘Active’ indicates, that the display is updated with measuring values. ‘Freeze’ indicated a frozen display. The actual displayed values don’t change until ‘Active’ is choosen again.
  In the second line ‘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 submenu 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. *Options*) again.

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

### 4.4.1 Misc.

On older instruments this key was called ‘Function’.
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 ‘.’.

**Contrast:** Here you can change the contrast of the display.

**Bright:** Here you can change the brightness of the display.

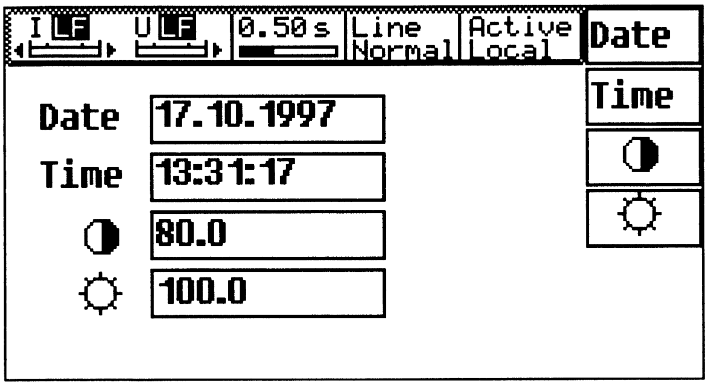


**Figure 8: Misc. menu**

### 4.4.2 IF/IO

On older instruments this key was called ‘Options’.

In this menu you can setup 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

Here you have to distinguish between the logical devices (logging and remote control) and the physical devices (COM interfaces, parallel interface, GPIB interface and memory card). The logical devices define what you do, the physical devices define where you do it.

#### Printer symbol for logging (logical device)

In this menu you define the conditions and settings for storing of data to memory card and printer.

**Dev** This selects the physical device which is used for storing. If a devices is used for other purposes (e.g. for remote control) it is not available in the following list.

| | |
|---|---|
| off | No device selected. |
| COM1 RS232 | The COM1 jack is used with RS232 voltage levels. |
| COM1 RS485 | The COM1 jack is used with RS485 voltage levels. |
| COM2 RS232 | The COM2 jack is used with RS232 voltage levels. |
| Printer | The printer port is used. |
| Memory Card | The memory card is used. |

**Mode** This defines when the data are stored:

Single Data are only stored on request. You get, what you see, e.g. if freeze is activated you get the freezed values.

Cycle Data are stored at the end of a mesuring cycle. You store always the actual data, independent, if freeze is active or not.

Integral Data are stored at the end of an integration interval. You store always the actual data, independent, if freeze is active or not.

Periodic Data are stored in periodic intervals. You store always the actual data, independent, if freeze is active or not.

**Typ** This defines the type of printer which is to be used. This point is important to be setup especially if you want to make graphical outputs.

**Per.** This defines the period time for periodic storing.

**more>** Here you can setup a header which is printed whenever you press the *Print* button.

**back** returns to last menu.

The 'next..' line shows when the next output of data will be done.

### R(e)mote

Here the conditions for remote control are defined:

**Dev** This selects the physical device which is used to communicate with a computer. If a devices is used for other purposes (e.g. for logging) it is not available in the following list.

off No device selected.

COM1 RS232 The COM1 jack is used with RS232 voltage levels.

COM1 RS485 The COM1 jack is used with RS485 voltage levels.

COM2 RS232 The COM2 jack is used with RS232 voltage levels.

GPIB The GPIB jack is used.

**Mode** This selects the operating mode of the choosen interface:

Local Setup and reading of the instrument can be done directly at the front panel. With the interface you can only read values.

Remote Setup and reading of the instrument can be done with the interface. From the front panel you can only read values.

**back** returns to last menu.

### Dev. (physical devices)

Here you can do all the settings of the physical devices:

With **Device** you can toggle to different interface types. You can change the displayed parameters with **Set**. Following you see the possible settings for the different interfaces:

GPIB Here you can setup the address of the LMG95 with **Adr**. The valid address range is from 1 to 30. In the lower line you see if this interface is used for printing, remote control or if it is unused.

COM1 Here you can setup the baud rate of the COM1 jack with **Baud**. **EOS** specifies the ending character of a remote string. 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 LMG95. With **Echo** you can switch the echoing on and off. Pressing **Proto** allows you to select another protocol for communication. Possible values are 'None' and 'RTS/CTS'.

COM2 Same setting like for COM1.

**back** returns you to main menu.

#### 4.4.2.2 Processing signal interface

With **IO** you reach the setup menus for the processing signal interface. With **Modul** you can choose the different types of input and output functions. **Set** is used to modify the settings. **back** returns to the *Options* menu.

##### 4.4.2.2.1 Analogue Input (Modul A_In)

If you are in the setting mode of this menu, you can do the following:

⇧⇩: This is used to select the input channel. You can do this also with the rotary knob.

**ZERO**: Here you setup, which value will be displayed with 0V input.

**FS**: Here you setup, which value will be displayed with 10V input.

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.

**back** returns you to main menu.

##### 4.4.2.2.2 Analogue Output (Modul A_Out)

If you are in the setting mode of this menu, you can do the following:

⇧⇩: This is used to select the output channel. You can do this also with the rotary knob.

**VALUE**: This allows you to setup the value which should be output. See chapter 4.5, 'Entering identifiers' for details.
Please note that the values 'wave u', 'wave i' and 'wave p' can only appear once!

**ZERO**: Here you setup, which value of **VALUE** will result an output of 0V.

**FS**: Here you setup, which value of **VALUE** will result an output of 10V.

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.

Example2: You select **VALUE** 'wave u', **ZERO** '0' and **FS** '100'. Now you get the sampling values of the voltage on the output. An instantaneous value of 100V will be output as 10V. The output is updated after every sample of the measuring channels (about 100kHz).

**back** returns you to main menu.

#### 4.4.2.2.3 Digital Inputs (Modul D_In)

In this menu you get the actual state of the six digital inputs. The inputs 1 to 4 are only used for state indicating. The inputs 5 and 6 can be used as state indicators or for frequency and direction input (determed 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 **Set** and **SCALE**.

#### 4.4.2.2.4 Digital Outputs (Modul D_Out)

If you are in the setting mode of this menu, you can do the following:

⇧⇩: This is used to select the digital output. You can do this also with the rotary knob.

**VALUE**: This allows you to setup the value which should be output. See chapter 4.5, 'Entering identifiers' for details.

**COND**: Here you setup, under which condition the output is in the 'alarm state' (= high impedance of output, symbolized 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 setup, which limit is compared to the **VALUE.**

Example: You select 'Itrms >= 164.00mA'. Now you get an alarm for every current bigger or equal to 164mA. The output becomes a high impedance state because a 'fail save' function is assumed.

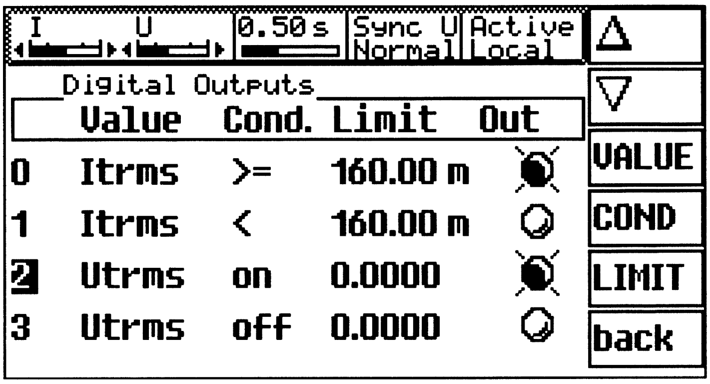


**Figure 9: Limit menu**

**back** returns you to main menu.

#### 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).

The 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.

### 4.4.3 Formula editor

You reach the formula editor by pressing **Forml** in *Custom* menu.

With **Set** you start entering the formula. This is done like written in 4.5, 'Entering identifiers, characters and text'.

#### 4.4.3.1 General

The formula 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 instructiuon 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 identifieres are not divided by them. At the end of a line an automatic carriage return and linefeet are performed. A '#' indicates the beginn of a comment. The comment lasts, until a return is detected (can be entered with '↵'). An automatic inserted newline will NOT end the comment!

The instruction

```
var0=Utrms*Itrms;
```

is identical to

```
var0 = Utrms* Itrms ;
```

or

```
var0 =
Utrms * Itrms;
```

You can force a linefeed with '\'. The cursor starts in the next line ('\' is not visible). <- 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 formula 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 program (which includes the formulas) is executed when all values of a cycle have been calculated.

With **Reset** the 8 variables are preset to 0.0 but the formulas are still valid. This is important if you use recursive formulas or conditions. The **Reset** key can be found in the *Custom* menu itself as well as in the **Forml** submenu.

### 4.4.3.2 Grammar

#### 4.4.3.2.1 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 instructiuon (except `if`) has to be finished with ';'. An instruction can be longer than one line. The result must not be assigned to a variable.

#### 4.4.3.2.2 Condition instruction

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

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

The brackets for the expression are necessary. Then there cold be one or more semicolon separeted instructions which are executed if the expression was true. The end of the conditional execution is marked with **fi**, which is also necessary.

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

```
if(expression1)
   if(expression2)
      If expression1 and expression2 then instructions;
   fi
fi
```

#### 4.4.3.2.3 Expressions

An expression is a sequence of operators, operands and functions. Expressions are in general recursiv, 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).

#### 4.4.3.2.4 Constants

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

#### 4.4.3.2.5 Variables

There is a decision between read only variables and read write variables. The first ones are all measuring values of LMG95 but also values like cycle time and measuring ranges. This variables can be used for calculation like constants. The second one are the 8 user defined variables.

So following is o.k.

```
var0=Utrms;
```

but

**Utrms=0;**

is not allowd.

The result of expressions can only be stored in the 8 user defined variables with the default identifiers 'var0' to 'var7'. This identifiers are valid until they are redefined in a formula. 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 identifieres are replaced in the order of the occurence. If you press **End**, all occurences 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'.

#### 4.4.3.2.6 Keywords

This are strings which are no variables or constants but which are used for controlling the formula editor:

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

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

#### 4.4.3.2.7 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 |
| **asin(x)** | arcus sine of x |
| **bell()** | generates a short sound with the internal speaker |
| **cos(x)** | cosine of x |
| **dout_off(nr)** | Switches digital output number nr off (into no-alarm state). $0 \leq nr \leq 3$ |
| **dout_on(nr)** | Switches digital output number nr on (into alarm state). $0 \leq nr \leq 3$ |

**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

**reset()** Same like **Reset** Softkey in *Time Int.* menu

**sin(x)** sine of x

**start()** Same like pressing *Start*

**stop()** Same like pressing *Stop*

**unfreeze()** activates the freezed display

#### 4.4.3.2.8 Operators

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

high priority

: Indexoperator, used for indexed values, e.g. U:5 is the 5th harmonic of the voltage

() Function call, the value inside the brackets is parameter to the function

- Negation

^ Exponent

/ * Division and multiplication

+ - Addition and Subtraction

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

= setting of a value

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

#### 4.4.3.2.9 Example 1: Freeze at limit violation

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

```
if(U:23 > 10)
   freeze();
   bell();
fi
```

**Attention!**

The function **freeze()** can cause the display to freeze at the startup of the instrument. So be careful when using this function.

#### 4.4.3.2.10 Example 2: Getting min/max values

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

```
if (Uhigh==0)
   Ulow=RngU;
fi
if (Uhigh<Utrms)
   Uhigh=Utrms;
fi
if (Ulow>Utrms)
   Ulow=Utrms;
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 *User* menu.

#### 4.4.3.2.11 Example 3: Calculating THD+N

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

```
THDN=((Utrms^2-U:1^2)/U:1^2)^0.5;
```

Please note that this will only work in the harmonic mode, because U:1 is only calculated there!

#### 4.4.3.2.12 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);
if (ibat>3.0)
   if (r == 0)
      n=n+1;
      r=1;
   fi
fi
if (ibat < 3.0)
   r=0;
fi
```

#### 4.4.3.3 Printing formulas

You can printout the formulas you have setup. For this purpose choose 'ASCII' as type of the logging (see 4.4.2.1 Interfaces). Please note, that the complete formula editor is printed out, not only the visible part.

### 4.4.4 Saving and restoring configurations

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

#### 4.4.4.1 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 setup values like range settings, formulas 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.

#### 4.4.4.2 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, formulas 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 pressing **Copy**. 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). Select one value with the rotary knob and press *Enter* to copy the list item into the edit line. If there is a ':' behind this value, you have to enter additional characters (e.g. the identifier for the analogue input 3 would be 'Ain:3'). If you don't specify this number, '0' is the default value. Confirm your choise with *Enter.*

To select another position in the text, you habe 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 '↵' you can insert a linefeed (if you have a multi line input box). Especially in conjunction with the formula editor you can reach a list of useful functions and operators by pressing *Misc.* (*Functions* on older instruments).

Finally close you inputs with **End**.

## 4.6 Entering numerical values

If you have entered a value by the nemerical 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 LMG95 works as an high precision power meter. The voltage, current and power are measured direct, many other values are derived from these values.

## 5.1 Measuring configuration (Measuring)

When you came to this menu by pressing *Measure* you first have to choose **Norm(a)l** to enter this mode. With **Set** you can do several settings. All possible setting are displayed similar to a schematic. So you can see, which influences a change will have.

**Sync** Selects the signal which is used for synchronisation. There are following possible settings:

U The voltage signal is used

I The current signal is used

X Extended Trigger. See **Xtrig**.

Line The line signal is used

Extn The signal at the external synchronisation jack is used.

Depending on the value of **Sync** there is one softkey which changes from **Xtrig** (setting 'X') to **Coupl** (all other settings).

**Coupl** Selects how the voltage or current signal is coupled to the following trigger stage. This setting has no influence to the measured signals!

AC+DC The signal is directly coupled, including all signal parts.

BP The low frequency parts (<10Hz) and the high frequency parts (>300Hz) of the signal are cut off.

AM The signal will be demodulated when measuring AM signals. Only the envelope is used.

**Xtrig** Here you reach a menu where you can define very precise, what should be your trigger condition. This menu should only be used from very experienced users, because if you select wrong conditions, you might get wrong measuring results.

**Signl** Here you define the signal you want to trigger on. Available are: u, i, p, $u^2$, $i^2$, $u_{filt}$, $i_{filt}$, $p_{filt}$. For the meaning of this values please watch the functional diagram in 15.5, 'Functional block diagram computing unit'

**Filt** Here cou can define a digital filter which influences the signal to be triggered on. Please note 2 points:
1. For Example: You have a 50Hz signal and select p, you have a 100Hz p-wave! So a 87.5Hz filter will influence this signal!!!
2. You should always try to switch the anti-aliasing-filter on (see point **Filter/S-Cpl**, **Filt** below) to prevent aliasing in the trigger signal.

**Level** Here you select the trigger level. If you for example select 'u' and a level of 100.0 the instrument will be triggered each time the voltage crosses the 100V line. Please note: If you select $u^2$ the level is $100V^2$!!

**Hyst** Usually you have a small noise on the signal. Without a hysteresis you might get several level crossings at a single 'real' crossing. With the hysteresis you can prevent this. For example you have a **Level** of 100V and a **Hyst** of 5V. If your signal comes from a value smaller than 95 V it has to climb up to 105V to get a positive crossing. If it comes from a value greater than 105V it has to fall below 95V to get a negative crossing.

**back** returns to the last menu.

What can you do with this very special trigger mode?
If you have signals with a big DC part and a quiet small AC part (e.g. pulsed loads with DC supply) you have the problem to trigger on the frequency of the AC part. The solution is, to set the **Level** to a value of about the DC part, so you get a good trigger level.
Another example is to measure pulse controlled currents. In fact this signals are AM signals with a 50Hz carrier and for example a 1.5Hz modulator. To get correct measuring results you would have to trigger on the 1.5Hz signal. To do this you just select 'i*i' as source and a 30Hz filter. So you have build up a quadratur demodulator. Now you select a trigger level (depending on the current) and your instrument will synchronize to the 1.5Hz signal of your pulse control.

**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.
While every cycle time the values of voltage, current and power are stored. 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 period time of the signal.

**Filter/S-Cpl**

You reach a pop up menu where you can set the signal filter (**Filt**) and the signal coupling (**S-Cpl**):

**Filt** Here you can select if the filters in the signal path of voltage and current are active or not. This filters are only in the signal way and don't influence the synchronisation settings ‘U’ and ‘I’. But they influence the synchronisation **Xtrig**! Possible settings are:

| | |
|---|---|
| off | All filters are switched off |
| AAF | The analogoue Anti-Aliasing-Filter (AAF) is switched on. |
| 30Hz | Additionally to the AAF a digital Low-Pass Filter with a cut off frequency of about 30Hz is used |
| 60Hz | Additionally to the AAF a digital Low-Pass Filter with a cut off frequency of about 60Hz is used |
| 87.5Hz | Additionally to the AAF a digital Low-Pass Filter with a cut off frequency of about 87.5Hz is used |
| 175Hz | Additionally to the AAF a digital Low-Pass Filter with a cut off frequency of about 175Hz is used |
| 1.4kHz | Additionally to the AAF a digital Low-Pass Filter with a cut off frequency of about 1.4kHz is used |
| 2kHz | Additionally to the AAF a digital Low-Pass Filter with a cut off frequency of about 2kHz is used |
| 2.8kHz | Additionally to the AAF a digital Low-Pass Filter with a cut off frequency of about 2.8kHz is used |
| 6kHz | Additionally to the AAF a digital Low-Pass Filter with a cut off frequency of about 6kHz is used |
| 9.2kHz | Additionally to the AAF a digital Low-Pass Filter with a cut off frequency of about 9.2kHz is used |
| 18kHz | Additionally to the AAF a digital Low-Pass Filter with a cut off frequency of about 18kHz is used |

**S-Cpl** Here you define the signal coupling. This setting has **no** 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 eleminated.

**Aver** Here you can setup, how many measuring cycles are averaged for the display. For example: If you choose 5 cycles, the display will allways be averaged over the 5 last cycles.

**back** returns you to main menu.

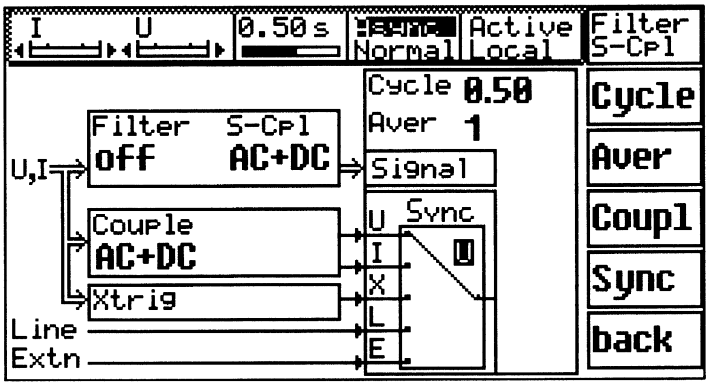


**Figure 10: Measuring menu in normal mode**

## 5.2 Measuring ranges (Range)

When you came to this menu by pressing *Range* you can choose with **I<->U** if you want to setup voltage or current.

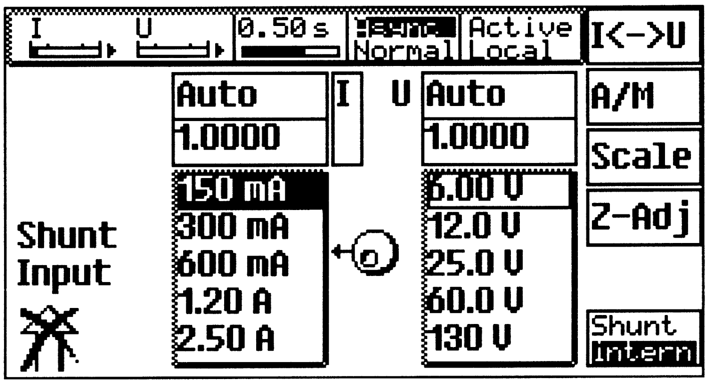


**Figure 11: Range menu in normal mode**

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 selection is selected. 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, voltage transformers or the size of an external shunt.

With the shuttle knob you can select the required range (not in auto range mode!).

With the **Shunt** button you can select if the internal shunt or the external shunt is used. If you choose 'Shunt extern' you have to specify the shunt value. This is done by entering the reverse shunt value under **Scale**.
Example: You have a shunt with 2.5mΩ and have to enter the reverse value (1/0.0025=400) under **Scale**. The 30mV range (displayed as 30mA range) becomes now the 12A range (=30mV*400).

**Z-Adj** allows you to adjust the DC components of the instrument. You can either adjust the internal current ranges together with the voltage ranges or you can adjust the external current ranges together with the voltage ranges. You have to choose this before pressing **Z-Adj** with **Shunt**.

***Be careful with this function because you can also deadjust the instrument!!!***

For the exact adjustment steps please refer to 13.2 'Zero adjustment of the instrument'.

### Some notes for auto ranging

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

- The peak current ranges (marked with 'Ap' in the range list) are never used for auto ranging. They can only be choosen manually.
- 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 made 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.

## 5.3 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 vales are calculated from same values of several cycles.

The following basic definitions are used:

$u(t)$ The instantaneous value if the voltage

$i(t)$ The instantaneous value if the current

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

### 5.3.1 Values from single measuring

#### Voltage and current

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

DCn negative root mean square:

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

DCp positive root mean square:

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

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

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

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

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

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

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

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

#### 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: $\lambda = \frac{|P|}{S}$

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:

$\lambda < 0.999995$ *and* $1.05 < Uff < 1.2$ *and* $1.05 < Iff < 1.2$

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.

### Impedances

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

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

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

## 5.3.2 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: $Pm = \frac{EP}{\sum_{n=0}^{N} T_n}$

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

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

### Miscellaneous

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

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

## 5.4 Display of values

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

### 5.4.1 Default

With *Default* you see the most important values of the instrument. With **4 Val** and **8 Val** you can choose a 4 measuring values display in big letters or 8 measuring values display in smaller letters.

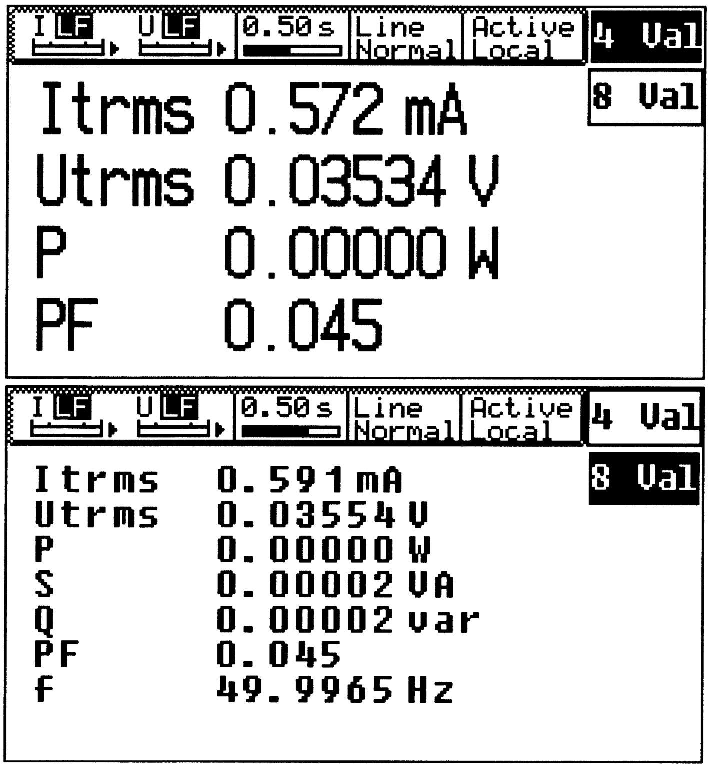


**Figure 12: Default display with 4 and 8 values**

### 5.4.2 Voltage

With *Voltage* you see the most important voltage values of the instrument. With **4 Val** and **8 Val** you can choose a 4 measuring values display in big letters or 8 measuring values display in smaller letters.

### 5.4.3 Current

With *Current* you see the most important current values of the instrument. With **4 Val** and **8 Val** you can choose a 4 measuring values display in big letters or 8 measuring values display in smaller letters. With the **Inrush** 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! 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. With **4 Val** and **8 Val** you can choose a 4 measuring values display in big letters or 8 measuring values display in smaller letters. Further on you get the following resistor values: Z, X and R. **Please note that the values of X and R are only correct, if the voltage and current have a sinusoidal waveform!**

### 5.4.5 Energy

With *Energy* you see the most important energy values as well as derived values which also depend on time. With **4 Val** and **8 Val** you can choose a 4 measuring values display in big letters or 8 measuring values display in smaller letters.

#### 5.4.5.1 Integral menu

The *Integral* menu defines the measuring conditions for time dependend signals. **Reset** sets the display values to their default state (i.e. 0 for all energy values). This is only possible if the state (left beside the mode) is 'Hold'.

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

off — No integartion 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 **t1** 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!

**t1** t1 is the time of the time interval in interval and periodic integration mode.

**t0** t0 is the start time of an integration. In an additional menu you can enter time and date of the start. If you leave this menu with *Enter* you have to press *Start* to change the state of the integration changes to 'wait'. If the entered time is reached, the integration starts.

$\Delta t$ 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 **t0**, or you can simply press the *Start* button or you can start via the external sync jack of the LMG95 (see 15.1.1 External Synchronisation (Sync.)). 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 integarted 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 invers.

### 5.4.6 Graphical display

With *Graph* you see the graphical display of the normal measuring mode. The first softkey changes to the different functions:

**Plot** Changes to the plot function.

**Scope** Changes to the scope function.

#### 5.4.6.1 Scope function

Above this graph you see the Y scaling (y/div) and the Y scaling factor. Under the graph you see the start position of the graph in seconds, the X scaling factor and the X scaling. You can do the following settings:

**Signal** Here you can choose the signal to be displayed. Possible values are:

i: The measured current after all activated filters.

u: The measured voltage after all activated filters.

p: The measured power after all activated filters.

Which of this values are available depends on the setup with **more**.

**xzoom** This selects how many values in horizontal direction are displayed at one horizontal position. So it is possible to zoom in or out.

**yzoom** Here you can choose the vertical size of the wave.

**move** If you press several times to this button you see the second line changing:

x-pos The signal is moved if you use the rotary knob. So it is possible to see other parts of the waveshape.

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 waveshape at this position. The selected cursor position is constant. That means if you scroll the waveshape 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 distance and the Y value distance between the two cursors.

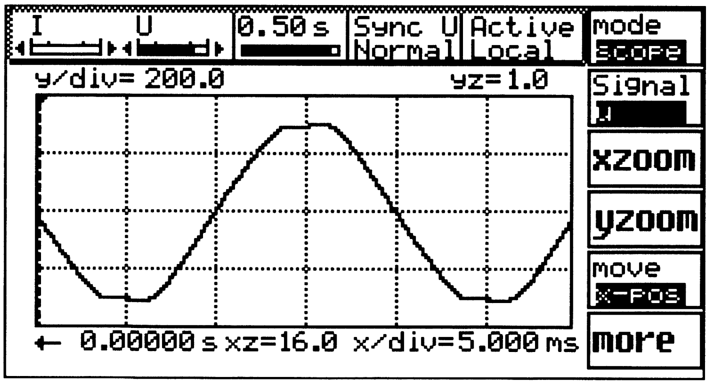


**Figure 13: Scope display**

**more** Here you can setup which sample values are stored for what time. The duration for recording the sample values depends on several points:

- The available memory. This is displayed in the first line.
- The number of signals to be stored. With the rotary knob you can move to a signal and select it with ✓.
- **Cycls** allows you to define the minimum duration in times of the cycle time.

Because of this many influence factors the storing rate and the real duration (both dislayed in bottom line) will vary if you change any of this parameters. In general you can say:

- The bigger the memory (65536 words or 4194304 words) the bigger the record rate. If the full record rate is reached, the duration will increase.
- The fewer signals to be stored, the bigger the record rate. If the full record rate is reached, the duration will increase.
- The shorter the cycle time, the bigger the record rate. If the full record rate is reached, the duration will increase.

If you transfer the sample values to a PC and you want to make evaluations in the frequency domain (e.g. digital filtering or FFT), please make sure that the sampling (record) rate is bigger than twice the bandwidth!

**dot** The dot joiner connects two following pixels with a line. This function can be set to 'on' or 'off'.

Please note that the grid is always displayed with integer numbers. The cursor positions are calculated from the sample values and have not to fit to the grid.

### 5.4.6.2 Plot function

Above this graph you see the two plot values, the Y scalings (y/div) and the Y offset y0. Under the graph you see the X scaling (x/div). The 't0=' value is the time oft the most right visible pixel in relation to the last measuring cycle. You can do the following settings:

**Chn** Here you select which plot function (A or B) should be setup (with **Set**) or readout with the cursors.

**Set** Sets all values of one plot function:

- **fit** This function takes the biggest and smallest recorded value and calculates from this two a new 'y0' and 'y/div' value, so that the signal fits into the screen. Please note, that the fit function takes all values into account, also the values you could see if moving the window!
- **Chn** Here you select which plot function (A or B) should be setup
- **signl** Here you select the signal to be plot. See chapter 4.5, 'Entering identifiers' for details.
- **y/div** Here you select the scaling factor of the Y axis.
- **y0** Here you select the value of the mid of the graph. If you for example select y0=200V and y/div=10V then you will see a window from 180V to 220V on the screen.
- **back** Returns to last menu.

**dot** The dot joiner connects two following pixels with a line. This function can be set to 'on' or 'off'.

**move** If you press several times to this button you see the second line changing:

- x-pos The signal is moved if you use the rotary knob. So it is possible to see other parts of the waveshape.
- 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 waveshape at this position.
- 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 distance and the Y value distance between the two cursors.

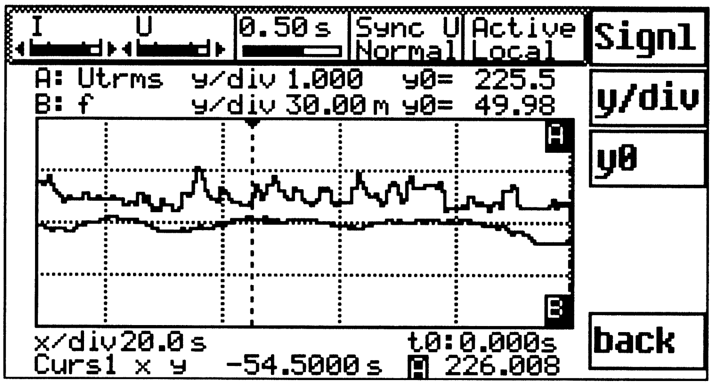


**Figure 14: Plot display**

**B=f(A)** This selects the XY plot function. If this is set to 'on', signal 'A' is displayed on X axis, signal 'B' on Y axis. Displayed are all values between the cursors which have to be set while B=f(A) is 'off'. With this function you can for example display current vs. voltage, power vs. rotation speed or current vs. temperature.
Usually this function is only used in freeze mode. But it can also be used in non freeze mode.

If you want to print or log the plot menu and choose the ASCII format, you get a list of all measuring values between the cursors.

### 5.4.7 Custom menu

With *Custom* you see the custom menu. You have the 8 variables 'var0' to 'var7'. This variables can be set with the formula editor (see 4.4.3, 'Formula editor') after pressing **Forml** or **Reset**.

## 5.5 Storage of values to memory card and printer

First you have to setup some general settings in the *Options* menu (see '4.4.2 IF/IO'). Now you change to the menu you want to print out or to store and press *Print* (exact handling see '12 Storage of values to memory card and printer'). All the values you see in this menu are printed out.

# 6 CE-Harmonic measuring mode

In the CE-Harmonic measuring mode the LMG95 works as an high precision harmonic analyser according to IEC61000-4-7. The number of settings has been reduced to the needed ones to avoid fail handlings.

**Note!**
In this measuring mode the standards define a special number of periodes which have to be used for measurement. 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)

When you came to this menu by pressing *Measure* you first have to choose **CEhrm** to enter this mode. The synchronisation is fixed to the voltage channel. With **Set** you can do several settings:

**Eval** Selects how the measuring results have to be evaluated:

Class A The signal is judged according class A of IEC61000-3-2

Class B The signal is judged according class B of IEC61000-3-2

Class C The signal is judged according class C of IEC61000-3-2

Class D The signal is judged according class D of IEC61000-3-2

**Vers** This selects the standard which defines the exact measuring mode of the harmonic analyser:

1993 IEC61000-4-7:1993

1997 draft IEC61000-4-7(this standard is under development! The main difference to IEC61000-4-7:1993 is that the measuring time is reduced to 200ms and that interharmonic components are added to the harmonic components. So this setting should be used with care!!!)

**Systm** 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 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 *Energy* menu.

**Smth** Here you can swith the 1.5s lowpass filters for smoothing the fluctuating harmonics on or off.

**back** returns you to main menu.

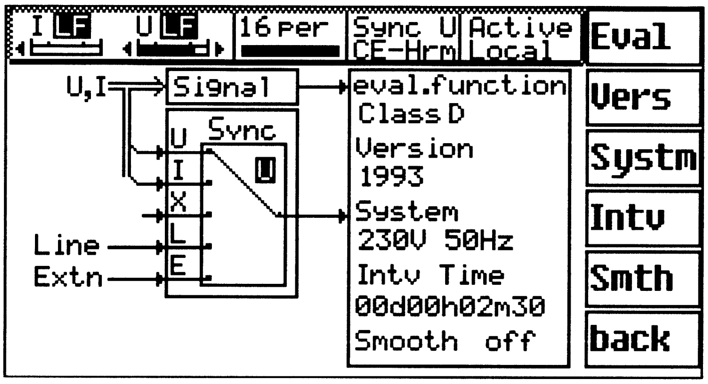


**Figure 15: Measuring menu in CE-Harm mode**

## 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. The integer factor depends on the standard IEC61000-4-7. Actually 16 periods are measured.

### Voltage and current

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

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

The harmonic values 'I(n)' and 'U(n)' are calculated by using a DFT algorithm. The limit values 'Limit (n)' are calculated according to IEC61000-3-2.

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

## 6.4 Display of values

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

### 6.4.1 Default

With *Default* you see the most important values of the instrument. With **4 Val** and **8 Val** you can choose a 4 measuring values display in big letters or 8 measuring values display in smaller letters.

### 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. 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.

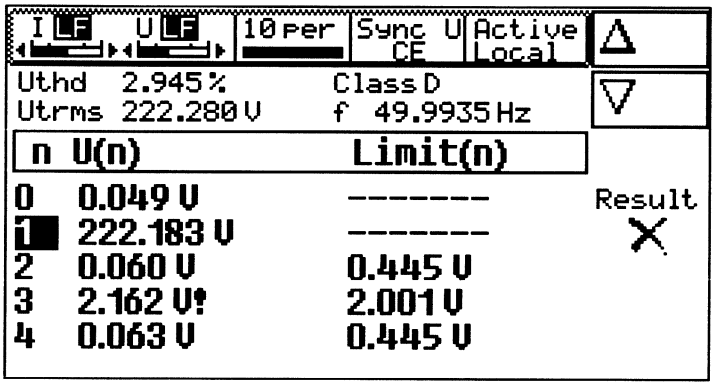


**Figure 16: Display of voltages in CE-harm mode**

### 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.

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 measurments.

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. With **4 Val** and **8 Val** you can choose a 4 measuring values display in big letters or 8 measuring values display in smaller letters.

### 6.4.5 Long time evaluation (Energy)

In this menu you see the result of the long time evaluation. This is started with *Start* and can be canceled 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 fullfill the standard!

In the last row you see if the test voltage has ever violated the harmonic limits.

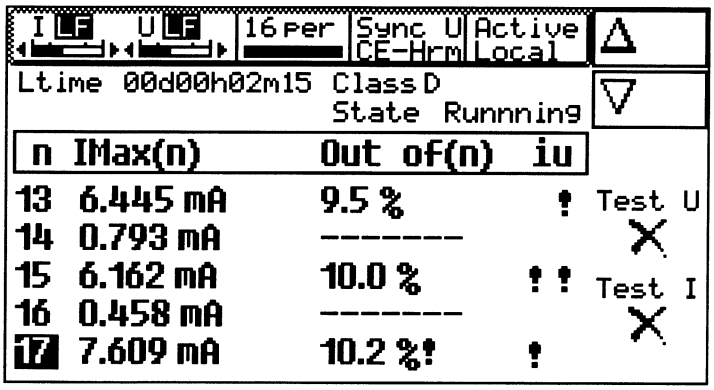


Figure 17: Long time evaluation of harmonics

Below the softkeys you see the total evaluation of the measurement. If any current harmonic has violated the standard at any time 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') and with ASCII format.

### 6.4.6 Graphical display

With *Graph* you reach the graphical displays in the CE-Harm mode. With the softkey right at the top you can choose different displays:

#### 6.4.6.1 Class D

The graphical display of the class D judgement. On the left side you see the waveform of the current and the envelop defined in the standard. On the right side you see if all three requirements are met:

The waveform has to be under the positive envelop for 95%
The waveform has to be under the negative envelop for 95%
The power has to be lower or same 600W

The last line is the total class D judgement.

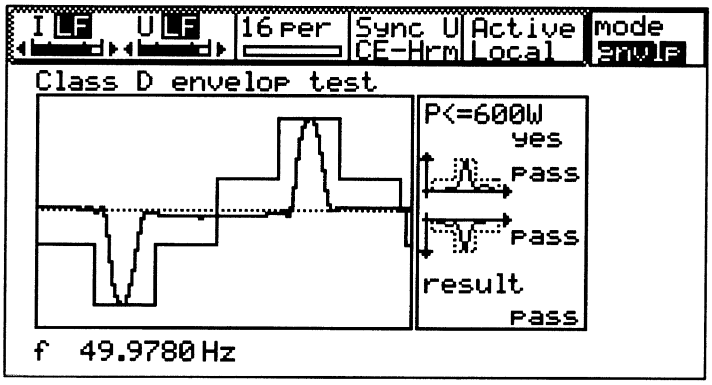


**Figure 18: Class D envelop test**

#### 6.4.6.2 Spectrum

The graphical display of the voltage, the current and the limits of the harmonics. On the left side you see one or two values as bargraph. At the top you see the scaling of the y-axis. The display is 'value/div' for linear display. That means that you have 'value' volt or ampere per division line. An other possible display is 'value 1:10' for logarithmic display. That means that the top line has 'value' volt or ampere and the lower lines each have ten times less.

On the very left in the box you see the order number of the harmonic at cursor position. Beside you see the actual zooming factor. At the right side you have the values at the cursor position. 'Ln=' is the value of the limit, 'yn=' is the value of the voltage or the current.

With **Signal** you can choose 4 displays:

-U- The voltage is displayed with one thick bar.
U-Lim The voltage and the voltage limits are displayed. For the display 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.
-I- The current is displayed with one thick bar.
I-Lim The current and the current limits are displayed. For the display 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.

**Log** changes between linear scaling (=off) and logarithmic scaling (=on) for the y-axis.

With **yzoom** you can zoom into the signal. **Move** is reserved for later usage.

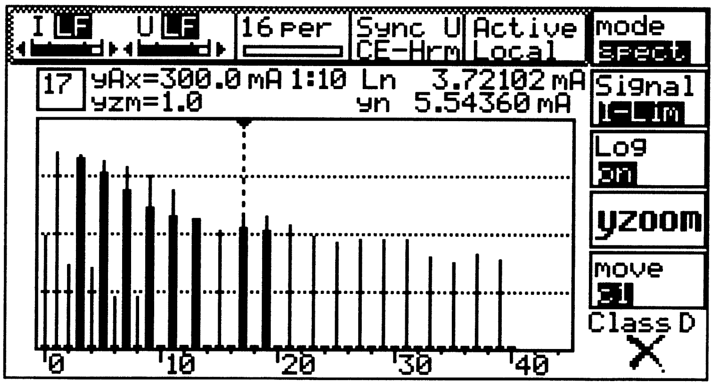


**Figure 19: Graphical display of harmonics**

### 6.4.7 Custom menu

With *Custom* you see the custom menu. You have the 8 variables 'var0' to 'var7'. This variables can be set with the formula editor (see 4.4.3, 'Formula editor').

## 6.5 Storage of values to memory card and printer

First you have to setup some general settings in the *Options* menu (see 4.4.2 IF/IO). Now you change to the menu you want to print out or to store and press *Print* (exact handling see 12 Storage of values to memory card and printer). 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 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 **Vers** to '1993' and select with **Eval** the class you want to test.

Now you can switch on the voltage. When the LMG95 is synchronised you can switch on the equipment under test (EUT). To check the special waveform of class D please notice the display in *Graph* menu.

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

# 7 CE-Flicker measuring mode (option)

In the CE-Flicker measuring mode the LMG95 works as an high precision flicker analyser according to IEC61000-4-15. The number of settings has been reduced to the needed ones to avoid fail handlings.

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

## 7.1 Measuring configuration (Measuring)

When you came to this menu by pressing *Measure* you first have to choose **CEflk** to enter this mode. This mode bases on the CEharm mode. The synchronisation is fixed to the voltage channel. With **Set** you can do several settings:

**Systm** 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.

**back** returns you to main menu.

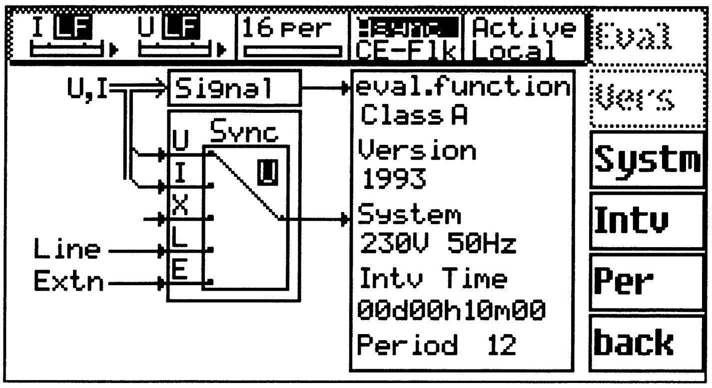


**Figure 20: Measuring menu in CE-Flicker mode**

## 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 IEC61000-4-7. Actually 16 periods are measured.

### Voltage and current

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

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

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 IEC868/IEC61000-4-15. 'dc' and 'dmax' are calculated according to IEC61000-3-3.

### 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

With *Default* you see the most important values of the instrument. With **4 Val** and **8 Val** you can choose a 4 measuring values display in big letters or 8 measuring values display in smaller letters.

### 7.4.2 Voltage

With *Voltage* you see the most important voltage values of the instrument. With **4 Val** and **8 Val** you can choose a 4 measuring values display in big letters or 8 measuring values display in smaller letters.

### 7.4.3 Current

With *Current* you see the most important current values of the instrument. With **4 Val** and **8 Val** you can choose a 4 measuring values display in big letters or 8 measuring values display in smaller letters.

### 7.4.4 Power

With *Power* you see the most important power values of the instrument. With **4 Val** and **8 Val** you can choose a 4 measuring values display in big letters or 8 measuring values display in smaller letters.

### 7.4.5 Flicker (Energy)

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' (20s from pressing *START*), 'running' (while the long term interval) and 'stoped' after the measuring.

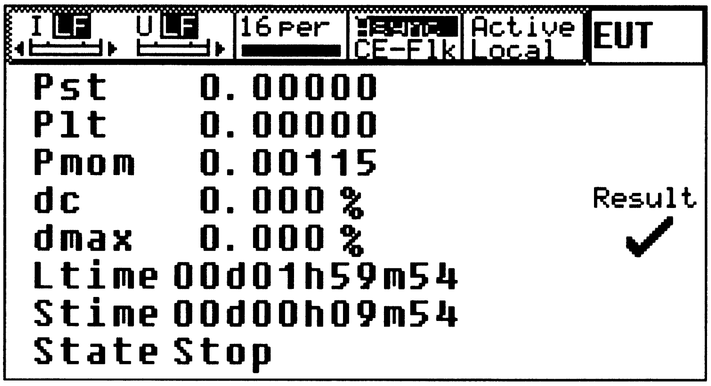


**Figure 21: Evaluation of flicker measurement**

$d_{max}$ 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.

### 7.4.6 Graphical display

With *Graph* you see the graphical display of the flicker measuring mode. The first softkey changes to the different functions:

**Plot** Changes to the plot function.

#### 7.4.6.1 Plot function

The handling of this menu is identical to the plot menu of the normal measuring mode (see 5.4.6.2 'Plot function'). 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 Ul). As said above, this values come every 10ms. The Pmoml and Utrms values are the average values of Pml and Ul. 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. You have the 8 variables 'var0' to 'var7'. This variables can be set with the formula editor (see 4.4.3, 'Formula editor').

## 7.5 Storage of values to memory card and printer

First you have to setup some general settings in the *Options* menu (see 4.4.2 IF/IO). Now you change to the menu you want to print out or to store and press *Print* (exact handling see 12 Storage of values to memory card and printer). 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!)

## 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 voltage of the EUT. Start the flicker process with *Start*. After a delay of 20s 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*.

# 8 100 Harmonics measuring mode (option)

In the 100 Harmonics measuring mode the LMG95 works as an high precision harmonic analyser. The difference to the **CEhrm** 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 **HM100** to enter this mode. With **Set** you can do several settings:

**Sync** Selects the signal which is used for synchronisation. There are four possible settings:

- U The voltage signal is used
- I The current signal is used
- X Extended Trigger. See **Xtrig**.
- Line The line signal is used
- Extn The signal at the external synchronisation jack is used.

**Coupl** Selects how the voltage or current signal is coupled to the following trigger stage. This setting has <u>no</u> influence to the measured signals!

- AC+DC The signal is directly coupled, including all signal parts.
- BP The low frequency parts (<10Hz) and the high frequency parts (>300Hz) of the signal are cut off.
- AM The signal will be demodulated when measuring AM signals. Only the envelope is used.

**Xtrig** Here you reach a menu where you can define very precise, what should be your trigger condition. <u>This menu should only be used from very experienced users, because if you select wrong conditions, you might get wrong measuring results.</u>

**Signl** Here you define the signal you want to trigger on. Available are: u, i, p, $u^2$, $i^2$, $u_{filt}$, $i_{filt}$, $p_{filt}$. For the meaning of this values please watch the functional diagram in 15.5, 'Functional block diagram computing unit'

**Filt** Here cou can define a digital filter which influences the signal to be triggered on. Please note 2 points:

1. For example: You have a 50Hz signal and select p, you have a 100Hz p-wave! So a 87.5Hz filter will influence this signal!!!

2. You should always try to switch the anti-aliasing-filter on (see point **Filter/S-Cpl**, **Filt** below) to prevent aliasing in the trigger signal.

**Level** Here you select the trigger level. If you for example select 'u' and a level of 100.0 the instrument will be triggered each time the voltage crosses the 100V line. Please note: If you select u² the level is 100V²!!

**Hyst** Usually you have a small noise on the signal. Without a hysteresis you might get several level crossings at a single 'real' crossing. With the hysteresis you can prevent this. For example you have a **Level** of 100V and a **Hyst** of 5V. If your signal comes from a value smaller than 95 V it has to climb up to 105V to get a positive crossing. If it comes from a value greater than 105V it has to fall below 95V to get a negative crossing.

**back** returns to the last menu.

**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)

**back** returns you to main menu.

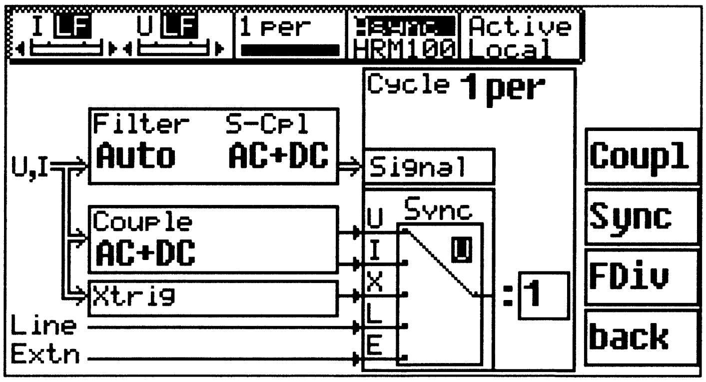


**Figure 22: Measuring menu in Harm100 mode**

## 8.2 Measuring ranges (Range)

The settings are the same like in 5.2 'Measuring ranges (Range)'.

## 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 | AAF |
| 320-640 | 16 | 1 | AAF |
| 160-320 | 8 | 1 | AAF |
| 80-160 | 4 | 1 | AAF |
| 40-80 | 2 | 1 | AAF |
| 20-40 | 1 | 1 | AAF |
| 10-20 | 1 | 2 | 18kHz |
| 5-10 | 1 | 4 | 1.4kHz |
| 2.5-5 | 1 | 8 | 1.4kHz |
| 1.25-2.5 | 1 | 16 | 1.4kHz |
| 0.625-1.25 | 1 | 32 | 175Hz |
| 0.3125-0.625 | 1 | 64 | 175Hz |
| 0.15625-0.3125 | 1 | 128 | 175Hz |
| 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: $Utrms = \sqrt{\frac{1}{T}\int_{t=0}^{T} u(t)^2 dt}$ $Itrms = \sqrt{\frac{1}{T}\int_{t=0}^{T} i(t)^2 dt}$

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

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:

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

### 8.4.1 Default

With *Default* you see the most important values of the instrument. With **4 Val** and **8 Val** you can choose a 4 measuring values display in big letters or 8 measuring values display in smaller letters.

### 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. The fundamental of the voltage is always set to 0°.

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.

### 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 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.

### 8.4.4 Power

With *Power* you see the harmonic values of the measured powers. With **List** you can choose several lists with the different combinations of the different powers.

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 power value of the different powers.

### 8.4.5 Custom menu

With *Custom* you see the custom menu. You have the 8 variables 'var0' to 'var7'. This variables can be set with the formula editor (see 4.4.3, 'Formula editor').

### 8.4.6 Graphical display

With *Graph* you reach the graphical displays in the Harm100 mode.

#### 8.4.6.1 Spectrum

The graphical display of the voltage and the current. On the left side you see one or two values as bargraph. At the top you see the scaling of the y-axis. The display is 'value/div' for linear display. That means that you have 'value' volt or ampere per division line. An other possible display is 'value 1:10' for logarithmic display. That means that the top line has 'value' volt or ampere and the lower lines each have ten times less.

On the very left in the box you see the order number of the harmonic at cursor position. Beside you see the actual zooming factor. At the right side you have the values at the cursor position. 'fn=' is the frequency of the component, 'yn=' is the value of the voltage or the current.

With **Signal** you can choose 2 displays:

-U- The voltage is displayed with one thick bar.
-I- The current is displayed with one thick bar.

**Log** changes between linear scaling (=off) and logarithmic scaling (=on) for the y-axis.

With **yzoom** you can zoom into the signal. **Move** is used to select if you want to move the window (to see the other Harmonics) or if you want to move the cursor.

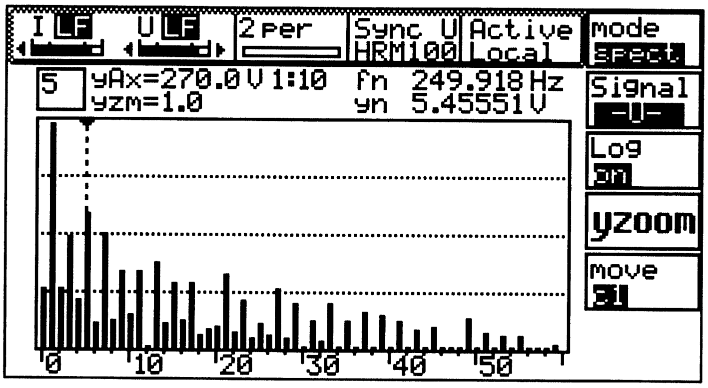


Figure 23: Graphical display of harmonics

## 8.5 Storage of values to memory card and printer

First you have to setup some general settings in the *Options* menu (see 4.4.2 IF/IO). Now you change to the menu you want to print out or to store and press *Print* (exact handling see 12 Storage of values to memory card and printer). 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 Transient mode (option)

In the transient measuring mode the LMG95 works as a transient recorder. You can define special events. If they occur the measuring is stopped and you can analyse the signal.

## 9.1 Measuring configuration (Measuring)

When you came to this menu by pressing *Measure* you first have to choose **Trans** to enter this mode. With **Set** you can do several settings.

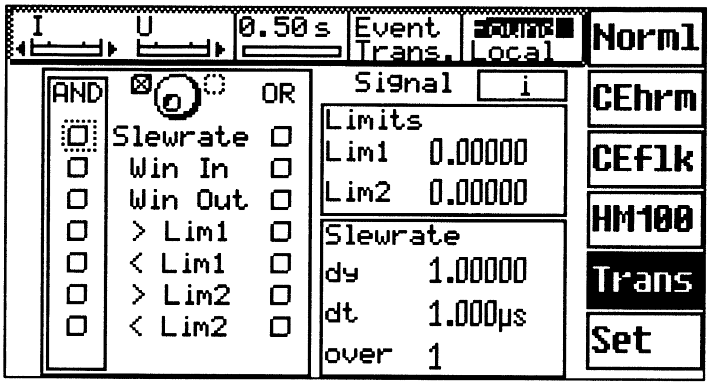


**Figure 24: Measuring menu in transient mode**

**Signl** This defines which signal should be watched for the transient event. Following settings are possible: i, $i^2$, u, $u^2$, p, $i_{filt}$, $u_{filt}$, $p_{filt}$

**Trms** Here you reach a sub-menu in which you can setup some settings:

**Sync** Selects the signal which is used for synchronisation. There are four possible settings:

U The voltage signal is used

I The current signal is used

LineThe line signal is used

Extn The signal at the external synchronisation jack is used.

**Coupl** Selects how the voltage or current signal is coupled to the following trigger stage. This setting has **no** influence to the measured signals!

AC+DC The signal is directly coupled, including all signal parts.

BP The low frequency parts (<10Hz) and the high frequency parts (>300Hz) of the signal are cut off.

AM The signal will be demodulated when measuring AM signals. Only the envelope is used.

**Filt** Here you can select if the filters in the signal path of voltage and current are active or not. This filters are only in the signal way and don't influence the synchronisation. For the possible settings see 5.1 'Measuring configuration (Measuring)'

You have to leave this menu by pressing *Enter* or *ESC*. The settings for **Coupl** and **Sync** you did in this menu are not used for the transient search itself but for continuously measuring the TRMS and peak values of voltage and current. This values are used to update the over- and underrange display in the status line.

**Limit** Here you can setup the limits for the events. The instantaneous value of the signal to be watched is checked against the limt if it is bigger (or smaller) an event is generated. If a function needs two limits (e.g. Win In) **Lim1** is the upper limit and **Lim2** the lower limit.

**Slewr** Here you can setup the maximum allowed slewrate of the signal. For this you have 3 possible settings:

**dSig** This is the required signal change in the time interval **dt**.

**dt** This is the time interval.

**overx** This is the width of the slewrate watch window in number of sample values.

For example you have a signal with a typical rise time of 3.5V in 450µs. In this case you have to enter 3.5 with **dSig** and 450µ with **dt**. Herewith you have defined the steep of the signal: 7.777V/ms or 7.777mV/µs. With a sample interval of about 10µs this is only about 2 digit (in 600V range) of the converter resolution. That means if the difference between two sample values is bigger than 2 digits you would get an event. But from several sources you have a small noise on the signal. This would cause fail events. To prevent this you can use the parameter **overx**. With it you can define, that the slewrate is not determed over one sample periode but over up to 15. If you for example choose 15 the signal has to change 24 digits in this example! So you can use **overx** to supress noise effects.

**more>** Here you reach a sub-menu in which you can setup some settings:

**TDur** This is the minimum duration of the event. If you for example set this value to 5ms and check for an overlimit, the signal has to be over the limit for 5 seconds until the event is generated.

**TRec** This is the recording time. The signal is recorded for this time to the memory. If you have more memory, it might be recorded for a longer time. Please note: If your memory is too small and/or you want to record too much signals the recording rate might be reduced. This has no influence to the sampling rate or to the event detection.

**PreTr** This is the pretrigger duration in %. If you for example have a record time of 200ms and 50% pretrigger you will get at minimum 100ms before the event and exact 100ms after the event.

**back** Returns to the last menu

**back** returns you to main menu.

While you are in the **Set** mode you can use the rotary knob to define the trigger condition. Move to the desired position and press *Enter* to mark/unmark a condition. In the left column you can setup the AND condition. Only if all of the marked events happen at the same time the result of the AND condition will be true. In the right column you can setup the OR condition. If one or more of the marked events happen or the result of the AND condition is true you will get an event.

If you enter the transient mode the instrument is always in a 'found' state. To start a transient search press *Start*. To end a search press the *Stop* key. In this case an event is simulated and you can check if for example your trigger time definitions are okay.

If you are searching a transient, you see the record time in the status line. The bar below blinks and in the right corner you see the word 'Search'. If the event has been found, the bar is empty and the word 'Found' blinks.

## 9.2 Measuring ranges (Range)

The settings are the same like in 5.2 'Measuring ranges (Range)'.

## 9.3 Display of values

For the display of the values you can choose only one menu.

### 9.3.1 Graphical display

The settings are the same like in 5.4.6 'Graphical display', but there is no plot function in the transient mode.

## 9.4 Storage of values to memory card and printer

First you have to setup some general settings in the *Options* menu (see '4.4.2 IF/IO'). Now you change to the menu you want to print out or to store and press *Print* (exact handling see '12 Storage of values to memory card and printer'). All the values you see in this menu are printed out.

# 10 Interfaces (option)

The data interface is used for two general purposes:

Logging: Logging means that you select values which are transfered to a physical device (seriell port, printer, memory card, ...) once or in periodic intervals. The transfer is controlled by the keys of the LMG95. Setup and handling of logging are described in '4.4.2 IF/IO' and '12 Storage of values to memory card and printer'.

Remote control: Remote control means that the LMG95 is connected to a computer by using a physical device (seriell port, parallel port, GPIB ...). The computer can setup the instrument as well as read out values. The transfers are controlled by the computer.

## 10.1 Remote control

The LMG95 is SCPI compatible. The SCPI standard is used to have the same set of commands for different instruments. This commands can become very long, so we have also implemented a SHORT command set. These commands are much smaller and faster in execution.

### 10.1.1 SCPI

The SCPI Command set has been developed to standardize the use and remote control of different devices from different manufacturers. This makes it possible to control different devices with the same commands. The SCPI consortium has defined some basic devices, like digital meters, power supplies, RF & Microwave Sources and signal switchers. All devices have a specific signal routing. And all together have a signal routing looking like this:

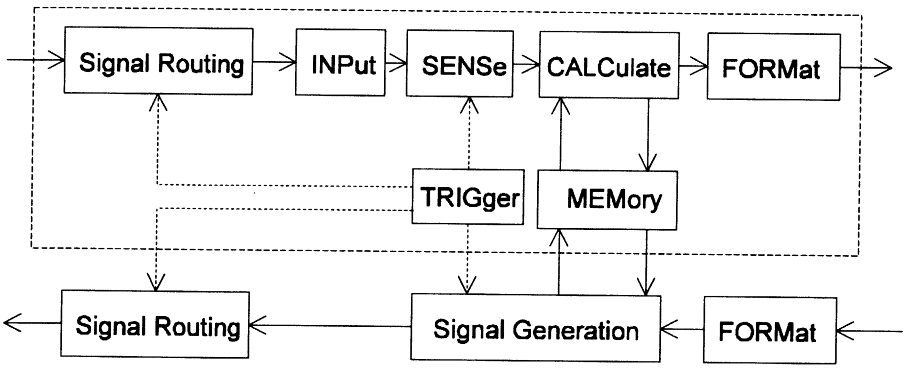


**Figure 25: SCPI Functional Model**

For a measurement instrument only the upper blocks are necessary. The command set is build up in a tree structure, based on the proposals of the Appendix A of IEEE Std 488.2-1992.

The tree structure is comparable with the structure of computers running with the DOS operating system and it's directory structure. There is a root (e.g. drive C:\) followed by some subdirectories and again subdirectories. At the bottom there is the complete command, which can be used to ask the measurement device for values, or to change some parameters.

All headers are seperated by colon. At the root there is the first colon (:) followed by the first header, which defines in which direction to go.

In our case we have the root headers:

:CALC<br>
:DISPlay<br>
:INITiate<br>
:FETCh<br>
:READ<br>
:SENSe<br>
:STATus<br>
:SYSTem<br>
:TRIGger<br>
:WAVeform

The 'Display' header directs to the setup commands concerning the display. The 'Measure' header directs to the headers asking the device for measurement values. The 'Sense' header directs to the setup of the ranges an so on.

When one header is directly followed by a questionmark (?) then a value is requested. The instrument looks for the value (a measurement value or even a simple parameter) and sends it back to the interface. If there is no questionmark (?) at the end of one command, then you propably want to send the instrument a command or you may want to change a parameter (e.g. the range).

It is possible to send the instrument more than one command. Then several commands have to be seperated by semicolons (;).

Example: You want to change the range and ask the device for the dc-voltage.

„:SENSE:VOLTAGE:RANGE:UPPER 2;:FETCH:VOLTAGE:DC?"

As you can see, the first command sets the instrument to the voltage range for 2V measurements, and the second command asks the instrument for the dc-voltage value. Please remark, that at the beginning of one command string, there may be the colon (:) but it must not. But when starting another command (or demand) within one string, then there must be the colon (:) to start from the root within the SCPI system. If there is no colon (:) then the SCPI parser inside the instrument tries to find out the next command while it keeps in mind the last position within the SCPI tree. So it is possible to ask the instrument for the dc voltage value and the ac voltage value in the following manner:

„:FETCH:VOLTAGE:DC?;AC?"

It is also possible to send

„:FETCH:VOLTAGE:DC?;:FETCH:VOLTAGE:AC?".

But this needs some more evaluation time.

There is also a short form of each command. It is possible to send the following to the instrument:

„:FETC:VOLT:DC?;AC?"

The short form is shown in the manual by writing down capital letters and small letters like: „FETCh", or „VOLTage". This has no effect on how the commands are sent to the instrument. It is possible to send either small or capital letters, or even mixed.

**But please note: To speed up evaluation, send capital letters, so the instrument don't have to convert them internaly to capital letters.**

### 10.1.2 Transfer buffer size

The buffer size of the instrument is fixed to 512Bytes. But: the instrument starts parsing the incoming data as soon as the first bytes are coming in. That means it is possible to send data to the instrument with more than 512Bytes! The same to the output buffer. The LMG95 is using FIFO's. That means it is using a kind of ring buffer. So it becomes possible to transfer sample values with e.g. 20.000 Bytes to a computer, by using a 512Byte FIFO. The LMG95 is generating a constant data flow over each interface. While it is reading in some data, it starts evaluating the first command. And while it is putting the evaluated data into the output FIFO, a connected computer can read out the same data.

### 10.1.3 Ending characters

The GPIB interface of the LMG95 is based on the standard IEEE488.2-1992. For the GPIB interface it is using the <lf> (linefeed, hex0A, dec10) character as ending char. Together with the ending char <lf> it sets the EOI line, a hardware wire within the GPIB bus system, to show the controller the end of a transmission. When the GPIB controller is sending some data to the instrument, it must send the <lf> itself at the end of a data transmission or only set the EOI line with the last data byte! EOI is only set while the last data byte.

The RS232 interface accepts more ending chars. It is possible to set up the instrument to <lf> (0Ah), <cr> (0Dh), or both (<cr><lf>). See also 4.4.2.1, 'Interfaces'.

### 10.1.4 Settings in LMG95

It is possible to set all values via interface which can be set via the keyboard. To prevent a double entering from both sources you have to set the instrument to the remote mode with the ren command using IEEE488.2. When using the RS232 interface the first incomming character forces the interface to remote mode. Without remote mode you can't set any values via the interface.

### 10.1.5 Register

The LMG95 uses the standardized register structure to follow all the requirements. There are three different register sets. The first register set is defined in the IEEE488.2 and is called **„Standard Status Data Structure“**. The both other ones are defined in SCPI specifications and are called **„Questionable Status Register Structure“** and **„Operation Status Register Structure“**.

### 10.1.5.1 Standard Status Data Structure

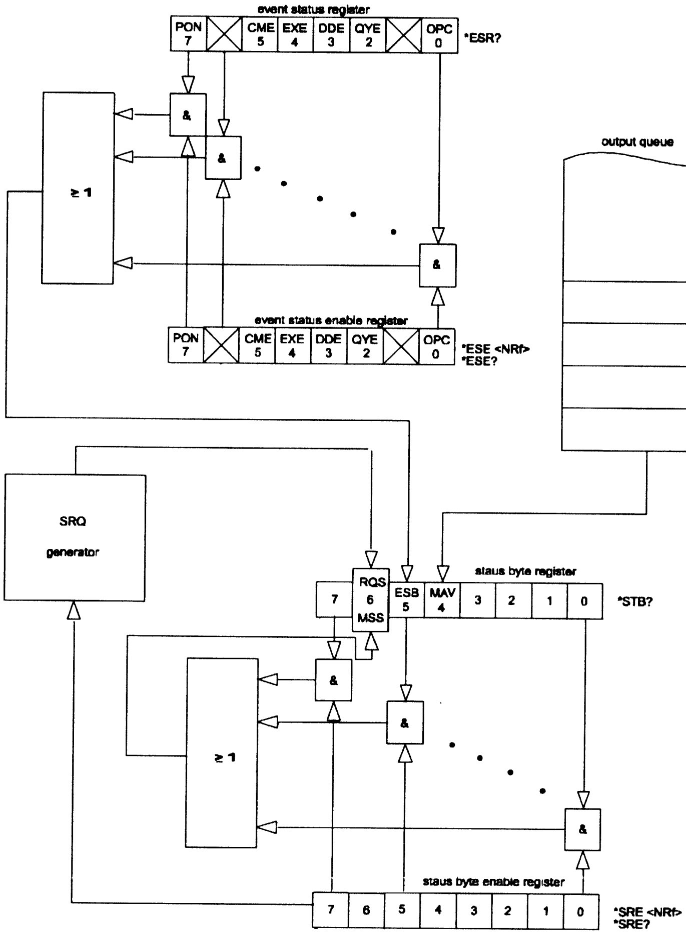


**Figure 26: Standard Status Data Structure**

The central register is the **status byte register**. This register collects the main events. It can be read out with the demand: „*STB?". The register can not be set. When the register is read out by the „*STB?" demand, then Bit6 will be the MSS-Bit, the master summary status. The register can be read out by a serial poll on the GPIB bus. Then Bit6 will be the RQS-Bit, the request service bit, coming from the „Service Request Generation".

Bit7 in the status byte register is the Summary Message of the **Operation Status.**

Bit5 in the status byte register is the Event-Status-Bit, ESB. It shows any occured event, registered by the **event status register**. But only when the corresponding bit in the **event status enable register** has been set. The event status register can be read out by the „*ESR?" demand. The event status enable register can be read out by the „*ESE?" demand. It can be set with the „*ESE <NRf>„ command, where <NRf> stands for a decimal number.

Bit4 in the status byte register is the Message-Available-Bit, MAV. It is used to signalize any data in the outpub buffer of the LMG95.

Bit3 in the status byte register is the Summary Message of the **Questionable Status.**

Bit7 in the event status register is the **PON** Power-On-Bit. It indicates an off-to-on transistion in the devices power supply.

Bit5 in the event status register is the **CME** Command-Error-Bit. It is used to indicate errors detected by the parser while examining the incoming commands.

Bit4 in the event status register is the **EXE** Execution-Error-Bit. It indicates that a <Program Data> element following a header was evaluated by the device as outside of its legal input range, or a valid program message could not be properly executed.

Bit3 in the event status register is the **DDE** Device-Specific Error-Bit, indicating that the detected error is neighter a Command Error, a Query Error, nor an Execution Error.

Bit2 in the event status register is the **QYE** Query-Error-Bit, indicating that an attemt is being made to read data from the Output Queue when no output is either present or pending, or any data in the output queue has been lost.

Bit1 in the event status register is the **RQC** Request-Control-Bit, never used by the LMG95, because this device will never become active controller in the GPIB bus system.

Bit0 in the event status register is the **OPC** Operation-Complete-Bit, indicating that all commands before the „*OPC“ command have been executed. This bit will only be set, when the *OPC command has been received by the LMG95.

### 10.1.5.2 Questionable Status Register Structure

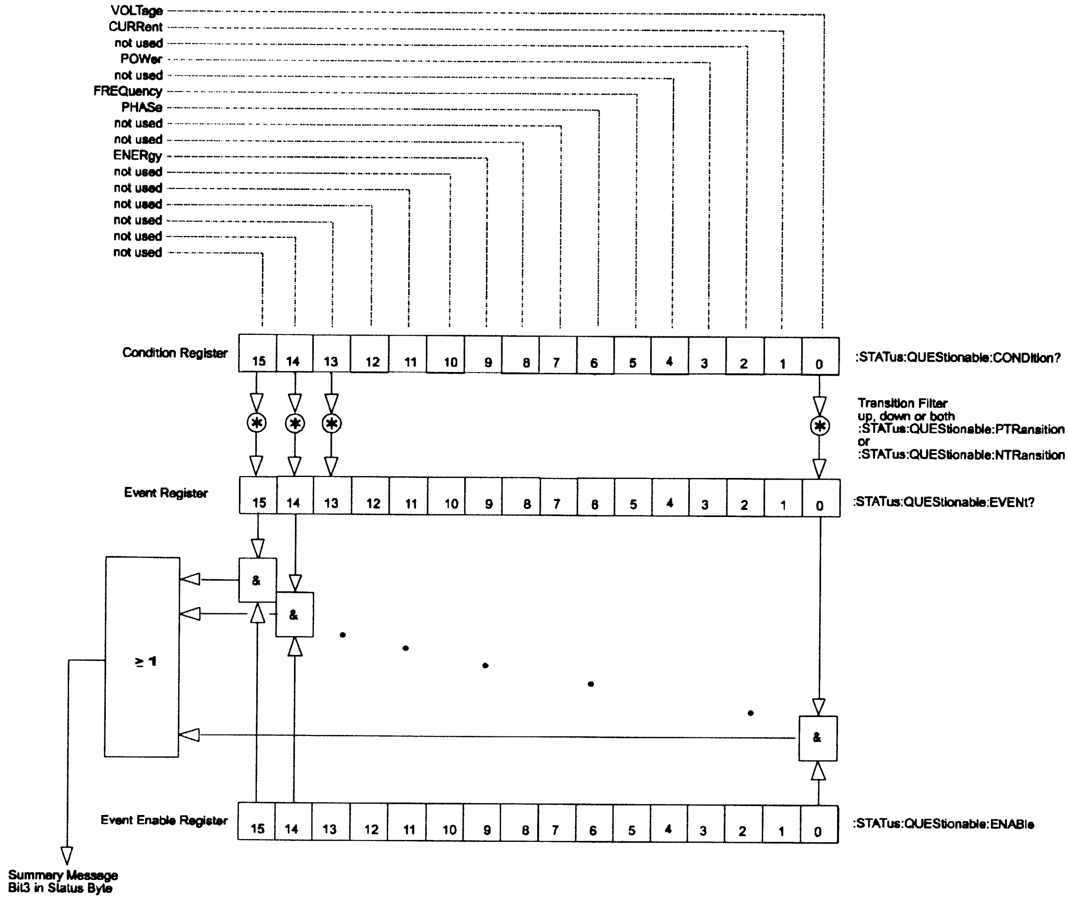


**Figure 27: Questionable Status Data Structure**

The Questionable Status shows what values are measured by this device. Whenever one type of value becomes valid, the corresponding bit in the **Condition Register** changes to high. Then a transition filter can be set up, to get only specific events into the **Event Register**. It is possible to detect only positive transitions or only negative transitions or both. The **Event Enable Register** is used to detect specific events and give them as summary message to the Status Byte.

### 10.1.5.3 Operation Status Data Structure

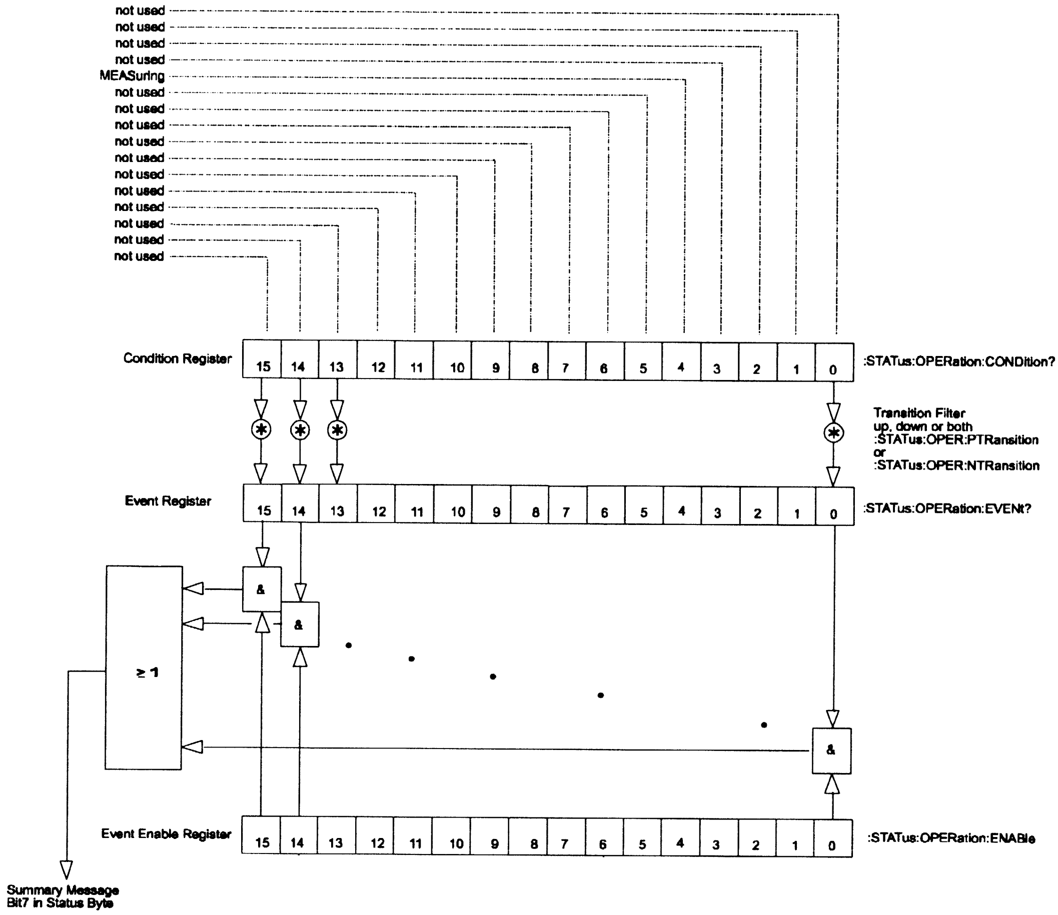


**Figure 28: Operation Status Data Structure**

The Operation Status shows what the device is actually doing. Whenever one action changes and becomes valid, the corresponding bit in the **Condition Register** changes to high. Then a transition filter can be set up, to get only specific events into the **Event Register**. It is possible to detect only positive transitions or only negative transitions or both. The **Event Enable Register** is used to detect specific events and give them as summary message to the Status Byte.

### 10.1.6 Syntax

The SCPI command set can not be parsed very fast. The SCPI command tree is very complex and large. This means fast applications can become impossible. Therefore we have implemented a SHORT command set with shorter commands, which is much faster. For further differences between SCPI and SHORT command set see also 10.2.4, ':FETCh and :READ commands'

It is not possible to enter a SHORT command before switching to this command set. To change from one command set to the other it is necessary to use the command: „SYST:LANG SHORT". This tells the parser now to use the compatibility command set, in our case the

SHORT command set. To get back to the SCPI command set send the command: „SYST:LANG SCPI“.

Explanation of syntax:

- Commands starting with a star (*) are IEEE488.2 common commands.
- brackets [..] are showing optional part of commands. There is no need to sent them to the device.
- '/qonly/' indicates, that this is only a value which can be demanded, but not set. Do not send the '/qonly/' string to the device. For examples 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. For example you can't request a trigger command.
- All commands without '/qonly/' and '/nquery/' can read and set.
- All parameters following the commands have to be separated from the command with a space character.

**Examples showing the syntax:**
Command for reading the TRMS value:
:FETCh:CURRent:TRMS?

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 a space after the questionmark!

Command for setting the 250V range:
:SENS:VOLT:RANG 250
Please notice that there is a space before the 250!

Command for setting the 250V range in the 3rd channel:
:SENS:VOLT:RANG3 250
Please notice that there is a space before the 250!

The commands are ordered in SCPI root structure.

### 10.1.6.1 Syntax for sending to the instrument

The following syntax diagram shows what you can send to the instrument:

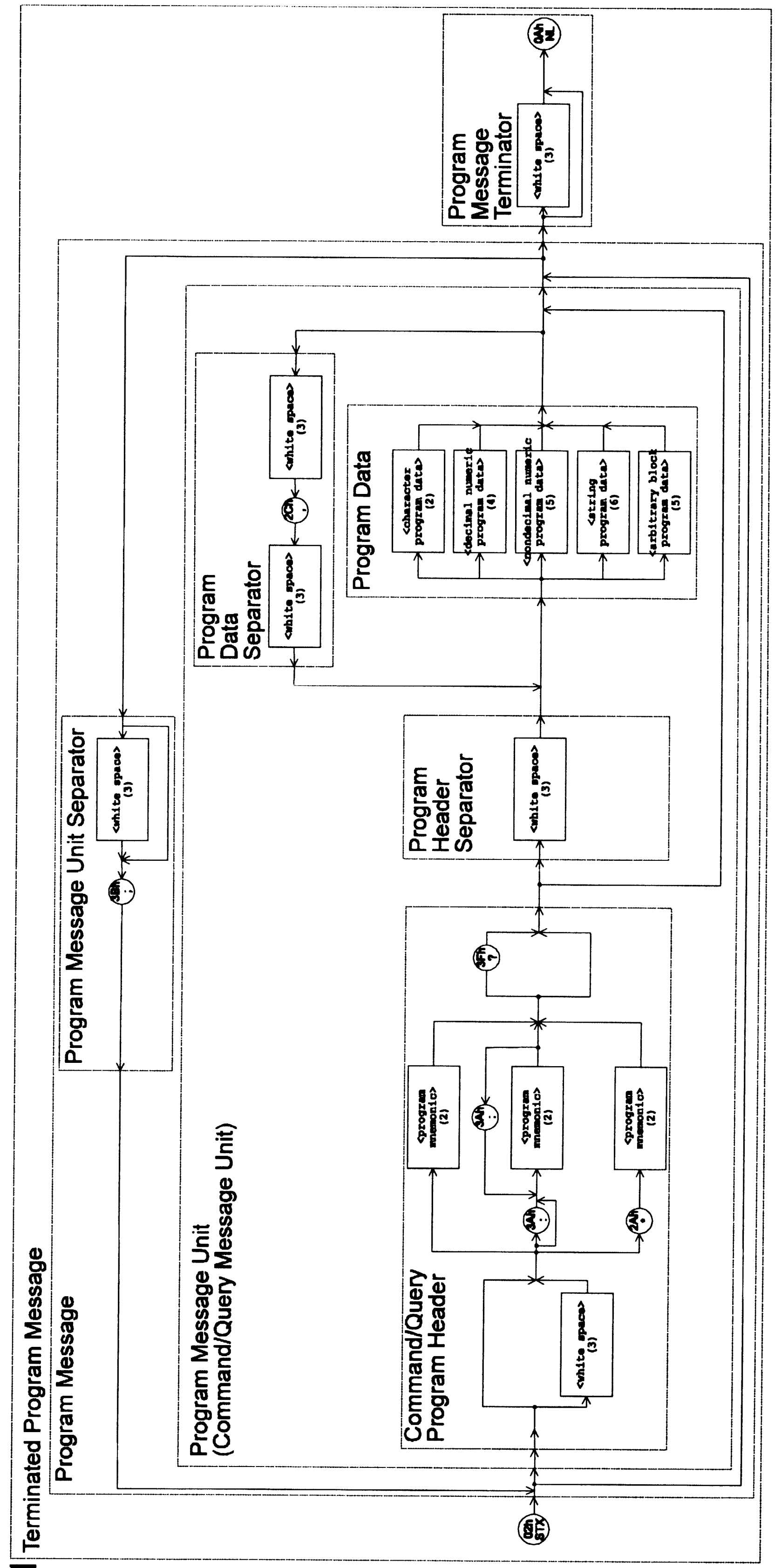


**Figure 29: Program messages I**

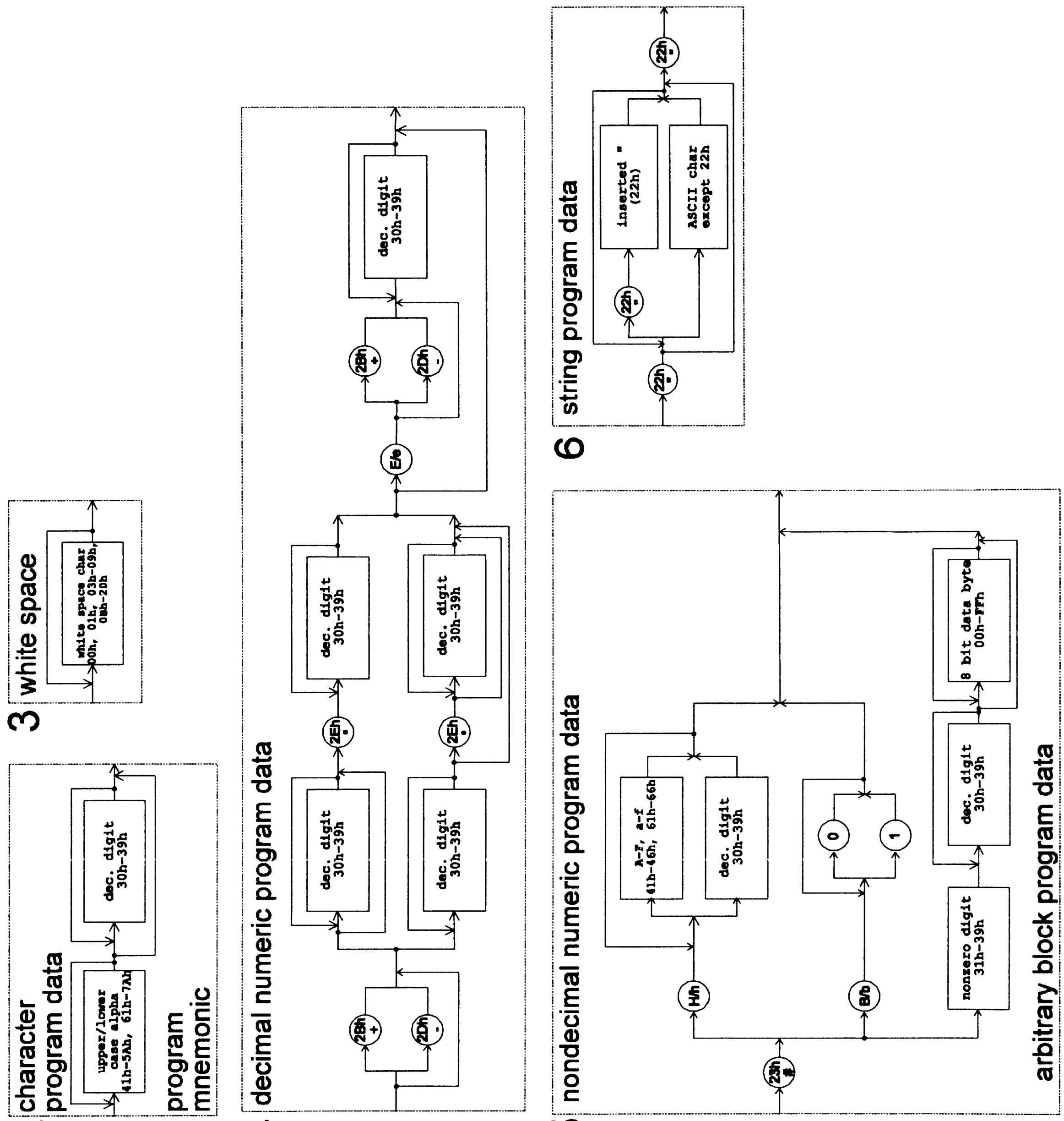


**Figure 30: Program messages II**

### 10.1.6.1.1 <NRf> data

<NRf> is a flexible numeric format. It follows the rules of box 4 (decimal numeric program data)

### 10.1.6.1.2 <NRi> data

<NRi> is a flexible numeric format. It follows the rules of box 2 (character program data) OR box 4 (decimal numeric program data) OR box 5 (nondezimal numeric program data).

### 10.1.6.1.3 <list> data

<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 you have to write '(3:11)'.

### 10.1.6.1.4 character program data

This are charcter data which are a synonym for a numerical value. The following strings are defined (upper and lower case letters can be used):

| String | OFF | ON |
|---|---|---|
| Value | 0 | 1 |

| String | MANUAL | AUTO |
|---|---|---|
| Value | 0 | 1 |

| String | INT | EXT |
|---|---|---|
| Value | 0 | 1 |

| String | ASCII | PACKED |
|---|---|---|
| Value | 0 | 1 |

| String | NORML | CEHRM | CEFLK | HRMHUN | TRANS |
|---|---|---|---|---|---|
| Value | 0 | 1 | 2 | 3 | 4 |

| String | SCPI | SHORT |
|---|---|---|
| Value | 0 | 1 |

| String | LINE | EXTS | U | I |
|---|---|---|---|---|
| Value | 0 | 1 | 2 | 3 |

| String | ACDC | BP | AM |
|---|---|---|---|
| Value | 0 | 1 | 2 |

So it is equal to write 'SYST:LANG 1', 'SYST:LANG shORt' or 'SYST:LANG ACDC'. The last one works, but it doesn't make any sence.

### 10.1.6.2 Syntax for answers from the instrument

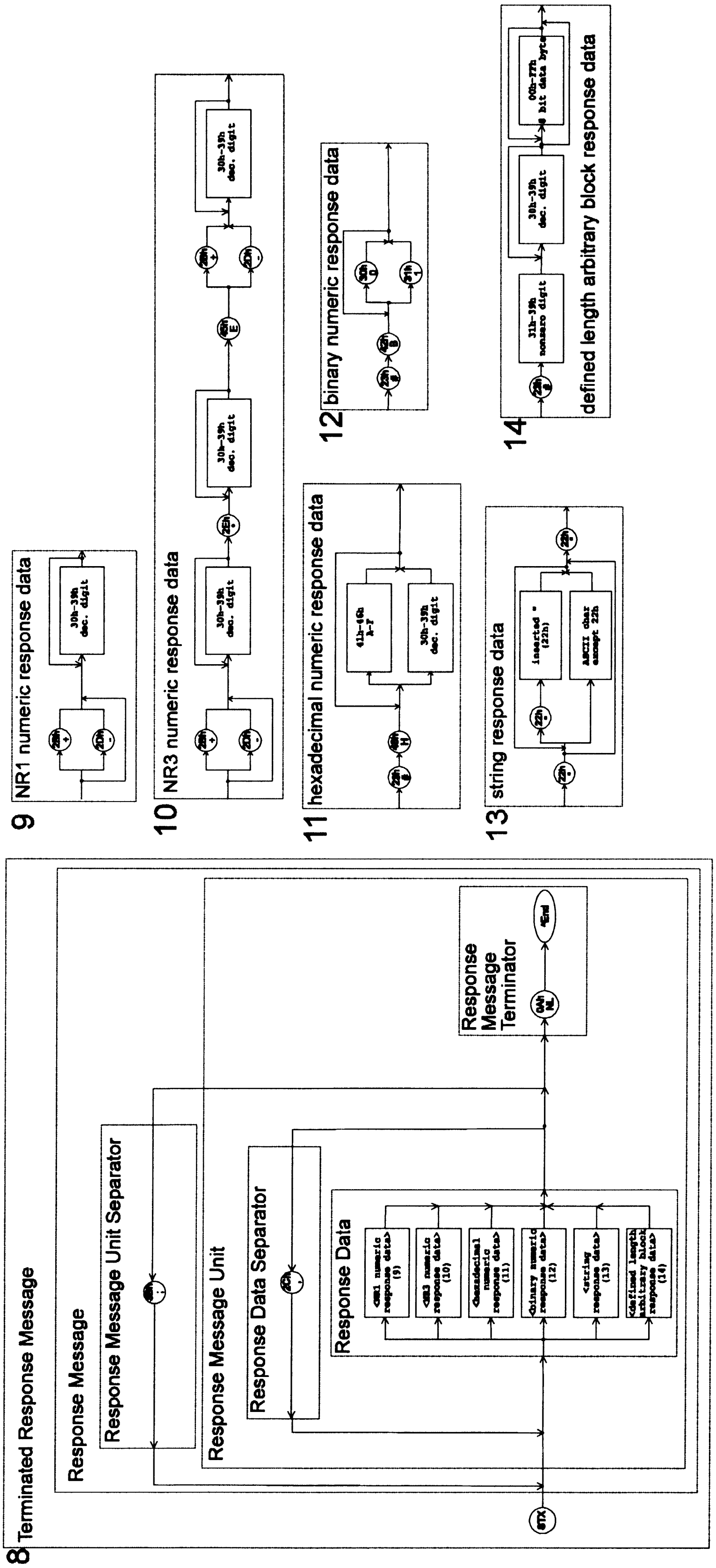


**Figure 31: Response messages**

#### 10.1.6.2.1 defined length arbitrary block response data

This kind of response is used to output results in a non ASCII format. The advantage is explained with following example:

If you want a float number as response you might get '-2.31234e-3'. This are 11 byte to be transfered. If you want to transfer the same data in the defined length arbitrary block response data format you might get '#14xxxx'. Each 'x' represents one data byte of the 32 bit float number and you have only 7 byte to transfer. So you have several advantages:

- less bytes to transfer which is faster
- in the instrument you need no time to convert the float number to an ASCII string which is faster
- in the PC you need no time to convert the ASCII string to a float number, which is faster
- You get the value with the full resolution and not only with 6 digit. So you have a better accuracy.

In the defined length arbitrary block response data format you always get a '#' as first character. The following digit specifies the number of digits which specify the number of following data. So the sequence '#40008' spezifies, that the length information is 4 digit wide. After the '0008' follow 8 byte of data.

## 10.2 Commands

### 10.2.1 IEEE488.2 common commands

This commands are equal in SCPI and SHORT command set, so there is only one definition

#### 10.2.1.1 *CLS/nquery/

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

#### 10.2.1.2 *ESE <NRi>

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

#### 10.2.1.3 *ESR?/qonly/

Reads out and clears the Event Status Register

#### 10.2.1.4 *IDN?/qonly/

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

#### 10.2.1.5 *IST?/qonly/

Individual Status Query. This returns the status of the 'ist' local message in the device. See 10.1.5, 'Register'. Possible values are '0' or '1' (30h or 31h).

#### 10.2.1.6 *OPC/nquery/

Causes the device to set the operation complete bit in the Standard Event Status Register, when all pending selected device operations have been finished.

#### 10.2.1.7 *OPC?/qonly/

Causes the device to place a „1" in the output queue, when all pending selected device actions have been finished (=operation complete).

#### 10.2.1.8 *PRE <NRi>

Used to set up or read out the Parallel Poll Enable Register

#### 10.2.1.9 *RST/nquery/

This performs a device reset. A lot of internal settings 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).

#### 10.2.1.10 *SRE <NRi>

Sets or queries the Service Request Enable Register

#### 10.2.1.11 *STB?/qonly/

Queries the Status Byte Register

#### 10.2.1.12 *TRG/nquery/

Triggers the same action that happen when programmer sends DT1 via IEEE488.1 interface or '&TRG<cr><lf>' via RS232 interface. Actually nothing is performed.

#### 10.2.1.13 *TST?/qonly/ <NRi>

Initiates a self test. Returns a value depending on <NRi>. This command should only be used by ZES and not by customers.

#### 10.2.1.14 *WAI/nquery/

Waits 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.

### 10.2.2 :CALCulate commands

Here you find commands which influence the calculation of formulas or limits.

#### 10.2.2.1 :FORMula

##### 10.2.2.1.1 [:DEFine] <string program data>, FORM <string program data>

SCPI: :CALCulate:FORMula[:DEFine] <string program data>
SHORT: FORM <string program data>

Sets or reads the formula of the formula editor. There is no *RST default value.

For example 'FORM „a=1;"<lf>' sets the internal variable a to 1.

#### 10.2.2.2 :LIMit:

##### 10.2.2.2.1 VERSion <NRi>, EDIT <NRi>

SCPI: :CALCulate:LIMit:VERSion
SHORT: EDIT

sets the edition of the harmonic standard:
0: IEC61000-4-7:1993 [*RST default value]
1: IEC61000-4-7:1997

#### 10.2.2.2.2 :CLASs <NRi>, EVAL <NRi>

SCPI: :CALCulate:LIMit:CLASs <Nri>
SHORT: EVAL <NRi>

sets the evaluation of the harmonics in the CE mode:

0: Harmonics class A [*RST default value]

1: Harmonics class B

2: Harmonics class C

3: Harmonics class D

### 10.2.3 :DISPlay commands

#### 10.2.3.1 :BRIGhtness <NRf>, DISB <NRf>

SCPI: :DISPlay:BRIGhtness <NRf>
SHORT: DISB <NRf>

Sets or reads the brightness of the display. Valid range is 0...100. *RST default value is 80.

#### 10.2.3.2 :CONTrast <NRf>, DISC <NRf>

SCPI: :DISPlay:CONTrast <NRf>
SHORT: DISC <NRf>

Sets or reads the contrast of the display. Valid range is 0...100. *RST default value is 65.

### 10.2.4 :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 10.2.6.2, ':IMMediate/nquery/, INIM/nquery/' 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!

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 sence, 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 perfomed!). So if you want to perform the last example with SHORT commands you have to enter**
INIM;UDC?;IDC?

When not other specified, the return values are float numbers.

### 10.2.4.1 [:SCALar]

#### 10.2.4.1.1 :CURRent

##### 10.2.4.1.1.1 :AC?/qonly/, IAC?/qonly/

SCPI: :FETCh[:SCALar]:CURRent:AC?/qonly/ | :READ[:SCALar]:CURRent:AC?/qonly/
SHORT: IAC? \f if/qonly/

Reads the AC value of the current.

##### 10.2.4.1.1.2 :CFACtor?/qonly/, ICF?/qonly/

SCPI: :FETCh[:SCALar]:CURRent:CFACtor?/qonly/ | :READ[:SCALar]:CURRent:CFACtor?/qonly/
SHORT: ICF?/qonly/

Reads the crest factor of the current.

##### 10.2.4.1.1.3 :DC?/qonly/, IDC?/qonly/

SCPI: :FETCh[:SCALar]:CURRent:DC?/qonly/ | :READ[:SCALar]:CURRent:DC?/qonly/
SHORT: IDC?/qonly/

Reads the DC value of the current.

##### 10.2.4.1.1.4 :FFACtor?/qonly/, IFF?/qonly/

SCPI: :FETCh[:SCALar]:CURRent:FFACtor?/qonly/ | :READ[:SCALar]:CURRent:FFACtor?/qonly/
SHORT: IFF?/qonly/

Reads the form factor of the current

##### 10.2.4.1.1.5 :FSCale?/qonly/, FSI?/qonly/

SCPI: :FETCh[:SCALar]:CURRent:FSCale?/qonly/ | :READ[:SCALar]:CURRent:FSCale?/qonly/
SHORT: FSI?/qonly/

Reads the full scale value of the current

#### 10.2.4.1.1.6 :INRush?/qonly/, IINR?/qonly/

SCPI: :FETCh[:SCALar]:CURRent:INRush?/qonly/ | :READ[:SCALar]:CURRent:INRush?/qonly/
SHORT: IINR?/qonly/

Reads the value of the inrush current

#### 10.2.4.1.1.7 :MAXPK?/qonly/, IMAX?/qonly/

SCPI: :FETCh[:SCALar]:CURRent:MAXPK?/qonly/ | :READ[:SCALar]:CURRent:MAXPK?/qonly/
SHORT: IMAX?/qonly/

Reads the biggest sample value of the current

#### 10.2.4.1.1.8 :MINPK?/qonly/, IMIN?/qonly/

SCPI: :FETCh[:SCALar]:CURRent:MINPK?/qonly/ | :READ[:SCALar]:CURRent:MINPK?/qonly/
SHORT: IMIN?/qonly/

Reads the smallest sample value of the current

#### 10.2.4.1.1.9 :PPEak?/qonly/, IPP?/qonly/

SCPI: :FETCh[:SCALar]:CURRent:PPEak? \f if/qonly/ | :READ[:SCALar]:CURRent:PPEak?/qonly/
SHORT: IPP?/qonly/

Reads the peak peak value of the current.

#### 10.2.4.1.1.10 :RECTify?/qonly/, IREC?/qonly/

SCPI: :FETCh[:SCALar]:CURRent:RECTify?/qonly/ | :READ[:SCALar]:CURRent:RECTify?/qonly/
SHORT: IREC?/qonly/

Reads the rectified value of the current.

#### 10.2.4.1.1.11 [:TRMS?]/qonly/, ITRMS?/qonly/

SCPI: :FETCh[:SCALar]:CURRent[:TRMS]?/qonly/ | :READ[:SCALar]:CURRent[:TRMS]?/qonly/
SHORT: ITRMS?/qonly/

Reads the TRMS value of the current.

#### 10.2.4.1.2 :CYCLe

##### 10.2.4.1.2.1 :COUNt?/qonly/, COUNT?/qonly/

SCPI: :FETCh[:SCALar]:CYCLe:COUNt?/qonly/ | :READ[:SCALar]:CYCLe:COUNt?/qonly/
SHORT: COUNT?/qonly/

Reads an idividual number of the measuring cycle counter which is copied into memory. This value runs up to 65535 and starts then again at 0.

##### 10.2.4.1.2.2 :DINPut?/qonly/, DIST?/qonly/

SCPI: :FETCh[:SCALar]:DINPut?/qonly/ | :READ[:SCALar]:DINPut?/qonly/
SHORT: DIST?/qonly/

Reads the status of the digital inputs. 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

#### 10.2.4.1.3 :ENERgy

##### 10.2.4.1.3.1 [:ACTive]?/qonly/, EP?/qonly/

SCPI: :FETCh[:SCALar]:ENERgy[:ACTive]?/qonly/ | :READ[:SCALar]:ENERgy[:ACTive]?/qonly/
SHORT: EP?/qonly/

Reads the active energy (integrated active power).

##### 10.2.4.1.3.2 :APParent?/qonly/, ES?/qonly/

SCPI: :FETCh[:SCALar]:ENERgy:APPArent?/qonly/ | :READ[:SCALar]:ENERgy:APParent?/qonly/
SHORT: ES?/qonly/

Reads the apparent energy (integrated apparent power).

##### 10.2.4.1.3.3 :CHARge?/qonly/, EI?/qonly/

SCPI: :FETCh[:SCALar]:ENERgy:CHARge?/qonly/ | :READ[:SCALar]:ENERgy:CHARge?/qonly/
SHORT: EI?/qonly/

Reads the charge (integrated DC current).

#### 10.2.4.1.3.4 :REACtive?/qonly/, EQ?/qonly/

SCPI: :FETCh[:SCALar]:ENERgy:REACtive?/qonly/ | :READ[:SCALar]:ENERgy:REACtive?/qonly/
SHORT: EQ?/qonly/

Reads the reactive energyenergy (integrated reactive power).

#### 10.2.4.1.3.5 :TIME?/qonly/, INTR?/qonly/

SCPI: :FETCh[:SCALar]:ENERgy:TIME?/qonly/ | :READ[:SCALar]:ENERgy:TIME?/qonly/
SHORT: INTR?/qonly/

Reads the time of the running integration as long in ms

#### 10.2.4.1.4 :FLICker

#### 10.2.4.1.4.1 [:EUTest]

Selects the equipment under test measuring results. They are measured at the voltage input jacks.

#### 10.2.4.1.4.1.1 :APMoment?/qonly/, FLMO?/qonly/

SCPI: :FETCh[:SCALar]:FLICker[:EUTest]:APMoment?/qonly/ |
:READ[:SCALar]:FLICker[:EUTest]:APMoment? \f if/qonly/
SHORT: FLMO?/qonly/

Reads the averaged momentary flicker level of the equipment under test. This is the value which is displayed as 'Pmoml'. It is averaged over 16 periods.

#### 10.2.4.1.4.1.2 :DC?/qonly/, FLDC?/qonly/

SCPI: :FETCh[:SCALar]:FLICker[:EUTest]:DC?/qonly/ |
:READ[:SCALar]:FLICker[:EUTest]:DC?/qonly/
SHORT: FLDC?/qonly/

Reads the $d_c$ value of the equipment under test.

#### 10.2.4.1.4.1.3 :DELTat? /qonly/ <list>, FLDT?/qonly/ <list>

SCPI: :FETCh[:SCALar]:FLICker[:EUTest]:DELTat?/qonly/ <list>|
:READ[:SCALar]:FLICker[:EUTest]:DELTat?/qonly/ <list>
SHORT: FLDT?/qonly/ <list>

Reads the d(t) values of the equipment under test. After each measuring cycle over 16 periods you can get 32 values. The smallest and biggest requestable values in the list are 0 and 31.

### 10.2.4.1.4.1.4 :DMAX?/qonly/, FLDX?/qonly/

SCPI: :FETCh[:SCALar]:FLICker[:EUTest]:DMAX?/qonly/ |
:READ[:SCALar]:FLICker[:EUTest]:DMAX?/qonly/
SHORT: FLDX?/qonly/

Reads the $d_{max}$ value of the equipment under test.

### 10.2.4.1.4.1.5 :HWTRms? /qonly/ <list>, FLRM?/qonly/ <list>

SCPI: :FETCh[:SCALar]:FLICker[:EUTest]:HWTRms?/qonly/ <list>|
:READ[:SCALar]:FLICker[:EUTest]:HWTRms?/qonly/ <list>
SHORT: FLRM?/qonly/ <list>

Reads the half wave TRMSvalues of the equipment under test. This is the value which is displayed as 'Ul'. After each measuring cycle over 16 periods you can get 32 values. The smallest and biggest requestable values in the list are 0 and 31.

### 10.2.4.1.4.1.6 :PLT?/qonly/, FLLT?/qonly/

SCPI: :FETCh[:SCALar]:FLICker[:EUTest]:PLT?/qonly/ |
:READ[:SCALar]:FLICker[:EUTest]:PLT?/qonly/
SHORT: FLLT?/qonly/

Reads the $P_{lt}$ value of the equipment under test.

### 10.2.4.1.4.1.7 :PMOMentary? /qonly/ <list>, FLMS?/qonly/ <list>

SCPI: :FETCh[:SCALar]:FLICker[:EUTest]: PMOMentary?/qonly/ <list>|
:READ[:SCALar]:FLICker[:EUTest]: PMOMentary?/qonly/ <list>
SHORT: FLMS?/qonly/ <list>

Reads the momentary flicker level of the equipment under test. This is the value which is displayed as 'Pl'. After each measuring cycle over 16 periods you can get 32 values. The smallest and biggest requestable values in the list are 0 and 31.

### 10.2.4.1.4.1.8 :PST?/qonly/, FLST?/qonly/

SCPI: :FETCh[:SCALar]:FLICker[:EUTest]:PST?/qonly/ |
:READ[:SCALar]:FLICker[:EUTest]:PST?/qonly/
SHORT: FLST?/qonly/

Reads the $P_{st}$ value of the equipment under test.

### 10.2.4.1.4.1.9 :RESULT?/qonly/, FLRE?/qonly/

SCPI: :FETCh[:SCALar]:FLICker[:EUTest]:RESult?/qonly/ |
:READ[:SCALar]:FLICker[:EUTest]:RESult?/qonly/
SHORT: FLRE?/qonly/

Reads the result of the flicker measuring at the equipment under test. It is returned as long number with following meaning:

Bít 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 >4%, cleared otherwise.
Bit 4: Set if d(t) was >3% for more than 200ms, cleared otherwise.
Bit 5: Set if $d_c$ was > 3%, cleared otherwise.

#### 10.2.4.1.4.2 :LTRemain?/qonly/, FLTR?/qonly/

SCPI: :FETCh[:SCALar]:FLICker:LTRemain?/qonly/ | :READ[:SCALar]:FLICker:LTRemain?/qonly/
SHORT: FLTR?/qonly/

Reads the remaining long time for the flicker measurement in seconds.

#### 10.2.4.1.4.3 :SOURce

Selects the source's measuring results. They are measured at the current input jacks.

#### 10.2.4.1.4.3.1 :APMoment?/qonly/, FSMO?/qonly/

SCPI: :FETCh[:SCALar]:FLICker:SOURce:APMoment?/qonly/ |
:READ[:SCALar]:FLICker:SOURce:APMoment?/qonly/
SHORT: FSMO?/qonly/

Reads the averaged momentary flicker level of the source. This is the value which is displayed as 'Pmoms'. It is averaged over 16 periods.

#### 10.2.4.1.4.3.2 :DC?/qonly/, FSDC?/qonly/

SCPI: :FETCh[:SCALar]:FLICker:SOURce:DC?/qonly/ |
:READ[:SCALar]:FLICker:SOURce:DC?/qonly/
SHORT: FSDC?/qonly/

Reads the $d_c$ value of the source.

#### 10.2.4.1.4.3.3 :DELTat? /qonly/ <list>, FSDT?/qonly/ <list>

SCPI: :FETCh[:SCALar]:FLICker:SOURce:DELTat?/qonly/ <list>|
:READ[:SCALar]:FLICker:SOURce:DELTat?/qonly/ <list>
SHORT: FSDT?/qonly/ <list>

Reads the d(t) values of the source. After each measuring cycle over 16 periods you can get 32 values. The smallest and biggest requestable values in the list are 0 and 31.

### 10.2.4.1.4.3.4 :DMAX?/qonly/, FSDX?/qonly/

SCPI: :FETCh[:SCALar]:FLICker:SOURce:DMAX?/qonly/ |
:READ[:SCALar]:FLICker:SOURce:DMAX?/qonly/
SHORT: FSDX?/qonly/

Reads the $d_{max}$ value of the source.

### 10.2.4.1.4.3.5 :HWTRms? /qonly/ <list>, FSRM?/qonly/ <list>

SCPI: :FETCh[:SCALar]:FLICker:SOURce:HWTRms?/qonly/ <list>|
:READ[:SCALar]:FLICker:SOURce:HWTRms?/qonly/ <list>
SHORT: FSRM?/qonly/ <list>

Reads the half wave TRMS values of the source. This is the value which is displayed as 'Us'. After each measuring cycle over 16 periods you can get 32 values. The smallest and biggest requestable values in the list are 0 and 31.

### 10.2.4.1.4.3.6 :PLT?/qonly/, FSLT?/qonly/

SCPI: :FETCh[:SCALar]:FLICker:SOURce:PLT?/qonly/ |
:READ[:SCALar]:FLICker:SOURce:PLT?/qonly/
SHORT: FSLT?/qonly/

Reads the $P_{lt}$ value of the source.

### 10.2.4.1.4.3.7 :PMOMentary? /qonly/ <list>, FSMS?/qonly/ <list>

SCPI: :FETCh[:SCALar]:FLICker:SOURce: PMOMentary?/qonly/ <list>|
:READ[:SCALar]:FLICker:SOURce: PMOMentary?/qonly/ <list>
SHORT: FSMS?/qonly/ <list>

Reads the momentary flicker level of the source. This is the value which is displayed as 'Ps'. After each measuring cycle over 16 periods you can get 32 values. The smallest and biggest requestable values in the list are 0 and 31.

### 10.2.4.1.4.3.8 :PST?/qonly/, FSST?/qonly/

SCPI: :FETCh[:SCALar]:FLICker:SOURce:PST?/qonly/ |
:READ[:SCALar]:FLICker:SOURce:PST?/qonly/
SHORT: FSST?/qonly/

Reads the $P_{st}$ value of the source.

### 10.2.4.1.4.3.9 :RESULT?/qonly/, FSRE?/qonly/

SCPI: :FETCh[:SCALar]:FLICker:SOURce:RESult?/qonly/ |
:READ[:SCALar]:FLICker:SOURce:RESult?/qonly/
SHORT: FSRE?/qonly/

Reads the result of the flicker measuring at the source. It is returned as long number with following meaning:

Bít 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 >4%, cleared otherwise.
Bit 4: Set if d(t) was >3% for more than 200ms, cleared otherwise.
Bit 5: Set if $d_c$ was > 3%, cleared otherwise.

#### 10.2.4.1.4.4 :STATe?/qonly/, FSTA?/qonly/

SCPI: :FETCh[:SCALar]:FLICker:STATe?/qonly/ | :READ[:SCALar]:FLICker:STATe?/qonly/
SHORT: FSTA?/qonly/

Reads the status of the flicker measuring. It is returned as long number with following meaning:
0: Reset
1: Wait
2: Run
3: Stop

#### 10.2.4.1.4.5 :STRemain?/qonly/, FSTR?/qonly/

SCPI: :FETCh[:SCALar]:FLICker:STRemain?/qonly/ | :READ[:SCALar]:FLICker:STRemain?/qonly/
SHORT: FSTR?/qonly/

Reads the remaining short time for the actual short term measurement in seconds.

### 10.2.4.1.5 FREQuency

#### 10.2.4.1.5.1 :FINPut?/qonly/, DIFQ?/qonly/

SCPI: :FETCh[:SCALar]:FREQuency:FINPut?/qonly/ |
:READ[:SCALar]:FREQuency:FINPut?/qonly/
SHORT: DIFQ?/qonly/

Reads the value of frequency input of the processing signal interface.

#### 10.2.4.1.5.2 :SSOurce?/qonly/, FREQ?/qonly/

SCPI: :FETCh[:SCALar]:FREQuency[:SSOurce]?/qonly/ |
:READ[:SCALar]:FREQuency[:SSOurce]? \f if/qonly/
SHORT: FREQ?/qonly/

Reads the frequency of the synchronisation source

### 10.2.4.1.6 :HARMonics

#### 10.2.4.1.6.1 :CDResult?/qonly/, HENS?/qonly/

SCPI: :FETCh[:SCALar]:HARMonics:CDResult?/qonly/ |
:READ[:SCALar]:HARMonics:CDResult?/qonly/
SHORT: HENS?/qonly/

Reads the class D result of the harmonic measuring. It is returned as long number with following meaning:

Bít 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.

#### 10.2.4.1.6.2 :CURRent

##### 10.2.4.1.6.2.1 :AMPLitude?/qonly/ <list>, HIAM?/qonly/ <list>

SCPI: :FETCh[:SCALar]:HARMonics:CURRent:AMPLitude?/qonly/ <list> |
:READ[:SCALar]:HARMonics:CURRent:AMPLitude?/qonly/ <list>
SHORT: HIAM?/qonly/ <list>

Reads the amplitude of the harmonics of the current . The smallest and biggest requestable values in the list are 0 and 40 in CE-HRM mode or 0 and 99 in HRM100 mode.

##### 10.2.4.1.6.2.2 :GFResult?/qonly/, HIGF?/qonly/

SCPI: :FETCh[:SCALar]:HARMonics:CURRent:GFResult?/qonly/ |
:READ[:SCALar]:HARMonics:CURRent:GFResult?/qonly/
SHORT: HIGF?/qonly/

Reads the global final result of the current check in CE-HRM mode. It is returned as long number with following meaning:

Bít 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.

### 10.2.4.1.6.2.3 :LIMit?/qonly/ <list>, HILM?/qonly/ <list>

SCPI: :FETCh[:SCALar]:HARMonics:CURRent:LIMit?/qonly/ <list> |
:READ[:SCALar]:HARMonics:CURRent:LIMit?/qonly/ <list>
SHORT: HILM?/qonly/ <list>

Reads the limits of the harmonics of the current in CE-HRM mode. The smallest and biggest requestable values in the list are 0 and 40.

### 10.2.4.1.6.2.4 :MAMPlitude?/qonly/ <list>, HIMX?/qonly/ <list>

SCPI: :FETCh[:SCALar]:HARMonics:CURRent:MAMPlitude?/qonly/ <list> |
:READ[:SCALar]:HARMonics:CURRent:MAMPlitude?/qonly/ <list>
SHORT: HIMX?/qonly/ <list>

Reads the maximum amplitude of the harmonics of the current in CE-HRM mode. The smallest and biggest requestable values in the list are 0 and 40.

### 10.2.4.1.6.2.5 :PHASe?/qonly/ <list>, HIPH?/qonly/ <list>

SCPI: :FETCh[:SCALar]:HARMonics:CURRent:PHASe?/qonly/ <list> |
:READ[:SCALar]:HARMonics:CURRent:PHASe?/qonly/ <list>
SHORT: HIPH?/qonly/ <list>

Reads the phase of the harmonics of the current in HRM100 mode. The smallest and biggest requestable values in the list are 0 and 99.

### 10.2.4.1.6.2.6 :THDistort?/qonly/, HIHD?/qonly/

SCPI: :FETCh[:SCALar]:HARMonics:CURRent:THDistort?/qonly/ |
:READ[:SCALar]:HARMonics:CURRent:THDistort?/qonly/
SHORT: HIHD?/qonly/

Reads the THD of the current.

### 10.2.4.1.6.3 [:VOLTage]

### 10.2.4.1.6.3.1 :AMPLitude?/qonly/ <list>, HUAM?/qonly/ <list>

SCPI: :FETCh[:SCALar]:HARMonics[:VOLTage]:AMPLitude?/qonly/ <list> |
:READ[:SCALar]:HARMonics[:VOLTage]:AMPLitude?/qonly/ <list>
SHORT: HUAM?/qonly/ <list>

Reads the amplitude of the harmonics of the voltage harmonics. The smallest and biggest requestable values in the list are 0 and 40 in CE-HRM mode or 0 and 99 in HRM100 mode.

Reads the THD of the voltage.

#### 10.2.4.1.7 :POWer

##### 10.2.4.1.7.1 :AACTive?/qonly/, PM?/qonly/

SCPI: :FETCh[:SCALar]:POWer:AACTive?/qonly/ | :READ[:SCALar]:POWer:AACTive?/qonly/
SHORT: PM?/qonly/

Reads the average active power.

##### 10.2.4.1.7.2 :AAPParent?/qonly/, SM?/qonly/

SCPI: :FETCh[:SCALar]:POWer:AAPParent?/qonly/ | :READ[:SCALar]:POWer:AAPParent?/qonly/
SHORT: SM?/qonly/

Reads the average apparent power.

##### 10.2.4.1.7.3 [:ACTive]?/qonly/, P?/qonly/

SCPI: :FETCh[:SCALar]:POWer[:ACTive]?/qonly/ | :READ[:SCALar]:POWer[:ACTive]?/qonly/
SHORT: P?/qonly/

Reads the active power.

##### 10.2.4.1.7.4 :APParent?/qonly/, S?/qonly/

SCPI: :FETCh[:SCALar]:POWer:APParent?/qonly/ | :READ[:SCALar]:POWer:APParent?/qonly/
SHORT: S?/qonly/

Reads the apparent power.

##### 10.2.4.1.7.5 :AREactive?/qonly/, QM?/qonly/

SCPI: :FETCh[:SCALar]:POWer:AREactive?/qonly/ | :READ[:SCALar]:POWer:AREactive?/qonly/
SHORT: Q?/qonly/

Reads the average reactive power.

##### 10.2.4.1.7.6 :FSCale?/qonly/, FSP?/qonly/

SCPI: :FETCh[:SCALar]:POWer:FSCale?/qonly/ | :READ[:SCALar]:POWer:FSCale?/qonly/
SHORT: FSP?/qonly/

Reads the full scale value of the power.

#### 10.2.4.1.7.7 :ICAPacity?/qonly/, INCA?/qonly/

SCPI: :FETCh[:SCALar]:POWer:ICAPacity?/qonly/ | :READ[:SCALar]:POWer:ICAPacity?/qonly/
SHORT: INCA?/qonly/

Reads the status of the inca flag. It shows, if the system is inductive or capacitive. It is returned as a long number with following meaning:

+1 inductive
0 undefined
-1 capacitive

#### 10.2.4.1.7.8 :PFACtor?/qonly/, PF?/qonly/

SCPI: :FETCh[:SCALar]:POWer:PFACtor?/qonly/ | :READ[:SCALar]:POWer:PFACtor?/qonly/
SHORT: PF?/qonly/

Reads the power factor.

#### 10.2.4.1.7.9 :PHASe?/qonly/, PHI?/qonly/

SCPI: :FETCh[:SCALar]:POWer:PHASe?/qonly/ | :READ[:SCALar]:POWer:PHASe?/qonly/
SHORT: PHI?/qonly/

Reads the phase between current and voltage.

#### 10.2.4.1.7.10 :REACtive?/qonly/, Q?/qonly/

SCPI: :FETCh[:SCALar]:POWer:REACtive?/qonly/ | :READ[:SCALar]:POWer:REACtive?/qonly/
SHORT: Q?/qonly/

Reads the reactive power.

### 10.2.4.1.8 :RESistance

#### 10.2.4.1.8.1 :ASResist?/qonly/, RSER?/qonly/

SCPI: :FETCh[:SCALar]:RESistance:ASResist?/qonly/ |
:READ[:SCALar]:RESistance:ASResist?/qonly/
SHORT: RSER?/qonly/

Reads the active serial resistance.

#### 10.2.4.1.8.2 :IMPedance?/qonly/, Z?/qonly/

SCPI: :FETCh[:SCALar]:RESistance:IMPedance?/qonly/ |
:READ[:SCALar]:RESistance:IMPedance?/qonly/
SHORT: Z?/qonly/

Reads the impedance (apparent resistance).

#### 10.2.4.1.8.3 :RSIMpedance?/qonly/, XSER?/qonly/

SCPI: :FETCh[:SCALar]:RESistance:RSIMpedance?/qonly/ |
:READ[:SCALar]:RESistance:RSIMpedance?/qonly/
SHORT: XSER?/qonly/

Reads the reactive serial impedance.

#### 10.2.4.1.9 :VARiable?/qonly/ <list>, VAR?/qonly/ <list>

SCPI: :FETCh[:SCALar]:VARiable?/qonly/ <list> | :READ[:SCALar]:VARiable?/qonly/ <list>
SHORT: XSER?/qonly/ <list>

Reads value of the defined variables. The smallest and biggest requestable values in the list are 0 and 7.

#### 10.2.4.1.10 [:VOLTage]

#### 10.2.4.1.10.1 :AC?/qonly/, UAC?/qonly/

SCPI: :FETCh[:SCALar][:VOLTage]:AC?/qonly/ | :READ[:SCALar][:VOLTage]:AC?/qonly/
SHORT: UAC?/qonly/

Reads the AC value of the voltage.

#### 10.2.4.1.10.2 :AINPut?/qonly/ <list>, AIVA?/qonly/ <list>

SCPI: :FETCh[:SCALar][:VOLTage]:AINPut?/qonly/ <list> |
:READ[:SCALar][:VOLTage]:AINPut?/qonly/ <list>
SHORT: AIVA?/qonly/ <list>

Reads the voltage of the analogue input of the processing signal interface. With <list> you specify the required values.

#### 10.2.4.1.10.3 :CFACtor?/qonly/, UCF?/qonly/

SCPI: :FETCh[:SCALar][:VOLTage]:CFACtor?/qonly/ |
:READ[:SCALar][:VOLTage]:CFACtor?/qonly/
SHORT: UCF?/qonly/

Reads the crest factor of the voltage.

#### 10.2.4.1.10.4 :DC?/qonly/, UDC?/qonly/

SCPI: :FETCh[:SCALar][:VOLTage]:DC?/qonly/ | :READ[:SCALar][:VOLTage]:DC?/qonly/
SHORT: UDC?/qonly/

Reads the DC value of the voltage.

### 10.2.4.1.10.5 :FFACtor?/qonly/, UFF?/qonly/

SCPI: :FETCh[:SCALar][:VOLTage]:FFACtor?/qonly/ |
:READ[:SCALar][:VOLTage]:FFACtor?/qonly/
SHORT: UFF?/qonly/

Reads the form factor of the voltage.

### 10.2.4.1.10.6 :FSCale?/qonly/, FSU?/qonly/

SCPI: :FETCh[:SCALar][:VOLTage]:FSCale?/qonly/ | :READ[:SCALar][:VOLTage]:FSCale?/qonly/
SHORT: FSU?/qonly/

Reads the full scale value of the voltage.

### 10.2.4.1.10.7 :MAXPK?/qonly/, UMAX?/qonly/

SCPI: :FETCh[:SCALar][:VOLTage]:MAXPK?/qonly/ | :READ[:SCALar][:VOLTage]:MAXPK?/qonly/
SHORT: UMAX?/qonly/

Reads the biggest sample value of the voltage.

### 10.2.4.1.10.8 :MINPK?/qonly/, UMIN?/qonly/

SCPI: :FETCh[:SCALar][:VOLTage]:MINPK?/qonly/ | :READ[:SCALar][:VOLTage]:MINPK?/qonly/
SHORT: UMIN?/qonly/

Reads the smallest sample value of the voltage.

### 10.2.4.1.10.9 :PPEak?/qonly/, UPP?/qonly/

SCPI: :FETCh[:SCALar][:VOLTage]:PPEak?/qonly/ | :READ[:SCALar][:VOLTage]:PPEak?/qonly/
SHORT: UPP?/qonly/

Reads the peak peak value of the voltage.

### 10.2.4.1.10.10 :RECTify?/qonly/, UREC?/qonly/

SCPI: :FETCh[:SCALar][:VOLTage]:RECTify?/qonly/ |
:READ[:SCALar][:VOLTage]:RECTify?/qonly/
SHORT: UREC?/qonly/

Reads the rectified value of the voltage.

### 10.2.4.1.10.11 [:TRMS?]/qonly/, UTRMS?/qonly/

SCPI: :FETCh[:SCALar][:VOLTage][:TRMS]?/qonly/ | :READ[:SCALar][:VOLTage][:TRMS]?/qonly/
SHORT: UTRMS?/qonly/

Reads the TRMS value of the voltage.

### 10.2.5 :FORMat

Here you can setup the output format.

#### 10.2.5.1 :DATA/nquery/ <NRi>, FRMT/nquery/ <NRi>

SCPI: :FORMat:DATA/nquery/ <NRi>
SHORT: FRMT/nquery/ <NRi>

Defines the data output format. Parameter is:
'0' or 'ASCII' for ASCII output [*RST default value]
'1' or 'PACKED' for a packed output.

In the packed output the data are output as defined length arbitrary block response data. If there are more data to be output than available buffer memory, there are several sequential following 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 transfered, so that the receiving PC program can store the data directly in memory. The number 0x11223344 is ordered 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.

### 10.2.6 :INITiate commands

Here you can start or stop special actions.

#### 10.2.6.1 :CONTinuous <NRi>, CONT <NRi>

SCPI: :INITiate:CONTinuous <NRi>
SHORT: CONT <NRi>

This activates or deactivates the continuous execution of the string defined with :TRIGger:ACTion or ACTN. The programmer should only use :FETCh commands to be executed, because when 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.

#### 10.2.6.2 :IMMediate/nquery/, INIM/nquery/

SCPI: :INITiate:IMMediate/nquery/
SHORT: INIM/nquery/

This forces an actualisation of the values to be read with the :FETCh commands. In general the instrument measures continuously. 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 timeout for expecting the answer of a following command.

### 10.2.7 :INSTrument commands

Here general setups of the instrument are done.

#### 10.2.7.1 :SELect <NRi>, MODE <NRi>

SCPI: :INSTrument:SELect <NRi>
SHORT: MODE <NRi>

Sets or reads the measuring mode:
'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
'4' or 'TRANS' for transient measuring mode

### 10.2.8 :MEMory commands

#### 10.2.8.1 :FREeze <NRi>, FRZ <NRi>

SCPI: :MEMory:FREeze <NRi>
SHORT: FRZ <NRi>

Freezes the scope RAM. The scope has too much memory so it can't copied each cycle into a 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]

### 10.2.9 :SENSe commands

#### 10.2.9.1 :AINPut

##### 10.2.9.1.1 :FSCale <NRf>, AIHI <NRf>

SCPI: :SENSe:AINPut:FSCale <NRf>
SHORT: AIHI <NRf>

Sets or queries the setting of the full scale of the analogue inputs . The *RST default value is 10.

##### 10.2.9.1.2 :ZERO <NRf>, AILO <NRf>

SCPI: :SENSe:AINPut:ZERO <NRf>
SHORT: AILO <NRf>

Sets or queries the setting of the zero position of the analogue inputs . The *RST default value is 0.

#### 10.2.9.2 :AVERage

##### 10.2.9.2.1 :COUNt <NRi>, AVER <NRi>

SCPI: :SENSe:AVERage:COUNt <NRi>
SHORT: AVER <NRi>

Sets or queries the setting of the average parameter. Values are valid from 1 to 16. The *RST default value is 1.

#### 10.2.9.3 :CURRent

##### 10.2.9.3.1 :DETector <NRi>, IEXT <NRi>

SCPI: :SENSe:CURRent:DETector <NRi>
SHORT: IEXT <NRi>

Reads and sets internal or external shunt input:
'0' or 'INT' for internal shunt (current input) [*RST default value]
'1' or 'EXT' for external shunt input (voltage input)

##### 10.2.9.3.2 :RANGe

###### 10.2.9.3.2.1 :AUTO <NRi>, IAM <NRi>

SCPI: :SENSe:CURRent:RANGe:AUTO <NRi>
SHORT: IAM <NRi>

Reads and sets the status of the autorange function:
'0' or 'MANUAL' for manuel range selection
'1' or 'AUTO' for automatic range selection [*RST default value]

#### 10.2.9.3.2.2 [:UPPER] <NRf>, IRNG <NRf>

SCPI: :SENSe:CURRent:RANGe[:UPPER] <NRf>
SHORT: IRNG <NRf>

Reads and sets the range for the current measurement. The parameter is the nominal value of the range. There is no *RST default value.

#### 10.2.9.3.3 :SCALe <NRf>, ISCA <NRf>

SCPI: :SENSe:CURRent:SCALe <NRf>
SHORT: ISCA <NRf>

Reads and sets the scaling of the current range. The *RST default value is 1.0.

#### 10.2.9.4 :FILTer

#### 10.2.9.4.1 [:LPASs]

#### 10.2.9.4.1.1 [:STATe] <NRi>, FILT <NRi>

SCPI: :SENSe:FILTer[:LPASS][:STATe] <NRi>
SHORT: FILT <NRi>

Reads and sets the filter settings:
0: Filter off [*RST default value]
1: AAF on
2: Lowpass '2kHz' on
3: Lowpass '9.2kHz' on
4: Lowpass '60Hz' on
5: Lowpass '18kHz' on
6: Lowpass '6kHz' on
7: Lowpass '2.8kHz' on
8: Lowpass '1.4kHz' on
11: Lowpass '175Hz' on
12: Lowpass '87.5Hz' on
13: Lowpass '30Hz' on

#### 10.2.9.5 :FINPut

##### 10.2.9.5.1 :SCALe <NRf>, DIFS <NRf>

SCPI: :SENSe:FINPut:SCALe <NRf>
SHORT: DIFS <NRf>

Sets or queries the setting of the scale of the frequency input . The *RST default value is 1.

#### 10.2.9.6 :FLICker

##### 10.2.9.6.1 :PERiods <NRf>, FLPS <NRf>

SCPI: :SENSe:FLICker:PERiods <NRf>
SHORT: FLPS <NRf>

Reads and sets the number of periods for flicker measuring. The *RST default value is 12.

##### 10.2.9.6.2 :STIMe <NRf>, FTIM <NRf>

SCPI: :SENSe:FLICker:STIMe <NRf>
SHORT: FTIM <NRf>

Reads and sets the short term flicker measuring time in seconds. The *RST default value is 600.

#### 10.2.9.7 :HARMonics

##### 10.2.9.7.1 :SMOoth <NRi>, SMOO <NRi>

SCPI: :SENSe:HARMonics:SMOoth <NRi>
SHORT: SMOO <NRi>

Reads and sets the state of the smoothing:
'0' or 'OFF' for direct measuring [*RST default value]
'1' or 'ON' for smoothed measuring

##### 10.2.9.7.2 :TIME <NRf>, HTIM <NRf>

SCPI: :SENSe:HARMonics:TIME <NRf>
SHORT: HTIM <NRf>

Reads and sets the harmonics measuring time in seconds. The *RST default value is 150.

### 10.2.9.8 :INTegral

#### 10.2.9.8.1 :DATE <NRf>,<NRf>,<NRf>, INTD <NRf>,<NRf>,<NRf>

SCPI: :SENSe:INTegral:DATE <NRf>,<NRf>,<NRf>
SHORT: INTD <NRf>,<NRf>,<NRf>

Reads and sets the start date for an energy measurement. Example: INTD 1998,02,09 sets the date to the 9th February, 1998

#### 10.2.9.8.2 :INTerval <NRf>, INTI <NRf>

SCPI: :SENSe:INTegral:INTerval <NRf>
SHORT: INTI <NRf>

Reads and sets the time interval for an energy measurement in s.

#### 10.2.9.8.3 :MODE <NRi>, INTM <NRi>

SCPI: :SENSe:INTegral:MODE <NRi>
SHORT: INTM <NRi>

Reads and sets the integration mode:
0=off [*RST default value]
1=continuous
2=interval
3=periodic
4=summing

#### 10.2.9.8.4 :STATe?/qonly/, INTS?/qonly/

SCPI: :SENSe:INTegral:STATe?/qonly/
SHORT: INTS?/qonly/

Reads the state of the energy measurement. The returned long value means:
0=Reset
1=Wait
2=Start
3=Run
4=Stop
5=Hold

#### 10.2.9.8.5 :TIME <NRf>,<NRf>,<NRf>, INTT <NRf>,<NRf>,<NRf>

SCPI: :SENSe:INTegral:TIME <NRf>,<NRf>,<NRf>
SHORT: INTT <NRf>,<NRf>,<NRf>

Reads and sets the start time for an energy measurement. Example: INTT 19,26,49 sets the time to 19:26:49.

#### 10.2.9.9 :SWEep

##### 10.2.9.9.1 :TIME <NRf>, CYCL <NRf>

SCPI: :SENSe:SWEep:TIME <NRf>
SHORT: CYCL <NRf>

Reads and sets the cycle time in seconds. The *RST default value is 0.5.

#### 10.2.9.10 :VOLTage

##### 10.2.9.10.1 :RANGe

###### 10.2.9.10.1.1 :AUTO <NRi>, UAM <NRi>

SCPI: :SENSe:VOLTage:RANGe:AUTO <NRi>
SHORT: UAM <NRi>

Reads and sets the status of the autorange function:
'0' or 'MANUEL' for manuel range selection
'1' or 'AUTO' for automatic range selection [*RST default value]

###### 10.2.9.10.1.2 [:UPPER] <NRf>, URNG <NRf>

SCPI: :SENSe:VOLTage:RANGe[:UPPER] <NRf>
SHORT: URNG <NRf>

Reads and sets the range for the voltage measurement. The parameter is the nominal value of the range. There is no *RST default value.

##### 10.2.9.10.2 :SCALe <NRf>, USCA <NRf>

SCPI: :SENSe:VOLTage:SCALe <NRf>
SHORT: USCA <NRf>

Reads and sets the scaling of the voltage range. The *RST default value is 1.0.

#### 10.2.9.11 :WAVeform

##### 10.2.9.11.1 :IUPDate/nquery/, SACT/nquery/

SCPI: :SENSe:WAVeform:IUPDate/nquery/
SHORT: SACT/nquery/

Requests new information about the scope date. Before this command you should set ':MEMory:FREeze ON'. After this command you can use ':SENS:WAV:SATR', ':SENS:WAV:SBTR' and ':SENS:WAV:SSAM'.

### 10.2.9.11.2 :SATRigger?/qonly/, SATR?/qonly/

SCPI: :SENSe:WAVeform:SATRigger?/qonly/
SHORT: SATR?/qonly/

Reads how many sample values are available after the trigger event. See also ':SENS:WAV:IUPD' for further information.

### 10.2.9.11.3 :SBTRigger?/qonly/, SBTR?/qonly/

SCPI: :SENSe:WAVeform:SBTRigger?/qonly/
SHORT: SBTR?/qonly/

Reads how many sample values are available before the trigger event. See also ':SENS:WAV:IUPD' for further information.

### 10.2.9.11.4 :SSAMples?/qonly/, SSAM?/qonly/

SCPI: :SENSe:WAVeform:SSAMples?/qonly/
SHORT: SSAM?/qonly/

Reads which sample values are stored in the memory. See also ':SENS:WAV:IUPD' for further information. It is returned as long number with following meaning:

Bit 3: i
Bit 4: u
Bit 5: p

The Bits are counted from 0 to 7!

### 10.2.9.11.5 :WAVE?/qonly/ <NRi>,<list>, WAVE?/qonly/ <NRi>,<list>

SCPI: :SENSe:WAVeform:WAVE?/qonly/ <NRi>,<list>
SHORT: WAVE?/qonly/ <NRi>,<list>

Reads out sample values spezified with <NRi>. It is a long number with following meaning:

4: i
5: u
6: p

The first value in <list> is the value read by :SENSe:WAVeform:SBTRigger?, the last value that read by :SENSe:WAVeform:SATRigger?

## 10.2.10 :SOURce

### 10.2.10.1 :DIGital

#### 10.2.10.1.1 :CONDition <NRi>, DOCO <NRi>

SCPI: :SOURce:DIGital:CONDition <NRi>
SHORT: DOCO <NRi>

Sets or queries the setting of the condition of the digital outputs . The *RST default value is 0. Possible parameters are:

0: off
1: on
2: >=
3: <

#### 10.2.10.1.2 :LIMit <NRf>, DOLI <NRf>

SCPI: :SOURce:DIGital:LIMit <NRf>
SHORT: DOLI <NRf>

Sets or queries the setting of the limits of the digital outputs . The *RST default value is 0.

#### 10.2.10.1.3 :VALue <string>, DOIX <string>

SCPI: :SOURce:DIGital:VALue <string>
SHORT: DOIX <string>

Sets or queries the setting of the value of the digital outputs . The *RST default value is 'Utrms'. As <string> you have to enter the same string as you would enter when using the instrument without interface.

### 10.2.10.2 :VOLTage

#### 10.2.10.2.1 :VALue <string>, DOIX <string>

SCPI: :SOURce:VOLTage:VALue <string>
SHORT: AOIX <string>

Sets or queries the setting of the value of the analogue outputs . The *RST default value is 'Utrms'. As <string> you have to enter the same string as you would enter when using the instrument without interface.

### 10.2.10.2.2 :SCALe

#### 10.2.10.2.2.1 :FSCale <NRf>, AIHI <NRf>

SCPI: :SOURce:VOLTage:SCALe:FSCale <NRf>
SHORT: AOHI <NRf>

Sets or queries the setting of the full scale of the analogue outputs . The *RST default value is 10.

#### 10.2.10.2.2.2 :ZERO <NRf>, AILO <NRf>

SCPI: :SOURce:VOLTage:SCALe:ZERO <NRf>
SHORT: AOLO <NRf>

Sets or queries the setting of the zero position of the analogue outputs . The *RST default value is 0.

### 10.2.11 :STATus commands

### 10.2.11.1 :OPERation

#### 10.2.11.1.1 :CONDition?/qonly/, SOC?/qonly/

SCPI: :STATus:OPERation:CONDition?/qonly/
SHORT: SOC?/qonly/

Reads the Operation Status Condition Register.

#### 10.2.11.1.2 :ENABle, SOEN

SCPI: :STATus:OPERation:ENABle
SHORT: SOEN

Reads and sets the Operation Status Enable Register.

#### 10.2.11.1.3 [:EVENt]?/qonly/, SOE?/qonly/

SCPI: :STATus:OPERation[:EVENt]?/qonly/
SHORT: SOE?/qonly/

Reads the Operation Status Event Register and clears it.

#### 10.2.11.1.4 :NTRansition, SONT

SCPI: :STATus:OPERation:NTRansition
SHORT: SONT

Reads and sets the Operation Status Negative Transition Register.

#### 10.2.11.1.5 :PTRansition, SOPT

SCPI: :STATus:OPERation:PTRansition
SHORT: SOPT

Reads and sets the Operation Status Positive Transition Register.

### 10.2.11.2 PRESet/nquery/, PRES/nquery/

SCPI: :STATus:PRESet/nquery/
SHORT: PRES/nquery/

Presets the operation and the query registers. The p-transition registers are filled with 0x7FFF, the n-trasnsition registers with 0x0000 and the enable registers with 0x0000.

### 10.2.11.3 :QUEStionable

#### 10.2.11.3.1 :CONDition?/qonly/, SQC?/qonly/

SCPI: :STATus:QUEStionable:CONDition?/qonly/
SHORT: SQC?/qonly/

Reads the Questionable Status Condition Register.

#### 10.2.11.3.2 :ENABle, SQEN

SCPI: :STATus:QUEStionable:ENABle
SHORT: SQEN

Reads and sets the Questionable Status Enable Register.

#### 10.2.11.3.3 [:EVENt]?/qonly/, SQE?/qonly/

SCPI: :STATus:QUEStionable[:EVENt]?/qonly/
SHORT: SQE?/qonly/

Reads the Questionable Status Event Register and clears it.

#### 10.2.11.3.4 :NTRansition, SQNT

SCPI: :STATus:QUEStionable:NTRansition
SHORT: SQNT

Reads and sets the Questionable Status Negative Transition Register.

#### 10.2.11.3.5 :PTRansition, SQPT

SCPI: :STATus:QUEStionable:PTRansition
SHORT: SQPT

Reads and sets the Questionable Status Positive Transition Register.

## 10.2.12 :SYSTem commands

### 10.2.12.1 :BEEPer

#### 10.2.12.1.1 :IMMediate/nquery/, BEEP/nquery/

SCPI: :SYSTem:BEEPer:IMMediate/nquery/
SHORT: BEEP/nquery/

Forces the internal beeper to beep a short sound.

### 10.2.12.2 :DATE <NRf>,<NRf>,<NRf>, DATE <NRf>,<NRf>,<NRf>

SCPI: :SYSTem:DATE <NRf>,<NRf>,<NRf>
SHORT: DATE <NRf>,<NRf>,<NRf>

Reads and sets the system date. Format is DATE yyyy,mm,dd. Example: DATE 1998,02,09 sets the date to the 9th February, 1998

### 10.2.12.3 :ERRor

#### 10.2.12.3.1 :ALL?/qonly/, ERRALL?/qonly/

SCPI: :SYSTem:ERRor:ALL?/qonly/
SHORT: ERRALL?/qonly/

Reads all errors, including error code and error description, seperated by commas out of the error/event queue.

#### 10.2.12.3.2 :COUNt?/qonly/, ERRCNT?/qonly/

SCPI: :SYSTem:ERRor:COUNt?/qonly/
SHORT: ERRCNT?/qonly/

Reads the number of errors in the error/event queue.

#### 10.2.12.3.3 [:NEXT]?/qonly/, ERR?/qonly/

SCPI: :SYSTem:ERRor[:NEXT]?/qonly/
SHORT: ERR?/qonly/

Reads the oldest entry from the error/event queue, including error code and error description, seperated by commas.

#### 10.2.12.4 :HELP

##### 10.2.12.4.1 :HEADers?/qonly/, HEAD?/qonly/

SCPI: :SYSTem:HELP:HEADers?/qonly/
SHORT: HEAD?/qonly/

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.

##### 10.2.12.4.2 :SHEaders?/qonly/, SHEAD?/qonly/

SCPI: :SYSTem:HELP:SHEaders?/qonly/
SHORT: SHEAD?/qonly/

Returns a list of all SHORT 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.

#### 10.2.12.5 :KEY <NRi>, KEY <NRi>

SCPI: :SYSTem:KEY <NRi>,
SHORT: KEY <NRi>

Queries the last pressed key or simulates the pressing of a key. Valid key numbers are:

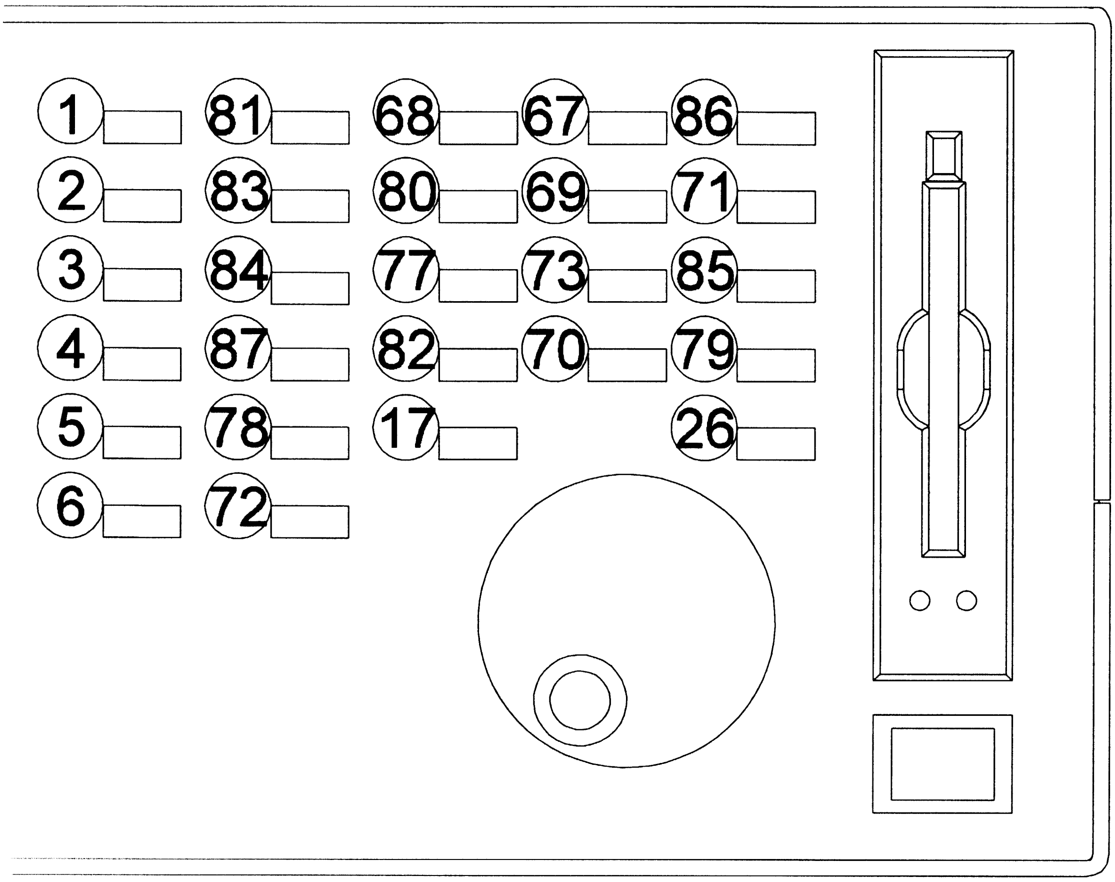


**Figure 32: Keynumbers**

### 10.2.12.6 :LANGuage/nquery/ <NRi>, LANG/nquery/ <NRi>

SCPI: :SYSTem:LANGuage/nquery/ <NRi>,
SHORT: LANG/nquery/ <NRi>

Changes the command set to be used. Parameter can be:
'0' or 'SCPI' to go to the SCPI command set [*RST default value]
'1' or 'SHORT' to go to the SHORT command set

The new language will be used beginning with the following command header.

### 10.2.12.7 :TIME <NRf>,<NRf>,<NRf>, TIME <NRf>,<NRf>,<NRf>

SCPI: :SYSTem:TIME <NRf>,<NRf>,<NRf>
SHORT: TIME <NRf>,<NRf>,<NRf>

Reads and sets the system time. Format is TIME hh,mm,ss. Example: TIME 10,26,46 sets the time to 10:26:46.

#### 10.2.12.8 :VERSion?/qonly/, VER?/qonly/

SCPI: :SYSTem:VERSion?/qonly/
SHORT: VER? \f if/qonly/

Returns the version of the SCPI implementation. Returns always '1999.0'.

### 10.2.13 :TRIGger commands

#### 10.2.13.1 :ACTion/nquery/, ACTN/nquery/

SCPI: :TRIGger:ACTion/nquery/
SHORT: ACTN/nquery/

Defines an action 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 10.2.6.1, ':CONTinuous <NRi>, CONT <NRi>'. The same example in SCPI syntax would be.
:TRIG:ACT;:FETC:TRMS?;:FETC:CURR:TRMS?

There is no *RST default value!

#### 10.2.13.2 :ICURrent/nquery/, IINC/nquery/,

SCPI: :TRIGger:ICURrent/nquery/
SHORT: IINC/nquery/

Triggers the measuring of the inrush current. The value for the inrush current is reset to 0.

#### 10.2.13.3 :INTerval

##### 10.2.13.3.1 :RESet/nquery/, RESET/nquery/

SCPI: :TRIGger:INTerval:RESet/nquery/
SHORT: RESET/nquery/

Resets the energy measurement.

##### 10.2.13.3.2 :STARt/nquery/, START/nquery/

SCPI: :TRIGger:INTerval:STARt/nquery/
SHORT: START/nquery/

Starts the energy measurement.

#### 10.2.13.3.3 :STOP/nquery/, STOP/nquery/

SCPI: :TRIGger:INTerval:STOP/nquery/
SHORT: STOP/nquery/

Stops the energy measurement.

### 10.2.13.4 [:SEQuence]

#### 10.2.13.4.1 :COUPle <NRi>, COUPL <NRi>

SCPI: :TRIGger[:SEQuence]:COUPle <NRi>
SHORT: COUPL <NRi>

Sets or reads the coupling mode for the trigger (synchronisation) signal. Possible values are:
'0' or 'ACDC' for AC/DC coupling mode [*RST default value]
'1' or 'BP' for BP coupling mode
'2' or 'AM' for AM coupling mode

#### 10.2.13.4.2 :SOURce <NRi>, SYNC <NRi>

SCPI: :TRIGger[:SEQuence]:SOURce <NRi>
SHORT: SYNC <NRi>

Sets or reads the synchronisation source. Possible values are:
'0' or 'LINE' for line synchronisation
'1' or 'EXTS' for external synchronisation
'2' or 'U' for synchronisation to the voltage signal [*RST default value]
'3' or 'I' for synchronisation to the current signal

### 10.2.14 Example

Following you find a small example for data exchange via RS232 interface:

```
' QBasic 1.1
' Example for reading data from a LMG95
' LMG95 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 LMG95 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 LMG95
   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
```

### 10.2.15 Testing the interface using a terminal program

For testing if the interface works, or how any commands work it is recommended to use a terminal program (e.g. HyperTerminal under WIN95).

Setup the LMG95 pressing *IF/IO*, **Rmote** and **Dev.** until 'Device' is set to 'COM1 RS232'. Use **back** and **Dev.** to change the menu. Use **Device** until 'COM1' appears. Setup Baud=38400, EOS=Terminal, Echo=On, Protocol=None.

Now setup you computer. Start you terminal program and set it up to 38400Baud, 8Data Bit, 1Stop Bit, No Parity and No Protocol. Select this for COM1 of your computer.

Now connect COM1 of your computer with COM1 of the LMG95 with a 1:1 cable without any crossings or null modem functions.

If you now type in '*RST' and press Return, the status bar of LMG95 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 all this fails, check all setings and cables and try again.

## 10.3 Physical devices

The physical devices are the jacks at the rear panel of the instrument.

**Please note:**
**COM1 and COM2 in the following sections are the COM1 and COM2 connectors of the LMG95! They are not the connectors of the PC!**

### 10.3.1 COM1, RS232/RS485

In this jack a null modem is implemented. That means if you want to connect COM1 of the LMG95 to a PC you have to use a cable which connects 1:1 (without a null modem function).

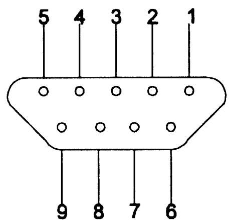


**Figure 33: COM1 connector**

| Pin | Comment |
|---|---|
| 1 | TA (RS485) |
| 2 | TxD (RS232) |
| 3 | RxD (RS232) |
| 4 | RA (RS485) |
| 5 | GND (RS232) |
| 6 | TB (RS485) |
| 7 | CTS (RS232) |
| 8 | RTS (RS232) |
| 9 | RB (RS485) |

Please note:

If you use RS485 levels don't connect any RS232 pins. If you use RS232 levels don't connect any RS485 pins.

### 10.3.2 COM2, RS232

In this jack no null modem is implemented. That means if you want to connect COM2 of the LMG95 to a PC you have to use a cable with null modem function.

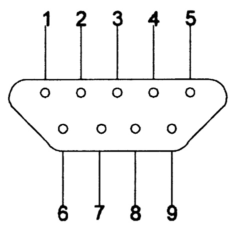


**Figure 34: COM2 connector**

| Pin | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Comment | DCD | RxD | TxD | DTR | GND | DSR | RTS | CTS | RI |

### 10.3.3 IEEE488.2

This port has the pinout defined in the standard IEEE488. You can use the standard cables.

### 10.3.4 Parallel Port

This port has the same pinout like a PC parallel port. You can use the same cables.

### 10.3.5 Set-up using DIP switches

| Bit | 16 | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| IEEE | 1 | 0 | 1 | Mode | | | | | | | | IEEE Address | | | | |
| other | Device | | | Mode | | | | Echo | Protocol | | EOS | | | Baud | | |

For the remote control the setup of the physical device can be done with the DIP switches at the rear of the instrument. This setting are setup each time the instrument powers up. They can be changed in the menus while the instrument is working. When switching on again, the DIP switch settings are used. Following settings are possible:

#### Device

| Bit 16 | Bit 15 | Bit 14 | |
|---|---|---|---|
| 0 | 0 | 0 | Setup only from menu. All other switches are ignored. |
| 0 | 0 | 1 | Select COM1 with RS232 levels |
| 0 | 1 | 0 | Select COM1 with RS485 levels |
| 0 | 1 | 1 | Select COM2 with RS232 levels |
| 1 | 0 | 1 | Select IEEE488 port |

#### Mode

| Bit 13 | Bit 12 | |
|---|---|---|
| 0 | 0 | Local mode |
| 1 | 0 | Remote mode |

#### Echo

| Bit 9 | |
|---|---|
| 0 | Echo off |
| 1 | Echo on |

## Protocol

| Bit 8 | Bit 7 | |
|---|---|---|
| 0 | 0 | No Protocol |
| 0 | 1 | RTS/CTS |

## EOS

| Bit 6 | Bit 5 | Bit 4 | |
|---|---|---|---|
| 0 | 0 | 0 | <lf> |
| 0 | 0 | 1 | <cr> |
| 0 | 1 | 0 | <cr><lf> |
| 0 | 1 | 1 | Terminal |

## Baud

| Bit 3 | Bit 2 | Bit 1 | |
|---|---|---|---|
| 0 | 0 | 0 | 1200 |
| 0 | 0 | 1 | 2400 |
| 0 | 1 | 0 | 4800 |
| 0 | 1 | 1 | 9600 |
| 1 | 0 | 0 | 19200 |
| 1 | 0 | 1 | 38400 |
| 1 | 1 | 0 | 57600 |
| 1 | 1 | 1 | 115200 |

## IEEE Address

Here you have to specify the IEEE address from 1 to 30.

# 11 Processing signal interface (option)

The processing signal interface has the following inputs and outputs:

- Four analogue outputs with ±10V. The outputs are updated with each measuring cycle for normal values or with the sampling rate for sample values. So this option can be used as a measuring converter. The four analogue outputs have one common ground (AOut_GND) which is isolated from all other grounds. The resolution is 16 bit.

- Four analogue inputs with ±10V. The inputs are sampled with 1kHz each for reading AC-values. An averaged value of this samples is displayed as DC value in the menus each measuring cycle. The four analogue inputs have one common ground (AIn_GND) which is isolated from all other grounds. The resolution is 16 bit. The (AC) values are stored in a 512kWord memory. They are synchronized to the normal inputs.

- Four digital outputs (open collector outputs). They are updated with each measuring cycle. The maximum load is 100mA at 30V. The four digital outputs have one common ground (DOut_GND)which is isolated from all other grounds.

- Four digital inputs. They are read with 1kHz each. The four digital inputs have one common ground (DIn_GND)which is isolated from all other grounds. They are also stored in a 512k value memory.

- Two frequency inputs. They can measure frequency and direction of a rotation speed converter. The maximum frequency is 5MHz. The inputs are CMOS compatible. The two frequency inputs have one common ground which is isolated from all other grounds but common to the ground of the auxiliary supply (Aux_F_GND). F_In0 is used to measure the frequency, F_In1 to detect the direction. They instantaneous values of the frequency signal are also stored in a 512k value memory with 1kHz sampling rate.

- One auxiliary supply. Here you can get an auxiliary voltage of ±5V. The ground is common with the ground of the frequency inputs (Aux_F_GND).

The connector has the following pinout:

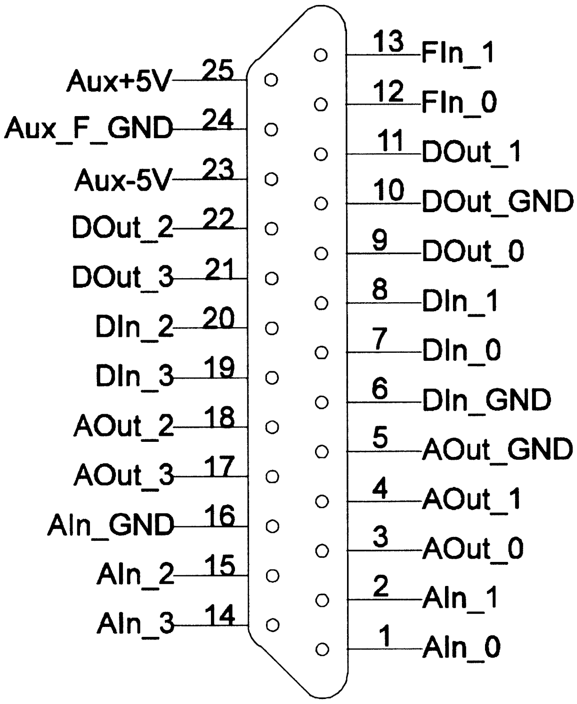


**Figure 35: Processing Signal Interface Connector**

For information how to setup this values see 4.4.2.2 Processing signal interface. The technical specifications you find in 14.9, 'Processing signal interface'.

# 12 Storage of values to memory card and printer

All menues you see can be stored to a memory card 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 freezed the display you get the freezed values. If you are in a periodic mode then you get the actual values, also if you have freezed the display.

## 12.1 Configuration

The configuration is done in the *Options* menu. Here you can define, how often the values are stored and on which device.

## 12.2 Handling

To store the values select the menu you want to store and press *Print.* A window appears which shows the actual storing state. An active printing or logging is indicated by a working printer symbol. In this case *ENTER* stops the actual job. If no job is active *ENTER* starts a new job which will output the actual display. With *ESC* you leave the menu without any changes.

With **Form** you determ the format of the data. Following settings are possible:

ASCII — The data are output as text without any special characters.

GRAPHIC — The data are formated according to the selected printer driver. They will contain special characters and control sequences for that printer.

Bitmap — The data are formated so that the ZES tool BMP2PC.EXE can read them. So you can transfer a copy of any screen to the PC.

Table — The data are formated according to the ZES data format.

Binary — The data are formated according to the ZES data format.

### Printer

If the output device is the printer, you have two softkeys for special purposes: with **formf** you eject the paper prom the printer. With **linef** you get a single line feed. This is only possible if no job is active.

### Memory Card

If the output device is the memory card, you have several softkeys for special purposes. Some are only active, if no job is running.

**File** Defines the filename for logging. 8 characters are valid. The filename is automatically extended with a '.100' for the first file to be logged with that name, '.101' for the second one and so on.

**Dir** You see the directory informations in the logging window. With the rotary knob you can scroll through the list of files and for example mark one with **Mark***.

**Del*** Deletes the marked files.

**Mark*** Marks or unmarks the actual selected file.

**State** Displays several informations about the memory card (e.g. battery state, ...)

**Erase** Formats the memory card. **Caution!** This formating will destroy all data on the card!

## 12.3 Data formats

The formats 'Table' and 'Binary' are very similar. It is a unique format for different kinds of data (measuring values, sampling values, ...). The data file contains always some lines in ASCII format which descripe the structure and contents of the file. Each line ends with <CR><LF>.

The following commands can be found in a file:

DATA_ASCII= After the <CR><LF> closing this line, the ASCII data follow. Data from the same time are seperated with one or more spaces, data from different times are seperated with <CR><LF>. The valid data are stored in floating point format until end of file (EOF). Empty columns have <>, invalid values are represented by '--------'. The time in the first column is relative to the start time X= (see down).

DATA_BINARY= After the <CR><LF> closing this line, the pseudo binary data follow (a nibble of a byte is represented by its ASCII value. eg. the byte <3Fh> is represented by the bytes <33h><46h>. The data are valid until end of file (EOF).

DATE=dd.mm.yy Date when logging started.

| | |
|---|---|
| DX=sec | sec is the time between two loggings in seconds. This information is used with binary data to get the time between two sample values. DX is ignored when XN is set. |
| FREQ= | Frequency of the signal when storing sample values. |
| REMark | Is the start of a comment. All characters including the closing YSEP belong to this comment. |
| TYPE= | Specifies the type of stored values:<br>NORMAL VALUES<br>HARMONIC VALUES<br>NORMAL SAMPLES |
| VAL_LEN=8 | Defines how much bytes are used to define one value. |
| X0=hh.mm.ss | The time when logging started. Defaultvalue is 00.00.00 |
| XN=Ynr | This shows, that you find the time in column nr. The default value for nr is 1. This command effects only data in ASCII format. |
| YCOLnr=Value/Unit | This command descipes the data in the column nr in ASCII format. Value is identical to the normal screen display, unit is the physical dimension. In empty columns after the '=' <CR><LF> follows |
| YFACT=factor | Binary stored data (16 bit signed integer) are just the sampling values of the LMG95. To get the real values you have to multiply them with factor (default = 1.0). |

# 13 Miscellaneous

## 13.1 Calibration

It is recommended that the calibration of the Precision Power Meter LMG95 will be performed with the manufacturer ZES ZIMMER. ZES ZIMMER has the necessary reference instruments traceable to national standards of the PTB (Physikalisch Technische Bundesanstalt in Braunschweig) according to ISO9000.

Especially, if a new adjustment is necessary or wanted by the customer, the instrument has to be sent back to the manufacturer for this purpose.
The adjustment is totally done by software, but this software runs only in combination with the special calibration means of the manufacturer.

### 13.1.1 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 LMG95. An optimal value is from 5 to 10 times better.

## 13.2 Zero adjustment of the instrument

The DC components of the LMG95 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. Now short circuit the voltage input and the external shunt input. Short circuit means, not to connect the inputs with any wire but to connect the as short as possible to get a minimized loop area!

Warm the instrument up for a minimum of 2h.

Now press **Z-Adj** in the *Range* menu (see 5.2 Measuring ranges (Range)).

Answer the warning with *Enter* if you have setup the instrument correctly. After about 1 minute the instrument is adjusted and a meassage appears.

Never switch the instrument off while adjusting because the adjustment might be corrupted and the instrument might measure wrong!

If you are in doubt about any detail of this adjustment please contact the manufacturer.

If the instrument is switched off and on, the default values from last factory adjustment are used.

## 13.3 Frequent asked questions

### 13.3.1 Accuracy of measured and computed values

The accuracy of the directly measured values I, U and P can be found in the tables in 14.4.3 '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):

$$\Delta U = \pm(0.01\%\ of\ Rdg. + 0.02\%\ of\ Rng.) = \pm(0.023V + 0.08V) = \pm 0.103V$$

$$\Delta I = \pm(0.01\%\ of\ Rdg. + 0.02\%\ of\ Rng.) = \pm(0.095mA + 0.75mA) = \pm 0.845mA$$

$$\Delta P = \pm(0.015\%\ of\ Rdg. + 0.02\%\ of\ Rng.) = \pm(8.194mW + 300mW) = \pm 308.2mW$$

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:

$$\Delta\lambda = \frac{\partial\lambda}{\partial P} * \Delta P + \frac{\partial\lambda}{\partial U} * \Delta U + \frac{\partial\lambda}{\partial I} * \Delta I$$

$$\Delta\lambda = \frac{\Delta P}{U * I} - \frac{P * \Delta U}{I * U^2} - \frac{P * \Delta I}{I^2 * U}$$

$$\Delta\lambda = \frac{308.2mW}{230V * 0.95A} + \frac{54.625W * 0.103V}{0.95A * (230V)^2} + \frac{54.625W * 0.845mA}{(0.95A)^2 * 230V}$$

$$\Delta\lambda = 0.0017$$

This is the absolute maximum error (worst case) that can occur in the calculation of the power factor. The typical error ist two to five times better!

The relative measuring errors are:

$$U\,\%_{measure} = \frac{\Delta U}{U} = 0.045\%$$

$$I\,\%_{measure} = \frac{\Delta I}{I} = 0.089\%$$

$$P\,\%_{measure} = \frac{\Delta P}{P} = 0.564\%$$

$$\lambda\,\%_{measure} = \frac{\Delta \lambda}{\lambda} = 0.68\%$$

To get the real error, the inaccuracy of display (1 digit) has to be taken into account:

$$U\,\%_{display} = \frac{0.001V}{230.0V} = 0.0004\%$$

$$I\,\%_{display} = \frac{0.00001A}{0.95A} = 0.001\%$$

$$P\,\%_{display} = \frac{0.001W}{54.625W} = 0.002\%$$

$$\lambda\,\%_{display} = \frac{0.00001}{0.25} = 0.004\%$$

This results in the following measuring values:

$U_{trms}$ = (230.000 ± 0.103)V
$I_{trms}$ = (0.95000 ± 0.00085)A
P = (54.625 ± 0.308)W
λ = 0.25000 ± 0.00170

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 $\Delta I_{DC}=\pm(10\mu V/Ri)=\pm(10\mu V/5m\Omega)=\pm 2mA$. 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:

$$\Delta I_{trms} = \pm\left(\frac{0.95A}{0.95A} * 0.845mA + \frac{1.12mA}{0.95A} * 2mA\right) = \pm 0.847mA$$

For the active power you have an additional error of $\pm(10\mu V^2/Ri/V_{DC})$= $\pm(10\mu V^2/5m\Omega/V_{DC})$=$\pm$2mW/$V_{dc}$. So with a reading of $U_{DC}$=0.013V you get a total error of

$$\Delta P_{tot} = \pm\left(\Delta P + 2\frac{mW}{V} * U_{DC}\right) = \pm\left(308.2mW + 2\frac{mW}{V} * 13mV\right) = \pm 308.226mW$$

For the appearent power you get:

$$\Delta S = \pm\left(\frac{\partial S}{\partial U} * \Delta U + \frac{\partial S}{\partial I} * \Delta I\right)$$

$$\Delta S = \pm(I * \Delta U + U * \Delta I) = \pm(0.95A * 0.103V + 230V * 0.847mA) = \pm 292.66mW$$

Please note that in this case you have to use $\Delta I_{trms}$ for $\Delta I$!

### 13.4 Function fault

If you think you have found an error or function fault in a LMG95 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 freezed values.

## Function fault at a LMG95

To:

Z E S ZIMMER Electronic Systems GmbH
Tabaksmühlenweg 30
61440 Oberursel
Germany
Tel. ++49 (0)6171 / 628750
Fax ++49 (0)6171 / 52086

From:
Name: ______________________
Company: ______________________
Street: ______________________
City: ______________________
Country: ______________________
Tel: ______________________
Fax: ______________________

Information about the instrument:

Type Plate:

Serial number: ____________ Supply Voltage: ____________

IF/IO Menu (Option on older instruments): List detail

Program Version: ____________

Interface: ____________ Harmonic 100: ____________
Process Signal: ____________ Transient: ____________
Flicker: ____________ extended memory: ____________

mod. channel U: ____________ mod. channel I: ____________
400kHz: ____________ 400kHz: ____________
mod. range ____________ mod. range ____________

Exact error description:

Range menu

| | | | |
|---|---|---|---|
| U range: | ________V | I range: | ________A |
| U range: | auto/manuell | I range: | auto/manuell |
| U scale: | ________ | I scale: | ________ |
| | | Shunt: | intern/extern |

Measuring menu

| | |
|---|---|
| Filter: | ________ |
| Couple: | ________ |
| Trig: | ________ |
| Sync: | ________ |
| Cycle: | ________ |
| Aver: | ________ |

| Voltage menu | | Current menu | | Power menu | |
|---|---|---|---|---|---|
| Utrms: | ________ | Itrms: | ________ | P: | ________ |
| Uac: | ________ | Iac: | ________ | Q: | ________ |
| Udc: | ________ | Idc: | ________ | S: | ________ |
| Upp: | ________ | Ipp: | ________ | PF: | ________ |
| Urect: | ________ | Irect: | ________ | f: | ________ |
| Ucf: | ________ | Icf: | ________ | | |
| Uff: | ________ | Iff: | ________ | | |

If you have the interface option you can directly print out this menus.

## 13.5 Software update

The software of the LMG95 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 the Service jack of the LMG95. It has to be a 1:1 cable without any crossings or null modem functions, where all wires are connected (see 13.5.1 'Service connector').

For further information read the readme file delivered with the software.

### 13.5.1 Service connector

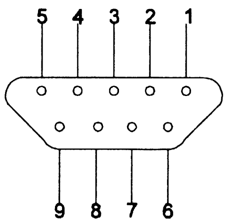


**Figure 36: Service connector**

| Pin | Comment |
|---|---|
| 1 | nc |
| 2 | TxD (RS232) |
| 3 | RxD (RS232) |
| 4 | nc |
| 5 | GND (RS232) |
| 6 | nc |
| 7 | CTS (RS232) |
| 8 | RTS (RS232) |
| 9 | nc |

# 14 Technical data

## 14.1 General

| | |
|---|---|
| Display: | Monochrome display,<br>resolution 256x128 Pixel |
| Weight: | 6.5kg |
| Mains supply: | 90...250V, 45...65Hz, ca. 30W, Fuse 5x20mm T1A/250V IEC127-2/3 |
| Storage temperature: | -20°C to +55°C |
| Climatic class: | KYG according to DIN 40040<br>0°C...40°C, humidity max. 85%, annual average 65%, no dewing |
| Protection method: | IP20 according DIN40050 |
| Protection class: | I<br>Mains supply:<br>Overvoltage class II and pollution degree 2 according IEC61010-1<br>Measuring inputs:<br>Overvoltage class III and pollution degree 2 according IEC61010-1<br>**Please note!**<br>If you have another overvoltage class, the allowed voltages might change (see 14.2, 'Operating voltages') |
| EMC: | EN55011, EN50082 |
| Safety: | EN61010 |
| Dimensions: | Desktop: 320mm (W) x 148mm (H) x 275mm (D)<br>19" rack: 63TU x 3HU x 315mm |

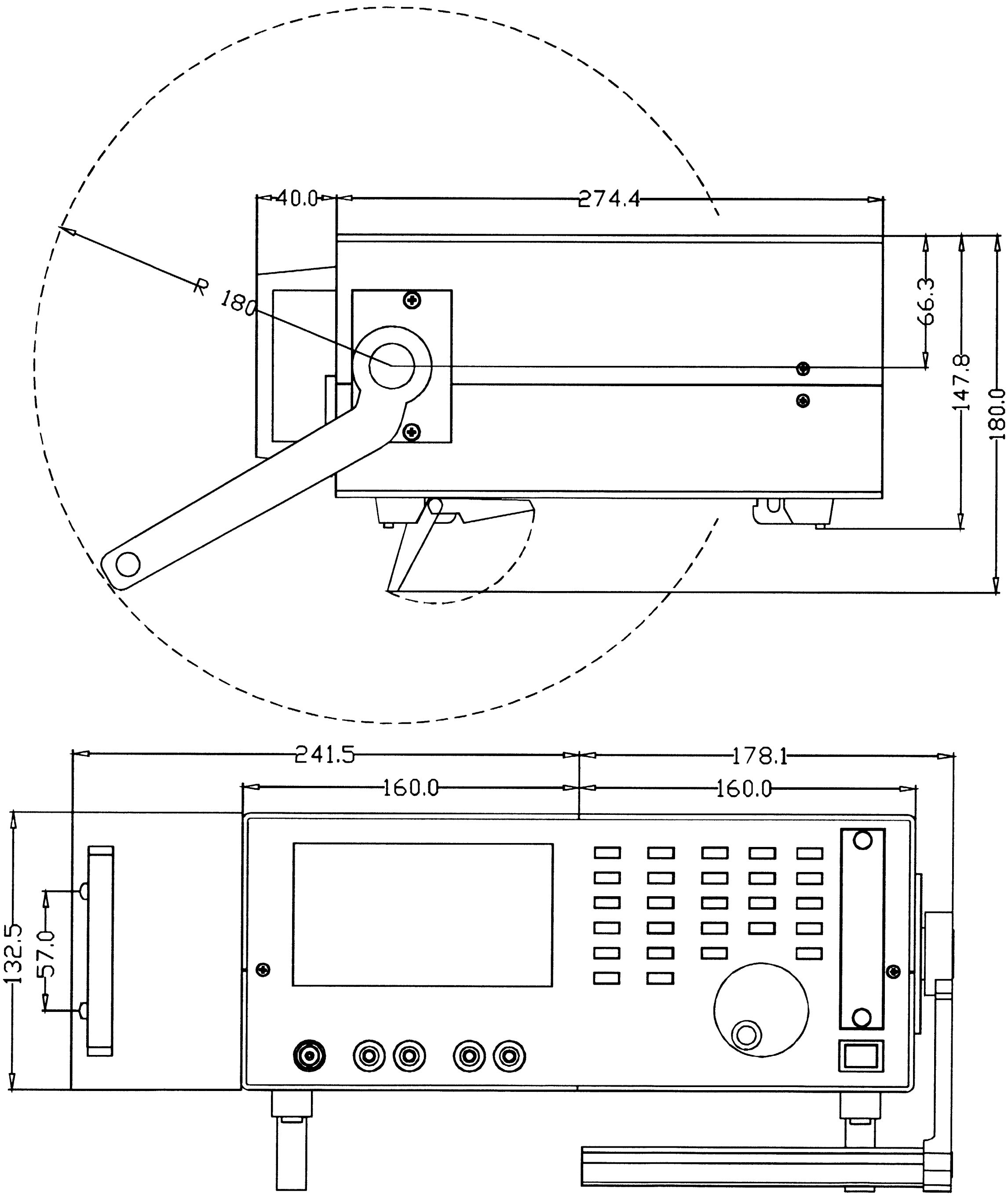


**Figure 37: Dimensions**

In the above picture you see the desktop instrument in combination with the rack mounting kit and the handle bar.

## 14.2 Operating voltages

The allowed operating voltage of the signals at the measuring inputs depends on the overvoltage category of the signals:

CAT II: Instruments with BNC connector:
Current inputs: 1000V
Voltage inputs: 1500V
Instruments without BNC connector:
Current inputs: 1500V
Voltage inputs: 1500V

CAT III: Instruments with BNC connector:
Current inputs: 600V
Voltage inputs: 1000V
Instruments without BNC connector:
Current inputs: 1000V
Voltage inputs: 1000V

## 14.3 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 0.75% of the measurable TRMS value of the range, all channel values are displayed as 0.0. For example in the 0.15A current range you get values from 0.000; 2.250mA...469.000mA.

## 14.4 Standard measuring channel

### 14.4.1 Sampling

The sampling is done synchronously at all channels with about 100kHz per channel.

### 14.4.2 Ranges

#### Voltage ranges

| Rated range value / V | 6 | 12.5 | 25 | 60 | 130 | 250 | 400 | 600 |
|---|---|---|---|---|---|---|---|---|
| Measurable TRMS value / V | 7.2 | 14.4 | 30 | 60 | 130 | 270 | 560 | 720 |
| Permissible peak value / V | 12.5 | 25 | 50 | 100 | 200 | 400 | 800 | 1600 |

Overload capability 600V continuously, 1500V for 1s
Input resistance 1MΩ, 23pF
Capacitance against earth 45pF
Common mode rejection >140dB (measured with 100V at 100kHz)

⚠ **Note!**
The 'Measurable TRMS value' is the biggest TRMS value which can be measured with the full accuracy. That does not mean that it is allowd to measure with that value, if any

security standards define other values!

### Current ranges

| Rated range value / A | 0.15 | 0.3 | 0.6 | 1.2 | 2.5 | 5 | 10 | 20 | 120 | 240 | 480 | 960 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Measurable TRMS value / A | 0.3 | 0.6 | 1.3 | 2.6 | 5.2 | 10 | 21 | 21 | 21 | 21 | 21 | 21 |
| Permissible peak value / A | 0.469 | 0.938 | 1.875 | 3.75 | 7.5 | 15 | 30 | 60 | 120 | 240 | 480 | 960 |

Overload capability 24A continuously, 160A for 1s

Input resistance Ri 5mΩ

Capacitance against earth 51pF

Common mode rejection >150dB (measured with 100V at 100kHz)

Capacitance between U and I 5pF

Channel seperation >140dB (measured with 100V at 100kHz)

### Voltage inputs for current measuring with shunt / transducer

| Rated range value / V | 0.03 | 0.06 | 0.12 | 0.25 | 0.5 | 1 | 2 | 4 |
|---|---|---|---|---|---|---|---|---|
| Measurable TRMS value / V | 0.06 | 0.13 | 0.27 | 0.54 | 1 | 2 | 4 | 8 |
| Permissible peak value / V | 0.0977 | 0.1953 | 0.3906 | 0.7813 | 1.563 | 3.125 | 6.25 | 12.5 |

Overload capability 100V continuously, 250V for 1s

Input resistance 100kΩ, 28pF

Common mode rejection >134dB (measured with 100V at 100kHz)

## 14.4.3 Accuracy

### Measuring accuracy

The values are in ±(% of measuring value + % of measuring range)

| Frequency/Hz | DC | 0.05-15 | 15-45, 65-1k | 45-65 | 1k-3k | 3k-15k | 15k-50k |
|---|---|---|---|---|---|---|---|
| Voltage | 0.02+0.06 | 0.02+0.03 | 0.015+0.03 | 0.01+0.02 | 0.03...0.06 | 0.1+0.2 | 0.5+1.0 |
| Current | 0.02+0.07 | 0.02+0.03 | 0.015+0.03 | 0.01+0.02 | 0.03...0.06 | 0.1+0.2 | 0.5+1.0 |
| Active Power | 0.03+0.07 | 0.035+0.03 | 0.025+0.03 | 0.015+0.02 | 0.05...0.06 | 0.2+0.2 | 1.0+1.0 |

Accuracies based on:

1. sinusoidal voltages and currents
2. ambient temperature 23°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, $0 \leq |\lambda| \leq 1$
5. Voltage and current are ≥ 10% of range
6. calibration interval 1 year

Temperature effect: 0.01% of measuring value / K

### Influence of coupling mode

Coupling AC: No influence

Coupling AC+DC, DC: Current: additional DC current of up to ±(10μV/Ri)
Active Power: additional DC error of $\pm(10\mu V^2/Ri/V_{DC})$
Ri is the input resistance of the current channel. This influence has to be taken into calculation, if you use the direct current input of a current channel!

An example, how to handle this values, you find in 13.3.1, 'Accuracy of measured and computed values'

## 14.5 400kHz version (option)

### 14.5.1 Accuracy

### Measuring accuracy

The values are in ±(% of measuring value + % of measuring range)

| Frequency/Hz | DC | 0.05-15 | 15-45, 65-1k | 45-65 | 1k-3k | 3k-15k | 15k-100k | 100k-200k | 200k-300k | 300k-400k |
|---|---|---|---|---|---|---|---|---|---|---|
| Voltage | 0.02+0.06 | 0.02+0.03 | 0.015+0.03 | 0.01+0.02 | 0.025...0.05 | 0.03+0.06 | 0.1+0.2 | 0.5+1.0 | 1.0+2.0 | 3.0+3.0 |
| Current | 0.02+0.07 | 0.02+0.03 | 0.015+0.03 | 0.01+0.02 | 0.025...0.05 | 0.03+0.06 | 0.1+0.2 | 0.5+1.0 | 1.0+2.0 | 3.0+3.0 |
| Active Power | 0.03+0.07 | 0.035+0.03 | 0.025+0.03 | 0.015+0.02 | 0.04...0.05 | 0.05+0.06 | 0.2+0.2 | 1.0+1.0 | 2.0+2.0 | 6.0+3.0 |

Accuracies based on:

1. sinusoidal voltages and currents
2. ambient temperature 23°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, $0 \leq |\lambda| \leq 1$
5. Voltage and current are ≥ 10% of range
6. calibration interval 1 year

Temperature effect: 0.01% of measuring value / K

### Influence of coupling mode

Coupling AC: No influence

Coupling AC+DC, DC: Current: additional DC current of up to ±(10µV/Ri)
Active Power: additional DC error of ±($10\mu V^2/Ri/V_{DC}$)
Ri is the input resistance of the current channel. This influence has to be taken into calculation, if you use the direct current input of a current channel!

An example, how to handle this values, you find in 13.3.1, 'Accuracy of measured and computed values'

## 14.6 Special modified channels

### 14.6.1 200mV Channel

Instead of the standard 600V voltage channel we can implement this channel with following technical data:

| Rated range value / mV | 1.5 | 3 | 6 | 12 | 25 | 50 | 100 | 200 |
|---|---|---|---|---|---|---|---|---|
| Measurable TRMS value / mV | 1.8 | 3.6 | 7.2 | 14.4 | 30 | 60 | 120 | 240 |
| Permissible peak value / mV | 3 | 6 | 12 | 24 | 49 | 98 | 195 | 391 |

Overload capability 30V continuously, 80V for 1s
Input resistance 10kΩ, 200pF

### 14.6.2 3V Channel

Instead of the standard 600V voltage channel we can implement this channel with following technical data:

| Rated range value / V | 0.025 | 0.05 | 0.1 | 0.2 | 0.4 | 0.8 | 1.5 | 3 |
|---|---|---|---|---|---|---|---|---|
| Measurable TRMS value / V | 0.03 | 0.06 | 0.12 | 0.24 | 0.48 | 0.96 | 1.8 | 3.6 |
| Permissible peak value / V | 0.049 | 0.098 | 0.195 | 0.391 | 0.781 | 1.563 | 3.125 | 6.25 |

Overload capability 100V continuously, 250V for 1s
Input resistance 100kΩ, 70pF

### 14.6.3 12V Channel

Instead of the standard 600V voltage channel we can implement this channel with following technical data:

| Rated range value / V | 0.1 | 0.2 | 0.4 | 0.8 | 1.5 | 3 | 6 | 12 |
|---|---|---|---|---|---|---|---|---|
| Measurable TRMS value / V | 0.16 | 0.33 | 0.67 | 1.33 | 2.5 | 5 | 10 | 20 |
| Permissible peak value / V | 0.24 | 0.47 | 0.94 | 1.88 | 3.75 | 7.5 | 15 | 30 |

Overload capability 100V continuously, 250V for 1s
Input resistance 100kΩ, 70pF

### 14.6.4 60V Channel

Instead of the standard 600V voltage channel we can implement this channel with following technical data:

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Rated range value / V | 0.4 | 0.8 | 1.5 | 3 | 6 | 12 | 25 | 60 |
| Measurable TRMS value / V | 0.48 | 0.96 | 1.8 | 3.6 | 7.2 | 14.4 | 30 | 60 |
| Permissible peak value / V | 0.781 | 1.563 | 3.125 | 6.25 | 12.5 | 25 | 50 | 100 |

Overload capability 250V continuously, 600V for 1s

Input resistance 330kΩ, 40pF

### 14.6.5 80mA Channel

Instead of the standard 960A current channel we can implement this channel with following technical data:

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rated range value / mA | 0.6 | 1.2 | 2.5 | 5 | 10 | 20 | 40 | 80 | 500 | 1000 | 2000 | 4000 |
| Measurable TRMS value / mA | 1.2 | 2.4 | 5 | 10 | 20 | 40 | 80 | 160 | 320 | 640 | 800 | 800 |
| Permissible peak value / mA | 2 | 4 | 8 | 16 | 32 | 65 | 130 | 250 | 500 | 1000 | 2000 | 4000 |

Overload capability 0.8A continuously, 2A for 1s

Input resistance Ri 0.5Ω

### 14.6.6 1.2A Channel

Instead of the standard 960A current channel we can implement this channel with following technical data:

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rated range value / A | 0.01 | 0.02 | 0.04 | 0.08 | 0.15 | 0.3 | 0.6 | 1.2 | 7.5 | 15 | 30 | 60 |
| Measurable TRMS value / A | 0.02 | 0.04 | 0.08 | 0.16 | 0.3 | 0.6 | 1.3 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 |
| Permissible peak value / A | 0.0293 | 0.0585 | 0.1171 | 0.2343 | 0.469 | 0.938 | 1.875 | 3.75 | 7.5 | 15 | 30 | 60 |

Overload capability 2A continuously, 5A for 1s

Input resistance Ri 0.1Ω

### 14.6.7 5A Channel

Instead of the standard 960A current channel we can implement this channel with following technical data:

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rated range value / A | 0.04 | 0.08 | 0.15 | 0.3 | 0.6 | 1.2 | 2.5 | 5 | 30 | 60 | 120 | 240 |
| Measurable TRMS value / A | 0.08 | 0.16 | 0.3 | 0.6 | 1.3 | 2.6 | 5 | 6 | 6 | 6 | 6 | 6 |
| Permissible peak value / A | 0.1171 | 0.2343 | 0.469 | 0.938 | 1.875 | 3.75 | 7.5 | 15 | 30 | 60 | 120 | 240 |

Overload capability 6A continuously, 15A for 1s

Input resistance Ri 20mΩ

## 14.7 Filter

### 14.7.1 Anti-Aliasing-Filter (AAF)

The analogue anti-aliasing 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 |

## 14.8 CE Harmonics

| | |
|---|---|
| Relative deviation between $f_1$ and frequency $f_{syn}$, to which the sampling rate is synchronized | < 0.015% of $f_1$ under steady-state conditions. |
| Attenuation of anti aliasing filter | >50dB |
| Amplitude error | The error of each harmonic is equal to the error the harmonic would have, if it is the only signal. This is valid, if the amplitude of the harmonic is > 0.1% of range peak value |
| Phase error | 0.15°+0.25°/kHz, if the amplitude of the harmonic is > 0.1% of range peak value |

**Please note**

The influence of the anti aliasing filter is compensated for the amplitudes of the harmonics. The values for U, I and P are not recalculated from the harmonics, but are calculated from the sampling values to get for example interharmonics. So it is not possible to compensate the influence of the filters for this values!

## 14.9 Processing signal interface

### 14.9.1 Analogue inputs

Sampling frequency: 1kHz

Resolution: 16Bit

Accuracy: ±(0.05% of measuring value + 0.05% of full scale)

Input signal: ±12V

Overload capability: -15...+25V

Input resistance: 100kΩ

Sample memory: 512kWord

### 14.9.2 Analogue outputs

Update rate: 100kHz

Resolution: 16Bit

Accuracy: ±(0.05% of measuring value + 0.05% of full scale)

Output signal: ±11V

Output load: load resistance > 2kΩ

### 14.9.3 Digital inputs

Sampling frequency: 1kHz

Input signal: $U_{low}$max=1V, $U_{high}$min=4V@2mA, $U_{high}$max=60V@3mA

Sample memory: 512k values

### 14.9.4 Frequency inputs

Input signal: $U_{low}$max=1V, $U_{high}$min=4V, $U_{high}$max=10V

Input resistance: 1MΩ

Maximum frequency: 5MHz

### 14.9.5 Digital outputs

Open collector outputs.

Output high impedance: max 30V@100µA

Output low impedance: max. 1.5V@100mA

### 14.9.6 Auxiliary supply

Output voltage: ±5V, 10% @ 50mA

## 14.10 Auxiliary transducer supply

This output delivers two voltages:

+15V, ±10%, $I_{max}$=0.4A

-15V, ±10%, $I_{max}$=0.2A

With a special cable you can directly supply a PSU600 current transducer. Do not use a 1:1 cable!

# 15 System design

## 15.1 Further connectors

### 15.1.1 External Synchronisation (Sync.)

The sync connector has the following features:

- You can use it for the external synchronisation of the LMG95. For this purpose you can use the pins 1 and 2.
- You can use it for controlling and sensing the energy measurement. For this purpose you can use the pins 6, 7 and 9.

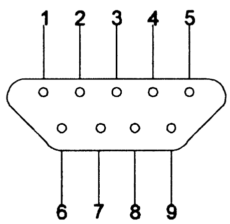


**Figure 38: Sync. connector**

| Pin | Usage |
|---|---|
| 1 | Ground for external sync |
| 2 | +5V signaling input for external sync |
| 6 | Ground for Control |
| 7 | Control Out |
| 9 | Control In |

The external sync is a 5V input which is used to synchronize the LMG95 to the signal. For this purpose the LMG95 uses the rising edge of this signal to simulate a positive zero crossing and the falling edge to simulate a negative zero crossing. The signal has to drive a LED with a series resistor of 1.5kΩ.

The 'Control In' is a 5V input which is used to control the energy measuring of the LMG95. The falling edge simulates a pressing of the *Start* button, the rising edge simulates a pressing of the *Stop* button (see 5.4.5.1 Integral menu). The signal has to drive a LED with a series resistor of 1.5kΩ.

The 'Control Out' is an open collector output. It is in the low impedance state while the LMG95 is integrating. Without integrating the output has high impedance.

### 15.1.2 Auxiliary transducer supply

With this jack you can supply external current sensors (e.g. PSU600).

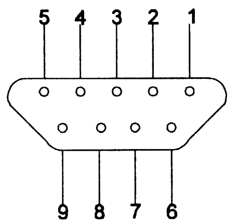


**Figure 39: Supply of external current sensors**

| Pin | Usage |
|---|---|
| 1, 2, 6 | -15V |
| 3, 7, 8 | GND |
| 4, 5, 9 | +15V |

You find the exact technical specification in chapter 14.10, 'Auxiliary transducer supply'.

## 15.2 Functional block diagram LMG95

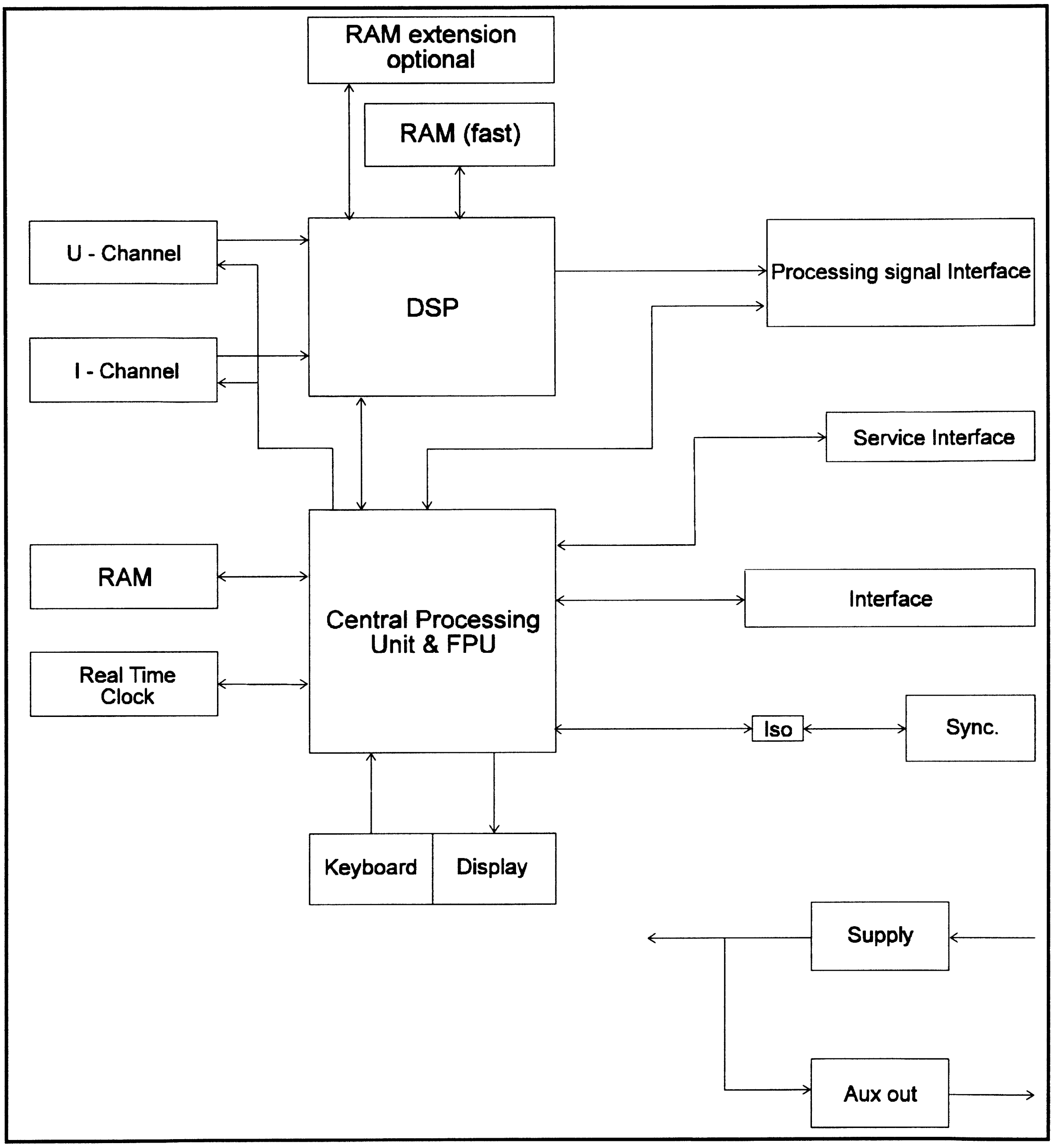


**Figure 40: Functional block diagram LMG95**

## 15.3 Functional block diagram voltage channel

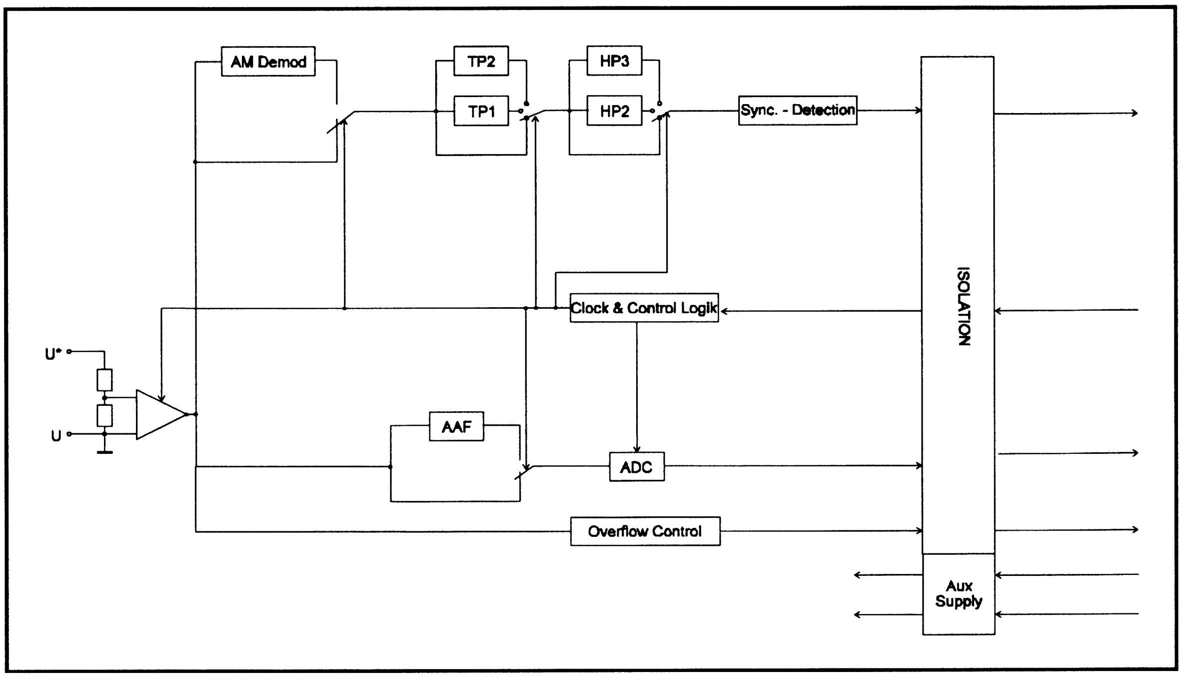


**Figure 41: Functional block diagram voltage channel**

## 15.4 Functional block diagram current channel

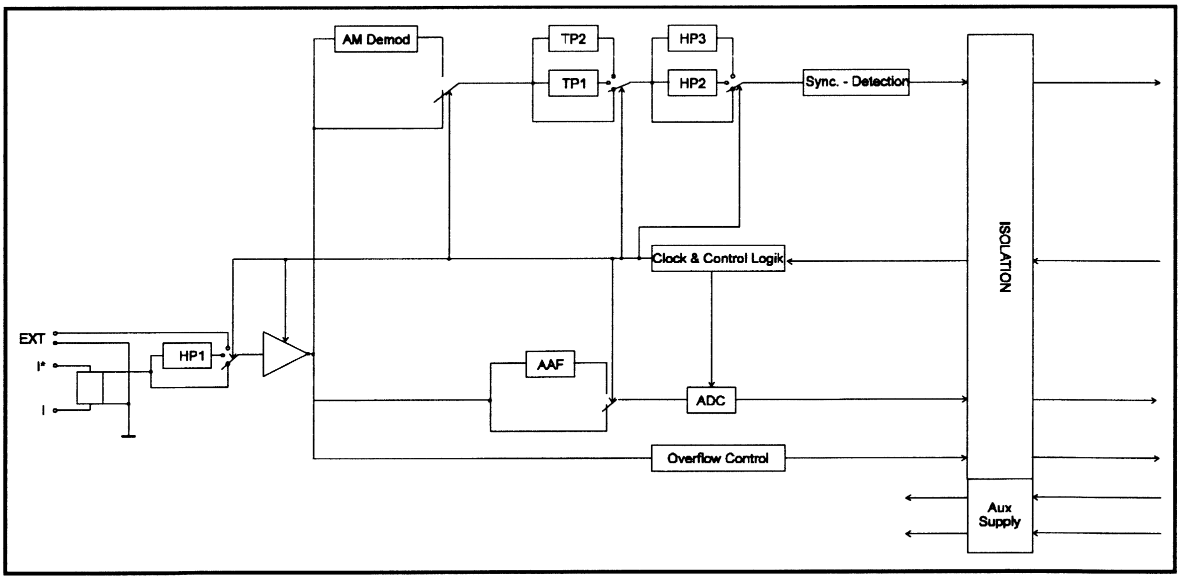


**Figure 42: Functional block diagram current channel**

## 15.5 Functional block diagram computing unit

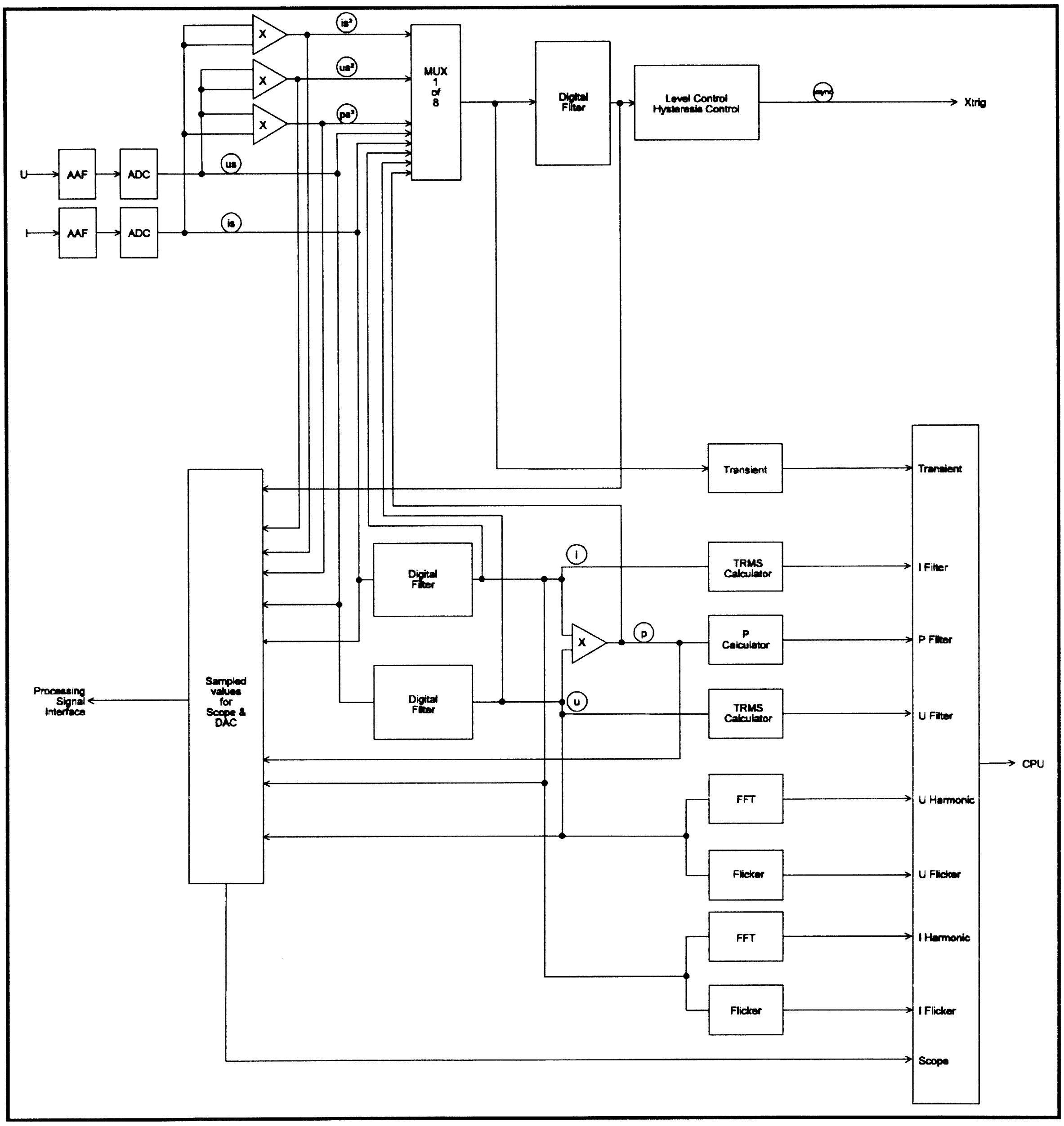


**Figure 43: Functional block diagram computing unit**

The labels in the circles define the signals you can select in different menus, for example extended trigger, scope, ...

## 15.6 Functional block diagram computer interface

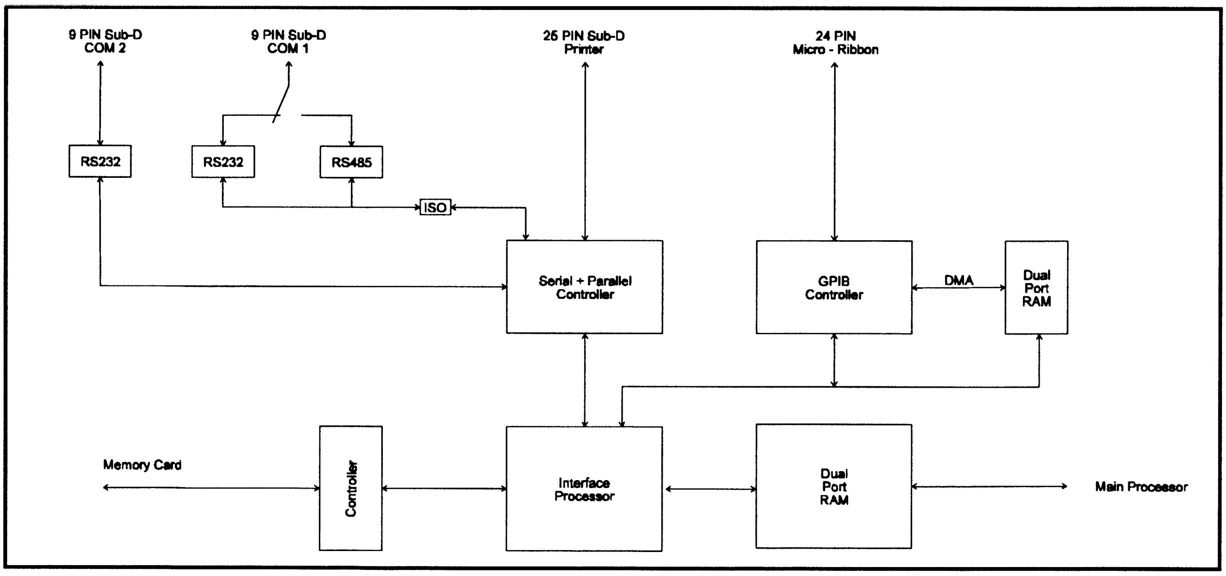


**Figure 44: Functional block diagram computer interface**

## 15.7 Functional block diagram processing signal interface

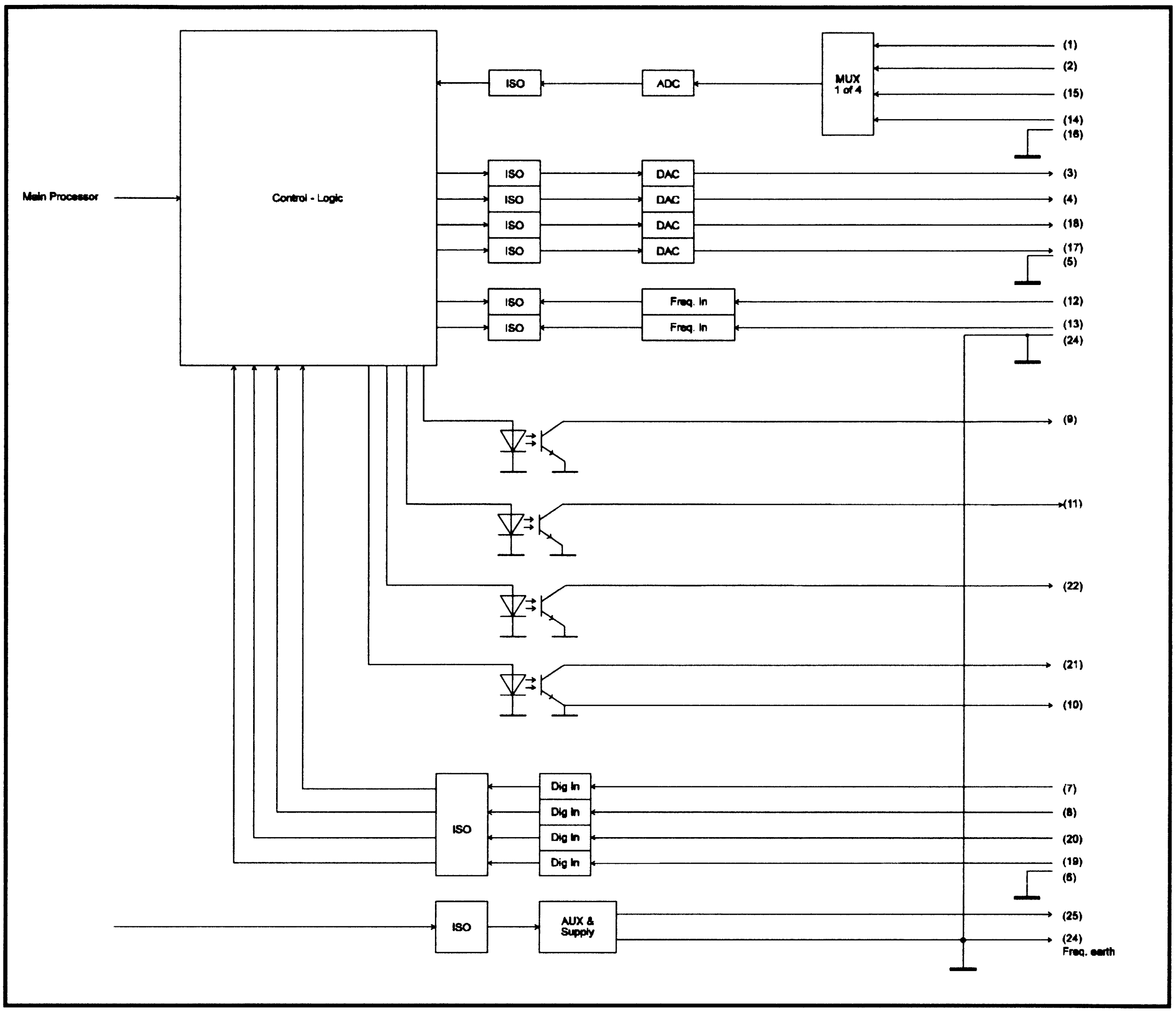


**Figure 45: Functional block diagram processing signal interface**

# 16 Index

# 17 Interface command index

## *



## :

## *H*



## *I*

## R



## S