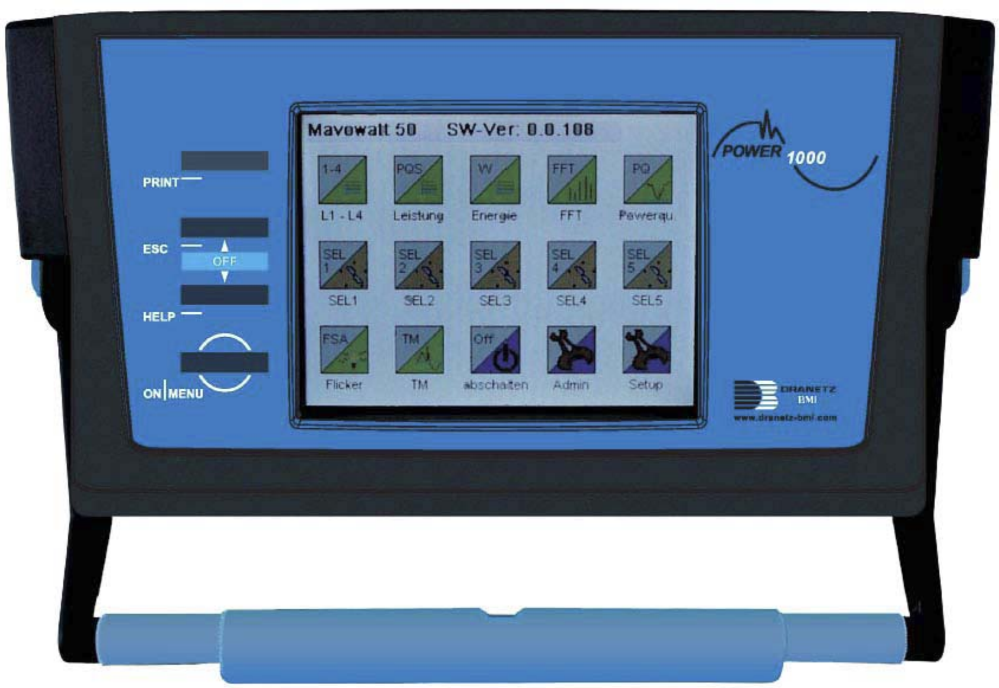
# POWER1000
## Power Analyzer

3-349-343-03
1/06.08



## WARNING

Death, serious injury, or fire hazard could result from improper connection of this instrument. Read and understand this manual before connecting this instrument. Follow all installation and operating instructions while using this instrument.

Connection of this instrument must be performed in compliance with the National Electrical Code (ANSI/ NFPA 70-2005) of USA and any additional safety requirements applicable to your installation.

Installation, operation, and maintenance of this instrument must be performed by qualified personnel only. The National Electrical Code defines a qualified person as “one who has the skills and knowledge related to the construction and operation of the electrical equipment and installations, and who has received safety training on the hazards involved.”
Qualified personnel who work on or near exposed energized electrical conductors must follow applicable safety related work practices and procedures including appropriate personal protective equipment in compliance with the Standard for Electrical Safety Requirements for Employee Workplaces (ANSI/NFPA 70E-2004) of USA and any additional workplace safety requirements applicable to your installation.

### ADVERTENCIA

Una conexión incorrecta de este instrumento puede producir la muerte, lesiones graves y riesgo de incendio. Lea y entienda este manual antes de conectar. Observe todas las instrucciones de instalación y operación durante el uso de este instrumento.
La conexión de este instrumento a un sistema eléctrico se debe realizar en conformidad con el Código Eléctrico Nacional (ANSI/NFPA 70-2005) de los E.E.U.U., además de cualquier otra norma de seguridad correspondiente a su establecimiento.
La instalación, operación y mantenimiento de este instrumento debe ser realizada por personal calificado solamente.
El Código Eléctrico Nacional define a una persona calificada como "una que esté familiarizada con la construcción y operación del equipo y con los riesgos involucrados."
El personal cualificado que trabaja encendido o acerca a los conductores eléctricos energizados expuestos debe seguir prácticas y procedimientos relacionados seguridad aplicable del trabajo incluyendo el equipo protector personal apropiado en conformidad con el estándar para los requisitos de seguridad eléctricos para los lugares de trabajo del empleado (ANSI/NFPA 70E-2004) de los E.E.U.U. y cualquier requisito de seguridad adicional del lugar de trabajo aplicable a su instalación.

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**Appendix**

**The appendix is enclosed on the attached CD-ROM**

A Power and Energy Measurement ........................................125
B Harmonics and Interharmonics (FFT) ............................ 144
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I. Incoming Inspection

Immediately after receipt of the instrument and included accessories, unpack and inspect for completeness and any possible damage:

**Unpacking**

Other than the usual care required for the unpacking and handling of electronic instruments, no special precautions are necessary.

The transport packaging is made from recyclable material and provides for sufficient protection under normal transport conditions. Use equivalent material if the instrument needs to be repacked.

**Visual Inspection**

Compare the order number and type designation shown on the instrument and / or its packaging with those in the shipping documents.

Make sure that all accessories have been included (→ 1.4.1 included accessories

Inspect the packaging and the mechanical components of the instrument for transport damage.

**Complaints**

If damage has determined, a complaint should be filed immediately with the forwarding agent (save the packaging!). If other defects occur, or if repair of the instrument is required, please inform your local representative, or contact us directly at the address shown on the last page of these instructions.

## II. Safety Precautions

The POWER1000 Power Analyzer has been manufactured and tested as a protection class II instrument with function key (for EMC reasons) in accordance with safety regulations IEC/EN 61010-1/VDE 0411 T1. If used properly, the safety of the operator, as well as that of the instrument, is assured. However, safety cannot be guaranteed if the instrument is operated incorrectly or handled improperly.

In order to maintain orderly technical safety conditions and assure hazard-free operation, the user must observe all warnings and safety precautions which are included in these instructions. These have been identified with the following terminology and visual highlights:

**WARNING!**

Instructions, concerning instrument operation or application, which must absolutely be observed in order to assure safe operation of the instrument and to prevent bodily injury.

**ATTENTION!**

Instructions, concerning instrument operation or applications which must absolutely be observed in order to avoid damage to the instrument and to assure correct operation.

The most important general safety precautions are summarised below. Reference is made to these warnings at the corresponding points within the operating instructions.

**WARNING 1**

If connected to the mains, the instrument may only be operated when the protective conductor has been connected. Interruption of the protective conductor, either inside or outside of the instrument, may result in hazardous operating conditions. Intentional interruption is prohibited.

The instrument is connected to the mains by means of a
3 conductor power cable with an earthing contact plug. This plug may only be inserted into an appropriate outlet socket with an earthing contact. Do not disable the protective function through the use of an extension cable without protective conductor.

**WARNING 2**

The instrument may only be operated by personnel who are capable of recognising contact hazards and implementing appropriate safety precautions.

Contact hazards are present anywhere where voltages of greater than 50 V exist.

**WARNING 3**
Do not work alone when performing measurements which involve contact hazards. In such cases, a second person must always be present.

**WARNING 4**
It is absolutely essential that the measurement inputs are not overloaded beyond allowable capacities. The maximum allowable potential

- for the voltage and current inputs against ground and to each other is
  - in circuits of overvoltage category CAT III 1000 V
  - in circuits of overvoltage category CAT IV 600V
- for the digital inputs (at the rear inset 1 - 8) 48 V DC.
- The overload capacity of the measuring inputs can be taken from Technical Data, → chap. 8
- The maximum allowable potential for the auxiliary inputs / outputs (Aux. Supply) against ground is 48 V DC.

**WARNING 5**
No measurements may be performed within circuits with corona discharge (high-voltage).

**WARNING 6**
Special care must be taken when measurements are performed within HF circuits. Dangerous oscillating voltages may be present.

**WARNING 7**
It must be assumed that unexpected voltages may occur at devices under test (e.g. defective instruments). Capacitors, for example, may be dangerously charged.

**WARNING 8**
Measurements under damp ambient conditions are prohibited.

**WARNUNG 9**
The measurement leads must be kept in flawless conditions, e.g. no damage to insulation, no interruptions at cables and plugs etc.

**WARNING 10**

If it may be assumed that the instrument can no longer be safely operated, it must be removed from service and secured against unintentional use.

Safe operation can no longer be assumed:

- if the instrument shows visible damage
- if the instrument no longer functions
- After lengthy periods of storage under unfavourable conditions
- After exposure to unusual transport stresses

**WARNING 11**

As long as the instrument is connected, voltage conducting parts may be exposed if the instrument's cover panels are opened.

Maintenance and repair work, as well as internal device balancing, may only be performed by trained personnel who are familiar with the dangers involved.

In as far as is possible, the instrument must be disconnected from all external power sources before the performance of this type of work. A waiting period of 5 minutes must be observed after the instrument has been disconnected, in order to allow for the discharging of internal capacitors to a safe voltage level.

**WARNING 12**

Only designated fuse types with the indicated current ratings may be used for the replacement of blown fuses (see Technical Data and information printed on the instrument next to the fuse switch).

Tampering with fuses or the fuse holder ("repairing" fuses or short-circuiting the fuse holder etc.) is prohibited.

# 1 Technical Description

## 1.1 General

In this operating manual, description and device functions correspond to the firmware version at delivery ex works. Updates and expansions are subject to change without notice. Firmware updates and the corresponding revised operating manual are available as download via the internet (→ cap. 2.ff).

## 1.2 Use and Application

The 8-channel Power Analyzer has been designed for the measurement of electrical Quantities in DC systems, as well as single phase and three phase AC systems with balanced or unbalanced loads. The 40 kHz frequency (sample rate 100 kHz) covers measurements from 16.7 Hz rail frequency through 50/60Hz supply and 400Hz onboard networks up to 1 kHz. Eight isolated measuring circuits, four each for voltage and current, avoid from compensatory currents and provide for simultaneous measuring of phase and neutral voltages and currents. Alternatively the fourth channel can be used for measuring a further physical quantity when connected to a suitable transducer, such as temperature of transformers/motors or wind speed in wind turbine generator systems. A supplementary function makes the instrument suitable for measuring in frequency converter controlled circuits. Moreover acquisition of transients from 10µs and voltages up to 1300Vp can be performed.

Applications range from acquisition, display and recording of mains quantities through recording of energy consumption up to recognition, statistical calculation, analysis and presentation of voltage characteristics of electricity in accordance to EN 50160.

In the industrial field, the precise measuring instrument can be used for the determination of the characteristically quantities of electrical loads or generators, for static procedures as well as for dynamic procedures.

Thanks to its compact and rugged design, the
POWER1000 can be implemented as operable instrument, as well as for stationary applications. In case of auxiliary voltage drops the implemented accumulator takes over the supply of the instrument for several minutes.

## 1.3 Included Functions

**Configuring**

- Clear menu-driven user interface through colour LCD touch screen and four pushbuttons on the front panel.
- Remote control on the personal computer via Ethernet LAN 10/100 and incorporated internet browser.

**Measuring**

- Simultaneous acquisition of measuring data on eight analog bipolar and mutual isolated inputs, four for voltage and four for current, adjustable for AC and/or DC systems, with 100 kHz sample rate and 16 bit resolution.
  - Direct voltage measurement up to 900 $V_{eff}$ / CAT III
- Four isolated digital inputs for control tasks, e.g. start and Stop of recording, reset of meter readings, time interval synchronisation.
- Four potential free digital inputs for representation of status, e.g. operating status of machines, equipments and alarm installations.

**Calculation**

- Calculating of derived electrical quantities for single phase and three phase systems as effective values, at a minimum aggregation time interval of 200ms, as well as for extreme and average values in the defined or selected time interval:
  – neutral-to-phase and phase-to-phase voltages,
  – phase and neutral currents,
  – active-, reactive- and apparent power and -energy,
  – power- and crest factor, frequency
  – spectral shares of current, voltage and power
  – calculation of characteristics of the power quality

**Display**

- Numeric and graphic display of measured values and calculated quantities in predefined combination or in free assignment, simultaneously for over 1000 measuring quantities.
- Display of configuration menus in different national languages
- View of operating and connecting information

**Monitoring**

- Reporting over and under exceeding for adjustable limits of four free selectable measuring quantities through switch over the potential free relay contact. Printing on the USB interface if required.
- Time synchronisation manually or remote controlled via internet browser.

**Control**

- Start and stop recording manual, through adjusting time parameters or via the digital input (optical coupling)

**Recording and Documenting**

The measured results are available as files

- at the incorporated non volatile flash memory, an user replaceable CF-card (compact flash memory card) or an USB storage medium (USB stick, USB hard disc) plugged to the USB port.
- at the LAN- interface connected to a remote personal computer. The transmitted date can be analysed via analysing software (accessory) and exported to other programs.

## 1.4 Accessories

### 1.4.1 Includes Accessories (M816A)

1 POWER1000 Power Analyzer

1 Cable set for voltage measurement inputs, consisting of 4 pairs of measurement leads (length approx. 2m) with test probe and plug-on dolphin clips [1])

3 Short measurement leads with 4-mm safety plugs (stackable) for bridging the measuring inputs [2])

1 Power cord with grounded plug (120Vac plug)

3 Terminal strips, 4-pol
1 Ethernet-interface cable

1 Carrying case for instrument and accessories

1 Operating manual

1 CD-ROM with actual operating manual, technical data sheet and actual practical notes

[1]) Measurement category CAT IV at 600V
CAT III at 900V

[2]) Measurement category CAT III at 300V / 15A

### 1.4.2 Optional Accessories

**Current Measuring Accessories**

|-------------------A-------------------||------------------B------------------||------C------||-------D-------||-----E-----||----F----||----G----||--H--|

| Type | Figure | Description | Max. Cond. Dia. | Suitable for | | Measuring Ranges | | Intrinsic Error at Ref. Conditions ±[…% rdg. + … A] | Output Signal | Article Number |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Appli-cation*) | Meas. Cat. | Nominal Value | Usable Range with POWER1000 | | | |
| **CF3x45** | A | C-*FLEX* flexible AC current sensor, 3-phase set, switchable, 10Hz to 500 Hz, with battery and mains power pack | 3x 45 cm circumf. | a, b, c | 600 V CAT. III | 200 A~<br>2000 A~<br>20 kA~ | 5 … 200 A~<br>5 … 2000 A~<br>50 A~ … 20 kA~ | 1% + 0.2 A<br>1% + 2 A<br>1% + 20 A | 10 mV/A<br>1 mV/A<br>0.1 mV/A | Z824A |
| **AF033A** | B | Amp*FLEX* flexible AC current sensor, switchable, 10 Hz to 20 kHz, with 9 V battery (operating hours: approx. 150) | 45 cm circumf. | (a), b, c | 1000 V CAT. III | 30 A~<br>300 A~ | 0.5 … 30 A~<br>0.5 … 300 A~ | 1% + 0.5 A<br>1% + 0.6 A | 100 mV/A<br>10 mV/A | Z207A |
| **AF33A** | B | Amp*FLEX* flexible AC current sensor, switchable, 10 Hz to 20 kHz, with 9 V battery (operating hours: approx. 150) | 60 cm circumf. | (a), b, c | 1000 V CAT. III | 300 A~<br>3000 A~ | 0.5 … 300 A~<br>5 … 3000 A~ | 1% + 0.6 A<br>1% + 3 A | 10 mV/A<br>1 mV/A | Z207B |
| **AF101A** | B | Amp*FLEX* flexible AC current sensor, switchable, 10 Hz to 20 kHz, with 9 V battery (operating hours: approx. 150) | 120 cm circumf. | (a), b, c | 1000 V CAT. III | 1000 A~<br>10 kA~ | 5 … 1000 A~<br>50 A~ … 10 kA~ | 1% + 3 A<br>1% + 20 A | 1 mV/A<br>0.1 mV/A | Z207C |
| **AF11A** | B | Amp*FLEX* flexible AC current sensor, 10 Hz to 20 kHz, with 9 V battery (operating hours: approx. 150) | 45 cm circumf. | (a), b, c | 1000 V CAT. III | 1000 A~ | 5 … 1000 A~ | 1% + 3 A | 1 mV/A | Z207D |
| **Z821B** | C | Clip-on AC current sensor, 30 Hz to 5 kHz | 64 mm | a, b, (c) | 600 V CAT. II | 3000 A~ | 3 … 3000 A~ | 0.5% + 1.5 A | 0.33 mV/A | Z821B |
| **Z3512A** | D | Clip-on AC current sensor, switchable, 10 Hz to 3 kHz | 52 mm | a, b, c | 600 V CAT. III | 1 A~<br>10 A~<br>100 A~<br>1000 A~ | 0.001 ... 1.2 A~<br>0.01 ... 120 A~<br>0.1 ... 120 A~<br>1 ... 1200 A~ | 0.7 ... 3% + 0.001 A<br>0.5 ... 1% + 0.002 A<br>0.2 ... 1% + 0.02 A<br>0.2 ... 1% + 0,2 A | 1000 mV/A<br>100 mV/A<br>10 mV/A<br>1 mV/A | Z225A |
| **WZ11B** | G | Clip-on AC current sensor, switchable, 30 Hz to 500 Hz | 20 mm | a, (c) | 600 V CAT. III | 20 A~<br>200 A~ | 0.5 … 20 A~<br>5 … 200 A~ | 1 … 3% + 0.05 A<br>1 … 3% + 0.5 A | 100 mV/A<br>10 mV/A | Z208B |
| **Z13B** | E | Active AC/DC clip-on current sensor, switchable, DC to 10 kHz, with 9 V battery (operating hours: approx. 50) | 50 mm | b, c | 300 V CAT IV. | 40 A~/60 A–<br>400A~/600A– | 0.2 … 40 A~/60 A–<br>0.5… 400 A~/600A– | 1.5% + 0.5 A | 10 mV/A<br>1 mV/A | Z231B |
| **Z201A** | F | Active AC/DC clip-on current sensor, switchable, with 9 V battery (operating hours: approx. 30) | 19 mm | b, c | 300 V CAT. III | 20 A~/30 A– | 0.01… 20 A~/30 A– | 1% + 0.01 A | 100 mV/A | Z201A |
| **Z202A** | F | Active AC/DC clip-on current sensor, switchable, DC to 10 kHz, with 9 V battery (operating hours: approx. 50) | 19 mm | b, c | 300 V CAT. III | 20 A~/30 A–<br>200A~/300A– | 0.1 … 20 A~/30 A–<br>1 … 200 A~/300 A– | 1% + 0.03 A<br>1% + 0.3 A | 10 mV/A<br>1 mV/A | Z202A |
| **Z203A** | F | Active AC/DC clip-on current sensor, switchable, DC to 10 kHz, with 9 V battery (operating hours: approx. 50) | 31 mm | b, c | 300 V CAT. III | 200A~/300A–<br>1 kA~/1 kA– | 1 … 200 A~/300 A–<br>1 …1000A~/1000A– | 1% + 0.5 A | 1 mV/A | Z203A |
| **Z860A** | H | Plug-in shunt 50 Ω, 0.2%, 1.5 W | – | a, b | 600 V CAT. III | 20 mA | 50 µA … 20 mA | 0.2% | 50 mV/mA | Z860A |
| **Z861A** | H | Plug-in shunt 1Ω, 0.2%, 1.5 W | – | a, b | 600 V CAT. III | 1 A | 1 mA … 1.2 A | 0.2% | 1000 mV/A | Z861A |
| **Z862A** | H | Plug-in shunt 0.05 Ω, 0.2%, 1.5 W | – | a, b | 600 V CAT. III | 5 A | 0.02 … 6 A | 0.2% | 50 mV/A | Z862A |
| **Z863A** | H | Plug-in shunt 0.01 Ω, 0.2%, 1.5 W | – | a, b | 600 V CAT. III | 16 A | 0.1 … 16 A | 0.2% | 10 mV/A | Z863A |

*) a = Long-Term measurement  b = Harmonic measurement  c = Frequency converter measurement

# 2 Initial Start-Up

## 2.1 Mains Connection

The incorporated wide range power supply of the POWER1000 provides for operating from 80V to 250V mains voltage. Connection to the power line is performed via the combined supply input socket which is integrated into the housing base. Furthermore, the mains switch and the mains fuses are incorporated in the combined element.

Observe **WARNING 1!**

The POWER1000 incorporates a gel bound lead accumulator. If the instrument is operated as power quality monitor and supplied from the mains in test, the accumulator takes over the supply for < 30 min in case of power interruption.

### 2.1.1 Replacing Mains Fuses

Observe **WARNING 12!**

**WARNING!**
Disconnect the instrument at all poles from the
measuring circuit before opening the fuse holder.
Disconnect the instrument from the mains by pulling the mains plug from the outlet.

☞ Open the fuse link cover with an appropriate tool (e.g. screw driver) by lifting the cover up at the protruding lug.

☞ Remove the fuse holder (see arrow).

☞ Replace the fuse with the correct rating (see serial label next to the mains switch at the combined element and refer to chapter 9, Maintenance and repair)

☞ Close the cover.

### 2.1.2 Switching the Instrument On

> ON|MENU

The device is supplied via the supply network or on a short-term basis via the built-in gel bound lead accumulator.

⇒ For the supply via the supply network
- Connect the device to the supply network over the included power cord.
- Switch on the mains switch on the right-hand side of the device. An integrated glow lamp indicates that the instrument has been switched on.
- Press button ON|MENU.

⇒ For short term supply via the incorporated accumulator
- touch button **ON|MENU**.


3…ON-Button

3a…OFF-Buttons


2…Mains Switch

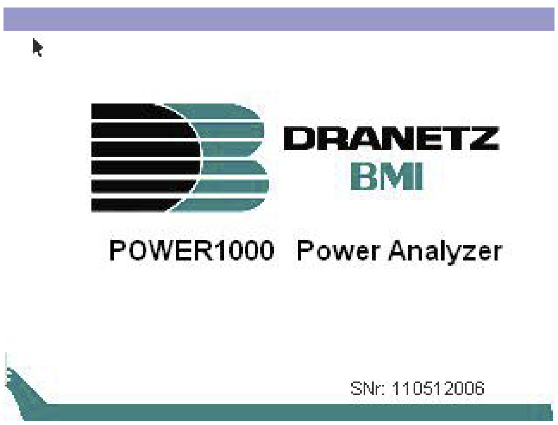
1…Mains Connection

After touching button **ON|MENU** the fan is turned on. During the initialization process the following information are displayed in succession:

• the company logo

• the designation of the device (POWER1000)

• the serial number in the bottom line




The device then switches to the main menu and is ready for service. In the headline left-side

• the actual version of the firmware together with the previous implemented is displayed.

### 2.1.3 Switching the Instrument Off

**HELP+ESC**

⇒ The device is switched off by pressing the buttons HELP and ECS simultaneously.

⇒ The power supply of the device is switched off by switching off the mains switch on the right-hand side.

***Note:*** switch the device always off via **HELP+ESC**. With it you avoid discharging the accumulator. With the accumulator completely discharged the device can be set into operation the after waiting approx. 30 minutes.

## 2.2 Updating/Upgrading the Device Firmware

### 2.2.1 General

The POWER1000 follows the existing standards and regulations in a wide extent of its measuring functions. Standards and regulations change or are new introduced. Based on the state of the art design including flash memory elements the processor controlled device functions can be easily updated or upgraded. New firmware can be uploaded

- either from a USB-stick via the incorporated USB-A-interface
- or from the internet via the incorporated Ethernet- LAN- interface.

This feature is specially designed to allow for:

- installation of firmware versions in another dialog languages for setup menus and online help
- Installation of new device firmware which has resulted from on-going technical developments.

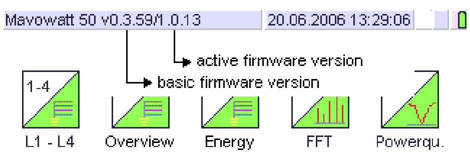
Furthermore, this flexibility allows for user specific adaption on special applications.

### 2.2.2 Uploading the Firmware via USB-A- Interface

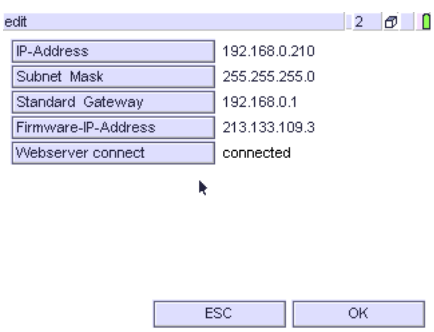
The Program- update is available as compressed file in the Internet on a *firmware IP address*. An update is carried out starting from a firmware basic version. Proceed as follows:

☞ Note the current basic version of your device down. Fot this, press the button ON|MENU. The display changes into the main menu.

The left side of the headline shows the type designation, the basic firmware version and the actual firmware version.




☞ Note the firmware IP address down. For this purpose, open the entry mask for the Internet protocol through a touch the keys set-up and net configuration in succession:



☞ Start the internet explorer browser on your PC.

☞ Enter the firmware IP address from your device: http://213.133.109.3/mw50/

The monitor of the PC displays the implemented firmware versions and their updates:

*update - [basic version] – current..*

☞ Search fort he corresponding update, i.e. the basic version implemented in your device with the update „current“. Copy the version onto an USB- data carrier.

The program file with the name

**Update-[basic version]-current.tar.gz** is compressed.

**Note:**
The compressed file can be copied to any available data carrier. For transmission to the device a USB data carrier is required.

For downloading the program to the device, the program remains compressed. This procedure is carried out by the device automatically.

☞ Start the device with the button ***ON|MENU***.

### 2.2.3 Program-Update via the USB-A- Interface

The transmission from the USB- data carrier onto the device performs via the USB-A-interface.

**Note:**
If the program update is available on another data carrier (3½“ dics, HD, etc.), copy the file onto a USB- data carrier.

☞ Close the current measurement program on the device

☞ Touch the key ***Admin*** to enter the administration program.

Note: If the ***Admin*** button is not available in the main menu screen print the keys in following succession:

**ON|MENU > HELP > ON|MENU > PRINT > ON|MENU**

☞ Insert the USB- data carrier in the jack designated with USB-A on the rear side of the POWER1000.

☞ Touch the key ***Update***

☞ Touch the key ***update USB-Basis***

Download of the program is stared. After download, the display shows „update successful”.

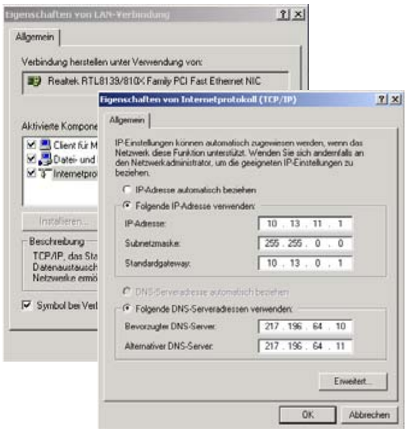
☞ Touch the key ***OK***.

The device switches off automatically.

☞ Start the device again by pressing the button **ON|MENU**.

### 2.2.4 Preparation for Program Uploading via Internet

The transfer of a firmware update or an available language module to the device requires an Ethernet- LAN- installation with known internet protocol (TCP/IP).This consists of the IP-Address of the device, the Subnet mask and the Standard gateway.

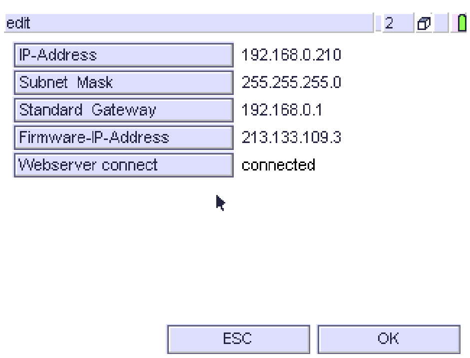



Before transfer is started, the Ethernet-protocol of the POWER1000 has to be adapted to your network infrastructure as follows:

☞ Close the current measuring program on the device

☞ Touch the key ON|MENU. The device enters the main menu.

☞ Select the entry format for the internet protocol via the keys ***Setup*** and ***Network***.




⇒ Enter the relevant internet parameters in the Parameter list.

☞ Choose an IP address which is free in your network. Ask the system administrator to receive the proper IP-system parameters. Conflicts in the network may lead to influence in data exchange and to damage of files.

☞ Confirm the entries with ***OK***. The display changes to the main menu.

☞ Stop and start the device again (chap. → 2.1.2 and 2.1.3). The changed settings for the internet protocol are activated.

### 2.2.5 Program Uploading via Prepared Internet Protocol

☞ Connect the POWER1000 to the LAN-network via the RJ45 LAN-Jack (→ Section 4.6)

☞ Close the current measuring program on the device.

☞ With the button ***ON|MENU*** enter the main menu.

☞ Touch the key ***Admin*** to enter the administration program.
Note: If the ***Admin*** button is not available in the main menu screen print the keys in following succession:
**ON|MENU > HELP > ON|MENU > PRINT > ON|MENU**

⇒ The device starts downloading the update program. After termination the display advices "update successful".

☞ Switch off the device and start it again.

⇒ The changed settings for the internet protocol are activated. All other configuration parameters remain unchanged.

## 2.3 Measuring Connections

Observe **WARNINGS 3 to 9!**

The POWER1000 includes the following measurement inputs:

- Four analog voltage measurement inputs - **$U_{L1}$, $U_{L2}$, $U_{L3}$, $U_{L4}$** - for direct and alternating voltages up to max. 600 V (overvoltage category CAT IV) or 1000 V (CAT III). Measurements in medium-voltage systems must generally be performed via voltage transformers at the system side! The corresponding voltage ratio (*Uratio*) can be set individually for each input via the setup menu for measurement parameters.

  The 2-pole floating inputs are electrically isolated from each other, also against the corresponding current measurement input. Input impedance is approx. 4 MΩ.

  Connector jacks: 1 pair each 4 mm safety jacks, black (high level) and red (low level) at the right hand side of the instrument. Voltage is normally connected to the device under test with the included measurement cables with 4 mm safety plug, and test probes with plug-on dolphin clips.

  Connection examples see chap. → 7.

- Four analog current measurement inputs - **$I_{L1}$, $I_{L2}$, $I_{L3}$, $I_{L4}$** – set up as voltage inputs (see technical data for measuring ranges) for the connection of shunts or clip-on current sensors with voltage output, or burdened current transformers. The corresponding transformation ratio (*Iratio*) can be set individually for each input via setup menu for measurement parameters.

  The 2-pole floating inputs are electrically isolated from each other, also against the corresponding current measurement input. Input impedance is approx.
  10 kΩ.
  Connector jacks: 1 pair each 4 mm safety jacks, black (high level) and red (low level) at the right hand side of the instrument.

  Connection examples see chap. → 7.

- Four isolated digital inputs **Status IN a, b, c, d** for control tasks, e.g. start and stop of recording as well as for reset of interval measuring data with the synchronising pulse.

  The 1-pole inputs with common ground ($S_0$-compatible, max. 30V= against ISO/comm) are potential free and electrically function isolated from each other.

- Four digital inputs **Control IN e, f, g, h** for representing operating conditions of machines, installations and alarm equipments.

  The 1-pole inputs with common ground (TTL-compatible) are potential free.

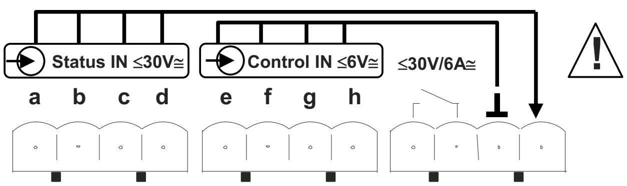
The digital inputs require a binary signal which is generated from an external auxiliary voltage source (safety extra-low voltage!).

### Signal Level

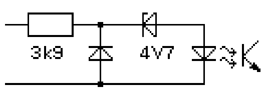
| Levell | Status IN | | Control IN | |
|---|---|---|---|---|
| | Voltage | Current | Voltage | Current |
| low | < +4V<br>(max -30V) | 0 mA @ 0...+4V | < | |
| high | > +12V<br>(max +30V)<br>nominal 24V | 2,6 mA @ +12V<br>6 mA @ +24V | > +4 V<br>(max. +6V) | |

**Connection:** via PCB-connector plugs at the rear side of the instrument and plug sockets with application-specific signal cable.

**Connector Pin Assignments (rear side fiew):**




☝ Due to EMC requirements, the length of the connecting leads must not exceed 3m!




Circuit Diagram for Isolated Digital Inputs

**ATTENTION!**
The application of a voltage higher than 48 V to the digital inputs **Status IN**, **Control IN** or the **Alarm output (relay)** may cause damage to the instrument.

**Functions of Digital Inputs:**

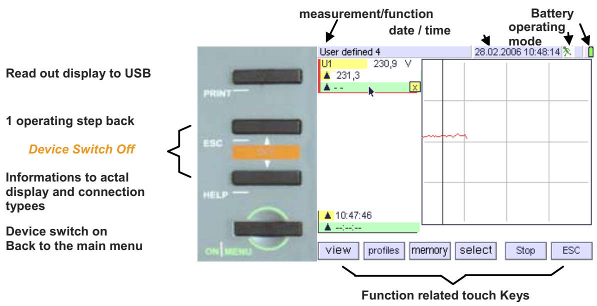
| Digital Input | Function | Value Range |
|---|---|---|
| Status IN a | counter input a, S0-compatible / digital status a | counter:<br>max. 200 Hz<br><br>status: 0/1 |
| Status IN b | counter input b, S0-compatible / digital status b | |
| Status IN c | counter input c, S0-compatible / digital status b | |
| Status IN d | counter input d, S0-compatible / digital status b | |
| Control IN e | digital status input e | 0 / 1 |
| Control IN f | digital status input f | 0 / 1 |
| Control IN g | digital status input g | 0 / 1 |
| Control IN h | digital status input h | 0 / 1 |

☞ The instrument must continuously monitor the period length (frequency) of the measuring signal for correct calculation of AC quantities. The acquisition is performed via the voltage measurement input L1. In case of dropout the period length is acquired in the voltage measurement input L2, and in case of dropout in L3. If all three voltage inputs fail, calculation is performed via the current inputs. In case of all inputs fail the internal setup nominal frequency is used for calculations. It is recommended to connect voltage input U1 in any case.

# 3 Operating and Display Elements

## 3.1 General

The control panel at the top of the instrument includes a colour LCD touch screen and 4 pushbuttons to the left of that. The user operates the device by applying pressure to the virtual touch keys of the screen with the included Stylus (Organizer-pen) or with a finger, in combination with the pushbuttons. The user guidance is based on symbols which are easily understood. In this way, the desired measuring modes, the functions and the parameters are adjusted. All of the measurement values, measured quantities and other information required for the performance of the measurements and settings are displayed at the integrated LCD.




## 3.2 Key Functions

With a short touch on the pushbutton **ON|MENU**, the device enters the main menu. The display presents the touch keys for selecting the desired measuring function as well as the setup menu, and the archive by which recorded data may be retrieved. The further adjustments are performed by touching the corresponding touch keys at the LCD in the order provided by the menu driven program.

The selected attitudes for the measurement and device parameters are listed in parameter lists. They are kept alive after switching off the device.

With simultaneous activation of **ECS** and **HELP** buttons the device is switched off.

With the button **HELP** the help menu is opened. It contains information for the actual operating mode and configuration of device and measurement parameters. The help menu is closed by pressing the **ON|MENU** button.

With a touch at the **ESC**-button

- in the setup menu the display changes from the actual view to the setup menu and/or the selection menu.

- in the measurement mode the display changes from the actual view to the main menu.

By pressing the **PRINT** button, the current contents of the LCD are transferred out to the plugged-in USB-memory medium.

| Touch Button | Description | Function |
|---|---|---|
| **ON\|MENU** | Menu button | - Switch On device<br>- Enter the first level of the configuration menu (main menu) |
| **HELP** | Help button | - Enter or exit the help menus.<br>- Operating and connection instructions for currently selected measurement function |
| **ESC** | Escape | - Reentry from the submenu to the main function |
| **PRINT** | Print at USB | - current contents of the LCD are transferred out to the connected USB-memory medium. |
| **HELP+ESC** | OFF | - Switch Off device. A current measuring session is closed. |

### 3.3 LC-Display

☝ For operating the touch sensitive display, avoid from using pointed or sharp subjects such as nails, screws or pointed tools. Use a slightly damped cloth for cleaning or special screen cleanser.

The presentation on the touch sensitive film of the display is adapted to the current operating condition. Basically two different display modes are available for the instrument:

In ***measurement mode*** the display unit is functionally subdivided into three fields:

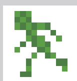
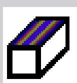
- The **headline** views information to the actual operating conditions. To this belong displaying date, time, operating mode as well as charge condition of the incorporated battery.
- At the **main display** the measured values and measuring sequences are displayed and are refreshed at a fixed time interval (cycle time 1 second). Either the alphanumeric or the graphic display format can be selected.
- At the **foot line** the function related on screen symbols (touch keys) for selecting operating parameters are displayed.
- A **yellow background** in a touch sensitive section points out further operating options for the current measuring sequence.

If the device is not operated the backlight of the LCD screen times-out after approx. 5 minutes. It is turned on again

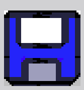
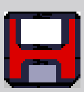
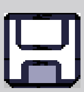
- with a touch at any point within the LC-display
- with pressing any button on the left hand side of the LC-display.

### Meanings of Operating Mode Display

#### Symbols fort he Display Mode

| Display | Designation | Meaning | See Chapter |
|---|---|---|---|
|  | Sample | The instrument measures and updates displayed measuring values at the fixed 1 second interval. | |
| | Hold | The measuring operation is temporarily interrupted | |
|  | Retrive | Read-in of measuring sequences stored to the selected storage medium (internal memory, CF-card, USB-memory). | |

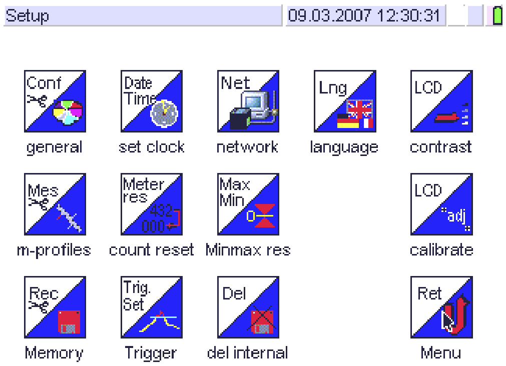
#### Symbols for the Memory Mode

| Display | Designation | Meaning | Note |
|---|---|---|---|
|  | Memory | Time controlled recording of measured data on the selected storage medium. Changing current function is not supported | Measured data are stored in selected time interval |
|  | Recording | - Storage of measured data running.<br>- Copy of measured data to an external storage medium. | The external medium must not be removed from the slot of the device |
|  | Enable | After occurrence of a trigger event, measured data are recorded to the selected medium | Measured data recording performs event controlled |

#### Symbols for the Battery Mode

| Display | Designation | Meaning | Note |
|---|---|---|---|
|  | Mains operated | Device connected to mains | Battery charged |
|  | Mains operated | Device connected to mains | Recharge of battery running |
|  | Battery operated | Device is operated by internal battery | Batterie wird entladen |
|  | Battery operated | Device is operated by internal battery | Battery discharged, device switches off shortly |

In ***configuration mode*** the touch sensitive symbols on the LCD screen are distributed over the main display. A firm place is assigned to each symbol. Functionally related parameters are listed together in a configuration menu. The designation of the current configuration menu is displayed in the head line.




### 3.4 Menu mode

The following optical displays guide the user during operation of the instrument:

- An ***icon*** in the main display symbolizes a measuring function (measurement mode) or setting function (setup mode).
- A ***Touch key*** in the foot line refers to a setup function in the current measuring or configuration mode.
- A ***marked field*** in the main display emphasizes the active adjusting field.
- The ***Help Menu*** is activated by pressing the pushbutton **HELP** in any representation. In place of the current representation, operating information is displayed for the current function. After pressing **HELP** again the help view is closed.

# 4. Configuring the Operating Parameters

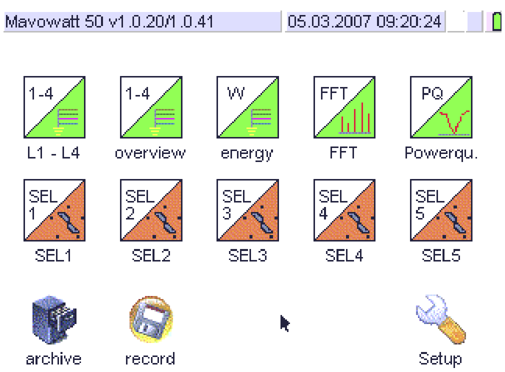
## 4.1 Menu Structure

The setup menu for the operating parameters encompasses several pages for the both configuration levels, the ***Measuring Mode*** and ***Configuration mode***. Functionally related parameters are listed together in a single page.

The summary of selected parameters defines the measuring and storage profile for a measurement. Up to six different setup configurations can be filed in six different profiles. This allows fast access to assigned measuring and storage parameters and in many cases avoids reconfiguring procedure when changing the measuring site.

In measuring mode, the functionally related configuration parameters (measuring profile, storage profile, start/stop measuring run) can be selected via the touch keys in the Menu Line. Measuring and device parameters apply for all measuring functions. When a parameter is changed at a later date, this change applies for all other measuring functions.

With a touch on the ON|MENU button the ***configuration mode*** is entered. The displayed format changes from the actual measuring presentation to the main menu. Here the display presents the symbols for the measuring functions and the setup menu. Moreover the main menu allows the access to the storage functions as well as to the data storage archive.




⇒ The type of the device and the actual firmware version are displayed at the left-hand side of the head line.

⇒ Date, time, operating mode and charging condition of the stand-by battery are displayed at the right side of the head line.

⇒ The main display presents the symbols for the measuring functions, the storage functions, the data storage archive and the setup menu.

With a touch on the **soft key** which represents the desired function the ***first level*** of the ***selection menu*** is opened.

Exception: an intermediate configuration menu is opened in the measuring functions SEL1 to SEL5.

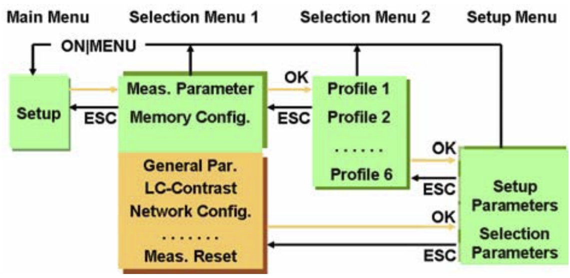
After selecting the desired function or selection menu the display enters

⇒ in measuring mode the corresponding ***measuring function*** in the last selected display format

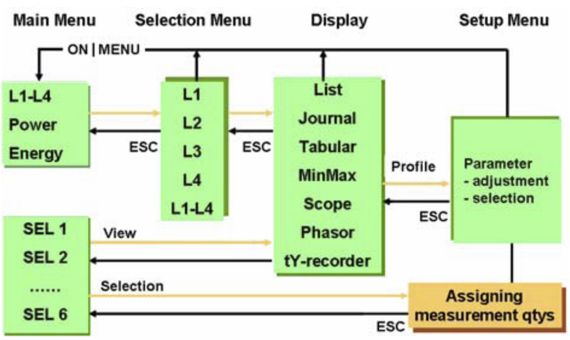
⇒ in configuration mode the ***second level*** of the ***selection menu***.

The ***second level*** of the selection menu comprises the selection of device and measuring parameters (configuration mode) or selection of a display format (measuring mode) respectively.

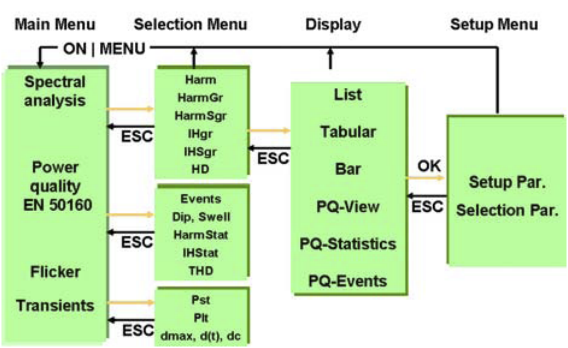
In the ***third level*** of selection menu the operating parameters being relevant may be selected or edited.




***Menu Structure in the Configuration Menu***




***Menu Structure for Power and Energy Measurement***




***Menu Structure for Spectral -, Power Quality - and Flicker Analysis***

## 4.2 Operating Parameters Configuration Procedure

This section describes in principle the procedure for configuring the operating parameters in the setup menu and for configuring the measuring mode. The following graphics represent only the operating elements being essential for configuring the parameters.

Basically under several possibilities for setting up operating parameters the most essential can be selected. This section mainly describes the selection of operating parameters via the setup menu.

☝ Enter the menus by touching the corresponding touch key with the stylos (included accessory)!

### 4.2.1 Switching the Instrument On

**> ON|MENU**

Switch on the instrument by turning on the mains switch at the right-hand side and sequentially touch the **ON|MENU** button (→ chapter 2.1.2)

After showing the company logo the display enters the main menu format.

### 4.2.2 Entering the Setup Menu

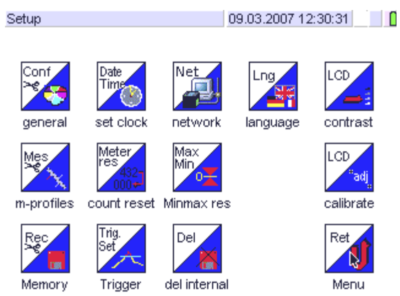
**Setup > [Configuration Menu] > edit**

For Measurement and storage parameters applies

**Setup > [Configuration Menu] > [Configuration Profile] > edit**

Touch the **ON|MENU key**. The LCD screen shows the main menu.


Touch the touch key ***Setup***. The display enters the selection menu ***Setup***.

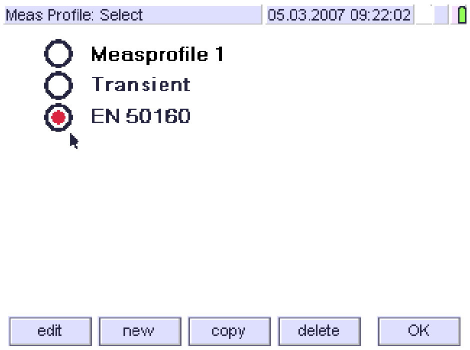



If the current device - and measuring parameter settings shall remain unchanged the menu can be closed via touching the touch key ***Menu*** or touching the button ***ON|MENU***. In both cases the display enters the main menu.


Touch the symbol for the desired configuration menu.

For opening the configuration menu ***m-profiles*** or ***Memory*** the display enters the format for profile selection.

The ***m-profile*** and ***storage profile*** display formats present the defined profiles. The active measuring - or storage profile respectively is marked with a dot ⦿ in the touch key.




⦿ Acknowledge the desired measuring or storage profile respectively with a touch on the corresponding touch key.

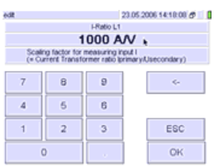
Return to the configuration menu with ***OK***.

With ***Edit*** you enter the parameter menu for the selected measuring – or storage configuration.

## 4.3 Adjusting Device- Measurement- and Storage Parameters

### 4.3.1 Adjusting Parameters with Numeric Variables

☞ Open the numeric entry display by touching at the desired numeric parameter with the stylos. ⇒ The desired numeric entry field is opened.




Enter the desired number by consecutive touching the corresponding number keys.

Acknowledge the changed entry by touching the touch key ***Enter***. The entry display is closed.

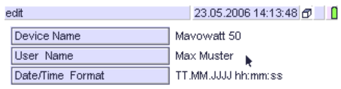
### 4.3.2 Adjusting Date and Time

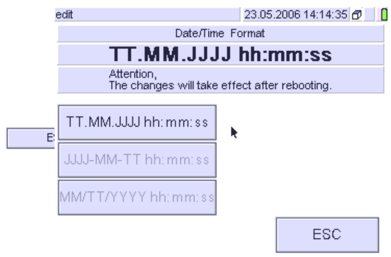
The POWER1000 supports the country specific display of date and time. Usually adjusting country specific device parameters is performed by the user once just after getting started the instrument. Adjustment is performed in two steps:

**Setup of Country Specific Date and Time Format**

**Setup > general > Date/Time Format > edit**


Open the parameter menu Date/Time Format by touching the touch keys ***Device parameter*** and ***Date/Time Format*** successively with the included stylos.



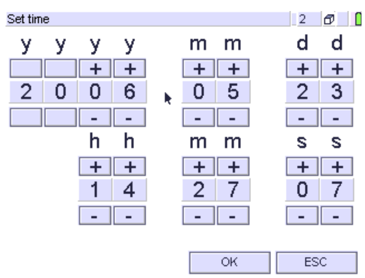

☞ Select the country specific time format. ⇒ The display returns to the selection menu ***general***.

**OK** Acknowledge setting with ***OK***. ⇒ The display returns to the Setup menu.

**Setup Date and Time**

**Setup > set clock > set time**


Open the entry display Set Time by touching the ***touch key set clock*** with the included stylos.



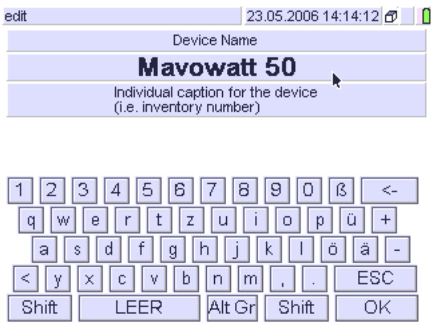

☞ Enter the actual date and time by touching the entry keys + and - respectively

OK Acknowledge the setting with the touch key ***OK***. ⇒ The display returns to the setup menu.

### 4.3.3 Adjusting Parameters with alphanumeric Variables

Setup > [parameter] > edit

☞ Open the alphanumeric entry display by touching the touch key for the desired alphanumeric parameter with the stylos. ⇒ The desired numeric entry field is opened.




☞ Enter the desired alphanumeric variable in the entry field. ⇒ The entry is displayed in the headline under the displayed designation for the parameter menu.

☞ With the touch key ***Shift*** the entry field can be adjusted for entering capital or small letters.

Enter Acknowledge the setting with the touch key ***Enter***. ⇒ The display returns to the Setup selection menu.

☞ The same procedure performs for all alphanumeric parameters to be changed.

### 4.3.4 Entering the Previous Menu Level and Main Menu

ESC With the touch key ***ESC*** you enter the previous menu level. When touching the key ***ECS*** again you enter the Configuration Menu.

OK With touching the touch key ***OK*** you enter the Configuration Menu without intermediate step.

**Note:** When touching the button ON|MENU in any display format the view returns to the Main Menu.

## 4.4 Operating Parameters Description

The **POWER1000** is described by device parameters that may be adjusted by the user. An exception is the serial number which is assigned by the manufacturer. Device parameters apply to all measurements.

A **measurement** is described by the combination of
- the selection of a measuring profile
- the selection of a storage profile and
- the selection of measurement quantities (applies to SEL1-5).

Measurement parameters apply to the current measurement.

| **Menu group** | Configuration menus |
|---|---|
| **Device parameters** | general – set clock – network – language – contrast – calibrate |
| **Measurement parameters** (Measurement profile) | m-profiles – counter reset - Minmax res |
| **Storage parameters** (storage profile) | Memory – Trigger – del internal |

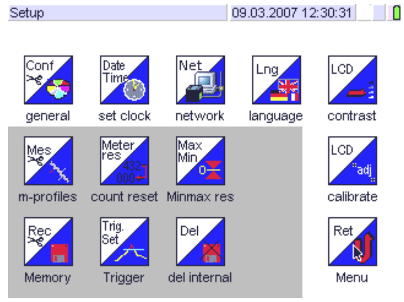
Configuration parameters are stored together with the respective measurement data. They are used for further measurement analysis.

Measurement quantities that characterise the entire measurement period are kept stored (drag pointer) and should be reset before starting a new measurement session. This applies for the counted values accumulated during the measurement period (energy) and for the extreme values (MaxMmin). These functions are assigned to the measurement parameters.

Non volatile storage contents (internal memory) are erased by an own menu. Furthermore, for a new measurement session the trigger configuration must be properly adapted. They are assigned to the storage parameters on account of relationship.

### 4.4.1 Setup of Device Parameters

**Setup > [device parameter] > edit**




The set-up of the device parameters contains several setting menus for the different device and measurement parameters.

Individually user definable parameters are summarized in the selection menu ***general***.

**Opening the Parameter Menu:** **Setup > general > edit**

**Acknowledge of adjustment:** **OK**


Parameters which apply to all measurements are adjusted via the individual setting menus
- Set Date/Time
- Trigger (value limit)

The corresponding device configuration is also stored with the measuring data. It is used for a subsequent measuring analysis.

## Setup-Parameters for the Device

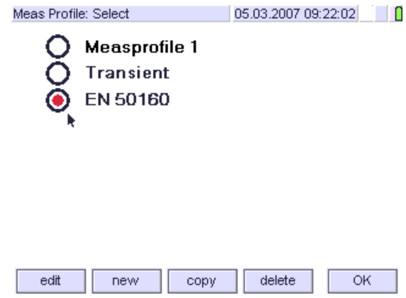
| | Parameter | Description | Settings Range | Default Setting | Notes |
|---|---|---|---|---|---|
| General | **Device Name** | iIndividual caption for the device<br>(i.e. inventory number) | alphanumeric | POWER1000 | max.25 characters |
| | **User Name** | Individual username<br>(i.e. name of company, division, user) | | DRANETZ | max.25 characters |
| | **Date / time Format** | current date in the selected date format | TT.MM.JJJJ / hh:mm:ss<br>JJJJT.MM.TT / hh:mm:ss<br>MM.DD.JJJJ / hh:mm:ss | TT.MM.JJJJ / hh:mm:ss | **Attention,**<br>The changes will take effect after rebooting. |
| Set Date/Time | **Date** | current date in the selected date format | 01.01.2005..<br>31.12.2099 | current date | |
| | **Time** | actual time in format hh:mm:ss | 00:00:00 …<br>23:59:59 | current CET | the point of time at which the setup menu was opened is displayed here |
| Network | **IP-Adress** | IP-Adress of the device | | 192.168.0.210 | |
| | **Subnetmask** | IP-Adress for Device Identification | | 255.255.255.0 | separates the IP-Adress in a network and a device or host section respectively. This allows for meeting routing decisions |
| | **Standardgateway** | IP-Adresse of the router | | 192.168.0.1 | |
| | **Firmware-IP-Adress** | IP-Adress of the Webserver. Required only for firmware-updates. | | 213.133.109.3 | |
| | **Webserver connect** | Connects / disconnects the Webserver | Yes / no | No | |
| Language | **Language** | Dialog language for menu mode and help texts | German / English | English | applies for implemented help texts only |
| Contrast | **Contrast** | adjust LCD contrast to ambient light conditions and viewing angle | 00 ...50 | | the contrast can be adjusted with the cursor keys ∨ and ∧ |
| Adjust | **Adjust** | positioning of the touch sensitive area of the display to the centre of the touch keys | 3 point | | |

### 4.4.2 Measuring Parameters

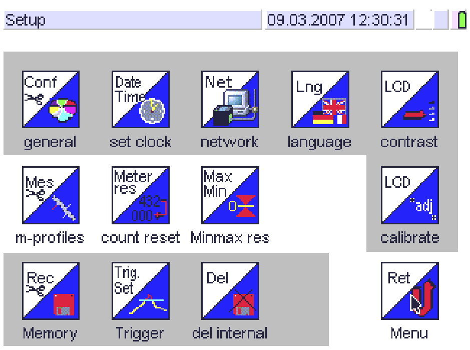
**Setup > m-profiles > Meas. Profile: Select > edit**

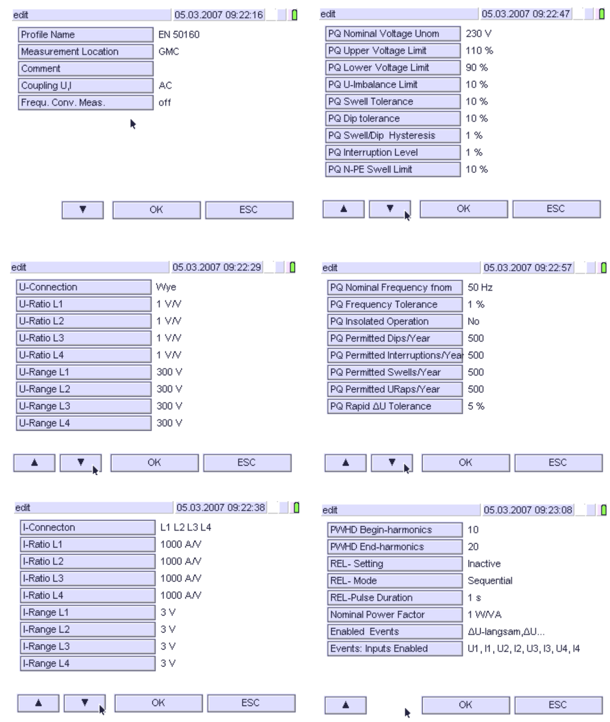
This configuration menu consists of six menu pages with a list of all available measuring factors and parameters. Closely related parameters were listed on successive pages.
The selected measuring configurations were stored in parameter files. Up to six different measuring configurations can be filed in six different configuration files.

For subsequent analysis of the measured data the measuring configuration is stored together with the belonging measuring data.




**Selection Menu m-profile**




**Configuration Menu Measurement Parameters**

**Opening the measuring profile:** Setup > m-profiles
**Edit m-profile:** m-profile > edit
**Save configuration:** OK

**Setup-Parameters for Configuration of Measurement Parameters**

| | Parameter | Description | Settings Range | Default Setting | Notes |
|---|---|---|---|---|---|
| Designation of Measurement | **Profile Name** | Individual Caption under which the following parameters are stored | max. 25 characters | Meas. profile ***n***+1 | ***n*** = Number of already existing measuring profiles |
| | **Meas. site** | Individual designation for the Measuring location or for the measuring task | max. 25 characters | blank | entry optional |
| | **Comment** | Description of measurin task, used transformers, limit values, etc. | max. 5 Zeilen à 50 Zeichen | blank | entry optional |
| | **Coupling Meas. inputs** | Coupling type for all U- and I-Measuring inputs:<br>AC = only alternating voltage<br>AC+DC = alternating and direct voltage | AC, AC+DC | AC+DC | In ***AC+DC*** mode the frequency range begins with DC due to the R-coupling.<br>The ***AC***-Coupling is a C-coupling without transmission of DC input signals.<br>The upper limit of the frequency range is equal for both coupling modes. |
| | **FC-Measurement** | Measuring mode for frequency converters | off / on | off | - Switching frequency must lie within a range of 1.5 to 30 kHz, and fundamental frequency between 10 and 100 Hz.<br>- Motor current is acquired in an electrically isolated fashion, e.g. by means of (clip-on) current sensors. |

| | Parameter | Description | Settings Range | Default Setting | Notes |
|---|---|---|---|---|---|
| U-Parameter | **U-Connection** | Connection type of U inputs L1, L2, L3:<br>Wye = Phase-to-Neutral<br>Delta = Phase-to-Phase | Wye / Delta | Wye | When U-connection *Delta* is selected, current measurement is performed in phases L1 and L3, input I2 keeps non-connected. The dispayed measuring value I2 as well as the derived measuring quantities are calculated after the two wattmeter principle. |
| | **U-Ratio L1** | Scaling factor for measuring input U1 (= Voltage Transformer ratio Uprimary. /Usecundary) | 0,950 ... 99999 V/V | 1,000 V/V | |
| | **U-Ratio L2** | Scaling factor for measuring input U2 (= Voltage Transformer ratio Uprimary. /Usecundary) | 0,950 ... 99999 V/V | 1,000 V/V | |
| | **U-Ratio L3** | Scaling factor for measuring input U3 (= Voltage Transformer ratio Uprimary. /Usecundary) | 0,950 ... 99999 V/V | 1,000 V/V | |
| | **U-Ratio L4** | Scaling factor for measuring input U4 (= Voltage Transformer ratio Uprimary. /Usecundary) | 0,950 ... 99999 V/V | 1,000 V/V | |
| | **U-Range L1** | Measuring range of meas. input U1 in Vrms (Limit for Vpeak = Vrms x 1,5) | 900 V<br>600 V<br>300 V<br>150 V | 300 V | Applies for all voltage measuring inputs with respect to Uratio |
| | **U-Range L2** | Measuring range of meas. input U2 in Vrms (Limit for Vpeak = Vrms x 1,5) | 900 V<br>600 V<br>300 V<br>150 V | 300 V | Applies for all voltage measuring inputs with respect to Uratio |
| | **U-Range L3** | Measuring range of meas. input U3 in Vrms (Limit for Vpeak = Vrms x 1,5) | 900 V<br>600 V<br>300 V<br>150 V | 300 V | Applies for all voltage measuring inputs with respect to Uratio |
| | **U-Range L4** | Measuring range of meas. input U4 in Vrms (Limit for Vpeak = Vrms x 1,5) | 900 V<br>600 V<br>300 V<br>150 V | 150 V | Applies for all voltage measuring inputs with respect to Uratio |
| I-Parameter | **I-Connection** | Active I-inputs:<br>- all<br>- L1 L2 L3<br>- L1 L3 L4 | L1 L2 L3 L4<br>L1 L2 L3<br>L1 L3 L4 | 1000 A/V | - all inputs measured<br>- I4 = calculated Σ(1+I2+I3)<br>- I2 = calculated Σ(I1+I3) |
| | **I-Ratio L1** | Scaling factor for measuring input I1 (= Current Transformer ratio Iprimary/Usecondary) | 0,000 ... 99999 A/V | 1000 A/V | |
| | **I-Ratio L2** | Scaling factor for measuring input I2 (= Current Transformer ratio Iprimary/Usecondary) | 0,000 ... 99999 A/V | 1000 A/V | |
| | **I-Ratio L3** | Scaling factor for measuring input I3 (= Current Transformer ratio Iprimary/Usecondary) | 0,000 ... 99999 A/V | 1000 A/V | |
| | **I-Ratio L4** | Scaling factor for measuring input I4 (= Current Transformer ratio Iprimary/Usecondary) | 0,000 ... 99999 A/V | 1000 A/V | |
| | **I-Range L1** | Measuring range of meas. input I1 in Vrms (Limit for Vpeak = Vrms x 1,5) | 3 V<br>300 mV | 3 V | |
| | **I-Range L2** | Measuring range of meas. input I2 in Vrms (Limit for Vpeak = Vrms x 1,5) | 3 V<br>300 mV | 3 V | |
| | **I-Range L3** | Measuring range of meas. input I3 in Vrms (Limit for Vpeak = Vrms x 1,5) | 3 V<br>300 mV | 3 V | |
| | **I-Range L4** | Measuring range of meas. input I4 in Vrms (Limit for Vpeak = Vrms x 1,5) | 3 V<br>300 mV | 3 V | |

| | Parameter | Description | Settings Range | Default Setting | *Notes* |
|---|---|---|---|---|---|
| PQ-Parameter for voltage | **PQ Nominal Voltage Unom** | Rated value of mains supply voltage (all voltage limits and tolerances refer to this value) | 0,000 … 999999 V | 230,0 V | |
| | **PQ Upper Voltage Limit** | Upper limit of mains supply voltage for slow voltage variations (10 minute mean) | 100 … 200% Unom | 110% | |
| | **PQ Lower Voltage Limit** | Lower limit of mains supply voltage for slow voltage variations (10 minute mean) | 0 … 100% Unom | 90% | |
| | **PQ U-Imbalance limit** | Limit value for unbalance of the 3-phase supply voltage (10 minute mean neg. sequence comp./pos. sequence comp.) | 0 … 100% | 2% | |
| | **PQ Swell-Tolerance** | Maximum allowed positive deviation from Unom for rapid voltage changes (1/2 cycle rms) | 0 … 100% Unom | 10% | |
| | **PQ Dip-Tolerance** | Maximum allowed negative deviation from Unom for rapid voltage changes (1/2 cycle rms) | 0 … 100% Unom | 10% | |
| | **PQ Swell / Dip-Hysteresis** | Hysteresis for the Swell and Dip Tolerances when voltage returns into tolerance band | 0 … 10% Unom | 1% | |
| | **PQ Interruption Limit** | Limit for deviation from Unom and for voltage dips | 0 … 100% Unom | 1% | |
| | **PQ N-PE Swell-Limit** | Limit for Neutral-to-Earth voltage | 0,000 … 999999 V | 25 V | |
| | **PQ Nominal Frequency fnom** | Nominal value for mains frequency | 12,00 … 400,0 Hz | 50,00 Hz | |
| | **PQ Frequency tolerance** | Maximum allowed deviation from nominal mains frequency | 0,1 … 15% fnom | 1,0% | |
| | **PQ Isolated Operation** | Limits for deviation from nominal value in systems without synchronous connection to an interconnected system | According to table | According to table | |
| | **PQ Permitted Dips/Year** | Limit for number of permitted dips per year | 0 … 9999 | 100 | |
| | **PQ Permitted Voltage Interruptions/Year** | Limit for Number of permitted voltage interruptions per Year | 0 … 9999 | 100 | |
| | **PQ Permitted Swells/Year** | Limit for number of permitted swells per year | 0 … 9999 | 100 | |
| | **PQ Permitted rapid u-changes/Year** | Limit for number of permitted rapid voltage changes per year | | | computed each 200ms |
| | **PQ rapid ∆U-Tolerance** | Maximum allowed deviation of the actual voltage value from the previous value | 0,1 … 100% | 5% | computed each 200ms |
| Harmonics | **PWHD Begin-Harmonics** | Begin harmonics of a harmonics group for calculating the partial weighted harmonic distortion PWHD | 2 … 50 | 10 | |
| | **PWHD End-Harmonics** | End harmonics of a harmonics group for calculating the partial weighted harmonic distortion PWHD | 2 … 50 | 20 | |
| Relais-Parameters | **REL-Setting** | defines the limit monitoring function | Inactive<br>Normally Open<br>Normally Closed | Inactive | The message is captured and transmitted onto<br>• the incorporated relay<br>• the activated data memory (USB-A interface or CF-card) together wit date and time<br>• the Ethernet LAN- Interface |
| | **REL-Mode** | defines the operating mode of the relay with respect to the operating potential | remains set<br>sequential<br>pulse | sequential | only active only when monitoring function is activated |
| | **REL-Pulse Duration** | defines the operating mode of the relay with respect to the duration | 1 … 3600 | 1 s | only active only when monitoring function is activated |
| | **Power Factor Nominal Value** | predefined power factor (cosφ) for calculating the reactive power correction | 0,200 | 1 W/VA | |
| Events Parameter | **Enabled Events** | defines the events enabled for recording | table events | | ∆U-slow / ∆U-rapid / Aux. supply<br>V-drop / Neutral Overvoltage. / U-Imbalance<br>Dip Begin / Swell Begin / Transients<br>Harmonics / Flicker / Frequency |
| | **Events: Inputs enabled** | defines the measuring inputs enabled for recording | U1, U2, U3, U4<br>I1, I2, I3, I4 | alle | |

## Setup – Reset of measured values (drag pointer function)

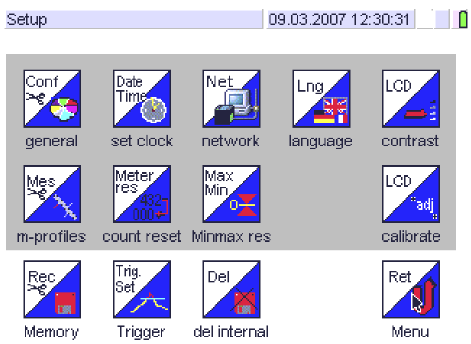
| | Parameter | Description | Settings Range | Default Setting | Notes |
|---|---|---|---|---|---|
| Counter reset | **Count reset** | Reset of accumulated energy (energy measurement) and events (PQ) | reset/ abort | none | with confirming of reset the reading of all accumulated meter values are seset to 0,000. Demand energy quantities are excluded. |
| Min/Max reset | **MaxMin res** | Reset of meter reading of all energy meters | reset/ abort | none | |

### 4.4.3 Storage Parameters

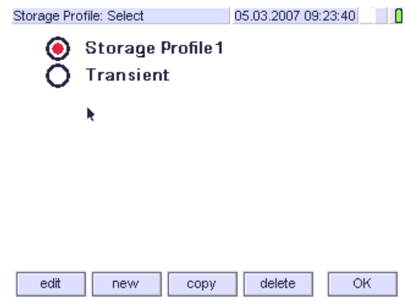
**Setup > Memory > Storage Profile: Select > edit**

This configuration menu consists of two pages with a list of all storage parameters for the available measuring functions. Closely related parameters were listed on successive pages.

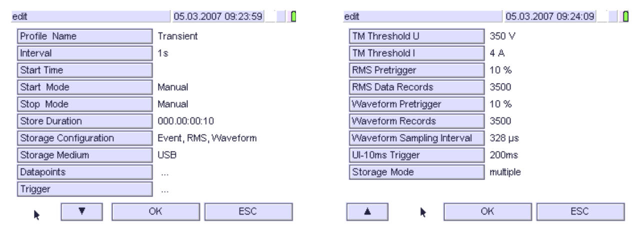
The selected storage configurations are stored in parameter files. Up to six different storage configurations can be filed in six different storage configuration files.




**Opening selection menu:** **Memory > Storage profile**
**Edit storage profile:** **Storage profile > select > edit**
**Save configuration:** **OK**




**Configuration Menu Storage Parameters**




**Configuration Menu Storage Parameters**

**Setup-Parameter for Configuring Storage Parameters**

| | Parameter | Description | Settings Range | Default Setting | Notes |
|---|---|---|---|---|---|
| | **Profile Name** | Individual Caption under which the following parameters are stored | max. 25 characters | Storage profile *n*+1 | *n* = Number of already defined storage profiles |
| | **Interval** | Time distance for storing records on the selected storage medium | 0,2 / 1 / 2 s<br>5 / 10 / 30 s<br>1 / 2 / 5 m<br>10 / 15 / 30 m<br>1 / 2 / h<br>Sync ext. | 1s | Setting applies for all measuring functions except:<br>- Power Quality Parameters according to EN 50160 / IEC 61000-4-30<br>- Transients measurement |
| | **Start Time** | Defines the time point from which the storage of records begins on the selected storage medium | immediately<br>time<br>extern | immediately | Reset to actual time after reset |
| | **Start Mode** | Parameter starting a record | manual<br>time<br>trigger<br>extern<br>extern inverse | manual | |
| | **Stop Mode** | Parameter for stopping a record | manual<br>duration<br>trigger<br>extern<br>extern inverse | manual | |

| | Parameter | Description | Settings Range | Default Setting | Notes |
|---|---|---|---|---|---|
| | **Store Duration** | Duration of data recording | | 10 s | Applies only fort the Stop mode duration |
| | **Storage Configuration** | Enabled storage configuration | - Interval<br>- Event<br>- RMS<br>- Waveform | Interval | |
| | **Storage Medium** | Enabled storage medium | - USB<br>- CF-Card<br>- Intern | USB | |
| | **Datapoints** | Defines the enabled measuring Quantities | | | Up to 1000 datapoints may be selected for each measurement run |
| | **Trigger** | Defines the threshold values for exceeding specified values of at maximum four selectable quantities | -- | -- | |
| | **TM Threshold U** | Defines the threshold value for the absolute value of the sampled voltage level | | 350 V | Applies for all voltage inputs with respect to Uratio |
| | **TM Threshold I** | Defines the threshold value for the absolute value of the sampled current level | | 1 A | Applies for all current inputs with respect to Iratio |
| | **RMS Pretrigger** | Temporal trigger position in % for effective values, related to the selected time duration of the actual recorded RMS-event | 10 / 30 / 50 / 70 / 90 | 30 % | half-period effective values $U_{rms1/2}$ |
| | **RMS Data records** | Defines the number of date records of effective values for each RMS-event | 300 .. 30k | 300 | half-period effective values $U_{rms1/2}$ |
| | **Waveform Pretrigger** | Temporal trigger position in % for effective values, related to the selected time duration of the actual recorded transient event | 10 / 30 / 50 / 70 / 90 | 30 % | applies for samples values |
| | **Waveform Records** | Defines the number of data records of effective values for each transient event | 300 …3500 | 300 | applies for samples values |
| | **Waveform Sampling Interval** | Defines the scanning interval for wave points of data records | 10 / 20 µs<br>41 / 82 / 164 µs<br>328 / 656 µs | 20 µs | |
| | **U-I 10ms Trigger** | Defines the aggregation time interval for U and I trigger | 10ms / 200ms | 10ms | |
| | **Storage Mode** | Sequence triggering and display mode for wave-form recording | single / multiple | multiple | single: write protection storage: recording from the first event occurred with automatic reactivation of the trigger onto the storage is filled up<br>multiple: continuous recording of all recognizable events with automatic reactivation of trigger. When the storage is filled up the oldest data were overwrit-ten blockwise. |

## Setup - Trigger

| | Parameter | Description | Settings Range | Default Setting | Notes |
|---|---|---|---|---|---|
| **Set Trigger** | **Enable Measured Quantities** | Defines the quantities for indicating the limit exceeding | 0 … 4 | -- | Up to 4 measured quantities may be enabled for each measurement run |
| | **Maximum [Quantity]** | Defines the upper limit of the limit indicator function | Corresponds to the value range of the selected quantity | none | For Uratio ≠ 1 and Iratio ≠ 1 the calculation relates to the primary signal |
| | **Minimum [Quantity]** | Defines the lower limit of the limit indicator func-tion | Corresponds to the value range of the selected quantity | | Corresponds to the value range of the selected quantity |

## Setup – Erase Stored Data

| | | | | | |
|---|---|---|---|---|---|
| **Storage clear** | **Del Internal** | Erases stored data on the internal memory | | | |

## 4.5 Storage Configuration

**Setup > Memory > Storage Profile: Select > edit**

In the menu memory configuration, the data carrier parameters being valid for all measuring functions are adjusted. The configurations are stored in parameter files. Up to 6 different store configurations can be filed (→ chapter 5.6-ff).

Different storage media are available for recording and representing interval data, event data and statistical data:

- The POWER1000 includes an **internal non-volatile NAND- flash**, in which the result of measurements and application-specific data are stored as files.
- Moreover, all measuring files as well as the display content can be transmitted to a plugged-in CF-Card (compact flash card) or a USB data carrier plugged-in to the USB-port.

The measuring data are filed in a list with a user definable name as measured data files. The four different measuring modes interval, r.m.s-signal, waveform and event are assigned to different file formats which are distinguished through different file extensions.

| Measurement File | Kennung / Extension |
|---|---|
| Interval measuring data (interval storage) | Sequential Number, 5-figure/ mw50i<br>Sample: 00001.mw50i |
| Signal measuring data (RMS storage) | JJJJ-MM-TT_hh;mm;ss_ms_DP_ … DP.mw50r<br>Sample: 2005-11-16_14;23;16_320_60,61,62.mw50r |
| Waveform meas. data (waveform storage, scope, transients) | JJJJ-MM-TT_hh;mm;ss_ms_ / mw50r<br>Sample: 2005-11-16_14;23;16_320_DP_…DP.mw50w |
| Event measuring data (event storage, num.) | Current number, 5-place / mw50e<br>Sample: 00017.mw50e |

Measurement files are automatically created after recognition of measuring mode. Type and number of the files are dependent on the selected measuring function. This allows for storing interval data, event data, waveform data, cyclical data (maxima, minima) as well as statistics simultaneously in different files.

A recording can be stared and ended manually, time controlled or automatically. The number of the possible records is dependent on the storage capacity of the storage medium, the type of measuring data and the selected time duration of the recording.

The recording density is appr. 250.000 measured values each MB Storage capacity.

The recorded measuring runs, measuring data, evaluations etc. can be displayed on the LC-display in a display format corresponding to the function.

Independent from a current recording, the measuring data of a selected function can be displayed on the LC-display.

The memory space requirement depends upon the chosen storage function, the number of measuring quantities for each data record, the recording interval and the number of events. For recording interval data, the memory space requirement can be calculated: it results from the number of data points (measurement quantities), multiplied by the storage interval and the measurement time interval:

Storage capacity = Itv x t x Z

- Z: Number of data points
- t: Measuring time interval
- Itv: Storage interval

Additionally, each start and stop of recording requires a header with a capacity which depends upon the number of data points.

At simultaneous recording of cyclical (interval) and event controlled data – at which the time distance of occurrence cannot be predicted – the recording time cannot be determined.

The maximum number of data records which can be achieved depends upon the chosen storage medium and the selected storage types. Therefore, the storage menu views only the yet available storage capacity.

**Note:** In order to avoid a storage overflow it is recommended to perform a test record before starting the recording. In this way, the storage demand can be determined. At increased occurrence of events, this method does not lead to the required result. Otherwise, it excludes the wrong adjustment for transient limits (to low). This leads to storage overflow within short time.

### 4.5.1 Changing the Memory Configuration

**Entering:**

**- in the main menu:** **Setup > Memory > edit**

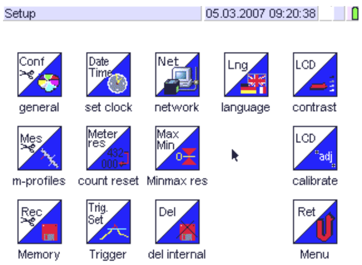
**- in the measuring mode:** **Store > Memory Profile > edit**

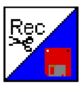
**or:** **ON|MENU > Store > Memory Profile > edit**

The entry into the menu memory configuration is performed via the symbol ***SETUP*** in the main menu or via the button memory in the display format of the current measurement mode. This allows for fast access if changes in the memory configuration should be made.

### Opening the Menu Memory Configuration in the Main Menu


Touch the key ***SETUP***. ⇒ The display enters the selection menu Setup.

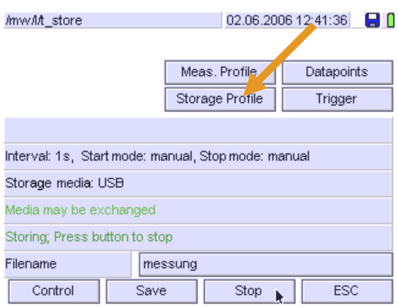



Touch the Symbol ***Memory***. ⇒ The display enters the list of storage profiles.


### Opening the Menu Memory Configuration in the Measuring Mode


Touch the Key ***Memory*** in the actual display format. ⇒ the display enters the ***Storage menu***.





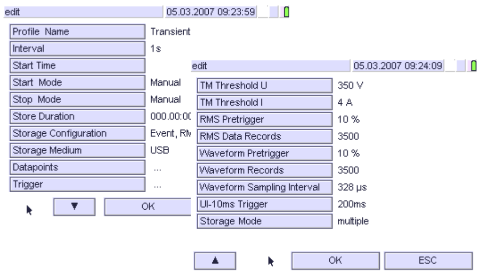
With a touch on the key ***Storage Profile*** the display enters the list of storage profiles. ⇒ The actual storage profil is marked with a red point in the circle.

⦿ In the storage profile list, select the profile which may be changed.

neu With ***new*** you can add a further profile. Six storage profiles are possible at most.

entf With ***delete*** you erase a storage profile from the list. The cancellation request must be confirmed with ***OK***.

***edit*** The LC-display enters the parameter menu. It consists of two pages where the storage parameters are listed.




▲▼ With the scroll cursors you can page in the parameter menu.

☞ With touching the corresponding key you open the desired storage parameter.

Adjust the parameter according to you decision (see → sections from 4.2.3 to 4.2.6).

ESC With touching ***ESC*** you return to the list of storage profiles without performing a change of storage parameters.

OK Acknowledge the changes with ***OK*** after adjusting.

⇒ The display returns to the list storage profiles, the parameters are changed according to the desired configuration.

OK With touching OK again the display returns to the storage menu.

Messung 1

Enter the name for the Measurement:

**[name]** With ***File Name*** you open an alphanumeric field in which you enter the name of the measurement.

☞ In order to avoid conflicts between the Linux operating system of the device and the Windows system usually installed on the PC entry of small letters is possible only.

Enter With ***Enter*** you return to the storage menu.

☞ Recording is started by touching the Key ***Start*** in the foot line of the storage menu or according to the adjusted staring parameters under the actual file name.

## 4.6 Assigning Measuring Quantities

**SEL1...SEL5 > Selection**

In the measuring functions SEL1 to SEL5 measuring, any measurement quantities can be assigned. The number is limited to 1000 measurement quantities at the sampling rate of 6,4 kHz.

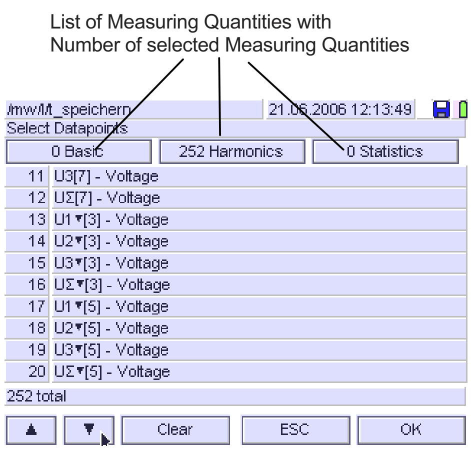
Assigning a selection of measurement quantities is performed in several Steps. In the following description it is assumed that the device in the measuring mode of any function except for SEL1 ... SEL5.

**ON|MENU** **with the key *ON/MENU*** the display changes into the Main Menu

**SEL1...4** Touch the soft key SEL1 or optional SEL2 to SEL5. The device changes into the measuring mode.

⇒ The Display presents the selection of measurement quantities in the last selected assignment.

Auswahl Touch the key **Selection.** The display enters the display format ***List of Measuring Quantities***.




▲▼ With the scroll cursors you can page in the list. Cursors were indicated only when the list incorporates more than one pages.

For a clear view, the functionally related measuring quantities are summarized in the three lists ***Basic Quantities***, ***Harmonics*** and ***Statistics***.

clear With ***clear*** the entire selection of measuring quantities will be erased.

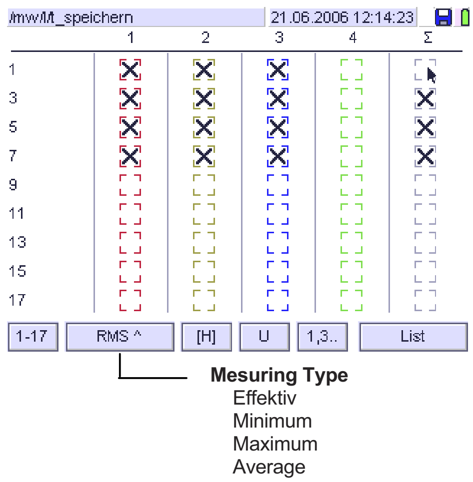
OK With ***OK*** you return to the Measuring mode.

### 4.6.1 Changing of the selection of measurement quantities and modes

**SEL1...SEL5 > Selection > List**

**Selection** In the Selection Menu select the list in which the quantity to be changed is listed.

⇒ The display enters the desired list of measurement quantities. This consists of several pages in which the available measurement quantities are represented functionally separated for each channel on a table. The first column views the designation of the measurement quantities, the following columns represent the channels 1 to 4 and the virtual sum channel Σ. In addition, for each channel the measuring modes ***instantaneous value***, ***mean value***, ***maximum*** and ***minimum*** are available.




The activated measuring quantities and measuring types are marked with [x].

▼ With the scroll key ▼ you select the page in which the desired measuring quantity is listed.

**[Meas.Type]** With the Touch Key for the ***Measuring Type*** you select the desired measuring type.

☞ Touch to the field in which you want to change the selection by using the incorporated stylos. In this way you activate a deactivated measuring quantity or deactivate an activated respectively.

⇒ When you touch on the channel designation in the head line, you activate or deactivate all measuring quantities listed in this channel column.

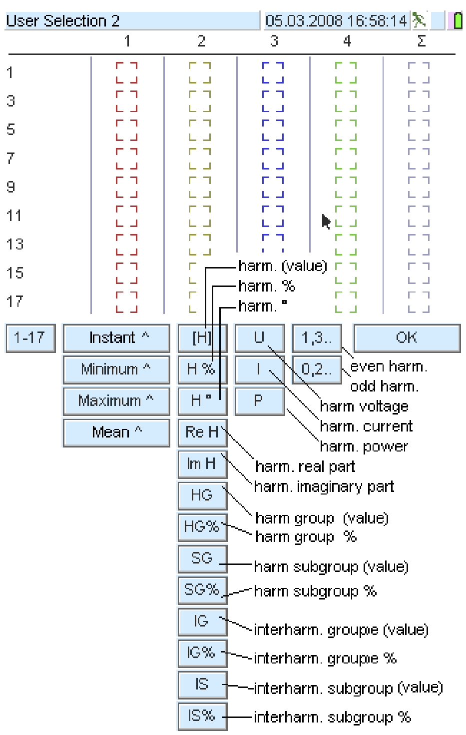
**[List]** With List you return to the display format ***List of Measuring Quantities***.

**OK** With ***OK*** you return to the measuring mode.

### Setup Notes

The measurement quantity lists include several pages in which the measurement quantities, the measuring modes and the statistical evaluations are separately listed in a functional relation. With the scroll key you change successively the pages in the list of measurement quantities.

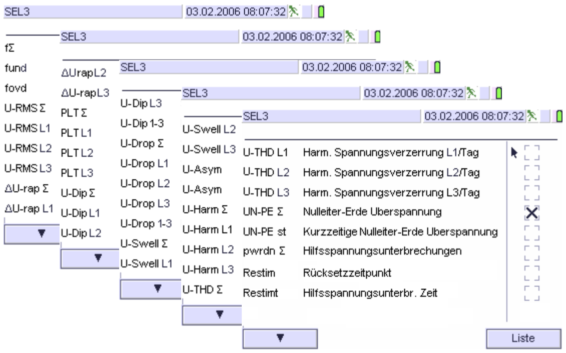
The extent of the harmonics measurement requires a subdivision of the list in even and odd harmonics, voltage and power harmonics, harmonic groups and harmonics subgroups.




With the Touch Key ***Measuring Type*** you can enter the list for instantaneous value, maximum, minimum or average value respectively. For energy measuring quantities additional pages are available for power and power demand.

In the attempt to define a not permissible measuring type for a measuring quantity the entry is not accepted.

The list statistics includes 5 pages with statistical values which in particular are used for power quality measurements in accordance with the standard EN 50160. They can be selected together with other measuring quantities in SEL1 to SEL5.




When assigning lists of measurement quantities for long-term recording, it is usually more advantageous to record maximum and minimum values for a given measured quantity at larger time intervals, instead of recording instantaneous rms values at short time periods. This reduces the amount of recorded data considerably and extends the possible recording time, although a minimal amount of data is lost: The measurement fluctuation range for the measured quantity which occurs during the interval is still apparent. Merely the date of occurrence of the registered extreme values can only allocated only to the temporal solution of the chosen time interval. Moreover the function Power Quality PQ allows for recording short-term events with a time stamp in a 10ms grid.

## 4.7 Remote Control via Web Server

**Setup > Network > Edit**

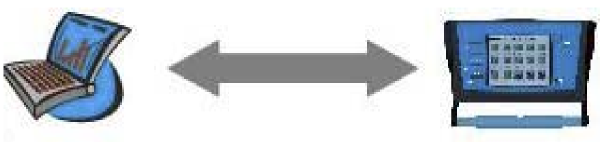
The ethernet 10/100 connection together with the integrated web server provide for remote control and interrogation of the POWER1000. For that the actual LC display format is downloaded to the remote computer by request and displayed on the monitor connected there. Furthermore, the LC display of the POWER1000 can be changed via the request of the remote controlled computer. Consequently all operating Steps which can be performed on the display of the device can also be performed via the monitor connected to the remote computer and transmitted onto the device by clicking the desired function.

Exceptions: Switching off the device and changing the IP-address of the device are not possible remote controlled.

### 4.7.1 Setting-up the Communication Path

**Direct Communication Device – PC (e.g. Laptop)**

☝ Before starting the transfer, adapt the ethernet protocol of the device to the infrastructure of your network. → See section 2.2.3



**LAN-Cable (RJ 45 Cross-Connect)**

☞ Connect computer and POWER1000 via the cross-over- LAN-cable with RJ45-jacks on each side.

☞ Arrange the internet protocol on you computer via Setup / Network connections / Characteristics / Internet Protocol (TCP/IP).

***Note:***

Since you do not work via the network at direct connection of your personal computer and the POWER1000, you must enter the suitable IP attitudes manually. Therefore, in the entry window for the network of the pc select ***manual*** for the parameter ***use following IP address***. The entry for the subnet mask in general is automatically carried out, for standard gateway enter the address predefined in the POWER1000. Otherwise, ask the system administrator in order to receive the suitable IP attitudes.

☞ Start communication via the web browser with entering the address http//: <device address>/ and Enter.

⇒ The monitor connected to the pc displays the entry format for remote control.

Enable remote control with a click on ***POWER1000 remote control***


**Communication Device – PC via Internet**

☞Before connecting the POWER1000 to the network, match the ethernet protocol of the device for the infrastructure of your network. Ask the system administrator in order to receive the suitable IP attitudes (see → cap. 2.2.4).

☞ Connect POWER1000 via a LAN-patch-cable with RJ45-jacks on each side to the hub (or switch) in your network.

***Note:***

If your hub (switch) supports autorouting you can use a cross-connect as well as a patch cable.

☞ Start communication via the web browser with entering the address http//: <device address>/ and Enter.

# 5. Operation

## 5.1 General Notes

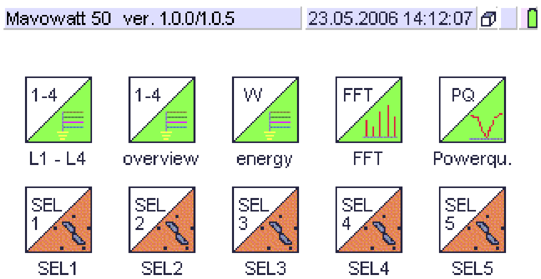
Basically, various methods are available for selecting and adjusting the operating parameters. In this chapter, the selection and the adjustment is described mainly over the menu.

After switching on the instrument the display shows the main menu. During a power fail the incorporated accumulator takes over the supply of the instrument for a short time (< 30min). Therefore, it is not required to maintain the current function in case of a mains failure.

## 5.2 Selecting Measuring Functions and Evaluations

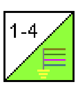
### 5.2.1 Selecting a Measuring Function

Touch the **ON|MENU** button. The display enters the main menu and presents the touch key symbols for the ***main functions***.



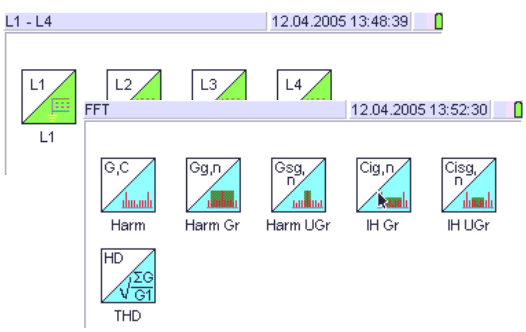

The touch keys [L1…L4], [View], [Energy], [FFT] and [PQ] represent measuring functions with predefined quantities, they cannot be changed.

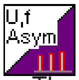
In the measuring functions SEL1 to SEL5 the quantities can be assigned by the user according to the application. (→ chap. 4.6). The maximum number of quantities is limited to 1000 for each assignment.




By touching the corresponding ***Touch Key*** in the main menu the selection menu for the desired ***Measuring function*** is opened.

Exception: In the measuring functions SEL1 to SEL5 the display enters the measuring mode without intermediate Step.






Select the desired measuring function by touching at the corresponding touch key.

⇒ The display enters into the previous selected display format.

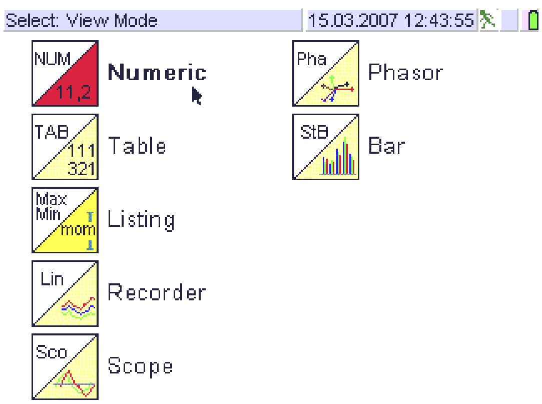
### 5.2.2 Selecting a Display Format (Measuring Mode)

For the representation of measuring values, measuring series and evaluations various display formats are available. In the single measuring functions only the suitable display formats can be opened. Furthermore, the appropriate format is up to the user.

The made selection is marked red. It remains valid for the current measuring function up to the next change. However, the represented measurement variables themselves change with the measuring function. If the current display format is not practicable for a measuring function, it is not presented in the format selection menu.

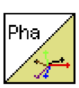
**Operating Procedure:**


Touch the key ***Display*** in the context related foot line to open the display format selection menu.





Touch ***ECS*** to discard changes in the display format.



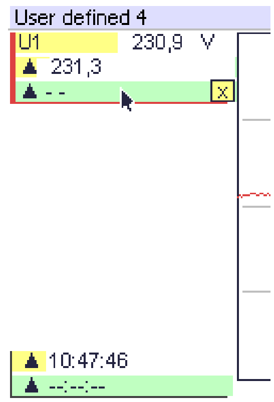

Touch the corresponding ***Key Symbol*** to enter into the desired display format.

play enters into the selected display format. The device remains in the measuring mode.

### 5.2.3 Selecting Measurement and Display Parameters

With the context dependent ***touch keys*** in the foot line the actual measurement and display parameters can be adapted to the actual conditions. Entering the setup menu is not required.

view — Selection of the representation type. For the current measuring function only applicable display formats can be selected.




profiles — Open the selection format ***m- profile***. With profiles configuration menu for the selected measuring > [m-profile] > edit opens the profile (→ chap. 4.4.2).

memory — Enter the memory setup menu for start and for adjusting the stopping a recording as well as recording parameters (→ chap. 4.4.3 and 4.5).

select — Display or change the assignment of actual measurement. Applies only for SEL1 to measurement quantities for the SEL5 (→ chap. 4.6.f).

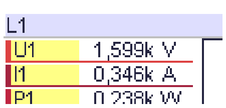
Stop / Start — „Freezing“ the actual display (hold status). The touch Key changes to ***Start***. With touching start the displayed measuring values are refreshed in the seconds clock cycle.

ESC — One operating step back

### 5.2.4 Enabling and Disabling Cursor Lines

The graphic display formats (recorder, scope, harmonics bar and phasor) show alphanumeric fields with frame lines in the colour predefined for the different phases and channels. Additionally, up to two horizontal and vertical cursor lines can be enabled and moved over the axis by the stylos. The numeric field on the left side of the display format shows the measuring data for the actual cursor positions (measuring value, time, date, harm. order etc) and thus allows for analysing the measuring sequence.

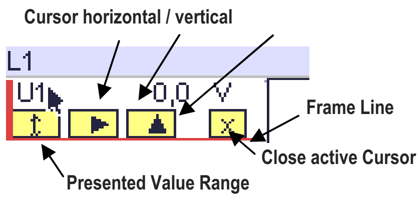
**Operating Procedure:**




①

Touch the yellow marked field of the desired measuring quantity in the alphanumeric data section.

Right under it a yellow marked field opens, fading in the scroll cursors horizontal ►, vertical ▲ and the represented value range ↕. The colour frame in the numeric field now also encloses the cursor field allocated to the measuring quantity.

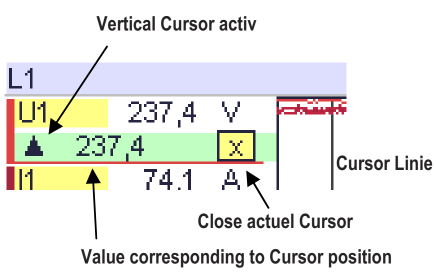



②
Touch at the symbol for the desired cursor

⇒ A green coded field is opened in the numeric field viewing the symbols for the selected type or cursor (vertical/horizontal) and the symbol for closing the field. The symbol “- - refers to the cursor position that was not yet selected or is outside of graphic display section. The same applies to the green field at the bottom left side for viewing the time corresponding to the cursor position.

The colour frame now encloses the fields for the measuring quantity and the allocated cursor field.

③
Touch at any or a desired dot within the graphic representation. The selected cursor line appears.





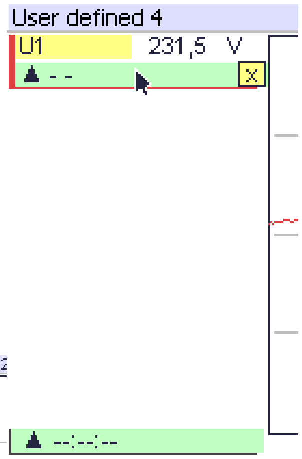
Additionally, the measuring value according to the cursor position is displayed in the green cursor field.
The green field at the lower left margin of the display shows the time related to the active vertical cursor ▲.

The above described procedure for the vertical cursors also applies for the horizontal Cursors.

④

Open the second cursor line in the way described before:


Touch at the yellow coded field of the same measuring quantity. The second cursor field fades in.

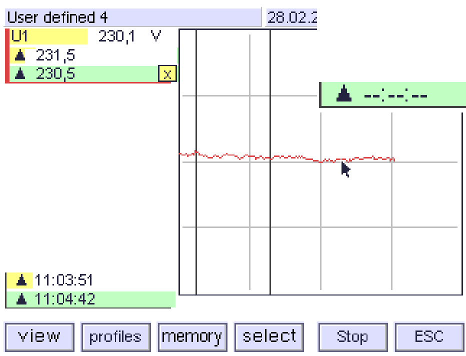



Select the desired cursor (vertical/horizontal) in the opened cursor field. The back-ground changes to green, the cursor is activated. Simultaneously, the background of the first cursor fades out.

The time corresponding to the second cursor appears in a second field faded in at the bottom left side. For the active cursor the field is green coded.

⑤

Touch at any or a selected dot within the graphic display. ⇒ Measuring value and time are displayed for the selected cursor position.




***Note:***

From the displayed cursor lines, one of each the vertical and horizontal can be moved over the screen with the stylos. The numerical presentations in the fields marked with a green background refer to the active cursors.

### ⑥ Fading out a Cursor Line

Touch the symbol  to close the current cursor line. Repeat the procedure for the other faded in cursor lines.

### 5.2.5 Reset Meter Readings, Maxima and Minima

Meter readings and extreme values are maintained up to their reset. In special, this applies for
- the energy cumulated from the last resetting date
- the maxima and / or minima of one ore more measuring quantities, recorded from the last resetting date
- the limit exceedings defined for the compatibility levels of power quality from the last resetting date.

If meter readings, maxima and minima shall refer to the actual measurement they must be reset before starting.

> **Important note:**
> Reset meter readings, minima, maxima and statistics before starting a recording. During recording reset is not possible.

**Operating Procedure**

a) Reset of Counter Readings

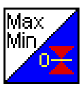
**Select: Setup > Count Reset**


After touching the key **Meter Res** a dialog window is opened in which the reset can be confirmed or discarded.

The meter readings of all energy quantities are reset after confirming the reset.

b) Reset of Maxima and Minima

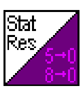
**Select: Setup > MaxMin Reset**




After touching the key **MaxMin reset** the captured maxima and minima of all relevant measuring quantities are reset.
See statistic display mode, → chap. 5.3.6

c) Reset of Event Statistics

**Select: PQ > Stat Reset**

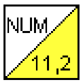



After touching the key **Stat reset** the counted exceedings of the power quality compatibility level are reset.

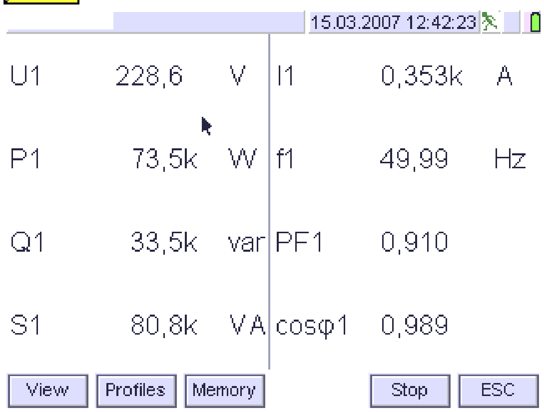
## 5.3 Display Modes for Time Controlled Measuring Data

### 5.3.1 List View – Numeric Display of Measured Quantities

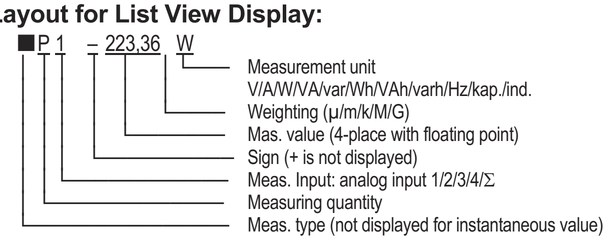
Available for: L1-L4 / L1...L4 / W / FFT / SEL1... SEL5




Current measuring values for measured quantities available in the selected function are displayed numerically.




**Layout for List View Display:**




Measuring values of the actual function are displayed in one display page. If more quantities are defined than space allows for one page, a yellow bar at the right or left margin of the screen points out further screen pages. In particular this applies for the user definable functions SEL1…SEL5. The sequence of the measuring quantities is predefined, it cannot be changed.

The character height for the displayed numeric measurement values varies automatically depending on the number of measured quantities to be displayed.

Viewed time data may fluctuate for by as much as 1 second due to rounding off or up. Measurement values are displayed with weighting factors (µ, m, k, …), the units of measure are viewed in the headline for each column or in the right column each line.

In the operating mode **Sample** the measuring values are refreshed in the predefined time interval of one second.

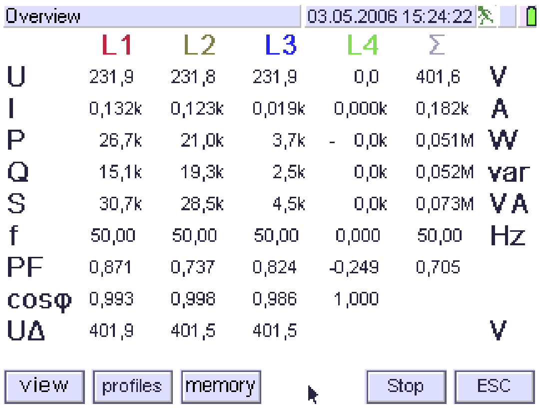
Measurement is stopped after changing to the **Hold** mode, and the last captured measurement values are displayed continuously.

**Note:** Reset of meter readings, maxima/minima and event statistics see → chap. 5.2.5

### 5.3.2 Overview – Tabular View of Measured Quantities

Available for: L1-L4 / Overview / SEL1... SEL5

Current measuring values for measured quantities available in the selected function are displayed for the three phases in the three phase three wire system and for the neutral in the three phase four or five wire system.



Overview 03.05.2006 15:24:22

| | L1 | L2 | L3 | L4 | Σ | |
|---|---|---|---|---|---|---|
| U | 231,9 | 231,8 | 231,9 | 0,0 | 401,6 | V |
| I | 0,132k | 0,123k | 0,019k | 0,000k | 0,182k | A |
| P | 26,7k | 21,0k | 3,7k | - 0,0k | 0,051M | W |
| Q | 15,1k | 19,3k | 2,5k | 0,0k | 0,052M | var |
| S | 30,7k | 28,5k | 4,5k | 0,0k | 0,073M | VA |
| f | 50,00 | 50,00 | 50,00 | 0,000 | 50,00 | Hz |
| PF | 0,871 | 0,737 | 0,824 | -0,249 | 0,705 | |
| cosφ | 0,993 | 0,998 | 0,986 | 1,000 | | |
| UΔ | 401,9 | 401,5 | 401,5 | | | V |

view profiles memory Stop ESC

In the operating mode **Sample** the measured values are refreshed in the predefined time interval of one second.

Measurement is stopped after changing to the **Hold** mode, and the last captured measurement values are displayed continuously.

***Note 1:***

Measured values under L1 up to L4 are viewed with regard to the parameter settings (U-connection, Uratio, Iratio, etc.).

Measured values under Σ are calculated with regard to the quantities in the three phase three wire and four wire system. As far as defined in the standard „DIN 40110-2 multi conductor circuits“, the quantities are calculated as collective quantities according to this standard. Measuring quantities not being defined as collective quantities are calculated as average values for the single phases L1, L2, L3).

***Note 2:***

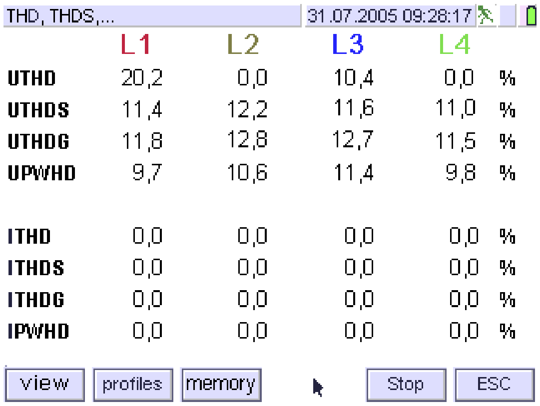
If no usable signal is available for the frequency detection, the nominal values are displayed in the Σ column, together with the nominal values of the phase voltages.

For frequency measurement, see also → chap. 2.3.

### 5.3.3 Tabular View of Distortion Factors of Current and Voltage

Available for FFT

The numeric view shows the relation of the harmonics or a harmonic group to the effective value of the fundamental in percent for all phases, the neutral and the three phase three wire or four wire systems.




***Note 1***

Among other specifications, the supplements to the standards IEC EN 61000-3-2:1995/A14:2000 and IEC EN 61000-3-2/A1:2001 require measurement methods for harmonics exclusively according to regulations of IEC EN 61000-4-7: 2002.

In the standards, in addition to the integer harmonics the interharmonics components are defined. As a consequence, probes creating interharmonics are weighted more server. Moreover, harmonic groups are defined providing a suitable evaluation for distinguished control procedures, such as pulse packet or phase angle control.

For evaluating interharmonics, according to standard it is not required to evaluate the single interharmonics by value or by percent. They are added to the individual harmonics by calculating their square route.

***Note 2***

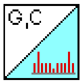
According to the old standard, only the integer harmonic components had to be calculated and evaluated for a time interval of 320ms.

The new standard requires calculation of 500 harmonics and interharmonics up to the 50th order for each phase and for a time interval of 200ms. This means a reasonable increase of calculation power which can only be maintained by a powerful processor system.

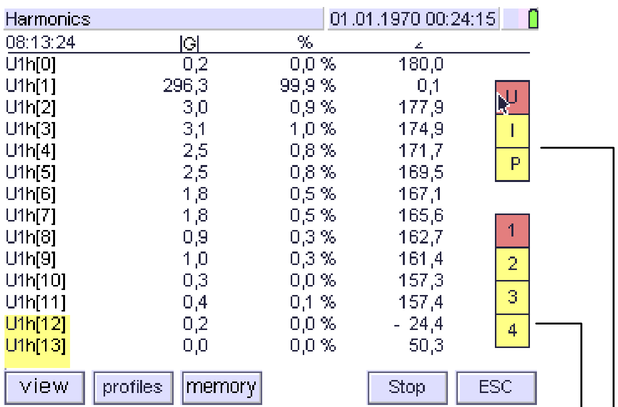
For description of the single harmonic or interharmonic groups see appendix A.

### 5.3.4 Tabular View of Spectral Shares of Current, Voltage and Power

Available for FFT (Harmonics and Interharmonics)



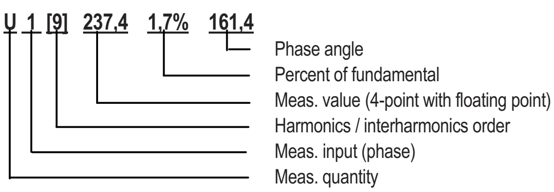

The format presents the actual measuring values of the spectral shares of current, voltage and power on several display pages together with value, percentage from the fundamental and respective phase angles. The number of pages depends from the selected measuring quantity.




**Layout of Tabular View of Harmonics Display:**

Selection of phase

Selection of Meas. Quantity U, I or P




In the operating mode **Sample** the spectral shares of the selected phase are displayed. They are refreshed in the predefined time interval of one second.

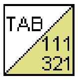
The selection fields at the upper right margin of the display refer to the measuring quantities; those at the lower right margin refer to the phases. The display changes into any desired view by touching the corresponding keys for the desired phase and quantity. The selected phase and quantity are marked red.

The yellow marked measuring quantities at the right margin refer to further display pages. The display changes to the next or preceding page by a touch on the yellow field.

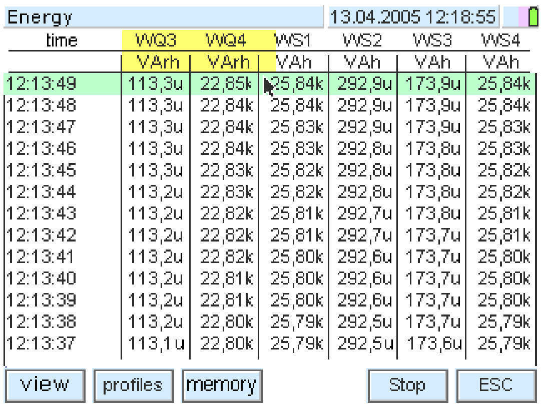
Measurement is stopped after changing to the **Hold** mode, and the last captured measurement values are displayed continuously.

### 5.3.5 Tabular View of Interval Measuring Data

Available for W / SEL1 … SEL5



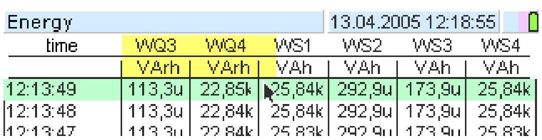

Numeric display of periodically sampled measuring data contained in the active memory as measuring value / time table.




| time | WQ3 | WQ4 | WS1 | WS2 | WS3 | WS4 |
|---|---|---|---|---|---|---|
| | VArh | VArh | VAh | VAh | VAh | VAh |
| 12:13:49 | 113,3u | 22,85k | 25,84k | 292,9u | 173,9u | 25,84k |
| 12:13:48 | 113,3u | 22,84k | 25,84k | 292,9u | 173,9u | 25,84k |
| 12:13:47 | 113,3u | 22,84k | 25,83k | 292,9u | 173,9u | 25,83k |
| 12:13:46 | 113,3u | 22,84k | 25,83k | 292,8u | 173,8u | 25,83k |
| 12:13:45 | 113,3u | 22,83k | 25,82k | 292,8u | 173,8u | 25,82k |
| 12:13:44 | 113,2u | 22,83k | 25,82k | 292,8u | 173,8u | 25,82k |
| 12:13:43 | 113,2u | 22,82k | 25,81k | 292,7u | 173,8u | 25,81k |
| 12:13:42 | 113,2u | 22,82k | 25,81k | 292,7u | 173,7u | 25,81k |
| 12:13:41 | 113,2u | 22,82k | 25,80k | 292,6u | 173,7u | 25,80k |
| 12:13:40 | 113,2u | 22,81k | 25,80k | 292,6u | 173,7u | 25,80k |
| 12:13:39 | 113,2u | 22,81k | 25,80k | 292,6u | 173,7u | 25,80k |
| 12:13:38 | 113,2u | 22,80k | 25,79k | 292,5u | 173,7u | 25,79k |
| 12:13:37 | 113,1u | 22,80k | 25,79k | 292,5u | 173,6u | 25,79k |

In the operating mode **Sample**, the uppermost line always views the current time with the refreshed measured values. At the end of the cycle time, these data are displaced into the line under it and the following lines are moved one line down by each.

Six measuring quantities at maximum can be displayed in the display window simultaneously. If more than six quantities have been defined or selected in a function, yellow marked fields in the header refer to additional quantities. These are shifted into the display window by touching the right or left yellow marked field. The yellow fields do not apply when no more than six measuring quantities are available.




| time | WQ3 | WQ4 | WS1 | WS2 | WS3 | WS4 |
|---|---|---|---|---|---|---|
| | VArh | VArh | VAh | VAh | VAh | VAh |
| 12:13:49 | 113,3u | 22,85k | 25,84k | 292,9u | 173,9u | 25,84k |
| 12:13:48 | 113,3u | 22,84k | 25,84k | 292,9u | 173,9u | 25,84k |

Measurement is stopped after changing to the **Hold** mode. The actual memory content is “frozen”, and the operator can browse through the memory with the scroll cursors ▼▲ and ◀▶ respectively.

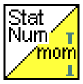
The functions of the context related touch keys in the foot line correspond to that of other display formats (→ chap. 5.2.3).

The sample above shows the listing of the effective values of energy data of L1, L2, L3 and L4, measured and refreshed every second.

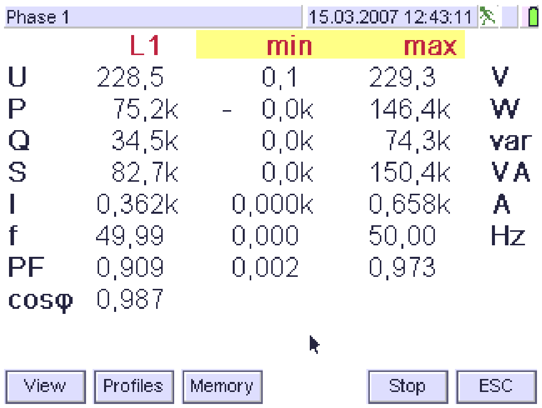
**Note:** Reset of meter readings of energy measuring quantities see → chap. 5.2.5

### 5.3.6 Statistics View

Available for L1 / L2 / L3 / L4 / SEL1…SEL5




Representation of actual measured values together with highest and lowest measured values since the last reset.

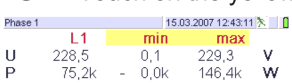



The measured values shown in the columns min and a max refer to the lowest and highest value which occurred since the last reset (drag indicator). The value represented in the phase column refers to the current instantaneous value which changes with the refresh cycle of the seconds clock pulse.

**Note:** If the measurement type maximum (e.g. ▲U1) or minimum (e.g. ▼U1) is selected in a SEL function for measurement quantity, the corresponding values in the phase column refresh in the seconds clock pulse, which means that the seconds clock maxima or minima are displayed. The device itself cannot distinguish between correct and unsuitable display formats. The proper selection remains left to the user.

**Operating Procedure for Resetting Maxima and Minima:**

① Touch on the yellow marked field in the main screen




② Touch on reset button to reset max and min


⇒ **The screen views the measuring function again**

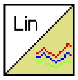
**Alternatively, enter the main menu:**

**ON|MENU > Setup > MaxMin reset > OK**

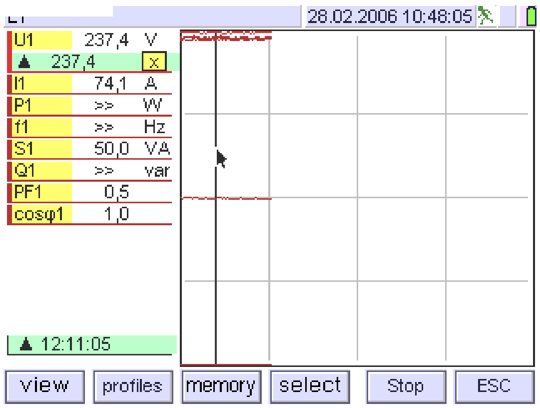
After reset, enter the desired measuring function again.

5.3.7 Graphics View (t-Y-Recorder)

Available for L1 / L2 / L3 / L4 / L1-L4 / W / SEL1…SEL5




Graphic display of measurement values in the FIFI register for defined or given measured quantities as t-Y graph.

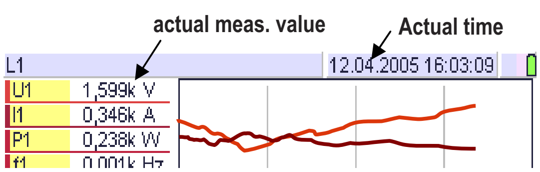



Up to eight measured quantities can be displayed simultaneously. The graph memory is not designed for a greater number of measurement quantities.

The plot is subdivided into four vertical and horizontal segments by grid lines.

Scaling of Y axes is performed automatically depending on the adjusted measuring range of the first (uppermost) measuring quantity. The respective numeric views are displayed by opening the cursor ↨ in the alphanumeric field.

The horizontally displayed time range includes 196 pixels. Each measurement value is displayed as an individual pixel. The maximum displayed time period is thus equal to 195 times the periodically sampled interval.




In the operating mode **sample**, the periodically measured data are shifted from the left margin of the image in the seconds clock to the right. The values displayed in the numeric section for each quantity correspond to the right pixel which represents the actually measured value. If the entire horizontal time range is used, that means the curve pixels achieved the right margin, the image is displaced to the left for one grid segment, so that the 49 oldest data are no more represented. The assignment of the graph to the measurement quantities and the measured values is emphasized by a frame line which shows the same colour as the corresponding graphic representation.

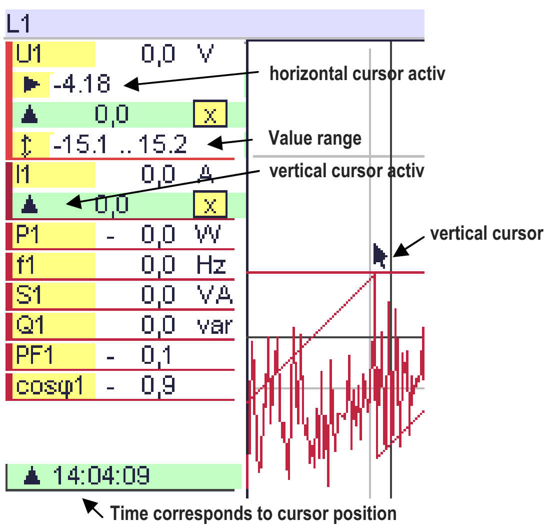
Additionally, up to two horizontal and vertical cursor lines can be enabled and moved over the axis by the stylos. Together with the values displayed in the numeric field the view allows for analysing the graphic presentation. The cursor lines can be activated independent from the operating modes Sample or Hold (see → chap. 5.2.4).

Measurement is stopped after changing to the **Hold** mode.

Stop For this purpose, touch the **stop** key in the foot line of the display. The actual memory content is “frozen”.

Open the cursor field by touching at the yellow field of the relevant measuring quantity. The numeric data display opens, showing the values according to the actual cursor position. The operator can browse through the graphic display by touching the desired pixel in the graphics display. The green field at the lower left margin of the display shows the time related to the active vertical cursor ▲.

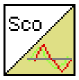
With the opened field value range ↕, maximum and minimum values for the actual measuring quantity are displayed within the represented time interval.



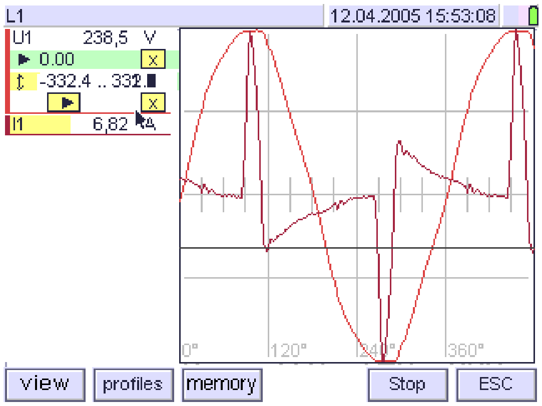

With touching at the key the actual cursor line disappears. The cursor lines can be faded in independent from the operating modes sample or hold (→ cap. 5.2.4)

### 5.3.8 Scope View (Presentation of Waveform)

Available for L1 / L2 / L3 / L4 / SEL1…4, but only for direct measured quantities U1, U2, U3, U4, I1, I2, I3, I4.




Graphic presentation of real time voltage and current waveforms, based on the actual sampled values of the analog inputs.




Up to four measured quantities can be displayed simultaneously. The desired display page can be selected by the scroll keys ▼▲.

Scaling of Y axis is performed automatically depending upon the respective signal amplitudes.

The X axis represents the time range which comprises the duration of 1⅓ periods for AC signals and is derived from the zero crossings. With this predefined time period the waveform relations between the three phases can be optimal displayed.

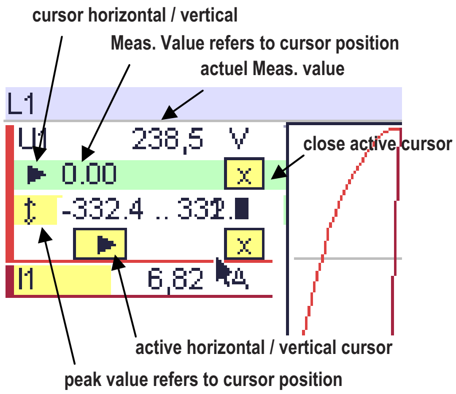
The waveform display always starts with the zero crossing of the reference measuring quantity. At stable signal relations, this is always U1. In case of dropout the period length is acquired in the voltage measurement input L2, and in case of dropout in L3 (see → chap. 2.3).

Measurement is stopped after changing to the **Hold** mode.


Touch the key ***Stop*** in the foot line of the display.

Open the cursor field by touching at the yellow field of the relevant measuring quantity.

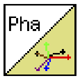
The numeric data display opens by touching at the desired cursor, showing the values according to the actual cursor position. Two for each the horizontal and the vertical cursor can be opened. The operator can browse through the graphic display by touching the desired pixel in the graphics display. The green field at the lower left margin of the display shows the time related to the active vertical cursor ▲.



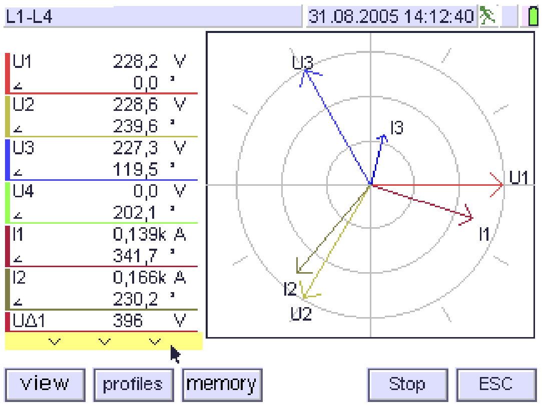

With the opened field value range ↨, the numeric field shows the peak values of the waveform for the actual measuring quantity displayed within the represented time interval.
With touching at the key [x] the actual cursor line disappears (see → chap. 5.2.4).

### 5.3.9 Phasor View (Vector Presentation)

Available for L1 / L2 / L3 / L4 / SEL1…4, but only for direct measured quantities U1, U2, U3, U4, I1, I2, I3, I4.




Graphic presentation of phase relations of the fundamental harmonics of voltage and current at the corresponding Measuring input.



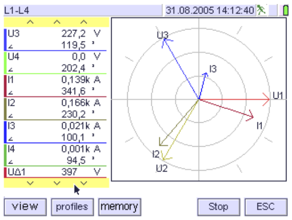

This combined numerical and graphical representation views the current measuring values to the left of the display, together with the phasors U1, U2, U3, U4 and I1, I2, I3, I4 scaled automatically with zero degrees to the right. Normally the angle of zero degrees is allocated to voltage U1. In case of dropout the POWER1000 automatically switches to U2 and in case of dropout to U3, using that voltage as reference.

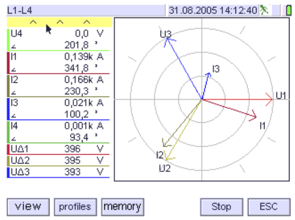
The phase relations between voltage and current are based on the phase angles of the fundamental harmonics. For calculation of the spectral shares of the signal the FFT method is applied.

Measurement is stopped after changing to the **Hold** mode.


Touch the key ***Stop*** in the foot line of the display.

By touching the yellow marked field above or below the alphanumeric display the further measuring quantities are shifted into the screen. The yellow field is dropped if no more measurement quantities than fit into the window are defined.




The Representation supplies a statement for the rotating field orientation in the three phase network. The sequence of the vectors U1-U2-U3 in the clockwise sense represents a positive sequence system.

**Note:**

In the symmetrical three-phase system, the following regulations apply to the complex rms values of the sinusodial phase-to-neutral voltages:

$\underline{U}_{1N} = U_{1N}e^{j0°}$; $\underline{U}_{2N} = U_{2N}e^{j240°}$; $\underline{U}_{3N} = U_{3N}e^{j120°}$

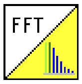
The same applies to the phase currents.

If in accordance with DIN 5489 "direction and sign in electrical engineering" the voltage of phase 1 is considered as reference voltage and assigned to the real axis, the vectors are displayed clockwise in the sequence U1-U2-U3 for a positive sequence system. A reversal of the sequence (U1-U3-U3) represents a negative sequence system.

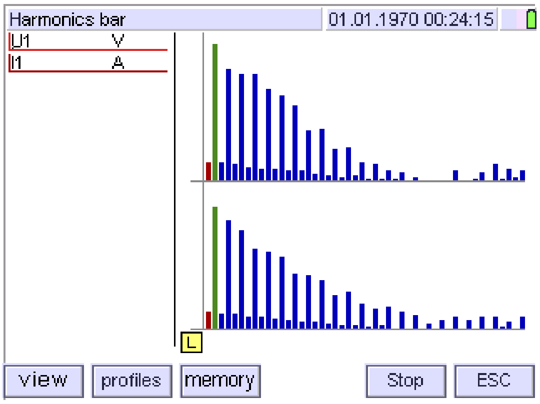
The angles between phase voltages and currents are computed after the arbitrary but conventional definitions in DIN 40110-1. Accordingly, the voltage advances in the case of *inductive* resistance of the load. The angle φ has a positive sign. In the case of *capacitive* resistance, the voltage lags behind the current, the angle has a negative sign.

### 5.3.10 Bar View – Spectral Analyses

Available for L1-L4 / L1…L4 / FFT / PQ

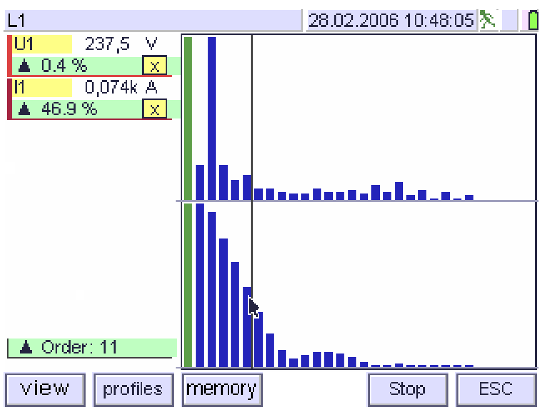



Graphic representation of the spectral shares of the periodic signal of voltage, current, and power as frequency spectrum with numeric information of values and the percentage of the spectral shares related to the fundamental harmonics.




The graphic representation shows the spectral shares up to the 50th Harmonics for the chosen measuring function (harmonics, harmonic group, harmonic sub group, as well as interharmonic group and interharmonic sub group). Scaling is performed automatically in terms of the highest absolute value of the represented spectral shares, the fundamental is cut off.

The sample above shows the odd harmonics shares of voltage and current as frequency spectrum up to the 49$^{th}$ harmonic for phase L1.





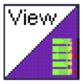
Open the cursor field by touching at the yellow field of the relevant measuring quantity. The numeric data display opens by subsequent touching at the desired cursor, showing the values according to the actual cursor position. The operator can browse through the graphic display by touching the desired bar in the graphics display. The green field at the lower left margin of the display shows the selected harmonic order.

The green field beneath the quantity view sows the percentage of the selected harmonics related to the fundamental.

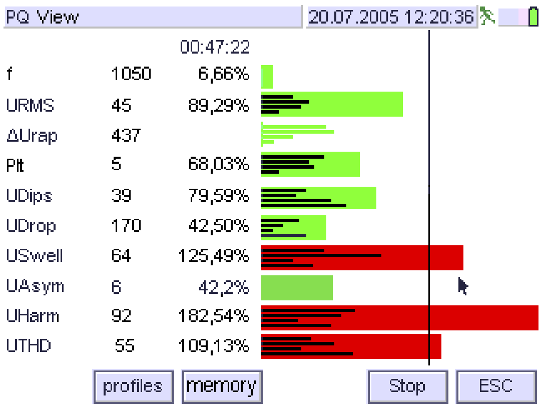
## 5.4 Display Modes for Event Controlled Measuring Data

### 5.4.1 Bar View – Power Quality Analysis

Available for PQ




Numeric and graphic representation of measuring data relevant for the determination of the voltage quality, with observation time interval, characteristic, number of limit exceedings and its percentages in relation to the allowed compatibility level.




In the left column, the PQ characteristics included in the evaluation are listed. For each characteristic the recognized exceedings of the compatibility levels are counted, and the phase counts are summarized. Additionally, for the characteristics dip, drop and swell multiphase events are defined. They are added to the corresponding characteristic. The respective numeric representation is shown in the second column. The sums of the limit exceeding for every characteristic are the basic for the analytic assessment of the quality of voltage in the considered supply.

The next column represents the ratio between allowed and recognized number of limit violations in percent for each characteristic. The result is the frequency of the limit violations referred to the given limits and consequently represents the result of the network analysis in accordance with EN 50160 for the supply network in consideration.

In the bar graphic, the length of the bars represent the ratio between given and detected number of limit violations, expressed in percent. The compatibility limit is marked by a 100%-line. This applies to all events. The black bars relate to single phase and multi phase events. If for any characteristic the number of limit violations exceeds the given limit the colour of the sum bar changes from green to red.

***Note 1:***

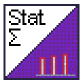
The allowed number of events refers to the supply network. According to EN 50160 it is of no importance in which phase events occur.

***Note 2:***

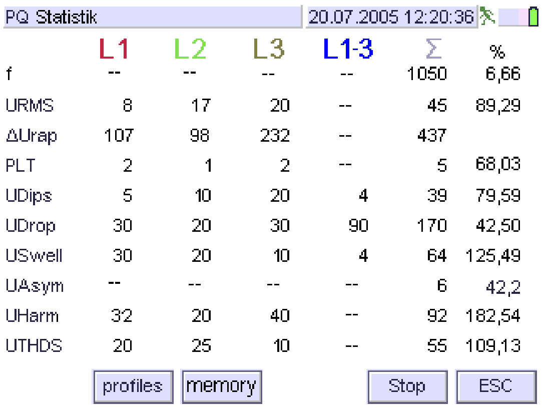
Characteristics without declared limits in EN 50160, are not considered. (e.g. interharmonics)

### 5.4.2 Statistics View

Available for PQ




Numeric representation of limit exceedings for each phase, multiphase and for the total supply network, relevant to power quality, together with the percentage in reference to the given compatibility level.



PQ Statistik 20.07.2005 12:20:36

| | L1 | L2 | L3 | L1-3 | Σ | % |
|---|---|---|---|---|---|---|
| f | -- | -- | -- | -- | 1050 | 6,66 |
| URMS | 8 | 17 | 20 | -- | 45 | 89,29 |
| ΔUrap | 107 | 98 | 232 | -- | 437 | |
| PLT | 2 | 1 | 2 | -- | 5 | 68,03 |
| UDips | 5 | 10 | 20 | 4 | 39 | 79,59 |
| UDrop | 30 | 20 | 30 | 90 | 170 | 42,50 |
| USwell | 30 | 20 | 10 | 4 | 64 | 125,49 |
| UAsym | -- | -- | -- | -- | 6 | 42,2 |
| UHarm | 32 | 20 | 40 | -- | 92 | 182,54 |
| UTHDS | 20 | 25 | 10 | -- | 55 | 109,13 |

profiles memory Stop ESC

The statistics view for each phase shows the characteristics included in the evaluation together with the number of the recognized limit violations. In the column L1-L3, the multiphase events are counted. They are only defined for dips, drops and swells.

The sums of the events (column) represent the number of the limit exceedings for each characteristic. They are the basis for the analytical evaluation of power quality.

The last column views the ratio between allowed and recognized limit exceedings in percent. It reflects the frequency of limit violations and thus allows for evaluating the power quality according to EN 50160.

The representation near to practice allows for analytical consideration of limit exceedings for the individual phases. In this way, useful irregular phenomena can be quantitatively recorded, which as a consequence may cause decisive actions. In particular, this applies for low voltage supplies with many single phase loads.

Reset of Event Statistics:

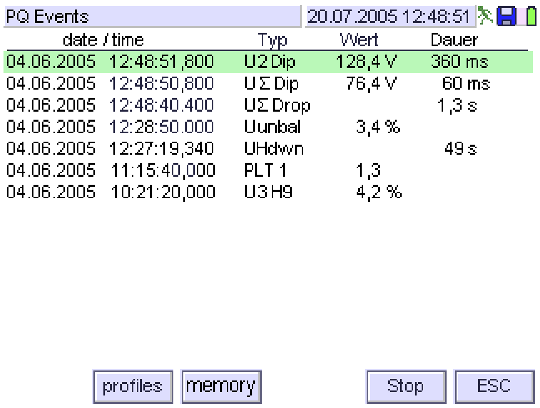
**Select:** **ON|MENU > PQ > Stat reset**


By touching the k**ey Stat reset** the recognized meter values are reset for all compatibility levels concerning the power quality.

### 5.4.3 List View

Available for PQ


Numeric presentation of recorded events in time related succession of appearance.




| date / time | | Typ | Wert | Dauer |
|---|---|---|---|---|
| 04.06.2005 | 12:48:51,800 | U2 Dip | 128,4 V | 360 ms |
| 04.06.2005 | 12:48:50,800 | UΣ Dip | 76,4 V | 60 ms |
| 04.06.2005 | 12:48:40.400 | UΣ Drop | | 1,3 s |
| 04.06.2005 | 12:28:50.000 | Uunbal | 3,4 % | |
| 04.06.2005 | 12:27:19,340 | UHdwn | | 49 s |
| 04.06.2005 | 11:15:40,000 | PLT 1 | 1,3 | |
| 04.06.2005 | 10:21:20,000 | U3 H9 | 4,2 % | |

Exceeding of limit values as well as events and transients which occurred at a non predictable time are displayed after exceeding a defined limit or compatibility level, which means after detection of a trigger condition. The list representation contains the date of occurrence, the event type (the trigger cause), the corresponding measured value and the duration of the event.

After opening the presentation mode, the entry field of the event list is empty. In the headline the marking refers to the measurement being alive. After recognition of a trigger condition the corresponding event data are displayed.

Those events which are registered in accordance with EN 50160 are represented. Furthermore, the function allows the phase related presentation.

**Operating Procedure:**

☞ Setup the PQ parameters listed in **Setup-m-profile** according to the condition in your supply network [1]).

OK Confirm each entry with **OK**

[1]) Factory default see → chap. 4.3.2, PQ-parameters

☞ Enter the function **PQ – Events**

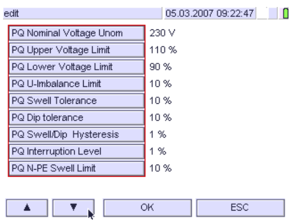
**Setting notes**

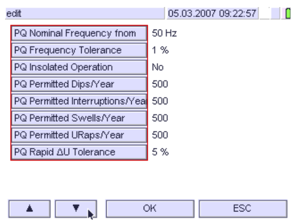
The representations described in chapters 5.4.1 and 5.4.2 apply exclusively for the representation of characteristics of the power quality. For its recording, the measurement parameters are to be adjusted as follows:


Open the menu Setup with touching on **Setup** in the main menu. ⇒ The display enters the Setup selection menu.

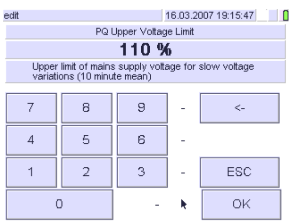
Select the desired PQ-Measuring parameter[1]) with **m-profile > [Profile] > edit >▲ ▼** .

***Note:*** The adjustment can be filed in a separate measuring profile. For it, open an new measuring profile with **m-profile > Profile > new**.

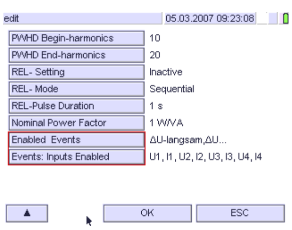


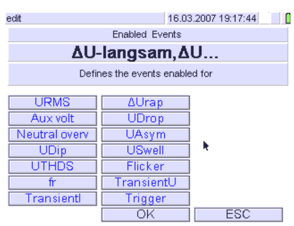




Open the adjustment menu with touching on the measuring parameter.




Set the desired limit for separately for each measuring parameter (→cap.4.3.2)

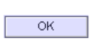



Measuring parameters > Enabled Events

Enable the following measuring parameters:

- **Enabled Events** all events
- **Events: Phases** **U1, U2, U3, U4**



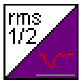

Confirm the selection with OK

***Note:*** The permitted number of events refers to the mains. According to EN 50160 it is not relevant in which phase the event occurred.

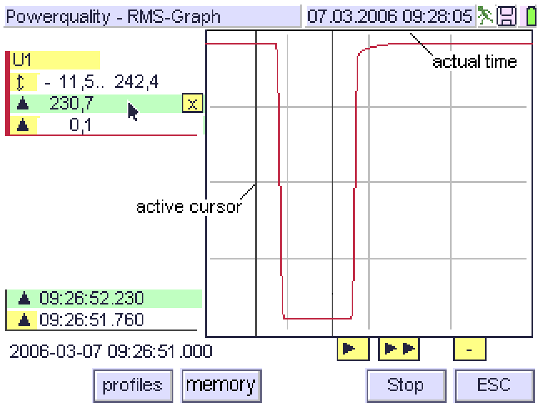
[1]) Factory default see cap. 4.3.2, PQ-Parameter

### 5.4.4 Profile View of Current and Voltage

Available for PQ




Graphic representation of the course of the rms voltage and / or current events recognized at last for a definable time interval.




The RMS graph represents the course of the ½-cycle r.m.s values of the last recognized short-term events for all enabled voltage and current channels. A recording is released by the signal exceeding the given limit of a short-term event defined in the standard EN50160. The record remains stored until a succeeding event is recognized and overwrites the previous one.

The interval of the curve pixels in x axis is predefined with a half cycle, this is 10 ms at 50 Hz. The recording duration is limited to 6 seconds. Thus the display represents a time period of 1960ms. The time period exceeding the view window can be moved into the display by the scroll cursors below the graphic.

With the additional cursor lines as well as the relevant numeric information the measurement sequence can be analyzed (→ chap. 5.2.4)

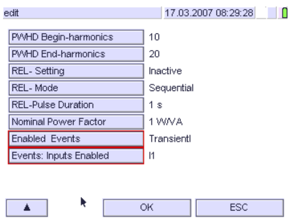
The example shown above represents a voltage jump from 230 to 0V, the vertical cursor lines mark a time period of 530 ms. Start time of the event is indicated on the lower left margin of the display. The green field in the alphanumeric section indicates that the left cursor line is alive. It can be shifted over the represented time interval.

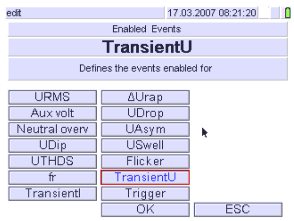
With the storage mode activated, the records can be transferred onto the chosen storage medium. The relevant symbol in the head line indicates the operating mode for the memory. The configuration is performed in the storage menu (→ chap. 4.5.-ff).

**Setting notes**

For recording the of the r.m.s voltage profile according to EN 50160, the measurement parameters are to be adjusted as follows:


Open the menu Setup by touching on **Setup** in the main menu. ⇒ The display enters the Setup selection menu



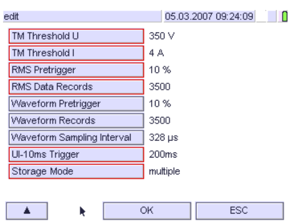




Measuring parameters > Enabled Events

Set the measuring parameters

- **Enabled Events** and
- **Events: Phases enable**

to the desired Measuring quantities (→cap.4.3.2).




Storage parameter

Set the storage parameters as follows:

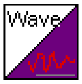
- **TM Threshold U** and/or **TM Threshold I** to the desired triggering level
- RMS **Pretrigger** to the time synchronised trigger position related to the total recording duration
- RMS **Data Records** to the number of data sets
- **Storage Mode** to the sequence mode for triggering and display


After setting the parameters enter the measuring menu **PQ > RMS Graph**.

***Note 1:*** With the storage mode set to multiple, thee last event is displayed in each case. When occurring two or more transients within the time required for recording, no further files are created. A new event can only be recognized after ending the filing the data for the previous occurred event.

### 5.4.5 Presentation of the Waveform of Voltage and Current – Transient Measurement

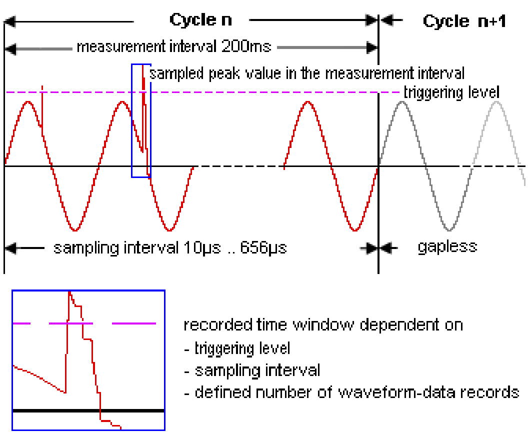
Available for: PQ




Graphic waveform representation of the greatest event of current and /or voltage which occurrred in a time window of 200ms and exceeded a definable trigger level

***Note:*** For the purpose of PQ measurements, transient events are distinguished from r.m.s events. Transients do not relate directly to the mains frequency. RMS events are derived from the frequency bond signal. However, the acquisition of mains frequent voltage and/or current jumps is of high interest since the recording caused by very short-term disturbances allows for drawing a conclusion of the actual status of the mains.

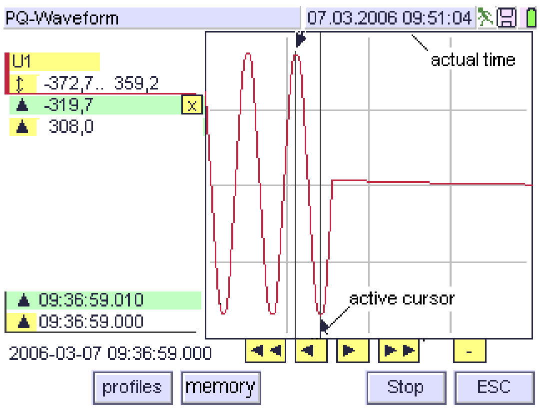
The graphic view **PQ-Waveform** represents the profile of the sampled values of all enabled voltage and current cannels around the peak value of transient events. For each 200ms measuring interval the peak value is detected and kept. Recording around that is released when the magnitude exceeds the set trigger level. The waveform (transient) trigger works on the absolute value of the voltage (and/or current), i.e. also negative transient are recorded. Recording remains stored as long as it is overwritten by the next event (ring mode).




The time distance of the curve points can be defined between 10µs and 655µs, the number of data points varies between 300 and 3500 for each event. The recorded time window corresponds to the sampling interval, multiplied by the number of the data records
(= curve points). At the display can be represented 196 curve points out of it. The time period outside the display window can be scrolled into the window by the scroll cursors below the graphics. With the scroll cursor ► the graphic is shifted for one pixel, with ►► the graphic is shifted for one grid to the right. Same applies to the shift to the left with the scroll cursors ◄ and ◄◄. If the end of the recorded time period is achieved, the corresponding scroll cursors are faded out.

Transients that occur within the time interval required for recording the current event are ignored. Only after storing the complete data set for the first captured transient the trigger is reset to armed and can capture the next transient.

With the additional cursor lines which can be faded in, as well as the relevant numeric information the measuring sequence can be analyzed (→ chap. 5.2.4)



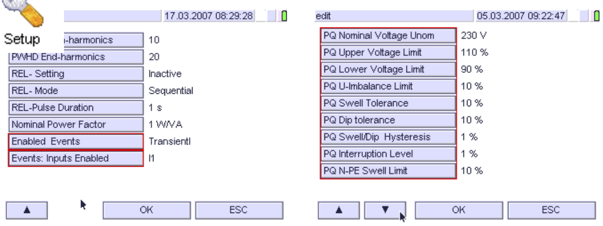

The above graphical presentation shows a voltage drop of a slightly unbalanced voltage. The 200ms effective magnitude is 222V (theoretical value), with a positive peak value of approx. 308,0V, and the negative peak value of approx. - 319,7 V. "Approx:" stands for the fact that the exact extreme magnitudes cannot be detected for to the chosen resolution of 655µs. The number of the data records was chosen with 300, the pretrigger position set to 10%. The record covers a time interval of 655[µs] x 300[records] = 196,5ms or 9,825 periods, including 19,65ms pretrigger duration (approx. 2 periods of mains frequency). The chosen small number of data records did not allow acquisition of voltage return within defined threshold values.

The additionally faded in cursor lines together with the numeric specifications allow for analysing the measuring sequence. The vertical cursor lines mark the time interval of 10ms. In the alphanumeric field on the lower left, the start time of the event is indicated. The right cursor line is active. It can be scrolled over the represented display window.

The events can be transmitted onto the selected and enabled storage medium. The symbol for storage enable appears at the right section of the head line. The storage configuration is performed in the storage menu (→ chap. 4.5.-ff).

### Operating Procedure for PQ-events

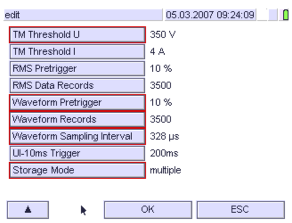
Open the setup menu by touching **Setup** in the main menu. The display enters the selection menu setup.




**Setup > m-profile > edit** (Trigger conditions)

Set the measuring parameters

- **Enabled Events** and
- **Events: Phases Enable**
  to the desired measuring quantities, and
- **PQ- Trigger Thresholds**
  to the desired triggering limits (→ cap.4.3.2).

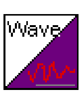



**Setup > Storage parameter > edit**

Set the storage parameters as follows:

- **TM Threshold U** to the desired triggering limit
- **Waveform Pretrigger** to the time synchronised trigger position related to the total recording duration
- **Waveform Records** to the desired number of data sets
- **Waveform Sampling Interval** to the time distance of the curve points
- **Storage Mode** to the sequence mode for triggering and display


Confirm the selection with **OK**




Enter the measurement menu **PQ** after adjusting the parameters. Open the graphic display by touching the key **Waveform.**

For acquisition the user can define the following data:
- the phases and quantities (voltage and/or current) which are relevant to the measurement
- the interval of the succeeding curve samples in the time axis
- the number of the curve points as well as the trigger position (that is the share of curve points in percent to be recorded before the trigger date).

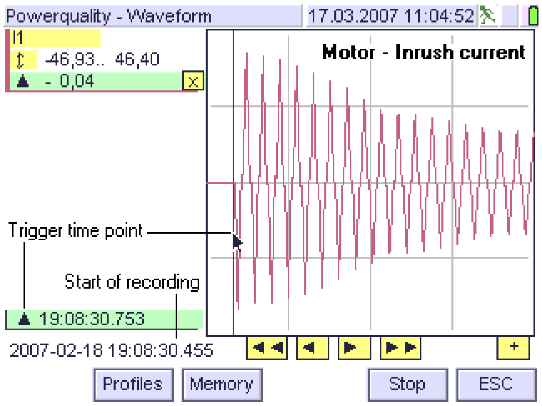
***Note 1:*** Trigger is released by a sample value exceeding the defined trigger level. If another sampled value within the current 200ms time interval exceeds the trigger level the highest one is recorded and retained as 200ms maximum. Therefore it could be that the initial exceeding gets lost. This condition meets the PQ requirement after which the maximum value has to be determined.

***Note 2:*** With the storage mode set to multiple, the last event is displayed in each case. When occurring two or more transients within the time required for recording, no further files are created. A new event can only be recognized after ending of filing the data for the previous occurred event.

***Note 3:*** Sampling interval and pretrigger are to be adapted to the expected duration of the event. At higher resolution and adverse triggering instant it may happen that the signal profile is only partially recorded.

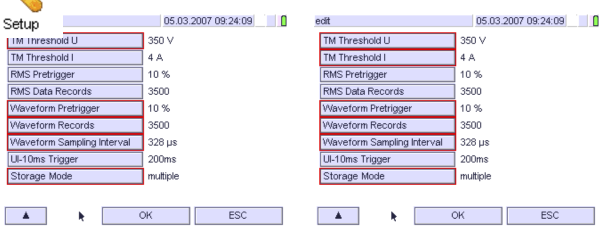
**Setting Notes for Transient Measurement**

**Sample: Inrush Current of a Motor**




For transient measurement, the setting of the essential measuring and storage parameter is performed as follows:


Open the setup menu by touching **Setup** in the main menu. The display enters the selection menu setup.



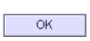

Measuring parameter    Storage parameter

Set the measuring parameters

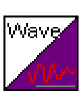
- **Enabled Events** and
- **Events: Phases Enable**
  to the desired Measuring quantities (→ cap.4.3.2).

Set the storage parameters as follows:

- **TM Threshold U** to the desired triggering limit
- **Waveform Pretrigger** to the time synchronised trigger position related to the total recording duration
- **Waveform Records** to the desired number of data sets
- **Waveform Sampling Interval** to the time distance of the curve points
- **Storage Mode** to the sequence mode for triggering and display




Confirm the selection with **OK**




Enter the measurement menu **PQ** after adjusting the parameters. Open the graphic display by touching the key **Waveform.**

## 5.5 Measurements at Frequency Converters

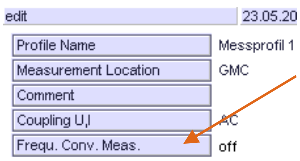
Available for L1-L4 / L1...L4 / W / FFT / / SEL1...5

***Note.*** Variable speed drives are realised with asynchronous motors which are conventionally equipped with an energy wasting bypass. Such machines can be constructed for high energy efficiency when they are operated via a frequency converter.

**View Modes**

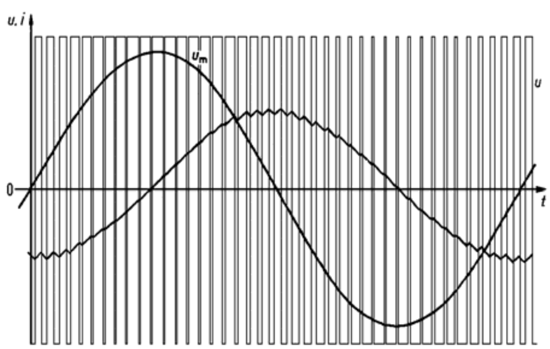
For measurements at frequency converters, the view modes list, matrix, recorder, scope, phasor and harmonics bar are available.

**Adjustment:**




In the menu
**Setup – Meas. profile**
set the parameter
**FU-Measurement**
to **on**

Amplitude and frequency of the output voltage are adjusted by the pulse-to-space ratio of the clock rate (also designated as pulse or chopper frequency). Furthermore, the pulse duty ratio between positive and negative voltage ratings is selected such that a sine function results as a mean value. The engine voltage consists of individual pulses with constant amplitude and variable pulse width (pulse-width modulation). The result is a variable output frequency with which the engine speed is controlled.




**Motor Voltages and Motor Currents of a Voltage link converter**

For voltage, current and frequency measurement with the **POWER1000**, voltage and current of the drive are fed over a digital filter with a limit frequency of approx. 120 Hz and a damping of higher than 70 dB at 500 Hz. By that the single voltage pulses of the load sided converter are filtered. As a result two basic measurement quantities of an AC voltage are available, from which voltage, current and rotating field frequency can be computed.

### 5.5.1 Calculation Modes for Measurements at Frequency Converters

**Calculation of Voltage and Current**

On account of the high informative value for the operating condition of a three-phase drive, the waveform representation is performed with the filtered signal.

***Note:*** The bandwidth of 100 kHz of the **POWER1000** does not lead to the desired result for measurements at converters. The chopper frequency of the frequency converter, normally lying within the bandwidth, must be filtered from the signal. For devices which are designed for nominal frequencies 50 / 60Hz, this measure is not required.

**Calculation of Active Power and Effective Current**

These calculations are performed out with the not filtered signal. Thus the harmonic share up to 20 kHz is included in the measuring result. This allows for accurate conclusions on mechanical power and temperature rise of windings.

**Calculation of Apparent Power**

For calculation of apparent power the product of filtered voltage and filtered (motor) current in used.

**Calculation and Representation of Harmonics**

Calculation of harmonics is performed via the FFT-method. The voltage harmonics are calculated with the filtered signal. The current harmonics of the (almost sinusoidal) output current of the frequency converter are measured unfiltered. Calculation of active power is performed wit the unfiltered signal.

### 5.5.2 Measuring Connection for Measurements with Frequency Converters

**Notes to Measurements in Frequency Converter Circuits**

The frequency converter acts as harmonics generator for the mains. Therefore, a check-up of the waveform of the voltage is recommended at the input of the frequency converter. Distortions, levelling or short-term disturbances (e.g. transients) may have influence to the operation conditions of the loads.

For measurements on the **input** of the frequency converter, select OFF for the parameter FU-Measurement. Disturbances in the mains can be represented in scope view at the display.

For measurements on the **output** of the frequency converter, the bandwidth is limited. Select ON for the parameter FU-Measurement.

#### Notes for Measuring Arrangement

The arrangement for measurements in frequency converter is dependent on the type of the converter at a high measure. Interferences through sidebands and the response of the star point add to those criteria those must especially be considered in the test arrangement. Additionally, the behaviour of the frequency converter is only partial or not known in the most cases. Therefore, in this section measuring arrangements are recommended which lead to a good result for the most measurements.

Basically for measurements with POWER1000 in converter circuits applies:

- Current transformers must be used for acquisition of current. A current measurement by means of shunts not applicable due to the bad ratio
  used signal : interfering signal.
- The acquisition of voltage must always be performed between phase and neutral. Thus the correct phase relations for the calculation of derived measuring quantities can be arranged. The connection of the voltage input can be arranged after
  → chap. 7.2.2.

### 5.6 Trigger - Limit Value Monitoring

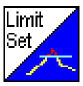
For measuring quantities selected in the menu **trigger** (limit value monitoring), exceeding of an upper and/or lower limit value is indicated for up to four measuring quantities at the alarm output (relay contact) performing as a collective alarm. Limit violations can be transferred onto the chosen storage medium (USB-storage or CF-card) and furthermore onto a PC, together with all measuring quantities chosen for storage.

**Operating Procedure**

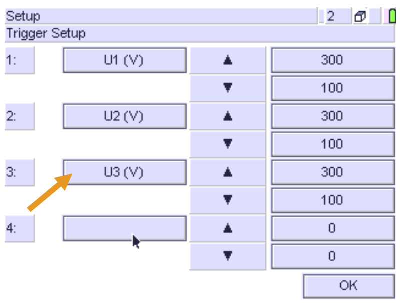
The following procedure must be performed successively for adjusting the limit value monitoring function and alarm printing:

① **Defining the Measuring Quantities to be Monitored**

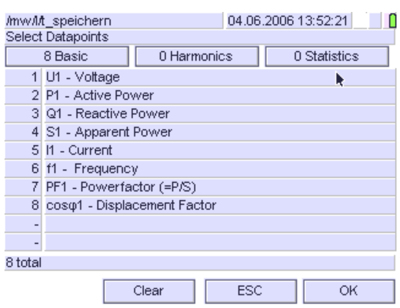
**ON|MENU – Setup – Trigger – [Position 1 .. 4]**



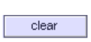

Open the selection menu ***Trigger***



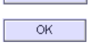

☞ Select the desired position for the measuring quantity to be monitored. The display enters the list of measuring quantities.




Select the measuring quantity to be monitored (→ **chap. 4.4. f**).




With ***clear*** the entire selection of measuring quantities is erased.




With **OK** the device enters the measuring mode.

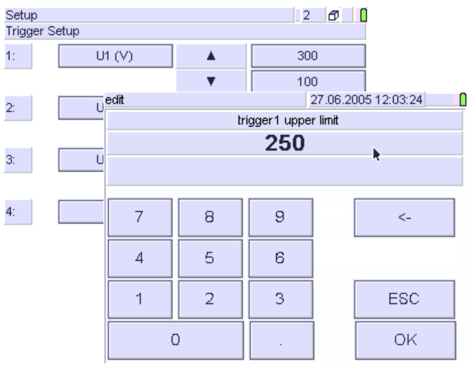
**Note:** If a measured quantity with assigned measurement type maximum (e.g. ▲**U1**) or minimum (e.g. ▼**U1**) exceeds the adjusted limit value, a continuous alarm is triggered. As a rule, only measurement quantities of types ***effective*** (instantaneous value) or ***average*** (mean value) are significant for limit monitoring.

### ② Adjusting the Limit Values

**ON|MENU – Setup – Trigger – [Limits 1 … 4]**

☞ Open the entry window limits

☞ Adjust the limit values for the desired Measurement quantity.




OK Acknowledge the entry with ***OK***.

After acknowledgement the entry window is closed, the display enters the selection window.

Select a lower and upper limit for each measured quantity to be monitored.

OK After entering all limits, confirm the selection with **OK** in the selection menu. The device enters the measuring mode.

### ③ Activating the Limit value monitoring Function

The limit monitoring function is acting without further operating step. The alarm signal is triggered as soon as one of the measurement values exceeds the adjusted limits, and is reset when all monitored quantities have returned to the values within the limits. Furthermore, the alarm signal can be transmitted to the relay:

**Adjusting: Setup – Meas. Parameter – Relay Parameter**

Signal response corresponds to the selected operating mode of the relay (N/O or N/C). It can be active permanently or time related. See → chap. 4.3.2

1-4 The measurement quantities activated for limit value monitoring are monitored in every measuring function.

## 5.7 Recording and Replaying Measurements

***Important note 1***: The measuring quantities (data points) recorded to a storage medium in general are not the same that are displayed on the screen.

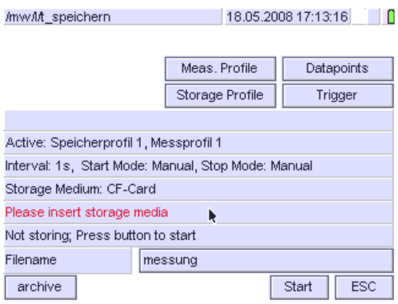
***Important note 2***: Resetting counts, minimum, maximum and statistical values is blocked during a recording,.

### 5.7.1 Opening the Storage Menu

To open the storage menu


-in the main menu touch the key **store**


- in the measurement mode touch the key **storage**




The upper line of the information display shows the actual storage and measuring profiles.

With the keys Meas. Profile, Datapoints, storage profile and trigger the actual measuring and storage parameters can be displayed. If desired, they can be changed:

- ☞ Select or change the desired measuring profile (→ chap. 4.4.2), the datapoints (→ chap. 4.6) and the storage profile
- Select a name for the storage file (→ chap. 4.5.1)

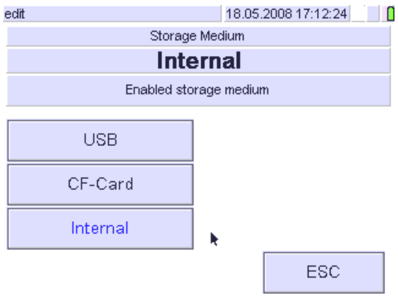
The adjusted parameters (measuring profile, storage profile, trigger) as well as the selected datapoints apply fort he actual recording. Readjusting can be done bevor starting a recording. During recording parameters cannot be changed.

### 5.7.2 Selecting the Data Carrier

Measuring data can be stored optionally to the internal memory, a storage medium connected to the USB port or a CF-Card.

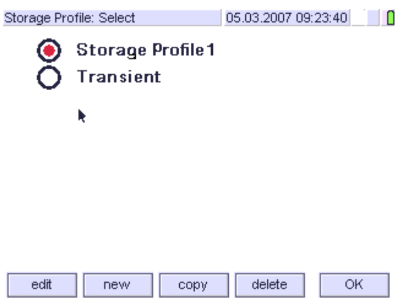
Operating sequence in the main menu:
record > Storage Profile > edit > storage medium > OK

Operating sequence in measuring mode:
memory > Storage Profile > edit > storage medium > OK




Leave out the step edit followed by storage medium when the desired storage medium is already adjusted in the appropriate storage profile:

record > Storage Profile [Select] > OK
or (in measuring mode)
memory > Storage Profile [Select] > OK



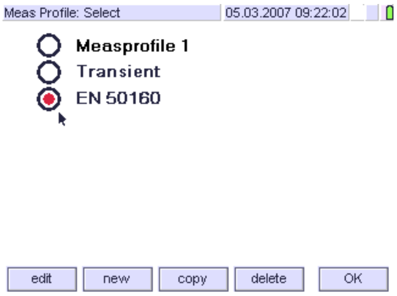

#### Inserting and Removing the Data Carrier

- ☝ Remove the storage medium only if the read operation is ended (USB: min. 3 s after touching the Print key)! Removing during the read operation can lead to loss of data.
- ☝ Before inserting the storage medium, check that its write protection (write protect switch) is not activated.
- ☞ Remove the CF-Card by pressing carefully the eject button.
- ☞ Select the desired measuring profile (→ chap. 4.2.2), the data points (→ chap. 4.4) and the storage profile (→ chap. 4.5.1).
- ☞ Chose a file name (→ chap. 4.5.1)

### 5.7.3 Adjusting the Storage Parameters

a) Select the Measuring Profile

record > Measuring Profile > [select] > OK

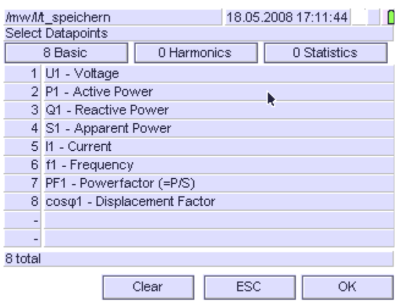



For adjusting the measuring parameters see
→ chap. 4.4.2

b) Selecting the data points

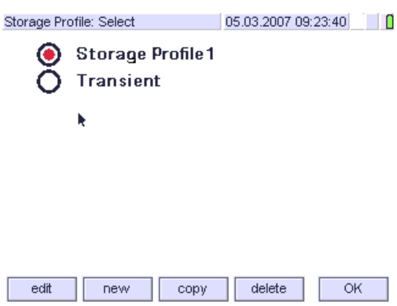
record > Datapoints> [select] > OK

Press the key Datapoints to enter the selection menu. The display shows the actual selection of datapoints. For adjusting see → chap. 4.6.1




c) Selecting the storage Profile

record > Storage Profile > [select] > OK




For adjusting the storage profile see chap. → 4.5.1

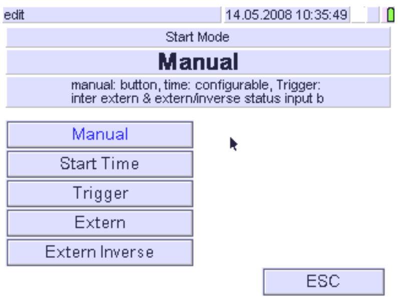
### 5.7.4 Starting of Recording

Recording onto the desired data carrier can be released

- Manually, immediately after touching the key start:

| | |
|---|---|
| **ON\|MENU > record > start** | **in the main menu** |
| memory > start | in the measuring mode |

- time controlled by entering start date and time
- event controlled, after occurance of the first trigger event
- extern / extern invers, by an external signal at the digital input Status IN b

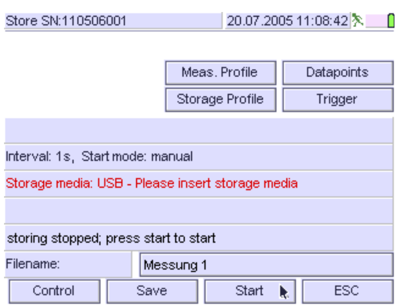



**a) Starting of Recording manually**


Recording starts with touching the key ***start.***

A corresponding announcement appears on the display if the selected storage medium is not inserted. When recording is started without taking notice of the announced request to insert the chosen data carrier, the data are buffered onto the internal memory.

A current recording is advised with the floppy disk symbol in the header. The measured values are buffered on the internal memory and transmitted to the selected data carrier in regular time intervals. While recording, the storage medium can be exchanged or removed if data transmission to the data carrier is not active. The corresponding information is shown on the display:




Data which are captured during the time of exchange of the selected data carrier are buffered on the intern memory.

#### b) Time Controlled start of Recording

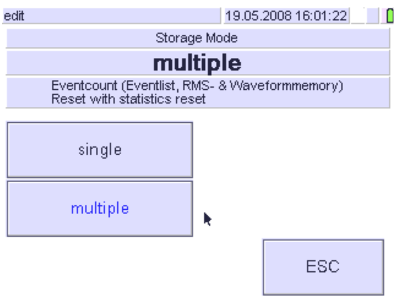
In the storage profile

- Set the parameter ***start time*** to the desired starting time.
- Set the parameter start mode to ***time***.

Recording has now been initialized, but is not yet acting. Recording is started if beginning date and start time are exceeded.

#### c) Event Controlled start of recording

Recording starts with the occurrence of the first event
With the storage mode set to ***multiple*** the event is filed corresponding to the settings. After that the device is "armed" again and can capture the next event.




In storage mode ***single*** recording stops after the first event, no forther event is recorded.

#### d) External Controlled Recording Start-Up

For start of recording of a measurement via an external signal apply a signal source to the digital input **Status IN b** (≤ 30V DC!). When the status of the input signal is changed, the recording is started or stopped.

- Set parameter start time to **extern**.
- Set the start mode in the storage profile to **extern** or **extern inverse** respectively.

Recording is started if the signal at the digital input **Status IN b** changes from low to high or high to low respectively.

### 5.7.5 Saving Measurement Data during Recording

**In the main menu:** **ON|MENU > Store > Stop**
**In the measuring mode:** **memory > Stop**

[save] In the storage menu: touch at the key **save**.

By touching the key **save** the measuring data buffered in the internal storage are transmitted to the chosen data carrier.

[Control] By touching the **Control** key the data being available in the internal memory are displayed.

### 5.7.6 Terminating a Recording

Recording can be ended

- manually, immediately after touching the key stop:
  **ON|MENU > Store > Stop**
- time controlled, by predefined start date and time
- event controlled, after recording the occurred trigger event
- extern / extern invers, by changing the status of the signal at the digital input Status **IN b**

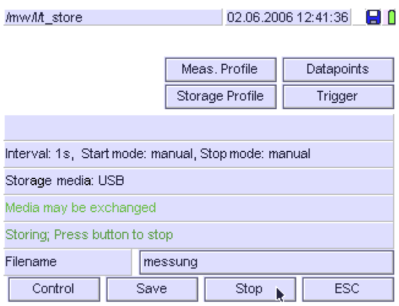
The parameters for recording and terminating are set in the menu storage configuration (→ chap. 4.5 and 4.5.1).

#### a) Manual termination of a Recording

Touch **ON|MENU**. The display enters the main menu showing the symbols for the main functions.

Touch the symbol record.

The storage menu opens, representing the actual memory status.





The recording stops immediately after touching the key Stop. Simultaneously disappears the symbol recording (disk in the head line).

#### b) Time Controlled Termination of Recording

An active recording terminates automatically after exceeding set **end date and end time.** Further operating steps are not required. The desired setting of recording parameters must be performed prior to start of recording.

#### c) Event Controlled Termination of Recording

After recording the actual trigger event the recording stops.

#### d) External Controlled Termination of recording

Recording is stopped after the signal on the digital input **Status IN b** changes from low to high or high to low respectively.

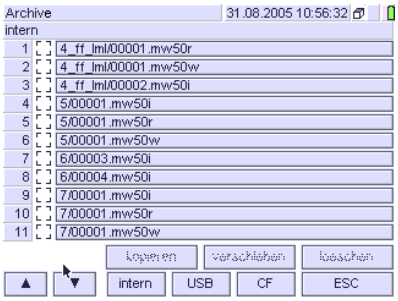
## 5.8 Retrieving and Analysing a Recording

**ON|MENU – Archive – [Select]**

Data stored to the selected data carrier can be displayed at the LC-Display.

Touch the **ON|MENU** key. The display enters the main menu showing the symbols for the main functions.

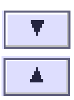

Touch the symbol ***Archive***




☞ Select the data carrier

The display opens the list of stored files, representing the sequential number according to the date of record, the automatically assigned number including the type of record and the name of the record.

☞ Select the file to be processed by touching onto the selection field between sequential number and file name. The selected file is marked with an x. After selection, the buttons for **copy**, **shift** and **erase** are activated.



If the archive covers more than one page, select the desired recording filed on another page with the scroll keys ▲ ▼.

### 5.8.1 Retrieving a Data Recording

☞ Select the desired file

☞ Touch onto the bar with the designation of that file which you want to display.

The filed data are presented at the LC-display. For graphic representations, cursor lines which refer to the data of the actual position can be added. Consequently, an analysis of the recorded data is possible at the device. See also → chap. 5.2.4

### 5.8.2 Shifting and Copying Recorded Data

☞ Select the desired file

☞ Select the desired type of process, **copy** or **shift.**

The display changes into the corresponding selection menu. If no manipulations should be carried out, touch onto the button **abort.** With it the display returns to the list of stored files.


☞ Select the data carrier the file should be copied or shifted to.

⇒ After touching the corresponding button the display returns to the list of stored files.

[☞] With ***abort*** the display returns to the list of stored files without change.

### 5.8.3 Erasing a Recording

☞ Select the file which should be erased.

☞ Select the process ***delete***.

On the LCD display a window is opened, showing the security query whether the file shall really be deleted.

⇒ With ***delete yes*** the file is deleted. The display returns to the corresponding changed list of stored files.

⇒ With ***delete no*** the display returns to the list of stored files without change.

## 6. Available Measured Quantities

All measured values are formed simultaneously and gaplessly every 200ms. They are synchronised on 10/12 signal periods at 50/60 Hz and are calculated in time intervals from 0.2s to 2h as instantaneous measured values or / and as highest or lowest or average value. Refresh at the display is performed in a second cycle.

**Identification of Measurement types:**

– Instantaneous (effective) value
  (formed over a gapless measuring interval of 1 second)
– For measurement intervals according to 61000-4-ff the time window has a band width of 200ms.
▲ Maximum in the adjusted time interval
▼ Minimum in the adjusted time interval
■ Average value within the adjusted time interval

### 6.1 Measurement Quantities for Power an Energy

| Symbol | Measured Quantity | Meas. Unit | L1 | L2 | L3 | L4 | Σ 1-3 |
|---|---|---|---|---|---|---|---|
| U*x* | phase-to-neutral voltage, rms value | V | • | • | • | • | • |
| UΔ*x* | phase-to-phase voltage, rms valus | V | • | • | • | | |
| I*x* | phase current, rms value | A | • | • | • | • | • |
| P*x* | active power | W | • | • | • | • | • |
| Q*x* | reactive power | var | • | • | • | • | • |
| S*x* | apparent power | VA | • | • | • | • | • |
| Qc*x* | reactive power correction for $\cos\varphi_{set}$ =1 | var | • | • | • | • | |
| Dx | harmonic reactive power | var | • | • | • | • | • |
| WP+*x* | active energy consumption | Wh | • | • | • | • | • |
| WP-*x* | active energy release | Wh | • | • | • | • | • |
| WQ*x* | reactive energy | varh | • | • | • | • | • |
| WS*x* | apparent energy | VAh | • | • | • | • | • |
| cosφ*x* | displacement power factor | – | • | • | • | • | |
| φ*x* | phase shift angle | °[deg] | • | • | • | • | |
| PF*x* | power factor (P/S) | – | • | • | • | • | • |
| CFU*x* | crestfaktor of voltage | – | • | • | • | • | • |
| CFI*x* | crestfaktor of current | – | • | • | • | • | • |
| f*x* | frequency of line voltage | Hz | • | • | • | • | |
| u*x*(t) | signal form of voltage | V | • | • | • | • | |
| i*x*(t) | signal form of current | A | • | • | • | • | |
| Rot | rotating field sequence of 3~-voltages | > / < | | | | | • |

## 6.2 Measurement Quantities for Spectrum Analysis

| Symbol | Measured quantity | Meas. Unit | L1 | L2 | L3 | L4 |
|---|---|---|---|---|---|---|
| **U*x* THD** | total harmonic distortion h2 ... h50 of voltage Ux | % | • | • | • | • |
| **U*x* THDG** | total harmonic group distortion hg2 ... hg50 of voltage U*x* | % | • | • | • | • |
| **U*x* THDS** | total harmonic subgroup distortion hg2 ... hg50 of voltage U*x* | % | • | • | • | • |
| **U*x* PWHD** | partial weighted harmonic distortion of Ux in the adjustable band hmin to hmax | % | • | • | • | • |
| **U*x* h0** | DC share of voltage U*x* (absolute and relative to U*x*H1) | V, % | • | • | • | • |
| **U*x* h1** | fundamental harmonic voltage of U*x* (absolute and relative to U*x*H1) | V, % | • | • | • | • |
| **U*x* h2 …<br>U*x* h50** | voltage of harmonics h2 ... h50 of U*x* (absolute and relative to U*x*H1) | V, % | • | • | • | • |
| **U*x* hG1 …<br>U*x* hG50** | voltage of harmonics group hg1 ... hg50 of U*x* (absolute and relative to U*x*H1) | V, % | • | • | • | • |
| **U*x* hS1 …<br>U*x* hS50** | Voltage of harmonics subgroup hs1 ... hs50 of U*x* (absolute and relative to U*x*H1) | V, % | • | • | • | • |
| **U*x* ig1 …<br>U*x* ig49** | voltage of intermediate harmonics group ig1 ... ig49 of U*x* (absolute and relative to U*x*H1) | V, % | • | • | • | • |
| **U*x* is1 …<br>U*x* is49** | voltage of intermediate harmonics subgroup ig1 ... ig49 of U*x* (absolute and relative to U*x*H1) | V, % | • | • | • | • |
| **I*x* THD** | total harmonic distortion h2 ... h50 of current I*x* | % | • | • | • | • |
| **I*x* THDG** | total harmonic distortion of group hg2 ... hg50 of current I*x* | % | • | • | • | • |
| **I*x* THDS** | total harmonic distortion of sub group hg2 ... hg50 of current I*x* | % | • | • | • | • |
| **I*x* PWHD** | partial weighted harmonic distortion of Ix in the adjustable band hmin to hmax | % | • | • | • | • |
| **I*x* h0** | DC share of current I*x* (absolute and relative to I*x*H1) | A, % | • | • | • | • |
| **I*x* h1** | fundamental harmonic of I*x* (absolute and relative to I*x*H1) | A, % | • | • | • | • |
| **I*x* h2 …<br>I*x* h50** | current of harmonic h2 ... h50 of I*x* (absolute and relative to I*x*H1) | A, % | • | • | • | • |
| **I*x* hG1 …<br>I*x* hG50** | current of harmonic group hg1 ... hg50 of I*x* (absolute and relative to I*x*H1) | A, % | • | • | • | • |
| **I*x* hS1 …<br>I*x* hS50** | current of harmonic subgroup hg1 ... hg50 of I*x* (absolute and relative to I*x*H1) | A, % | • | • | • | • |
| **I*x* ig1 …<br>I*x* ig49** | current of interharmonic group ig1... ig49 of I*x* (absolute u. relative to I*x*H1) | A, % | • | • | • | • |
| **I*x* is1 …<br>I*x* is49** | current of interharmonic subgroup ig1... ig49 of I*x* (absolute u. relative to I*x*H1) | A, % | • | • | • | • |
| **P*x* h0** | DC share of active power P*x* (absolute and relative to P*x*H1) | W, % | • | • | • | • |
| **P*x* h1** | fundamental active power of P*x* (absolute and relative to P*x*H1) | W, % | • | • | • | • |
| **P*x* h2 …<br>P*x* h50** | active power of harmonics h2 ... h50 of P*x* (absolute und relative to P*x*H1) | W, % | • | • | • | • |
| **φ U*x* h0 …<br>φU*x* h50** | phase angle of harmonics h0 ... h50 of U*x* related to fundamental voltage U*x*H1 | °[deg] | • | • | • | • |
| **φ I*x* h0 …<br>φI*x* h50** | phase angle of harmonics h0 ... h50 of I*x* related to fundamental current I*x*H1 | °[deg] | • | • | • | • |

## 6.3 Available Quantities for Transients Measurement Function

| Symbol | Measured Quantity | Meas. Unit | L1 | L2 | L3 | L4 | Σ 1-3 |
|---|---|---|---|---|---|---|---|
| u*x*(t) | signal course of voltage | V | • | • | • | • | |
| i*x*(t) | signal course of current | A | • | • | • | • | |

## 6.4 Available Quantities for Flicker Function

| Symbol | Measured Quantity | Meas. Unit | L1 | L2 | L3 | L4 |
|---|---|---|---|---|---|---|
| P(t)*x* | instantaneous flicker of voltage U*x* | - | • | • | • | |
| Pst*x* | short term flicker (10 min) og voltage U*x* | - | • | • | • | |
| Plt*x* | long term flicker (2 h) of voltage U*x* | - | • | • | • | |

## 6.5 Characteristics of Power Quality according EN 50160

| Characteristic | Requirements | Meas. interval | Observ. Duration |
|---|---|---|---|
| **Mains frequency** | 50Hz ± 0.5% during 95% of one week<br>50Hz +4 / -6% during 100% of one week | 10 sec average value | 1 week |
| **Voltage fluctuations** | slow voltage fluctuations:<br>Un ±10% during 95% of one week<br>Un + 10 / -15% during 100% of one week | 10 min average value | 1 week |
| | fast voltage fluctuations:<br>Ueff ± 10% during one day | ½-period effective value | 1 day |
| **Flicker** | long term flicker severity Plt ≤ 1 during 95% of one week | 2h per EN 61000-4-15 | 1 week |
| **Voltage dips** | number < 10 ... 1000 / year according to EURELECTRIC table (former UNIPEDE) | ½-period effective value | 1 week |
| **Voltage drops** | short term voltage drops:<br>number < 10 ... 1000 / year, from it > 70% with duration < 1 s<br>long term voltage drops:<br>number < 10 ... 50 / year, duration > 3 min | ½-period effective value | 1 year |
| **Transient overvoltage** | phase to neutral < 6 kV / µs ... ms | | |
| **Unbalance** | ratio U (negative sequence) / U (positive sequence < 2% during 95% of one week | 10 min average value | 1 week |
| **Harmonics** | UH2 ... UH25 < limit according table EN 61000-4-7 during 95% of one week | 10 min average value | 1 week |
| **THD** | Total harmonic distortion < 8% during 95% of one week | 10 min average value | 1 week |
| **Interharmonics** | limits / compatibility levels not yet fixed | | |
| **Mains signalling voltages** | limits / compatibility levels not yet fixed | | |

### 6.6. Designation of Measurement Quantities and Phases

The designation for measurement quantities and phases specified in the standards, are specific to countries and languages, and on the other hand sometimes long. Furthermore, the standards show also no country-specific throughout designation.

For a countries overlapping compromise, the designations in the POWER1000 in a wide field follow that of the relevant standards, with deviations which help to maintain the clarity of the display view. This is in particular applies for the voltage relations phase-to-neutral and phase-to-phase (measurement parameters U-Connection).

For the for- and five-wire system (setup: U-connection star), the phase designations L1, L2 and L3 refer to the phase-to-neutral voltages.

In the three-wire system (setup: U-connection delta), the phase designations L1, L2 and L3 refer to the phase-to-phase voltages, i.e. U1[h3] is the 3rd harmonic of the phase-to-phase voltage. Same applies to the PQ related voltage parameters.

# 7. Measuring Circuits

## 7.1 General Notes for Measuring Connection

For acquisition of analog measurement signals the **POWER1000** incorporates the eight galvanic separated two channel phase inputs L1, L2, L3, and L4. Except for the frequency measurement that is performed in the voltage path of L1 under normal conditions (in the case of loss in the current path, then in phase L2 or L3 successively), the layout is completely identically and allows measurements in

- four independent DC circuits
- four single-phase AC circuits of same frequency
- a three-phase three-wire, three-phase four-wire or three-phase five-wire system.

**phase L1**

**phase L2**

**phase L3**

**phase L4 (neutral)**

**aux. supply (e.g. rogowski winding)**

**mains input 85 … 250 VAC/DC**

**Hinweise**

- The analog measurement inputs have been designed for connection to overvoltage category IV circuits of up to 600 V (or CAT III up to 1000V.

  If the instrument is used in systems of this type, all measuring accessories (e.g. clip-on current-to-voltage transformers, shunts, measuring cables etc.) must also comply with the respective category. See accessory specifications for accessory category.
- The low potential from the corresponding voltage and current path must be connected to the corresponding input jack (Low).
- Connections between the voltage jacks (Low) for the measuring connections shown in the following chapter cannot be made internally within the instrument: they must be realised by the user.

## 7.2 Measurement via Phase Inputs L1…L4

In single-phase AC systems, in three-phase four-wire and three-phase five wire systems as well as in DC systems, current measurement is performed in the phases L1, L2, L3 and L4. Voltage measurement in L1, L2 and L3 is performed between the voltage inputs (High) L1, L2, L3 and the neutral conductor L4 (Low). Neutral-to-earth measurement is performed between L4 and the protective earth conductor. Phase inputs which are not connected are weighted with 0 and correspondingly calculated.

☝ Frequency measurement is performed in voltage channel of phase L1, at loss of voltage in phase L2 and L3 respectively. If voltage signals in all three phases fail, frequency measurement is performed in the current inputs, and last of all if no evaluable signal is available, the reference frequency is taken.

For measurements in three-phase three-wire systems two current measuring channels are sufficient. Usually, current is measured in L1 and L3. Voltage measurement is performed in the three voltage paths. The parameter I-connection is set L1, L3, L4.

Measurements related to phases are identified by the index 1, 2, 3 and 4. They are permanently allocated to a single phase. Current and voltage of a given phase are connected to the corresponding phase inputs. Commutating connections lead to erroneous interpretations.

The instrument does not differentiate between single-phase or three-phase measurements. No information is displayed at the LCD concerning complete or correct or incorrect connection of the object in test. For example, a phase which has not been connected for a three phase measurement may lead to misinterpretations during observation of three-wire measuring quantities, such as U12, U23, U31, UΣ, PΣ.

☝ At the beginning of a measurement, evaluate the plausibility of the measuring results. In particular check

- the correct settings of **Uratio** and **Iratio** for the respective input based upon the magnitude of the displayed measurement values
- the correct **polarity of the current measuring connections** inputs based upon the polarity of the P-measurement values
- the correct phase sequence based upon the phase relationship which can be seen in the scope view as well as in the phasor view and based upon the sequence of the phase colours red / yellow / green.

If active clip-on current-voltage sensors are used for AC current measurement, set the type of coupling to AC (***Setup – Meas. parameters –coupling)***. If coupling type AC+DC is used (e.g. in DC circuits), careful zero balancing is required, because active power measurement values would otherwise be distorted. Select the scope view for I1 to I4 and adjust according to the corresponding specification until the signal line is as near as possible to the zero line.

### 7.2.1 Measurements in Three-Phase four- or five-wire Systems

In general, three-phase four-wire or five-wire systems are low voltage networks (115/200 or 230/400Volt), so that no voltage converters are required for measuring equipment. The measuring voltage is derived from the current-carrying phases L1, L2, L3 and the neutral conductor L4, the current is usually measured by means of clip-on current-to-voltage converters in each phase.

Due to splitting of the three-phase system into three separate circuits with go- and return wire an equal load in each phase is not guaranteed. Furthermore the third order harmonics and multiple of them add to the fundamental if they occur in the return wire. This creates a compensatory current in the neutral wire flowing back to the star point of the supply system. Together with the protective earth PE which is held on constant reference potential, this results in a three-phase five-wire system.

With the POWER1000 the neutral voltage as well as the neutral current can be measured simultaneously via the phase input L4. If these measurement quantities are not required for an analytical evaluation, the connections for neutral and earth are bridged. This applies to all variants of the measuring connections described in this section.

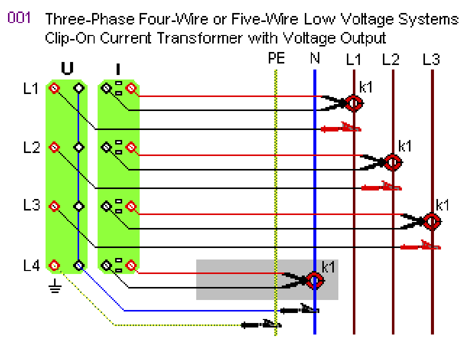
The following applies to the measurement connections shown below:

☞ The current and voltage path from a given phase are connected to the same phase

☞ In the Setup, the measuring parameters
***Coupling Measurement Input*** to ***AC+DC[1])*** and
***U-Connection Star*** are selected.

☞ Measuring parameters ***Uratio*** and ***Iratio*** are selected as follows:

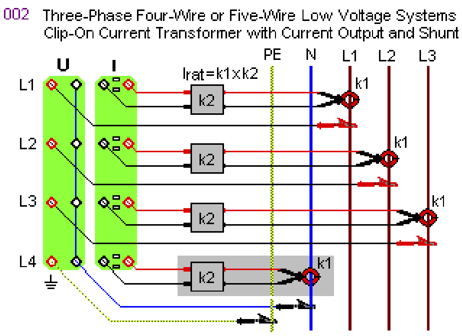
#### a) Clip-On Current Transformer with Voltage Output




***Uratio*** is set to 1 in setup menu for each phase.

***Iratio*** corresponds to the transformation ratio of the clip-on transformer in use (e.g. 10mV/A: Iratio = 100).

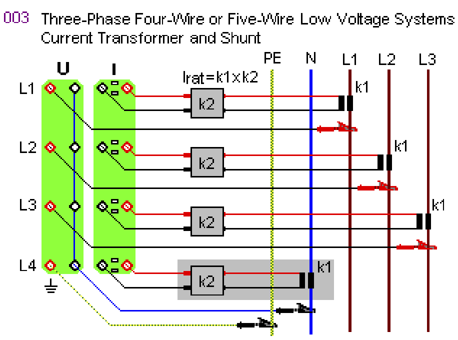
**b) Clip-On Current Transformer with Current Output and Shunt**




***Uratio*** is set to 1 in setup menu for each phase.

***Iratio*** is the product of the transformation ratios of the clip-on current transformer and the Shunt (k = k1×k2).

**c) Current Transformer with Shunt**




***Uratio*** is set to 1 in setup menu for each phase.

***Iratio*** is the product of the transformation ratios of the clip-on current transformer and the Shunt (k = k1×k2).

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[1]) In case of **AC+DC**, R-coupling is present so that the frequency range begins at DC. The **AC**-coupling is a C-type coupling, which does not transmit DC input signals. The upper end of the frequency range is identical for both types of couplings.

Accordingly, in the case of AC+DC coupling the DC components in AC circuits are included in the evaluation. If this is not requested, the coupling must be set on AC.

### 7.2.2 Measurements in Three-Phase Three-Wire Systems

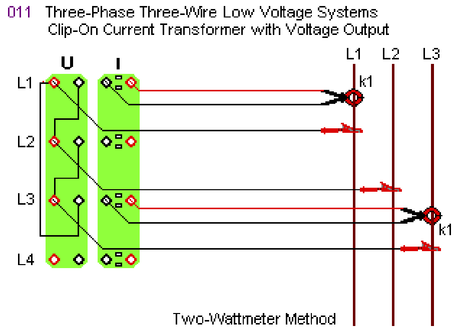
This mains type is mainly used in medium and high-voltage systems. In special cases it is also used in low voltage systems (motor measurement).

The measurement can be operated after the two wattmeter method (in Germany known under Aronschaltung). The circumstance is used here that no neutral conductor exists.

The following applies to the measurement connections shown below:

- The current and voltage path from a given phase are connected to the same phase
- In the Setup, the measuring parameters
  ***Coupling Measurement Input*** to ***AC+DC[1])*** and
  ***U-Connection Delta*** are to be selected.
- Current measurement is performed in
  phases L1 and L3.
- Measuring parameters ***Uratio*** and ***Iratio*** are selected as follows:

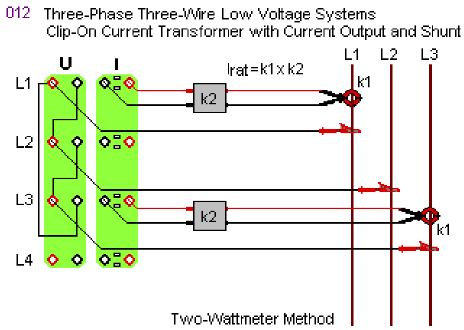
#### a) Clip-On Current Transformer with Voltage Output




***Uratio*** is set to 1 in setup menu for each phase.

***Iratio*** corresponds to the transformation ratio of the clip-on transformer in use (e.g. 10mV/A: Iratio = 100).

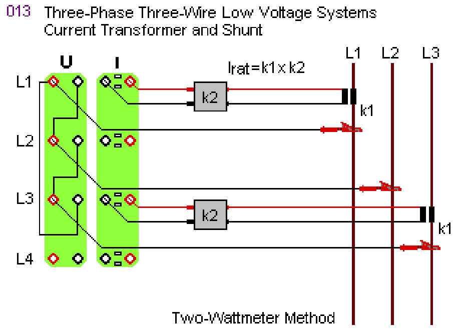
#### b) Clip-On Current Transformer with Current Output and Shunt




***Uratio*** is set to 1 in setup menu for each phase.

***Iratio*** is the product of the transformation ratios of the clip-on current transformer and the Shunt (k = k1×k2)

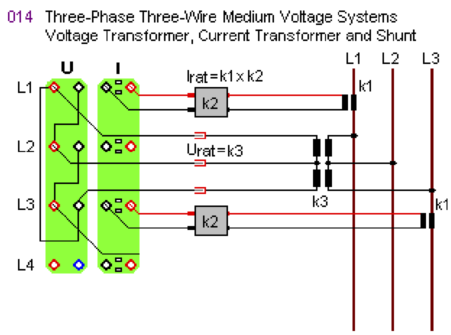
### c) Current Transformer with Shunt




***Uratio*** is set to 1 in setup menu for each phase.

***Iratio*** is the product of the transformation ratios of the clip-on current transformer and the Shunt (k = k1×k2)

### d) Measurements in Three-Phase Medium-Voltage systems with Voltage Transformer, Current Transformer and Shunt




***Uratio*** is set in accordance with the transformation ratio of the voltage transformer in setup menu.

***Iratio*** is the product of the transformation ratios of the current transformer and the Shunt (k = k1×k2)

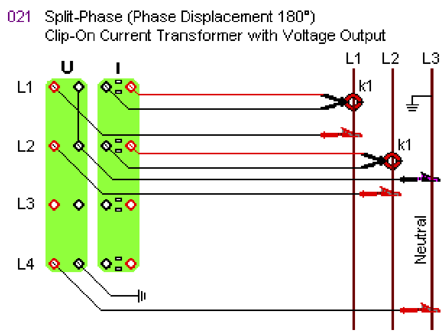
### 7.2.3 Measurements in Split Phase Systems

This supply system is commonly used in 115 V mains networks. In this case, the mains voltage is led via a transformer with center tap. Phase L3 is used as a neutral conductor, the both phase voltages L1 and L2 have a phase shift of 180°. Additionally, phase L4 can be used for measurement of the neutral-to-earth voltage.

The following applies to the measurement connections shown below:

- The current and voltage path from a given phase are connected to the same phase
- In the Setup, the measuring parameters
  ***Coupling Measurement Input*** to ***AC*** and
  ***U-Connection Delta*** are to be selected.
- Current measurement is performed in phases L1 and L3.
- Measuring parameters ***Uratio*** and ***Iratio*** are selected as follows:

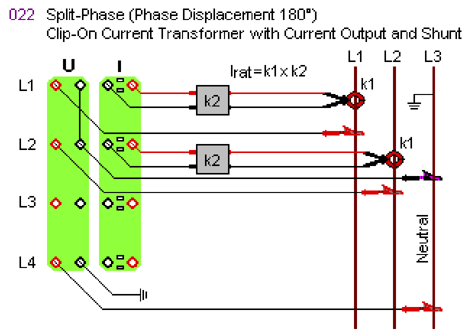
#### a) Clip-On Current Transformer with Voltage Output




***Uratio*** is set to 1 in setup menu for each phase.

***Iratio*** corresponds to the transformation ratio of the clip-on transformer in use (e.g. 10mV/A: Iratio = 100).

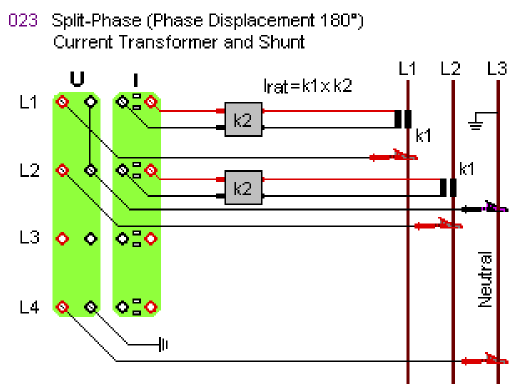
### b) Clip-On Current Transformer with Current Output and Shunt




***Uratio*** is set to 1 in setup menu for each phase.

***Iratio*** is the product of the transformation ratios of the clip-on current transformer and the Shunt: (k = k1×k2)

### c) Current Transformer with Shunt




***Uratio*** is set to 1 in setup menu for each phase.

***Iratio*** is the product of the transformation ratios of the clip-on current transformer and the Shunt: (k = k1×k2)

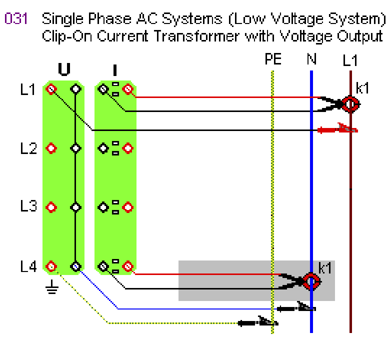
### 7.2.4 Measurements in Single-Phase AC Systems

Up to four measuring points can be connected to the four phase inputs with the **POWER1000** in single-phase AC systems. Phase input L4 preferably is used for measuring the neutral-to-earth voltage. Frequency measurement is performed voltage path of L1, in the case of loss in L2 and/or L3. In the case of loss of all voltage paths, the frequency measurement is performed in the currents path of L1, L2 and/or L3.

The following applies to the measurement connections shown below:

- The current and voltage path from a given phase are connected to the same phase (L1, L2 or L3).
- In the Setup, the measuring parameters
  ***Coupling Measurement Input*** to ***AC+DC*** and
  ***U-Connection Star*** are selected
- Measuring parameters ***Uratio*** and ***Iratio*** are selected as follows:

**a) Clip-On Current Transformer with Voltage Output**

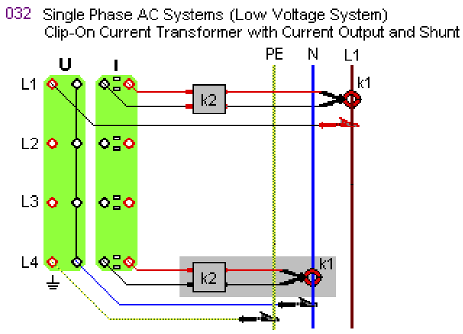



***Uratio*** is set to 1 in setup menu for each phase.

***Iratio*** corresponds to the transformation ratio of the clip-on transformer in use (e.g. 10mV/A: Iratio = 100).

Three additional measuring points within the same single-phase AC system can be measured simultaneously with phase inputs L2, L3 and L4.

### b) Clip-On Current Transformer with Current Output and Shunt

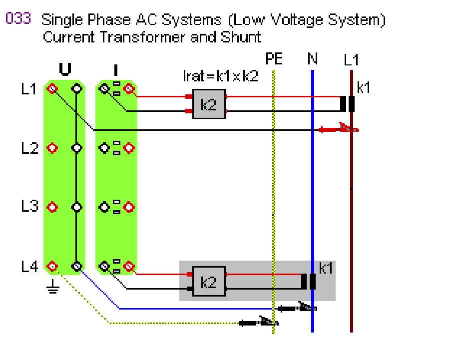



***Uratio*** is set to 1 in setup menu for each phase.

***Iratio*** is the product of the transformation ratios of the clip-on current transformer and the Shunt: (k = k1×k2)

Three additional measuring points within the same single-phase AC system can be measured simultaneously with phase inputs L2, L3 and L4.

### c) Current Transformer with Shunt




***Uratio*** is set to 1 in setup menu for each phase.

***Iratio*** is the product of the transformation ratios of the clip-on current transformer and the Shunt: (k = k1×k2)

Three additional measuring points within the same single-phase AC system can be measured simultaneously with phase inputs L2, L3 and L4.

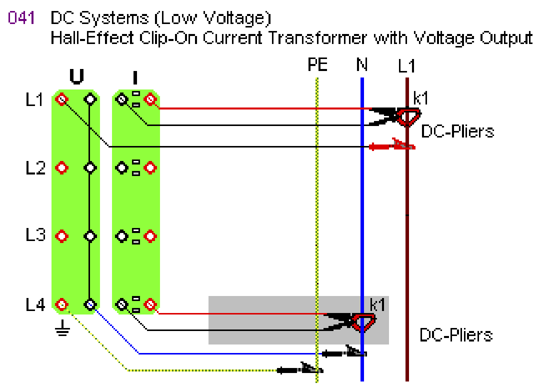
### 7.2.5 Measurements in Low-Voltage DC Systems

Measurements in DC systems are usually performed with Hall-effect clip-on current transformers in the current path. Special attention must be paid to the potential relationship if shunts are used in the current path of DC systems. This circuit configuration is used primarily in low-voltage range.

The following applies to the measurement connections shown below:

- The current and voltage path from a given phase are connected to the same phase (L1, L2 or L3).
- In the Setup, the measuring parameters
  ***Coupling Measurement Input*** to ***AC+DC*** and
  ***U-Connection Star*** are selected
- Measuring parameters ***Uratio*** and ***Iratio*** are selected as follows:

#### a) Hall-Effect Clip-On Current Transformer with Voltage Output

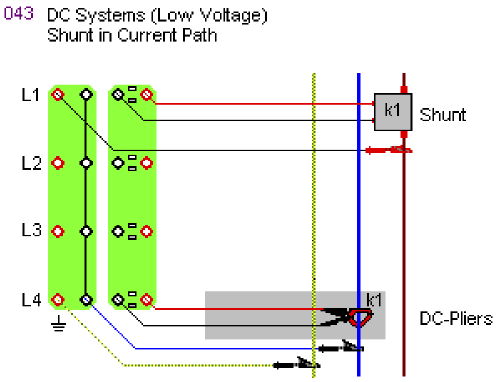



***Uratio*** is set to 1 in setup menu for each phase.

***Iratio*** corresponds to the transformation ratio of the clip-on transformer in use (e.g. 10mV/A: Iratio = 100).

Three additional measuring points within the same single-phase AC system can be measured simultaneously with phase inputs L2, L3 and L4.

b) Shunt in the Current Path




***Uratio*** is set to 1 in setup menu for each phase.

***Iratio*** corresponds to the current-to-voltage transformation ratio of the shunt (= 1/R in A/V).

Sample: R=50mΩ; Iratio = 1/0.05 = 200

Three additional measuring points within the same single-phase AC system can be measured simultaneously with phase inputs L2, L3 and L4.

# 8. Technical Data

Provided that no other note is available, the following data apply under the specified environmental conditions and the scaling factor 1.

The specified measurement uncertainties apply for a calibrating interval of 24 months and comply from 30 minutes after the device has been switch-on.

Voltage Measurement Inputs

| Characteristic | Specification | Note |
|---|---|---|
| Number | 4 | isolated from each other |
| Connection | 1 pair each 4-mm safety sockets | red (High), black (Low) |
| Connection types | 1-phase<br>2-phase (split-phase)<br>3-phase wye<br>3-phase delta | L1-N, PE-N<br>L1-N, L2-N, PE-N<br>L1-N, L2-N, L3-N, PE-N<br>L1-L2, L2-L3, L3-L1 |
| Input Impedance | 4 MΩ // 5 pF | |
| Coupling | AC / AC+DC | |
| Input Ranges | 0 ... 150 V / 300 V / 600 V / 900 V | manually selectable |
| Scaling Factors | 0.001 ... 99999 V/V | individually adjustable for each input |
| Overload Capacity | continuous: 1200 $V_{eff}$;<br>transient: (1.2/50µs): 6000 $V_{peak}$ | |
| Sampling Rate | 100 kS/s | Simultaneous on each input |
| Sampling Resolution | 16 bit | |
| Frequency Range | DC; 16 Hz ... 10 kHz | |
| Side-to-Side Crosstalk | -60 dB between voltage channels;<br>-95 dB between voltage and current channels | |

Current Measurement Inputs (for Clip-On Sensors or Shunts)

| Characteristic | Specification | Note |
|---|---|---|
| Number | 4 | isolated from each other |
| Connection | 1 pair each 4-mm safety sockets | ret (High), black (Low) |
| Connection Type | 3xL + N<br>3xL<br>2xL + N (2-wattmeter-method) | L1, L2, L3, N<br>L1, L2, L3, N calculated<br>L1, L3, N, L2 calculated |
| Input Impedance | 100 kΩ // 5 pF | |
| Coupling | AC / AC+DC | |
| Input Ranges | 0 ... 300 mV / 3 V | manually selectable |
| Scaling Factors | 0 / 0.001 ... 99999 V/V | individually adjustable for each input |
| Overload Capacity | continuous: 400 $V_{eff}$;<br>transient (1.2/50µs): 1000 $V_{peak}$ | |
| Sampling Rate | 100 kS/s | simultaneous on each input |
| Sampling Resolution | 16 bit | |
| Frequency Range | DC; 16 Hz ... 10 kHz | |

Frequency Measurement

Frequency measurement operates individually at every voltage measuring input. The selection of the system frequency for the 3~ system and the alignment of other measuring functions referred on it operates with priority at the voltage measuring channel U1, at missing of U1 signal automatically switches to U2 and/or U3.

| Measuring Quantity | Measuring Range | Resolution | Meas. Uncertainty ±(% of m.v. + Digits) |
|---|---|---|---|
| Frequency of Voltage U (U≥ 2% of Range) | 16.00 ... 99.99 Hz | 0.01 Hz | 0.05 +1 |
| | 100.0 ... 999.9 Hz | 0.1 Hz | 0.1 +2 |
| | 1.000 ... 9.999 kHz | 0.001 kHz | 0.2 +3 |
| | ≥10.00 kHz | 0.01 kHz | 0.5 +5 |

## Voltage Measurements

Effective Voltage U

| Selected Range | Measuring Range (CF ≤ 1.4 @ Umax) | Resolution | Meas. Uncertainty ±(% of meas. value + % of range) | | |
|---|---|---|---|---|---|
| | | | 16÷65Hz | DC/65÷1000Hz | 1 ÷10kHz |
| 150 V | 1.0 ... 150.0 Veff | 0.1 Veff | 0.1 + 0.1 *) | 0.4 + 0.2 | 1 + 0.5 |
| 300 V | 1.0 ... 300.0 Veff | 0.1 Veff | | | |
| 600 V | 1.0 ... 600.0 Veff | 0.1 Veff | | | |
| 900 V | 1.0 ... 900.0 Veff | 0.1 Veff | | | |

***) and/or in accordance with IEC/EN 61000-4-30**

Waveform Voltage u(t)

| Selected Range | Measuring Range | Resolu-tion | Meas. Uncertainty ±(% of meas. value + % of range) | | |
|---|---|---|---|---|---|
| | | | 15-65Hz | DC/65÷1000Hz | 1 ÷10kHz |
| 150 V | -215.0 ... +215.0 V | 0.1 V | 0.4 + 0.2 | 0.4 + 0.2 | 1 + 0.5 |
| 300 V | -425.0 ... +425.0 V | 0.1 V | | | |
| 600 V | -850.0 ... +850.0 V | 0.1 V | | | |
| 900 V | -1275 ... +1275 V | 1 V | | | |

Harmonic and Interharmonic Voltage

The specified measuring uncertainties apply for measuring voltages >5% of range. They correspond to Class 1 in accordance with EN 61000-4-7.

| Measurement Quantity (see table p. 49) | Measuring Range | Resolu-tion | Meas. Uncertainty ±(% of m.v. + % of range) | |
|---|---|---|---|---|
| | | | h1:16÷65Hz | 65÷1000Hz |
| Absolute Amplitude | 0.0... 150.0/.../900.0 Veff | 0.1 Veff | 3 + 0.1 | 5 + 0.2 |
| Relative Amplitude | 0.0 ... 200.0% | 0.1% | t.b.d. | t.b.d. |
| Phase Angle | -179.9° … +180.0° | 0.1° | 1.0° x h | 2.0° x h |
| THD | 0.0 … 200.0% | 0.1% | 2% | 4% |

## Current Measurements

Effective Current

| Selected Range | Measuring Range (CF ≤ 1,4 @ Umax) | Resolution | Meas. Uncertainty ±(% of meas. value + % of range) | | |
|---|---|---|---|---|---|
| | | | 16÷65Hz | DC/65÷1000Hz | 1 ÷10kHz |
| 300 mV | 0.0 ... 300.0 mAeff | 0.1 mAeff | 0.2 + 0.1 | 0.4 + 0.2 | 1 + 0.5 |
| 3 V | 0.000 ... 3.000 Aeff | 0.001 Aeff | | | |

Signal shape Current i(t)

| Selected Range | Measuring Range | Resolution | Meas. Uncertainty ±(% of meas. value + % of range) | | |
|---|---|---|---|---|---|
| | | | 15-65Hz | DC/65÷1000Hz | 1 ÷10kHz |
| 300 mV | -425.0 ... +425.0 mA | 0.1 mA | 0.4 + 0.2 | 0.4 + 0.2 | 1 + 0.5 |
| 3 V | -4.250 ... +4.250 A | 0.001 A | | | |

Harmonic and Interharmonic Currents

The specified measuring uncertainties apply for measuring voltages >5% of range without measuring accessories. They correspond to Class 1 in accordance with EN 61000-4-7.

| Measurement Quantity (see table p. 49) | Measuring Range | Resolu-tion | Meas. Uncertainty ±(% of m.v. + % of range) | |
|---|---|---|---|---|
| | | | h1:16÷65Hz | 65÷1000Hz |
| Absolute Amplitude | 0.0... 300.0 mAeff | 0.1 mAeff | 3 + 0.1 | 5 + 0.2 |
| | 0.0... 3.000 Aeff | 0.001 Aeff | 3 + 0.1 | 5 + 0.2 |
| Relative Amplitude | 0.0 ... 200.0% | 0.1% | t.b.d. | t.b.d. |
| Phase Angle | -180.0° … +180.0° | 0.1° | 1.0° x h | 2.0° x h |
| THD | 0.0 … 200.0% | 0.1% | 2% | 4% |

## Power Measurements

Active Power, Reactive Power, Apparent Power

The specified measurement uncertainties apply excluding the tolerances of the measurement accessories.

| Measuring Rang | Resolution | Meas. Uncertainty ±(% of m.v. + % of range) | |
|---|---|---|---|
| | | 16÷65Hz | 65÷1000Hz |
| (RangeU x Uratio) x (RangeI x Iratio)<br>Sample ::<br>(300V x 1V/V) x (3V x 100A/V)<br>= 90.000 W = 90.00 kW | 4 decimal pos. referred to end-scale value<br>sample: 0.01 kW | 0.5 + 5 | t.b.d. |

## Display

| Characteristic | Specification |
|---|---|
| Type | touch sensitive color-LCD, ¼ VGA |
| Resolution | 320 x 240 pixels |
| Display Range | 115 x 86 mm |
| Contrast Adjustment | very bright to very dark |
| Background Illumination | type CCFL; luminance type 80 cd/$m^2$ |
| Display Functions | measuring results, adjustment menus, status information, operating instructions, measurement circuits |

## Operating Elements

| Characteristic | Specification |
|---|---|
| Touch-Screen | touch sensitive virtual operating elements on the screen (softkeys) for menu driven operation of the device |
| 4 Touch keys | |
| ON\|MENU | start of device / enter the home screen |
| HELP | enter and close operating and connection references |
| ESC | return to the previous operating level |
| PRINT | screen shot onto the USB-data carrier |
| Mains Switch | for switching the mains supply of the instrument on and off, illuminated for indication of on/off status |

## Storage

| Characteristic | Specification | Note |
|---|---|---|
| Storage media | • internal flash-storage 4 MB<br>• plug-in compact-flash (accessory)<br>• plug-in USB-data carrier (accessory) | <br>any capacity<br>any capacity |
| Screen Shot | Storage of actual display as bitmap-file | Approx. 5 shots//MB |
| Measured Data | | |
| Interval data | time controlled recording of up to 1000 measuring quantities simultaneously in intervals from 0.2s ... 2h | >200.000 measurements/MB |
| Event Data | measuring value triggered recording of selectable events with time of occurence, type, phase and measuring value | >50.000 events/MB, 10ms timestamp resolution |
| Waveform | measuring value triggered recording of signal waveform u(t) and i(t) of selectable phases with adjustable sample rate (10µs ... 655µs), duration and pretrigger | |
| ½-period rms | measuring value triggered recording of half-cycle effective values $Ueff_{1/2}$ and $Ieff_{1/2}$ of selectable phases with adjustable recording duration and pretrigger | |
| Setup profile | | |
| | | |

## Clock

| Characteristic | Specification | Note |
|---|---|---|
| Type | real-time quartz clock | with backup battery |
| Time Format<br>time<br>date | <br>hh:mm:ss.00<br>TT.MM.JJJJ or<br>JJJJ-MM-TT or<br>MM/TT/JJ | |
| Time Resolution | 10 ms | |
| Deviation | max. 5 s/month | |

## Reference Conditions for Adjusting

| Characteristic | Specification |
|---|---|
| Ambient Temp. | 23±2°C |
| Humidity | 50±10% relative humidity |
| Power Supply | 230 V ±10% or 110 V ±10% |
| Meas. Connection<br>voltage<br>current | <br>3-phase wye (L1-N, L2-N, L3-N, PE-N)<br>3xL + N (L1, L2, L3, N) |
| 3~voltage imbalance | <0.1% |
| Waveform | sinus, without DC-component |
| cosφ | 1.0 |

## Digital Inputs

Status Inputs

| Characteristic | Specification | Note |
|---|---|---|
| Number | 4 | Potential free, common reference point |
| Functions | • representation and recording of binary signals | e.g. operating conditions of equipments, installations and alarm detectors |
| Connection | plug connector with screw terminals | |
| DC-input signal | Low < 3 V<br>High 5…24 V (6 mA @ 24 V) | $S_O$-compatible |
| Overload Capacity | 30 V, continuous | |

Control Inputs

| Characteristic | Specification | Note |
|---|---|---|
| Number | 4 | common ground faced reference point |
| Functions | • start/s/stop of a recording<br>• synchronization of storage intervals with the electrical utility clock pulse<br>• 2 meter inputs for energy measurements with pulses | |
| Connection | plug connector with screw terminals | |
| DC-input signal | Low < 2 V<br>High 4 … 5 V (0.5 mA @ 5 V) | TTL-compatible |
| Overload Capacity | 6 V, continuous | |

Alarm Output

| Characteristic | Specification | Note |
|---|---|---|
| Number | 1 | |
| Function | Signalling the limit exceeding of up to 4 measuring quantities | Works as combined alarm |
| Allocation | Measuring quantities and limits adjust-able | |
| Connection | Plug Connector with screw terminals | |
| Output Signal | Relay contact, potential free | |
| Switching Capacity | 30 V, 1 A | |

## Data Interface

Ethernet

| Characteristic | Specification |
|---|---|
| Functions | • remote control of the device via web-browser<br>• file transfer of measuring - and configuration files<br>• Installation of firmware-updates |
| Type | 10/100Base-T (RJ45) |
| Protocol | TCP/IP, HTTP, FTP |

USB-Host

| Characteristic | Specification |
|---|---|
| Functions | For connecting USB data carriers (USB-memory-stick, USB-hard disk) for<br>• Recording of measured data, adjustment profiles or screen shots<br>• Installation of firmware-updates |
| Type | USB 2.0 high speed interface, compatible with USB 1.1 |

USB-Slave

| Characteristic | Specification |
|---|---|
| Functions | • remote control of the device<br>• data transfer of measuring - and configuration files |
| Typ | USB 2.0 high speed interface, compatible with USB 1.1 |

Power Supply

| Characteristic | Specification | Note |
|---|---|---|
| Mains Voltage | 85 ... 250V AC/DC | |
| Mains Frequency | 45 … 65 Hz / DC | |
| Power Consumption | max. 40W / 70VA | |
| Mains Failure Bridge Time | >20 min through incorporated lead gel accumulator | after >2h load |
| Connection | 10-A-inlet connector with earthing contact (IEC 320) | |

## Electrical Safety

| Characteristic | Specification | Note |
|---|---|---|
| Protection Class | I per EN 61010-1 | |
| Measuring Category | CAT IV at 600 V<br>CAT IV at 900 V | per EN 61010-1 |

## Electromagnetic Compatibility

| Characteristic | Specification | Note |
|---|---|---|
| Disturbance Immunity and emission | per EN 61326 | Conform to EC-regulation 89/336 |

## Environmental Condition

| Characteristic | Specification | Note |
|---|---|---|
| Temperature<br>Operating<br><br>Storage/Transport | <br>0 … +40°C (within specification)<br>-10 … +50°C (without damage)<br>-20 … +70°C (-20°C for max. 48h) | <br>built-in forced ventilation must not be hindered |
| Humidity<br>Storage<br>Operating 0…25°C<br>25…40°C | <br>without condensation<br>max. 95% r.h, without condensation<br>max. 75% r.h. | <br>after condensation: 2h temperature compensa-tion before getting operated |
| Altitude (over NN)<br>Operating<br>Transport | <br>max. 2000 m<br>max. 12 km | |

## Mechanical Design

| Characteristic | Specification |
|---|---|
| Type | benchtop instrument in plastics case with handle |
| Protection<br>housing<br>connectors | According to DIN VDE 0470 T1 / EN 60529<br>IP30<br>IP20 |
| Dimensions | 290 x 245 x 140 mm (without handle) |
| Weight | 2,4 kg net (without accessories) |

## Applied Regulations and Standards

| Norm / Release | Description |
|---|---|
| **IEC 61010-1<br>EN 61010-1<br>VDE 0411-1:2001** | Safety requirements for electrical equipment for measurement, control and laboratory use |
| **IEC 60529<br>EN 60529<br>VDE 0470-1:2000** | Protection provided by enclosure (IP-Code) |
| **IEC 60068** | Basic environmental test procedures |
| **VDI/VDE 3540 Bl.2** | Reliability of measurement, control and regulating devices - Climatic categories for devices and accessories |
| **EN 61326+A1 ... A3<br>VDE 0843-20:2003** | Electrical equipment for measurement, control and laboratory use - EMC- requirements |
| **EN 50160:1999** | Voltage characteristics of electricity supplied by public distribu-tion systems |
| **EN 61000-4-30: 2003** | Testing and measurement techniques – Power quality meas-urement methods |
| **IEC 61000-4-7<br>EN 61000-4-7<br>VDE 0847-4-7:2003** | Testing and measurement techniques – General guide on harmonics and interharmonics measurements and instrumen-tation, for power supply systems and equipment connected thereto |
| **IEC 61000-4-15<br>EN 61000-4-15<br>VDE 0847-4-15:2003** | Flickermeter – Functional and design specifications |
| **DIN 40110 T1/T2** | Quantities used in alternating current theory; two-line circuits / multi conductor circuits |
| **DIN 43864** | Current interface for pulse transmission between impulsing meters and tariff devices |

# 9. Maintenance and Repair

## 9.1 Maintenance housing

No special maintenance is required for the housing. Keep the outside surface clean. Use a slightly damped cloth for cleaning (preferably use a micro fibre cloth). Avoid the use of cleaners and abrasives.

In particular ensure that the forced ventilation does not block. Longer blocking the fan can lead to destruction of the device. Plug no thin subjects like cords pins etc. into the ventilation slots at the left side of the case!

For cleaning the interior from soiling through the forced ventilation contact the service!

## 9.2 Maintenance Accumulator

The built-in lead gel accumulator is maintenance-free and constant against deep discharging. Beyond this, it is overcharge protected after longer service on the mains. The life cycle is > 5 years (manufacturer's specification). An unloaded accumulator requires at least 3 hours for recharging.

**Storage Conditions**

Storage up to 2 years at +20°C

**Accumulator Replacement**

The replacement of the accumulator is to be carried out by a service agency authorized by Dranetz-BMI.

**Accumulator disposal**

Dispose of accumulators which are no more capable for use properly at the collecting points arranged for this (WEEE directive 121/2005)

## 9.3 Fuses

**Mains Input**

These fuses are located inside the instrument close to the mains sockets and are not accessible from the outside.

**Replacement of Fuses** → chap. 2.1.1

**Observe WARNING 12**

**Power Supply Output**

These fuses are located inside the instrument

**Replacement of Fuses**

- ☞ Disconnect the instrument at all poles from the measuring circuits and mains power.
- ☞ Loosen the two screws at the bottom of the instrument, press the two green buttons to the side and lift the housing bottom at the same time.
- ☞ The two secondary fuses are now accessible and can be inspected and replaced if necessary.

**Observe WARNINGS 11 und 12**

## 9.4 Take-Back and Environmental Compatible Disposal

The POWER1000 complies with the environmental directives:
U Directive 2002/95/EC (RoHS), EU Directive 2003/11/EC and
EU Directive 2002/96/EC (WEEE).

According to WEEE 2002/96/EC, the devices are marked after DIN EN 50419 with the crossed-out wheeled bin illustrated on the image.

This symbol indicates collection separated from private households waste.

According to WEEE directive as well as to national regulations based on that, the POWER1000 is a device of category 9 (monitoring and test instruments). This category is not contained in the RoHS-guidelines.

Concerning take-back of waste electrical and electronic equipment please contact our service and/or your contractual partner.

## 9.5 Repair- and Replacement Service
### DKD*-Calibration and Rental Device Service

If required, please contact:

Dranetz-BMI
**Service-Center**
1000 New Durham Road
Edison, New Jersey 08818-4019
Telephone 732-287-3680
Telefax 732-248-1834
E-Mail sales@dranetz-bmi.com

This address applies for United States.
In your country please contact our authorized representative or partner organization.

* **DKD** Calibration Laboratory for Electric Quantities DKD – K – 19701, accredited per DIN EN ISO/IEC 17 025

Accredited quantities: DC-voltage, DC-curret Intensity, DC-resistance, DC-power, AC-voltage, AC-current intensity, AC-active power, AC-apparent power, capacity, frequency

**Note:**
Parts of software implemented on your POWER1000 are subject to GNU general Public License or other license Open-source-license agreements. The source code of these software packages can be requested over our services.

# Annex

## A Power and Energy Measurement

### A.1 General

Electric energy can be derived from every available primary energy carrier with comparably high efficiency and can be converted into other practical energy forms. On the contrary, a decisive disadvantage is the insufficient storage capability. From this follows an energy supply system in which a balance is guaranteed between generation and consumption at any time. The advantages are significant so that the relatively high costs for this system are accepted for numerous installations.

From the close link-up between producer and consumer follows the requirement to install measurement and control systems which cover continuous observation of the power supply system and allows for adapting the operating conditions to the actual requirements. In this way, a capable measurement system captures the basic measurement quantities current, voltage and power and calculates characteristics of electricity with the aim to optimize mains losses and secure reliable operation.

Generally, the following measurement quantities and analysis are of importance:

- RMS-voltage, currents (average value, min, max.)
- Power (active -, reactive – apparent power)
- Power factor cosφ and/or PF with magnitude and sign
- Total harmonic distortion
- Voltage events (peaks, dips, drops)
- Periodical analysis
- Statistical analysis
- Analysis of events
- Compensating currents

The sections A1 to A3 are concerned with formation of the basic measurement quantities for power and energy measurement under extensive consideration of the standard requirements. Required deviations from several standards are described more closely and reasonably explained.

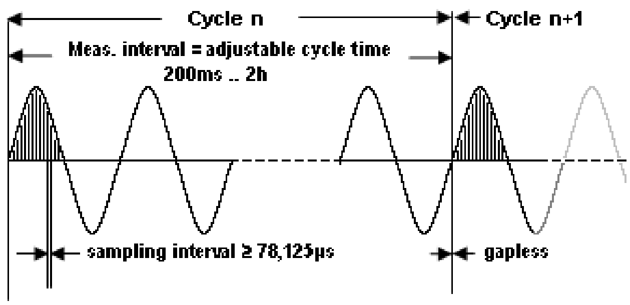
The sections following on it describe measurement quantities in the supply network which are derived from the basic measuring quantities. Those which are implemented in the POWER1000 are listed in chap. → 6.ff.

Finally measurement technologies are described, that apply to the specific fields of measurements in power supply networks.

## A.2 Description of Measurement Sequence

Each of eight analog Measurement inputs is led by separate via an internal voltage attenuator onto the A/D-converter. The input signals are sampled simultaneously with a frequency being appropriate for the selected measurement function and the adjusted measuring parameters, but 100kS/s at maximum, and converted into a 16-bit data word. The sampled values are squared in the signal processor (DSP) and consequently integrated in a low pass filter. The output value is computed every ½ cycle (TRMS). The root of it represents the effective value for the ½-period interval for 50 and 60 Hz. It is the basis for all succeeding display - and storage values.

A measurement cycle begins with the clock of the system time [1]), which can be synchronized with the internal or an external time reference.




Measurement cycle:

- Sampling interval for waveform and transients
- ½ period for PQ - short term events
- 200ms (10/12 periodes at 50/60Hz) for PQ- characteristics
- 1s for instantaneous measuring values
- 10- min mean value for PQ- long term events
- 2h for PQ- flicker algorithm
- Selectable aggregation intervals for further aplications (1s .. 60min)

In the operating mode sample the measured values as well as time and date are stored to the FIFO storage at the end of each time interval (time controlled quantities) or after recognition of an event (event controlled quantities). When the memory is filled up the, the oldest measurement data set record is overwritten by the current record. Stored measurements are thus continuously updated.

Measurement sequences taken over a longer time period as well as transients and events can be stored to an external data carrier (accessory). These can be displayed alphanumerically at the touch screen, or can be uploaded to, and analyzed at a PC with a PC-Software (accessory, in preparation).

[1]) The system time is defined with the Unix Time. With it the passed seconds from the start date 1. January 1970, 00:00 H UTC (world time, Coordinated Universal TIME) are counted. The UTC replaced the GMT (Greenwich Mean Time). It is defined independent from time zones and therefore is used for time zones independent statements (e.g. aviation). For computer programs the periods can be easily calculated, and adaptation of summer- on winter time is of no importance.

## A.3 Forming the Basic Measurement Quantities

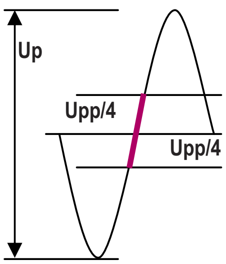
### Frequency Measurement

Frequency is determined from the number of complete oscillating periods during a defined time period as mean frequency value. In accordance with IEC EN 61000-4-30 the 10 s time interval was chosen.

In general, the real net signal is not pure sinus shaped. Disturbance signals cause distortion of the waveform which may lead to incorrect measuring results of the frequency. The standard mentioned above recommends filters for suppressing disturbances of higher frequencies, but accept other measurement methods that provide equivalent measuring results.

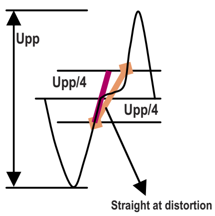
For the broadband POWER1000 the method of filtering the input signal does not achieve the objective. For frequency determination the measurement technique described subsequently is applied.

The start of measurement is synchronised over the internal clock. With the cycle accuracy of 1 minute/year (it corresponds to approx. 1,9 ppm) in connection with the possibility of the external time synchronisation, all normative requirements are met.




**Within each measurement period of 200ms (corresponds to 10 / 12 periods at 50 / 60 Hz) the peak-to-peak voltage is measured.**

**Subsequently the curve points +Upp/4 and –Upp/4 are determined and combined by a straight line.**




**The mean value from it is the intersection point with the zero crossing for the frequency determination. Frequency is calculated from the distance and number of zero crossings.**

Frequency measurement is performed in the voltage channel of phase 1 which is defined as a reference channel. In the case of dropout, the voltage channel of phase 2, then of phase 3 is used. In the case simultaneous dropout of the voltage channels the current channels 1 to 3 are used for frequency measurement.

With regard to the normative predefinitions for the assessment of power quality, the measurement performs gaplessly. The measured value is displayed every second on the display.

### Current an Voltage Measurement

Current measurements can be performed in both alternating and in direct-current circuits with POWER1000.

The current and voltage measured values can be represented and stored as

- Instantaneous values (200ms-value = effective value)
- Maximum, i.e. the in each case highest 200ms instantaneous value within the adjusted measurement interval
- Minimum, i.e. the in each case lowest 200ms-instantaneous value within the adjusted measurement interval
- Average values within the adjusted measurement interval

The measuring interval is the time distance of two immediately successive observation periods.

For voltage measurements up to 900 V in the most applications the test point is directly applied to the voltage measurement input.

The input signal for the current measurement is a voltage which is proportional to the measured current value. This voltage is integrated by digital and as a result, the output signal is equivalent to the measured current.

In addition to the commonly used current adapters such as shunt and pliers current transformer (with voltage output!) a current adapter based on the principle of the Rogowski coil is applicable.

The Rogowski coil consists of an iron-free coil with the one pole returning through the centre of the helical windings, so that both terminals are at the same end. Due to the air core the Rogowski coil has a low inductance and no iron saturation. Therefore it can respond to fast chang-ing processes as required for transient measurements. Furthermore, the advantage of high linearity is emphasized ranging from low current intensity up to high short-circuit intensities. Finally, a correctly formed Rogowski coil is largely immune to electromagnetic interference.

#### Configuring the Measurement Parameters for AC:

- Coupling measurement inputs  AC
- Urange L1…L3 is set corresponding to the mains voltage.
- Uratio L1…L3 and Iratio L1…L3 are set corresponding to the transmission ration of the voltage – and current transformer.

Voltages up to 900V can be applied to the device directly. For recognition of harmonics up to order 50 as well as for interharmonics the applied current transformer must have a bandwidth of 5 kHz at minimum.

In each case voltage and current inputs of the same path must be applied to the same phase inputs.

**Configuring the Measurement Parameters for AC/DC and DC:**

- Coupling measurement inputs  AC+DC

- Urange L1…L3 is set corresponding to the mains voltage.

- Uratio L1…L3 and Iratio L1…L3 are set corresponding to the transmission ration of the DC-voltage – and DC-current transformer.

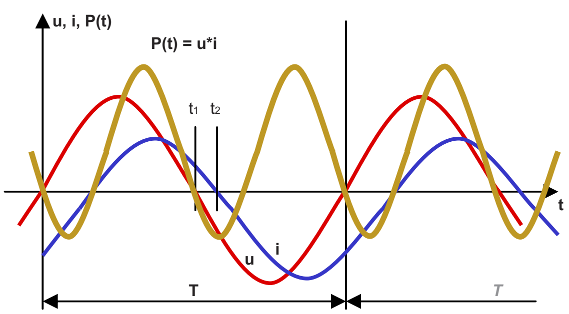
In mixed circuits (AC+DC) preferably hall-effect transformers are used for measuring voltage and current. In direct-current circuits, compared to the usually applied voltage attenuators and shunts, they have the advantage of galvanic separation between measurement circuit and measurement input. For recording the harmonics as well as the interharmonics up to the 50 harmonic, the current and voltage converters must be suitable for a bandwidth of at least 5 kHz.

## Electric Power P

The electric power is the product of the instantaneous values of current intensity and voltage on any measurement point of an electric circuit:

$$P(t) = u * i$$

This product in general takes positive and negative values within a period. If the signs from current intensity and tension are equal, the energy flux occurs in a (random) determined direction. If signs are different (e.g. between t1 and t2) the energy flows in the opposite direction.




For determination of electric power a proper arrow system is introduced. The POWER1000 mainly is applied for power consumption measurements. Therefore, in accordance with DIN 5489 the consumer arrow system applies: At energy flow in consumer direction, the power has a positive sign.

The active power P is the arithmetic mean value of the instantaneous power, aggregated over the duration of a period:

$$P = \frac{1}{N}\sum_{k=0}^{N-1} u * i$$

**N** **Number of sampling values per period**

k Index of the sampling values

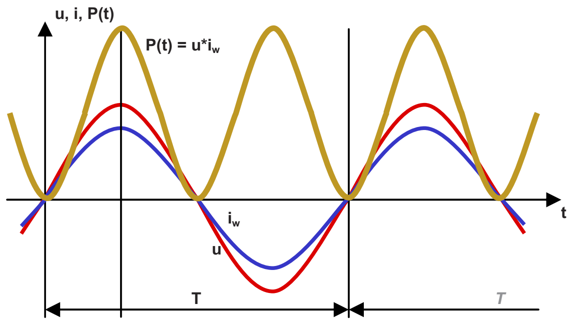
## A.4 Derived Measurement Quantities

The rms values of current intensity, voltage and electric power service are directly perceptible. The further measurement quantities are operands derived from it.

Apparent Power S

The apparent power S results from the highest attainable value of active power. This can only be achieved in the case of pure active resistance and is the product of the rms values of current intensity and voltage. It is always larger or equal to the magnitude of active power:

$$S = U * I \geq |P|$$




**Reactive Power Q**

The reactive power is an operand which is derived from active power P and the apparent power S. For the undisturbed signal it is a measure of the losses through inductive and capacitive resistances. Furthermore, non-linear burdens cause losses which affects harmonics. The result of losses is an increase of load of the electric net. Therefore, energy suppliers and consumer undertake efforts to keep the reactive share as small as possible.

In accordance to DIN 40110, for the single-phase network applies:

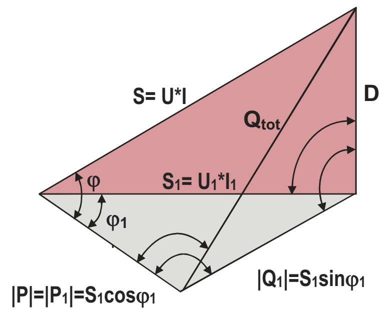
$$Q = \sqrt{S^2 - P^2}$$

This formula applies as well for arbitrary waveform. Reactive power occurs

- if current and voltage do not present the same phase relationship and/or
- if current and voltage are unequal in frequency, that is if harmonics occur.

## Distortion Power D

The energy transport from the producer to the consumer occurs basically only via the fundamental wave of current and voltage. In the case of waveforms which deviate from the cosine shaped process, the reactive power share contains an additional component which supplies no contribution for energy transportation. From the product of mains voltage (fundamental wave) and current harmonic oscillations results the distortion power D.




**Generally applies:** $S^2 = |P|^2 + |Q_1|^2 + D^2$

with $S_1^2 = |P|^2 + |Q_1|^2$ follows: $S^2 = S_1{}^2 + D^2$

$$Q_{tot}^2 = |Q_1|^2 + D^2 \rightarrow D = \sqrt{Q_{tot}^2 - Q_1^2}$$

## Power Factor PF (λ)

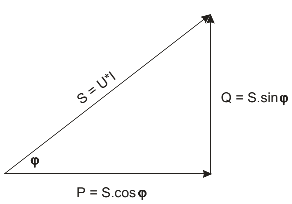
The power factor (or active factor) it is the ration of active power P and apparent power S:

$$\lambda = \frac{|P|}{S} \qquad 0 \leq \lambda \leq 1$$

It is a measure for the utilization degree of apparent power required by the consumer, therefore, indicates the share of usable active current flowing into the load during energy transformation.

## Displacement Factor cosφ

If the fundamental waves of current and voltage are not superimposed through no harmonics, the ratio P/S can be expressed as cosine of angle 1 (index 1 stands for the fundamental wave). For this special case, power factor and displacement factor are equal:




$$\lambda_{\varphi_1} = \cos\varphi_1 = \frac{|P|}{\sqrt{P^2 + Q_1^2}}$$

### Distortion Factor ($\lambda_d$)

$$\lambda_d = \frac{P}{\sqrt{P^2 + Q_{\varphi_1}^2 + D^2}}$$

- Decisive for dimensioning the conductor cross sections is always the total current flow that consists of real component and the described reactive shares.
- At capacitors and inductors the ratio

  $\frac{|P|}{|Q|} = d$ is defined as loss factor.

**Note:** The symbol for distortion reactive power was chosen in accordance to the general practice in literature. In the standard DIN 40110 the symbol $Q_d$ is indicated instead.

### Reactive Power Compensation

The phase shift between current and voltage caused by inductive and capacitive loads requires a higher loading of the supplier. For limiting the apparent power the power factor must be limited in compliance with a specific factor according to regulations of the supplier. The usual regulation accepts the power factor cosφ = 0,9 corresponding to tanφ of 0,48. Hence a reactive energy consumption exceeding 50% of the simultaneously arising active energy consumption normally is charged.

For calculation of the required compensation power, the phase shift between current and voltage must be compensated. For it the power factor $\lambda_{\varphi 1}$ is to be used:

$$\tan\varphi_1 = \frac{Q_1}{|P|} .$$

For a predefined power factor applies:

$$\tan\varphi_{1n} = \frac{Q_{1n}}{|P|} .$$

The required compensation reactive power results with

$$\Delta Q = |P| * (\tan\varphi_1 - \tan\varphi_{1n}) .$$

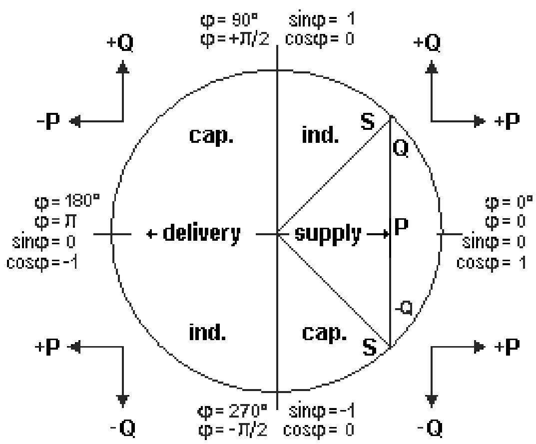
Basically, the understanding for power factor compensation is the compensation of the displacement reactive power. Compensating disturbing harmonics requires harmonic filters. As a calculation basic for it serves the distortion reactive power D.

When comparing the measurement results it is to consider that the cosφ required for displacement reactive power compensation deviates considerably from the power factor PF in severely disturbed networks.

### Energy Flow Direction

Making use of the consumer arrow system in accordance with DIN 5489 "sign and direction rules for electric networks", the active power consumed by a load has a positive sign. In case of reversal of the energy flow the sign of the active power also changes.

The reactive power always has a positive sign in accordance with definition after DIN 40110. By using the relations Q= U*I* sinφ and sinφ = cos(90°-φ), reactive power can also be recorded by using technical measurement methods for sinusoidal alternating quantities. In this case, the voltage is displaced around 90° by pre-switching of a low-pass filter. The reactive power computed from this is provided with a sign dependent on the type of load (capacitive or inductive) and the energy flow direction: In the case of energy consumption and inductive resistance, the phase angle has a positive sign. If the energy flow direction turns around, the sign also changes.



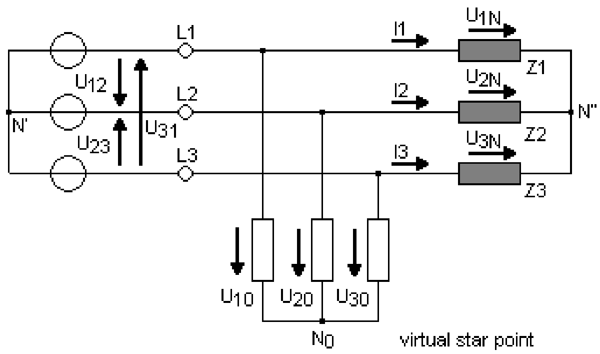

Four-quadrant representation of the power
at sinusoidal alternating quantities

***Note*: By convention it is assumed that capacitors generate reactive power and inductors consume it. This probably comes from the fact that most real-life loads are inductive and so reactive power has to be supplied to them from power factor correction capacitors.**

For distorted waveforms, different results are obtained for the value derived from the equation $Q = \sqrt{S^2 - P^2}$ according to DIN 40110 and the value calculated by sampling the signal. For every harmonic results a value dependent on the amplitude and the phase position. The sign of the individual products of the sampling values $q = u(t) * i(t)$ can change step-by-step. If the crossover points of harmonics match the crossover point of the fundamental oscillation, the value derived from the samples is equal to that calculated from the sinusoidal waveform. This applies on condition of sufficiently high number of samples as well as an exact band limitation.

## A.5 Three Phase Alternating Current – Rotary Current

For transmission and distribution of current with its enormously versatile application, the combination of several alternating current circuits turned out to be expedient whose voltages are phase shifted against one another. Practical importance attained the symmetrical the three-phase system. For the possibility to generate a rotary field it is also designated as alternating rotary system.




The count arrow system shown in above equivalent circuit was chosen in accordance with DIN 5489 (consumer-count arrow system).

### Voltages and Current Intensity

For the number of conductors, only the current carrying phases, and if appropriate the neutral conductor are counted. Protective earth, earth conductor, screens etc. are not considered. In order to avoid misinterpretations, and in agreement with the single-phase- AC system and in deviation from DIN 40110, part 2 voltages between two phases are designated as Wye (phase-to-phase) voltage, voltages between phase and neutral are designated as star (phase-to-neutral) voltages. If the neutral conductor is not available, the star voltages are measured against a virtual neutral point.

In accordance with the node law (first Kirchhoff- law) applies for the current intensity: $i_1 + i_2 + i_3 + i_N = 0$. From this results the neutral current: $i_4 = -(i_1 + i_2 + i_3)$.

This rule cannot be applied for networks with distorted waveforms – this appearing as a consequence of non linear loads. Therefore it is efficient to measure voltage and current separately (→ chap. B.5).

The collective effective values for the current intensity and the star voltages are calculated as follows:

$$\mathbf{I\Sigma} = \sqrt{\sum_{\mu=1}^{3} I_{\mu}^{2}} \quad \text{and} \quad \mathbf{U\Sigma} = \sqrt{\sum_{\mu=1}^{3} U_{\mu 0}^{2}}$$

**Collective Active Power PΣ**

In accordance with DIN 40110 part 2 in the three-phase system the active power PΣ is to be calculated from the sum of the three phase active power shares:

$$P\Sigma = \frac{1}{T}\left(\int_0^T u_{10} i_1 dt + \int_0^T u_{20} i_2 dt + \int_0^T u_{30} i_3 dt\right)$$

In agreement with the single-phase alternating current system, the formula applies also for unsymmetrical voltages and loads as well as for distorted waveform. Considering the relations $i_2 = -(i_1+i_3)$ for current intensity and $u_{10} - u_{20} = u_{12}$ as well as $u_{30} - u_{20} = u_{32}$ , the collective active power can be measured with two measurement systems (in German literature known under Aron-circuit)

$$P\Sigma = \frac{1}{T}\left(\int_0^T u_{12} i_1 dt + \int_0^T u_{32} i_3 dt\right)$$

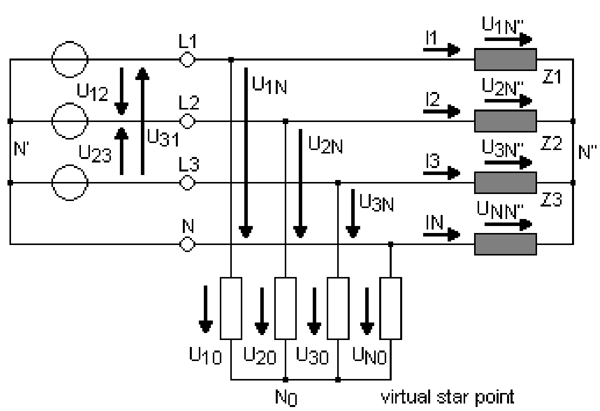
Measurement Connections see → chap. chap. 7

**Collective Apparent Power SΣ**

The general definition for the apparent power according to DIN 40110-2 results from the product of collective voltage and collective current intensity:

$$S\Sigma = U\Sigma * I\Sigma$$

In accordance to mentioned standard the current-carrying conductors are counted under normal operating conditions. As the neutral conductor in a four wire system can be current-carrying, it is considered like a phase. For three wire and four wire systems therefore apply different definitions for the apparent power:




$$S_\Sigma = U_\Sigma \cdot I_\Sigma = \sqrt{U_{1N}^2 + U_{2N}^2 + U_{3N}^2} \cdot \sqrt{I_1^2 + I_2^2 + I_3^2 + I_N^2}$$

Seen from the economic point of view, the realization of this calculation is only practicable for digital means of measure. Therefore in many devices is used the formula

$$S_{\Sigma}^{*} = U_{1N} I_1 + U_{2N} I_2 + U_{3N} I_3$$

With the POWER1000 both methods can be realized. In case of four wire systems, the "classic method" can be realized with the parameter U-Connection set to Delta.

### Collective Reactive Power QΣ

In the same way as for single phase alternating current, the collective reactive power is derived from **S**Σ und **P**Σ:

$$Q\Sigma = \sqrt{S\Sigma^2 - P\Sigma^2}$$

With it all losses are captured, caused by non linear loads, reactive resistors and asymmetry.

### Collective Power Factor PFΣ (λΣ)

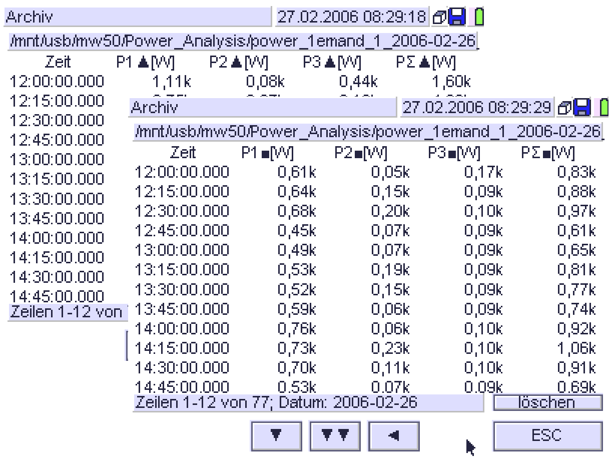
The collective power factor is calculated with

$$\lambda\Sigma = \frac{|P\Sigma|}{S\Sigma}$$

In the case of unsymmetrical load, the informative value of the collective power factor is to be evaluated differently than that one of a phase. In addition to the losses through reactive loads and distortion of waveform, the losses caused by the unsymmetrical loads are also considered here.

## A.6 Energy Measurement

The determination of the power demand to be carried out in the electric authorities for settlement purpose is fundamentally different from measurements in other fields of power measurement technology. Therefore, in addition to usual measurement parameters (Uratio, Iratio etc.), power demand measurement incorporates the metering interval "period" for energy and power measurement. Together with the predefined intervals for rms value parameters (200ms) and power quality parameters, the simultaneous measurement of the power accumulated within the interval "period" is required. As an example, the highest instantaneous power (effective magnitude) and the period power (power demand) might be considered. The first value considers the system load, the second the settlement.

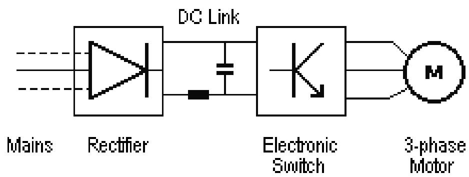



Simultaneous recording of interval data and 200ms-effective values:
power demand in 15-min-Intrerval and 200ms-peak value within the period

The energy consumption within each (power demand) period is accumulated and recorded. From the continuous measurement results the power demand profile. The period of highest power demand for each month is the basis for the power charged by the EVU's (settlement service).
The instantaneous magnitude within the power demand periods can be recorded simultaneously. It gives information over the highest short-term system load and therefore over the required system size.
Tariffs established by the power utilities include a wide variety of tariff types with different tariff zones. Tariff types for special customers and the consideration of quality requirements to the electrical energy supply (Power Quality) multiply the tariff types. The POWER1000 allows for acquisition and recording of fundamental characteristics of the power consumption within a daily interval. The device does not distinguish tariff types covering longer periods than one day (e.g. weekend, holiday, summer/winter etc.).

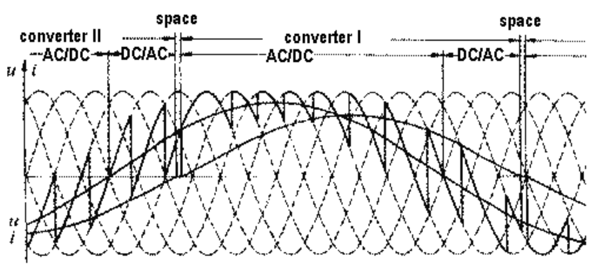
## A.7 Measurements on Frequency Converters

Converter controlled three-phase drives offer considerable advantages compared to direct current generators despite the fact of increased expenses. With availability of electronics components which are suitable for relatively high load currents and high reverse voltages, a wide field was opened for DC link converters. Single or three phase alternating voltage which is applied to the input of the frequency converter is first rectified and conditioned in the DC link. With electronic switches, (e.g. FET or GTO), the DC link voltage is distributed to the individual phases of the motor such that a rotating field is composed with the desired rotational speed, consequently generating the desired frequency.




Schematic diagram of an electronic frequency converter with DC link

Output voltage magnitude and frequency are altered by means of the mark-to-space ratio of the pulse frequency (also known as chopper frequency). With it the pulse duty ratio between positive and negative voltage values are selected such that a sine wave function results as a mean value. The motor voltage consists of individual pulses with constant amplitude and variable pulse width (pulse-width modulation). This results in the desired output frequency, with which the rotational speed of the motor is controlled.




Temporal course of current and voltage of a direct converter

The measurement of electrical quantities on frequency converters does not lead to the desired result for the output voltage. Nor does the pulse frequency provide for clues concerning frequency regulation. Rather, the mean value around the amplitude and frequency shows the characteristics that are required for the measurement of the actual operating condition of voltage and frequency. However, the two measurement variables can not be acquired by simple voltage and frequency measurements.

With the **POWER1000** that measuring problem is solved by means of a low-pass filter for the voltage measurement inputs, which can be activated or deactivated.

The current has a better sine waveform due to inductance of the drive. As a result, the current measurement can be performed with usual methods of measurement up into the highest frequency range of the instrument (100 kHz).

Based upon signals processed in this way, the instrument is then capable of deriving all required measured quantities for power and energy analysis, if it can be assumed that the following conditions are fulfilled:

- Switching frequency must lie within a range of 1.5 to 30 kHz, and fundamental frequency between 10 and 100 Hz.
- Motor current is acquired in an electrically isolated fashion, e.g. by means of (clip-on) current sensors.

Calculation of active power and the effective current are performed with the unfiltered signal. Thus all harmonic shares up to the 50th harmonic are taken into consideration in the measurement result. This allows good conclusions concerning mechanical power and winding warm-up.

For calculating the apparent power (multiplication
Ueff *Ieff), the product is derived from the filtered voltage and the unfiltered drive current. Power factor and reactive power are calculated with the known formulae PF=P/S and $Q = V (S^2 - P^2)$.

Harmonic shares cause warm-up losses and cause troubles in the electric supply system. They may also generate mechanical vibrations causing heat which does not contribute to usable mechanical momentum.
Although through its own heat losses converters reduce the efficiency for transformation of electrical in mechanical power, the average efficiency over the whole operational range is better. The additional energy effort for the heat loss in the power semiconductors is normally compensated with energy savings for a multiple on the mechanical side.

## A.8 Transients Measurement

Transients are defined with several very different characteristics. In general, transients are described as fast pulse-shaped phenomena, the occurrence of which is not predictable. Accordingly, the recording technique is performed event controlled.

Generally transients are understood as phenomena of 100 kHz and more. This deviates basically from the definition for electric power supply networks, for which transient events are defined as very short-term overvoltage with time duration of some microseconds up to some milliseconds and a magnitude up to 6,5 kV. In accordance with IEC/EN 61000-2-2, the standards EN 50160 and IEC 61000-4-30 are concerned with frequencies in the field less than 10 kHz. With its lowest sample rate of 10µs the **POWER1000** corresponds to this request for recording transients.

Transients are caused by permanent changes of the operating condition, such as connecting actions, errors and external atmospheric influences. Moreover, transients can be generated by atmospheric influence. As a consequence, the overall system may react through transient compensatory currents and voltages, until the steady state is achieved again.

***Note:*** For measurements in electric supply networks, events are first understood as characteristics with defined time interval (10ms to 2h), exceeding defined compatibility levels according to the standards and various regulations for voltage quality (EN 50160, Eurelectric). They distinguish from the original definition for transients basically, the acquisition of which performs by scanning the values in user definable sampling intervals.

In addition to the trigger system harmonized with the power quality compatibility turn-off levels, a further trigger system is required. Several trigger conditions may be enabled simultaneously (trigger threshold and trigger slope). Two trigger operating modes serve for detecting and recording the event controlled phenomenon:
In **single mode**, the highest value within each 200ms time interval is retained, and recorded when the defined limit magnitude is exceeded. The next one, occurring in a succeeding time interval can be recorded after manual reset of the trigger condition.
In **roll mode**, the trigger is reset automatically after the event detected in the actual time interval has been recorded. The trigger system ignores events occurring during a current recording.

With the storage function enabled the events can be transferred to an inserted storage media. Due to the fact that memory size does not play a considerable roll in up-to-date technique, storage can be performed in roll mode.

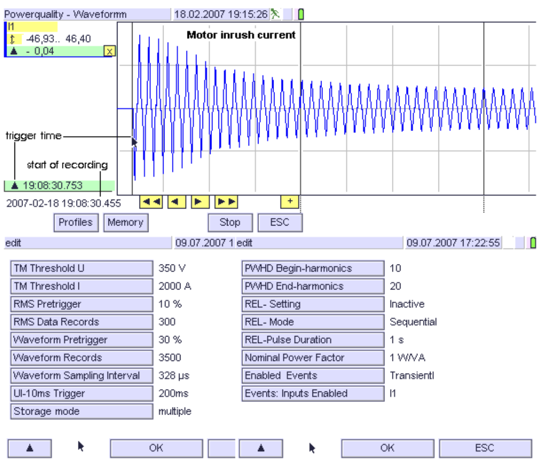
## A.9 Special cases of the Transients Measurement

In the most applications, the defined transgression of a trigger threshold plays a special role. In this way, the transients occurring during switching actions and voltage drops are in particular meant. After connecting a load of higher performance, a start-up current which leads to the drop of the mains voltage occurs on a short-term basis.

The determination of the start-up current as well as its limit belongs to the essential tasks in the development of power supplies.

### A.9.1 Motor Start-up Current

An electrical motor essentially consists of the housing (stator) and the multipolar rotors which are wrapped with copper wire. If the rotor winding is connected to the network, at first a high current rushes in and the engine begins to rotate. In this case, a generation current occurs which acts against the inrush current. The initial power demand decreases and approximates to the rated consumption at a specific rotation speed.

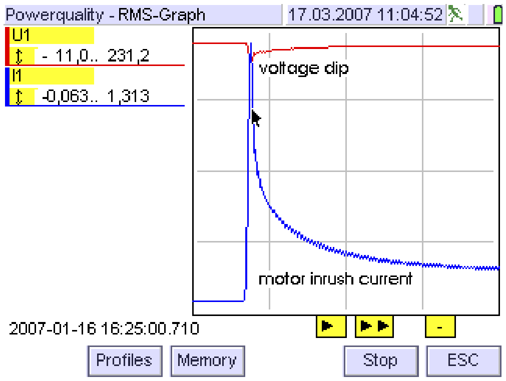



The example represents the start-up behaviour of a single-phase 1 KW engine. At engines of larger power demand, the high load can lead to voltage drops which in turn influence the performance of other consumers in the network. Therefore, electronic soft starters are installed, with which a defaulted current (and/or power) is not exceeded during the entire initial period. In such a way, the drive can be adapted for the critical start-up phase. In this case, it must be taken into consideration that e.g. phase angle controlled circuits lead to distortions of the wave form which generates harmonics, which in turn burden the network.

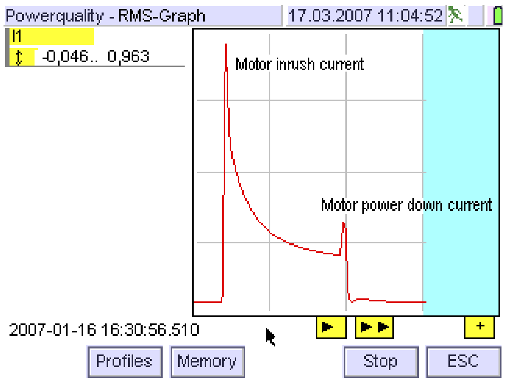
In the same way, the inrush current behaviour of switched mode power supplies can be recorded.

### A.9.2 Motor Start-up and Reverse Current

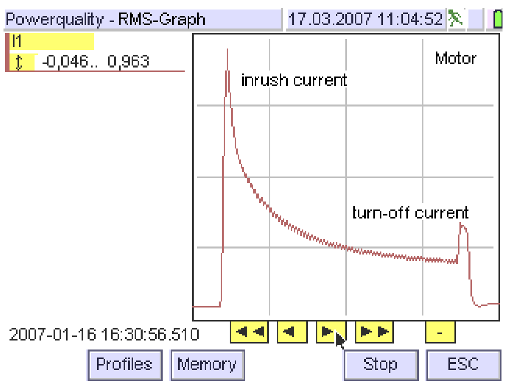
The **POWER1000** allows forming the r.m.s. value via half period aggregation. In addition to recording of the progress of the waveform as sampled points in a suitable solution, representation is possible as a 10ms signal response.




The example shows the short-term voltage drop simultaneously with the inrush current during the engine start-up.



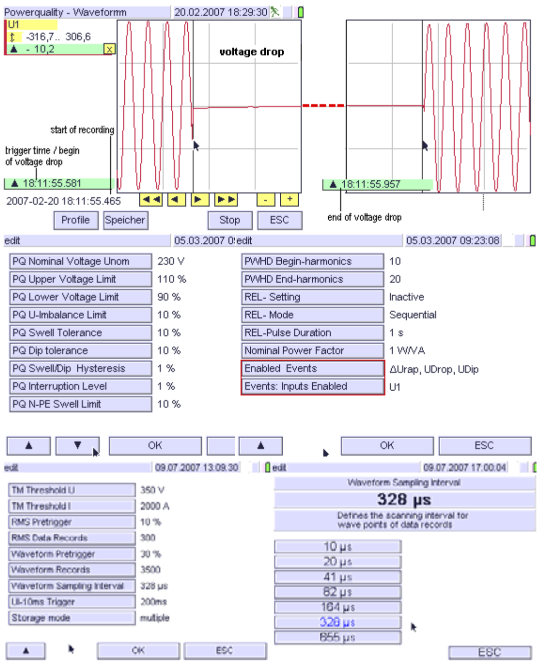

The zoom function allows for representation in suitable solution. The total process is represented above; the lower representation shows the essential part of the entire record.




After switching-off a considerable current rise can be observed, that could be traced back to the generator effect during switch-off procedure.

### A.9.3 Voltage dips and drops

These features of the voltage are indeed assigned to the power disturbance analysis, however, are allied with transient ones with recording. The POWER1000 allows for recording the 1/2 periods progress as well as for recording the curve points for the waveform.




In such a way, the measuring and storage parameters were chosen in the example so that a recording is given for long time duration at sufficient solution of the curve.

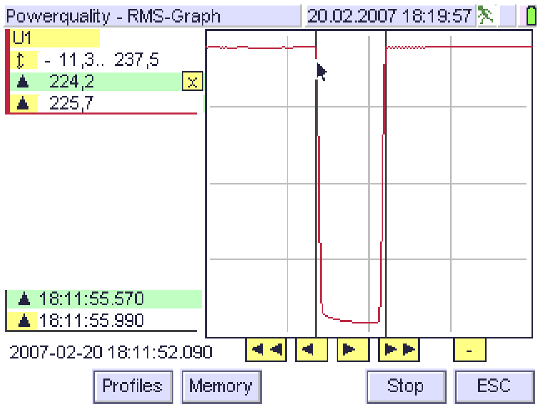
In the case of the maximally possible number of 3500 data points and the chosen interval of 328µs, results a recording time of 1148ms. In this way, a continuous recording of voltage dips and interruptions is possible for more than 1 second from the time when voltage drops.

With the cursor lines beginning and end of power failure can be marked and the period of the dip/drop can be computed. In the chosen example the drop duration lasts for 376ms.

Note: With the possible sampling interval of 655µs chosen, the recording duration is 2,29 seconds. In this way, voltage dips (and therefore transients too) of 2,29 seconds duration can be recorded gaplessly.

### A.9.4 Voltage dip and drop as RMS waveform

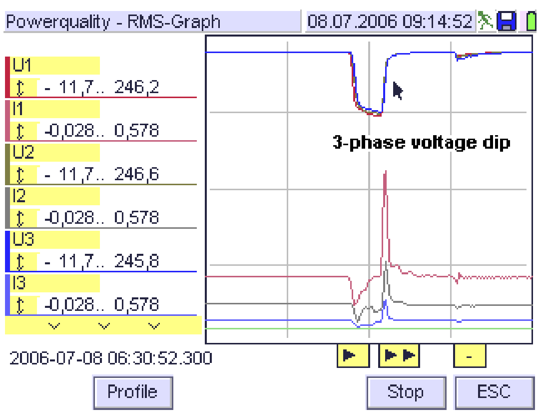
The process of the curve points represented in the previous chapter is recorded as 1/2 period process in the power disturbance analysis. In accordance to that the representation showed in the following figure results.




If beginning and end of power failure with the upright cursor lines are marked, a failure duration of 420ms results.

In the case of comparing the results from above representation and that one from the previous chapter, a difference of 44ms is visible. This can be explained with the fact that the two periods before interruption and after interruption were still considered in the r.m.s. view. Furthermore, the time resolution in 1/2 period resolution is indicated in 10ms steps, so that 4 ms are not considered there. The temporal connection of the two representations is recognizable from this.

A further example shows a three-phase voltage dip together with the current rise associated with it. It can be seen from the figure that the burden causes the greatest current rise in phase 1.

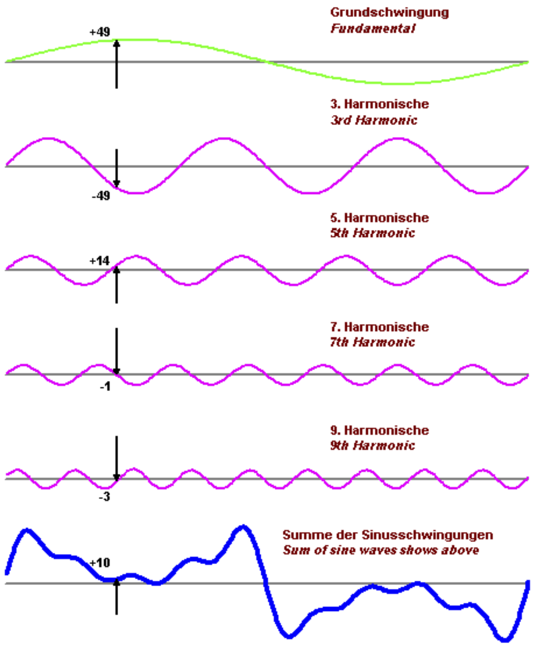


# B Harmonics and Interharmonics (FFT)

## B.1 General

An invariable, periodic deviation of the wave shape from the sine wave form means that the fundamental oscillation is overlaid by further oscillations. With the aid of the Fourier transformation, the signal can be split in a sum of sine functions. These spectral parts can be represented as a diagram in which amplitudes, phases and frequencies of the sinusoidal components are put on.

If from this separated shares the total signal can be composed by superimposition, the Fourier transformation of the signal was found.




Even if calculators wit high speed CPU's are used, the discrete Fourier transformation needs long time for calculation of the big number of amplitudes of sinusoidal components from the number of sampled values. The importance of the Fourier transformation became revolutionized with the algorithm of the "Fast Fourier Transformation", specified in 1965. It allows the calculation of the spectral components at shortest time.

## B.2 Description

The analog signal to be analysed is filtered via a low-pass filter (anti-aliasing filter), A/D-converted and buffered. Via the procedure of "fast Fourier transformation" the spectral parts of all four phases at intervals of 5 Hz are gained continuously. With it the width of the time window locked with the line frequency is 10 (50 Hz-mains) or 12 (60 Hz-mains) periods in accordance with standard IEC/EN 61000-4-7. The calculation occurs gaplessly (real time), i.e. two time windows are adjoining immediately together. The smoothing following on it and weighting are also handled in accordance with above previous mentioned standard.

The output supplies the rms values and the phase position of every computed frequency component for current and voltage. The DC components are taken into consideration, too. Power and phase angle of every spectral part are computed as well. In this case, the following terms are used with regard to the IEC/EN 61000-4-7 Ed.2 standard:

- Spectral shares which represent an integral multiple of the fundamental frequency of the mains voltage are designated as harmonics
- The spectral shares of a signal with a frequency between two consecutive harmonic frequencies are designated as intermediate harmonics. Its frequencies are no integral multiple of the fundamental frequency.

### B.3 Benchmark for Harmonics, Interharmonics and Groups of it

The higher frequent shares in the electric network, designated as harmonic oscillation are caused by devices (loads) with not sinusoidal current consumption. The increased use of such devices with not linear current and voltage characteristic, in particular in power electronics, led to a considerable rise of the shares of harmonics in the electric power supply.

High harmonic shares of voltage in the electric network may influence the function of devices and equipments of the customer as well as of the operating company, e.g.:

- malfunction fail of electronic devices
- acoustics perception (distortion) from electromagnetic circuits (transformers, coils, motors)
- reduction of life cycle of motors and capacitors with additional thermal load
- malfunction of protective and signalling equipments (e.g. ripple control systems)
- complication of ground faults compensation in the mains

With the increased use of frequency converters and in connection with the decentralized electricity generation in the liberalised energy marked the observation of interharmonics gained importance. Interharmonic shares are caused mainly through:

- Imbalances of the transmission line, e.g. fluctuations of phase angle of the fundamental share and / or the harmonic shares
- Power electronics circuits with switching frequencies those are not locked with the line frequency, e.g. not exactly locked trigger pulses

As well as the harmonics, interharmonics may cause effects which lead to influence of the function of devices and equipments. In particular the possible affects to light controllers (disturbed recognition of crossover point) and to ripple control systems (closures or unintentional addressing) are emphasized.

## B.4 Used Symbols in the POWER1000

| Symbol | Description | Note |
|---|---|---|
| **G** | effective magnitude of a harmonic | U for voltage<br>I for current<br>P for power<br>Φ (phi) for phase angle |
| **C** | effective magnitude of a spectral line (interharmonic) | U for voltage<br>I for current<br>P for power<br>Φ (phi) for phase angle |
| **x** | phase L1...L4 | 1, 2, 3, 4 |
| **h,n** | Harmonic of order n | n = 1...50 |
| **k** | Initial spectral line | 1...40 (50) |
| **hg,n** | harmonic group of order n | n = 1...40 (50) |
| **hs, n** | harmonic subgroup of order n | n = 1...40 (50) |
| **i, n** | interharmonic between harmonics $h_n$ and $h_{n+1}$ | i = 1...9 for 50 Hz<br>i = 1...11 for 60 Hz,<br>n = 1...40 (50) |
| **ig,n** | interharmonic group between harmonics $h_n$ and $h_{n+1}$ | i = 1...9 for 50 Hz<br>i = 1...11 for 60 Hz,<br>n = 1...40 (50) |
| **is,n** | interharmonic subgroup between harmonics $h_n$ and $h_{n+1}$ | i = 2...8 for 50 Hz<br>i = 2...10 for 60 Hz,<br>n = 1...40 (50) |

**Samples:**

| Symbol | |
|---|---|
| **U1h5** | phase voltage L1, or phase-to-phase voltage L1/L2N<br>5$^{th}$ order harmonic |
| **U2hg3** | phase voltage 2, or phase-to-phase voltage L2/L3<br>3$^{rd}$. order harmonic with interharmonic shares (harmonic group) |
| **U3hs7** | phase voltage 3, or phase-to-phase voltage L3/L1<br>7$^{th}$ order harmonic with directly adjacent interharmonics (harmonic subgroup) |
| **I1h5** | phase current L1,<br>5$^{rth}$harmonic |
| **I2hg3** | phase current L2,<br>3$^{rd}$ order harmonic with interharmonic shares (interharmonics group) |
| **I3hs7** | phase current L3,<br>7$^{th}$ order harmonic with directly adjacent spectral lines (interharmonics subgroup) |
| **I2ig7** | phase current L2,<br>7$^{th}$ order interharmonic group (interharmonics between two successive harmonics) |
| **I3is9** | phase current L3,<br>9$^{th}$ order interharmonic subgroup ((interharmonics between two successive harmonics without directly adjacent interharmonics) |

**Note:** With the POWER1000 the harmonics are calculated in the connection type

- ***Wye*** between corresponding phase and neutral
- ***Delta*** between the corresponding phases.

The designation of the harmonics remains the same. See also above samples.

## B.5 Calculating Harmonics, Interharmonics and Groups

### Calculating Harmonics and Harmonic Groups

| Parameter | Symbol | Description | Calculation / Equation |
|---|---|---|---|
| **Harmonic bin** | $G_n$ | r.m.s. value of a sinusoidal share of a non sinusoidal waveform with an integral multiple of the fundamental frequency | FFT-procedure |
| **Harmonic group** | $G_{g,n}$ | Includes the considered harmonic and the spectral shares of the adjacent interharmonics | for 50 Hz: $G_{g,n}^2 = \frac{C_{k-5}^2}{2} + \sum_{i=-4}^{4} C_{k+i}^2 + \frac{C_{k+5}^2}{2}$ <br> for 60 Hz $G_{g,n}^2 = \frac{C_{k-6}^2}{2} + \sum_{i=-5}^{5} C_{k+i}^2 + \frac{C_{k+6}^2}{2}$ |
| **Harmonic subgroup** | $G_{sg,n}$ | Includes the considered harmonic and the spectral shares of the directly adjacent interharmonics | $G_{sg,n}^2 = \sum_{i=-1}^{1} C_{k+i}^2$ |

**Note:** For evaluating the power quality according to EN 50160: 2000 the harmonic shares $G_n$ are to be compared with the given compatibility levels. For evaluating power quality after IEC/EN 61000-4-30: 2004 „Measurement Methods for Power Quality Parameters" applies the evaluation procedure for harmonic subgroups.

Both procedures are possible with the POWER1000. For power quality analysis (function PQ) applies the procedure specified after EN 50160.

### Calculating Interharmonics and Groups

| Parameter | Symbol | Description | Calculation / Equation |
|---|---|---|---|
| **Interharmonic bin** | $C_k$ | r.m.s. value of a sinusoidal component of an electric signal with a frequency between two consecutive harmonic frequencies | FFT-procedure |
| **Interharmonic group** | $C_{ig,n}$ | Considers the sum of the interharmonic components in the interval between two consecutive harmonic frequencies | for 50 Hz: $C_{ig,n}^2 = \sum_{i=1}^{9} C_{k+i}^2$ <br> for 60 Hz $C_{ig,n}^2 = \sum_{i=1}^{11} C_{k+i}^2$ |
| **Interharmonic subgroup** | $C_{isg,n}$ | Considers the sum of the interharmonic components in the interval between two consecutive harmonic frequencies, excluding the directly adjacent interharmonics | for 50 Hz: $C_{isg,n}^2 = \sum_{i=2}^{8} C_{k+i}^2$ <br> for 60 Hz $C_{isg,n}^2 = \sum_{i=2}^{10} C_{k+i}^2$ |

**Note:** For power quality evaluation after EN 50160 calculation is not required. For evaluation after the standard IEC 61000-4-30 „Measurement Methods for Power Quality parameters" the interharmonic subgroups apply for evaluation.

### Calculating Distortion Factors

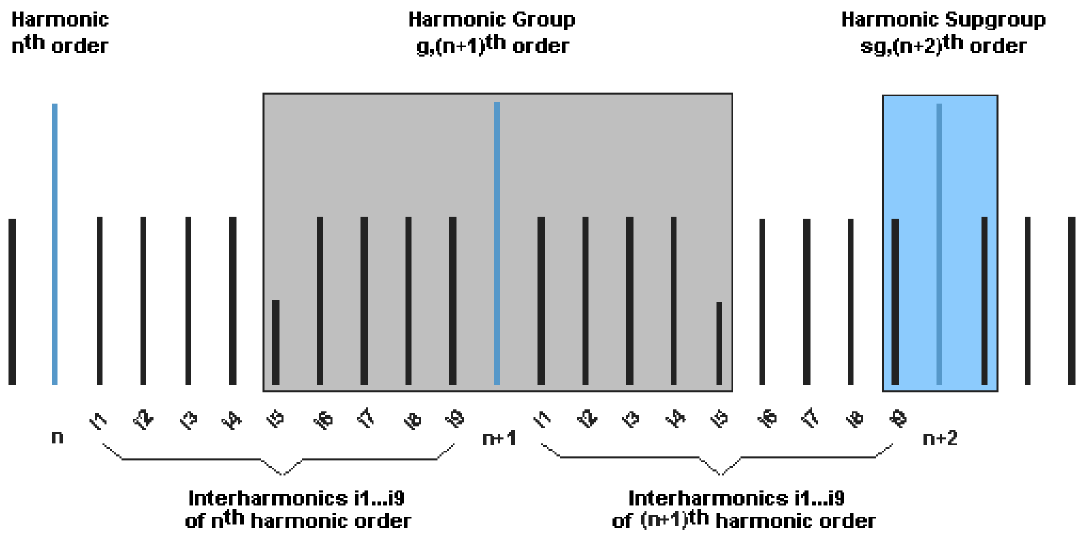
| Parameter | Symbol | Description | Calculation / Equation |
|---|---|---|---|
| **Total harmonic distortion** | THD | Ratio of the r.m.s. value of the sum of all harmonic components ($G_n$) up to a specified order to the r.m.s. value of the fundamental component ($G_1$) | $THD = \sqrt{\sum_{n=2}^{H} \left( \frac{G_n}{G_1} \right)^2}$ |
| **Group total harmonic distortion** | THDG | Ratio of the r.m.s. value of the harmonic groups (g) to the r.m.s. value of the group associated with the fundamental ($G_{g1}$) | $THDG = \sqrt{\sum_{n=2}^{H} \left( \frac{G_{gn}}{G_{g1}} \right)^2}$ |
| **Subgroup total harmonic distortion** | THDS | Ratio of the r.m.s. value of the harmonic groups (sg) to the r.m.s. value of the group associated with the fundamental ($G_{sg1}$) | $THDS = \sqrt{\sum_{n=2}^{H} \left( \frac{G_{sgn}}{G_{sg1}} \right)^2}$ |
| **Partial weighted harmonic distortion** | PWHD | Ratio of the r.m.s. value, weighted with the harmonic order n, of a selected group of higher order harmonics, i.e. from the order $H_{min}$ to $H_{max}$ to the r.m.s. value of the fundamental ($G_1$) | $PWHD = \sqrt{\sum_{n=H_{min}}^{H_{max}} n \left( \frac{G_n}{G_1} \right)^2}$ |

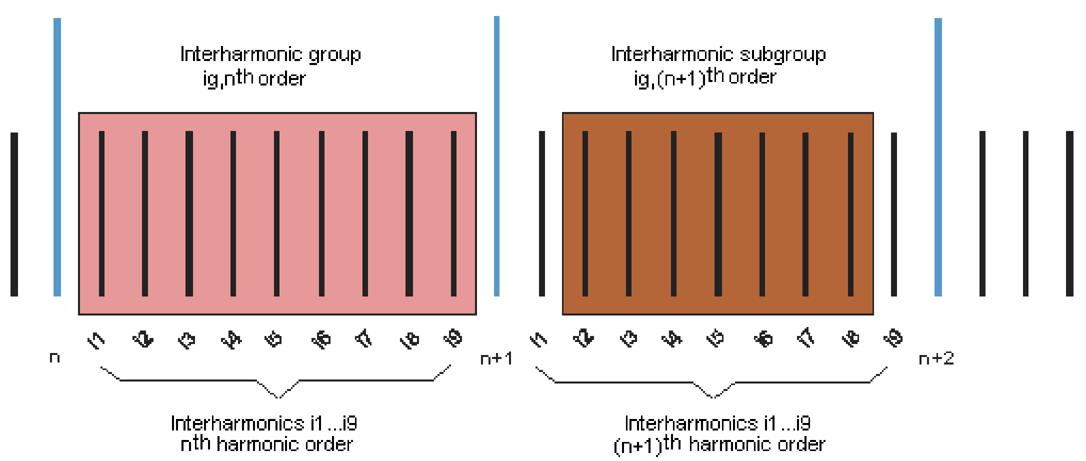
**Note:** For power quality evaluation after EN 50160 the total harmonic distortion THD is required, i.e. the r.m.s value of the non-linear signal without interharmonics spectral shares is to be considered.

The standard IEC 6100-4-30 Ed 1 does not consider the distortion factor THD. In view of the informative value for interharmonic shares of an electric signal, the subgroup total harmonic distortion can be computed with the POWER1000 in the function FFT.

### Graphics Representation of Harmonics, Interharmonics and groups

**Note:** For the graphics representation the mains frequency of 50 Hz was selected. For the 60 Hz mains, 11 spectral lines between two consecutive harmonic shares are to be considered.

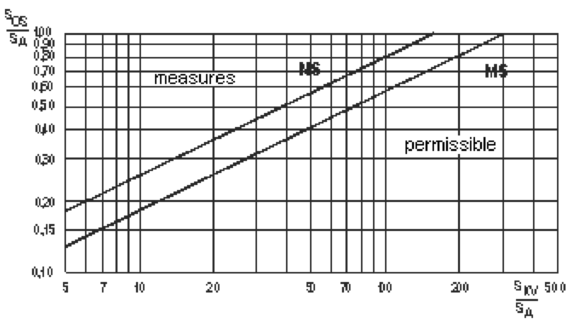


### B.6 Evaluation of Harmonics

As mentioned in the beginning the harmonics represent a seriously increasing problem for the electric distribution networks. The standard EN 50160 indicates compatibility levels for the public electricity supply system for the harmonic voltage shares which should not be exceeded. They are caused by harmonic burdened currents which influence the voltage waveform via the frequency-dependent mains impedances. Therefore, it is necessary to limit the harmonic currents contributions generated by the individual equipments of the participant in the mains. For this purpose, disturbance signals are assigned to the individual users, so that the sum effects does not exceed the given compatibility level. Emission values are determined both for individual harmonic currents and for the total share of the harmonic current.

For assessing mains reactions, the electric utilities worked out guidelines collected in the publication „*Technical and Organisation Rules for users and operators of electric supply network*“ (TOR). For that, the ratio of power and the harmonic load at the delivery point are considered (source: TOR 2).




| | |
|---|---|
| **$S_{OS}$** | harmonic load of the equipment |
| **$S_A$** | Supply power of the plant |
| **$S_{kV}$** | Short circuit power at the delivery point |

An evaluation considered as permissible for the mains participant can also be improved subsequently by the utility in the course of a technical inspection of the equipment, e.g. when considering the (changed) local network situation.

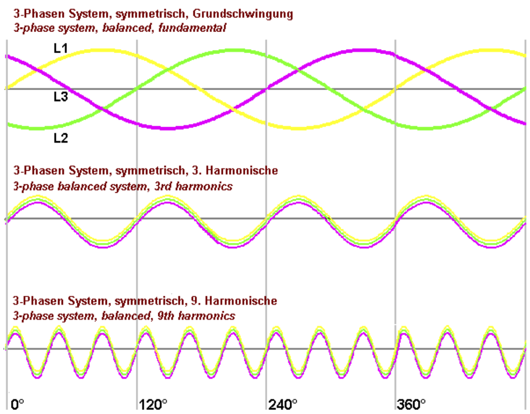
### B.7 Measures for Limitation of Harmonics

Measures can be set from the network user as well as from the operating company.

An increase of the short-circuit power in general leads to a reduction of the disturbing variables in the supply network since the network impedance is reduced and therefore the effect of radiated interferences reduces. However, the short-circuit power can not be increased as desired. In addition to the costs, technical factors such as permissible short-circuit power for the connected loads and standardization of equipment play an essential role.

In the plant of the network user, operation of devices with small content of total harmonic distortion THDi can be respected. If this is not possible, harmonics can be reduced by use of harmonic compensation filters, namely just behind the connection to the harmonics affected equipment.

Special attention is required for observation of the harmonic load in the neutral conductor. A considerable share of the non-linear burdens generates harmonics of 3$^{rd}$ order. The period is 1/3 of the fundamental frequency, and therefore the phase shift is 120°. Even if the load is completely symmetrical this leads to a summation in the neutral conductor. Same applies for all multiples of 3$^{rd}$ order harmonics.




Symmetrical system with harmonics of 3rd order

The sum current generated by the triple-harmonics (this are the harmonics of orders 3, 9, 15, …) can result in neutral conductor currents which cannot be neglected. In particular in older distribution networks the neutral conductor is undersized so that the situation can be considered to be critical.

# C EN 50160 Power Quality Analysis

## C.1 General

The increase of consumers with non-linear loads combined with the fact that the customer influences supply quality more than the supplier gains special importance in the course of liberalization of electricity supply. Deviations from permitted operating conditions in the electric distribution network occurring suddenly and unexpectedly, can lead to affection of operating conditions for other participants. With the aim to guarantee power supply safely and gapless and to proof the quality of electricity supply, the permanent observation and assessment of the variations in line voltage is required. An efficient mains distortion analysis helps to avoid troubles or at least allows for repair to be carried out more rapidly.

Power analysers which meet the current standard are embossed through the continuous and gapless observation of the voltage progress. In uninterrupted precedence the input signal is sampled, the changes of magnitude and waveform are registered and from that the relevant power quality is calculated. The amount of data pending in combination with the required time interval for signal aggregation requires either a large memory or special concepts for the efficient reduction of the amount of data.

The statistical evaluation methods described in the relevant standards have the aim to reduce the pending amount of data to the required minimum. This aim is supported by procedures with support calculation and storage of data according to different criteria within the measurement device. With an intelligent memory management, the amount of data can be reduced so far that mains measurement quantities can be recorded for an excellent price/power ratio.

Many predefinitions which are described in the standards for power quality refer to Europe-wide field tests of several years. They are based on "normal operating conditions" which may be interpreted differently by every power utility. This led to different predefinitions in different standards which are not applicable simultaneously (state October 2005). Therefore, only a general description of the given compatibility levels is possible.

In the function PQ of POWER1000, those functions which are required for description of power quality in accordance with the European standard EN 50160 are summarized. Over the purely alphanumeric representation as well as the automatic detection and registration of limit values and compatibility levels, an analytical consideration of the single characteristics is possible.

### C.2 Standards for Assessment of Power Quality

Compatibility levels serve as assessment basis for the permissible emitted interference of a plant. The standard EN 50160 describes the essential features of the mains voltage at the interchange point to the customer. It applies to the entire European field under normal operating conditions. Compliance with the compatibility levels proceeds on the assumption with a probability of 95% that no other mains participant is affected in its function.

It is pointed out that the values stated in the standard EN 50160 do not refer to levels for electro-magnetic compatibility or limit values for conducted susceptibility of the mains participants in public distribution systems (power supply assessment).

The standard IEC EN 61000-4-30 refers to measurement methods for the assessment of the quality of the supplied voltage. For the individual features, calculation methods are described which are to be kept for a class A instruments. Alternative procedures which apply simultaneously these lead to identical results are indicated. For these devices to be classified as class B instruments, the methods of measurement are to be described by the manufacturer.

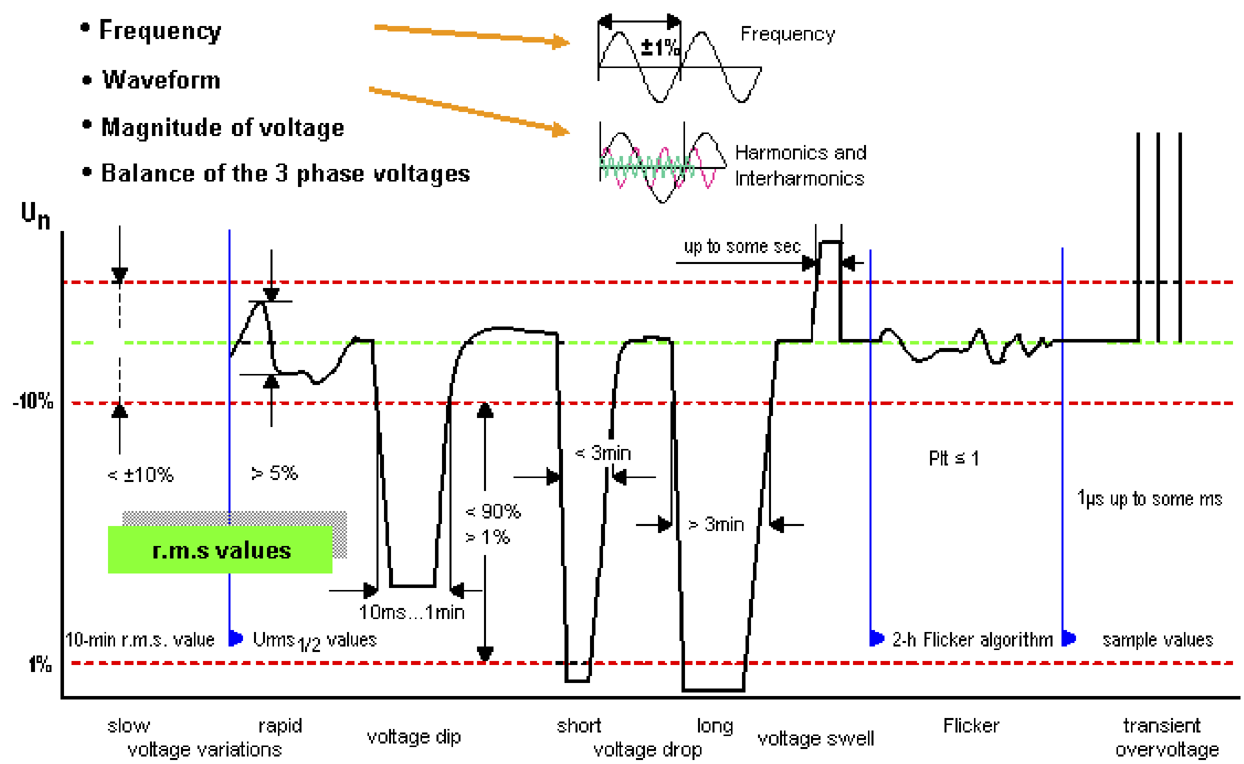
☞ In this connection, it might be mentioned that the assessment corresponding to the standard IEC 61000-4-30 is not possible when compliance with EN 50160 is required (status April 2005). As the European standard EN 50160 is preferably required for power quality assessment, the procedures leading to the proper result are applied with the POWER1000. In the consequence, the POWER1000 is classified as class B device with extensive application of measurement methods after class A.

As far as measurement methods, compatibility levels and value limits are not stated explicitly in the above mentioned standard, the relevant values stated in the standard line for electro-magnetic compatibility applies. This in particular applies to the limits stated in IEC 61000-2-2 as well as the measurement methods for harmonics (IEC EN 61000-4-7 Ed.2) and the flicker severity (IEC EN 61000-4-15).

In addition to the limit values and compatibility levels stated in the standards, the results of newer field tests carried out Europe-wide are relevant. They are summarized in the "*Technical and Organisation Rules for users and operators of electric supply network*" (TOR)" and extensively considered with the POWER1000.

## C.3 Voltage characteristics in accordance with EN 50160 and the realization with the POWER1000

The current situation concerning standard requirements described in the previous sections needs to make clear the interpretation and evaluation with POWER1000. It might be pointed out here that the methods of the evaluation realised with POWER1000 are based on the requirement to meet the predominant majority of the user applications.




### C.3.1 Mean Values over Time Intervals

• The fundamental measurement value (voltage dip, voltage drop, temporary power frequent overvoltage,) is calculated according to IEC/EN 50160 over a ½ period time interval, this is 10 ms at 50 Hz.

• The time interval for forming the effective value (mains voltage, harmonics, interharmonics, imbalance) is 200ms. This corresponds to 10 periods at 50 Hz or 12 periods at 60 Hz.

• From the effective value, the mean value for two different ime intervals is formed:

- 10-min interval
- 2-h interval

☞ The 3s-interval stated in the standard
IEC 61000-4-30 is only used for signalling voltages.

Simultaneously it was to consider to minimize the number of parameters to be adjusted so that users not being specialized quickly and without troubles come to the desired measurement result when adjusting limits and/or compatibility levels.

☞ For signal voltages applies the approximation method according to IEC 61000-4-30. With it the two interharmonics adjacent left and right to the signal frequency are considered, the calculation performs for 200ms intervals (currently not realised with POWER1000).

### C 3.2 Power Frequency

For calculating the frequency, the number of periods within a time interval of 200ms is counted. Phase 1 is defined as a reference channel. In the case of dropout, the voltage channel of phase 2, then of phase 3 is used. In the case simultaneous dropout of the voltage channels the current channels 1 to 3 are used for frequency measurement.

For assessment according to EN 50160 the mean value over 10 s is calculated and compared with the given limits.

### C 3.3 Slow Voltage Fluctuations (Voltage Regulation)

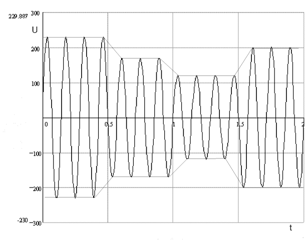
It is defined as increase or decrease of the voltage magnitude, usually on account of changes of the total load or a considerable part of it in a distribution network.

Over the 200ms accumulation period, the 10- minute mean value is formed and matched with the compatibility level. The assessment period is a minimum of 7 continuous days, in accordance with EN 50160.

For a positive result, the 10-minute mean value regulation does not exceed ±10% of the nominal system voltage for 95% of the assessment period. Furthermore, due to other standards (NRS-048-2) the highest and lowest 10- minute mean values can be recorded within every day period for the three phases. The highest value of all three phases is retained as daily value.

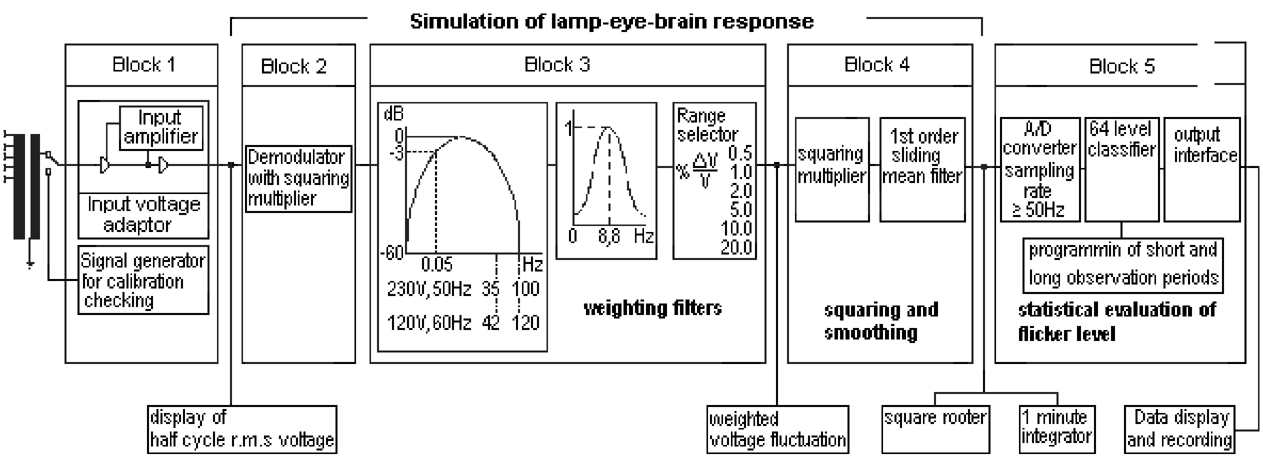
### C 3.4 Rapid Voltage Fluctuations

Rapid voltage fluctuations are voltage changes of the r.m.s voltage magnitude of two consecutive voltage levels with defined but not predicted duration. (EN 50160). TOR 2*) specifies a duration of 10ms, the standard IEC 61000-4-30 defines an aggregation time of 10/12 periods (50/60Hz) for the r.m.s. magnitude. With the **POWER1000** the parameters are defined as follows:



iniert:

For POWER1000 apply the following parameters:
At nominal voltage $U_{nom}$ = 230 V the change rate is 460V/sec, the minimum duration of the steady-state condition is 1 period (20msec). The measured values are captured continuously and the difference between two preceding steady-state conditions is calculated. If exceeding the given limit (5%), a quantitative recording is released and accumulated for a defined evaluation period (e.g. counts per week).



☞ Voltage fluctuations causing a voltage less than 90% the nominal system voltage shall be evaluated as voltage dips.

☞ Assessment of the magnitude of rapid voltage changes does not apply to standards, as the magnitude of voltage fluctuations moves within the permitted limits.

*) TOR = Technical and Organizational Rules for operators and users of networks, issued by E-CONTROL (former UNIPEDE)

### C 3.5 Flicker

Voltage fluctuations cause temporal variations of luminance in bulbs and fluorescent lamps and consequently, at a certain range of duty cycle and magnitude affect the optical perceptive ability of the human eye.

For acquisition of this phenomenon known under the term flicker severity, the total response of **lamp – eye - brain** chain must be considered for the assessment. The aim of the flicker measurement procedure is to simulate the process of visual perception of variations in line voltage in order to achieve a reliable statement about the reactions of an observer.

The measurement method for flicker severity complies with the standard IEC 61000-4-15, the limits are stated in the standard IEC 61000-2-2. With the POWER1000 the measurement method is simulated via a suitable algorithm. The flicker level resulting from that is a measure for the variations of luminance affecting the human perception of line voltage variations.

According to EN 50160, the flicker severity is assessed for the long term flicker $P_{lt}$ over an aggregation time interval of 2h with the PQ-function. Furthermore for industrial applications, the short term flicker $P_{st}$ and the instantaneous flicker $P_{mt}$ are available with the **POWER1000.**

**Description**

In block 1 the input voltage is conditioned so that a flicker measurement is possible independent from the actual magnitude of the line voltage.

After this, the measured voltage is sampled and led over a digital filter to simulate the effecting chain lamp - eye - brain (block 2 to 4). The flicker levels resulting from this are available in a table as weighted sum frequency distribution which corresponds to the current flicker sensitivity.

The short-term flicker severity Pst is calculated from the sum frequency distribution of the hold up time calculated in the level classifier (block 5). For that the following formula is used:

The quantiles P0,1, P1, P3, P10 und P50 are flicker levels which exceeded during 0,1%, 1%, 3%, 10% and 50% of

$$P_{st} = \sqrt{0{,}0314 \times P_{0,1} + 0{,}0525 \times P_{1s} + 0{,}0657 \times P_{3s} + 0{,}28 \times P_{10s} + 0{,}08 \times P_{50s}}$$

the observation period. For the quantiles marked with the suffix s in the above formula, the following smoothed values are set according to the formulas:

$$P_{1s} = \frac{P_{0,7} + P_1 + P_{1,5}}{3}$$

$$P_{3s} = \frac{P_{2,2} + P_3 + P_4}{3}$$

$$P_{10s} = \frac{P_6 + P_8 + P_{10} + P_{13} + P_{17}}{3}$$

$$P_{50s} = \frac{P_{30} + P_{50} + P_{80}}{3}$$

The short-term flicker is determined for an observation interval of 10 min and suitable for the assessment of the troubles with individual originators at short operating cycles. For the assessment of the common disturbing effects caused by several disturbing loads with non predictable operating cycle, or for assessment of disturbing effects with long and changeable operating cycles the long-term flicker is calculated for an observation period of 2h with the formula:

$$P_{lt} = \sqrt[3]{\frac{1}{N} \times \sum_{i=1}^{N} P_{sti}^3}$$

### Measurement Quantities and Assessment

For calculation of the flicker severity, the following measurement quantities are relevant for assessment of variations in line voltage (they are partially implemented in the POWER1000):

**Short-term flicker severity Pst:**

Flicker severity calculated for a short-term interval (selectable for 1 or 10 Minutes)

Measurement unit: none

**Long-term flicker severity Plt:**

Flicker severity calculated for a long-term interval. Itr is derived from 12 consecutive Pst-values.

Measurement unit: none

**Maximal relative voltage change dmax:**

Difference between highest and lowest value within a course of voltage change[1]).

Measurement unit: %

**Relative constant voltage deviation dc**

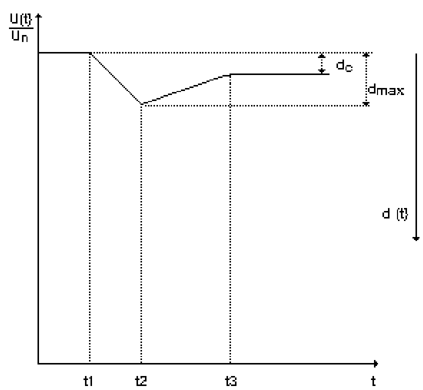
Difference between two constant[2]) voltages with at least one voltage change in between.

Measurement unit: %

**Maximal deviation duration dt>3%**

The maximum duration of a voltage change within a short-term interval exceeding 3% voltage deviation.

Measurement unit: s (seconds)




[1]) Relative voltage change progress d(t)
Temporary course of rms voltage value change within two constant voltages

A voltage whose rms value remains unchanged for at least 1 second is designated as "constant"

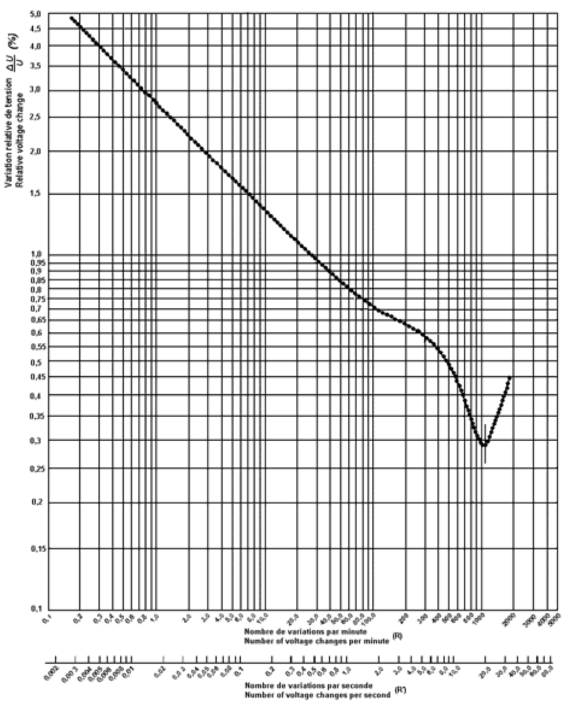
**Compatibility Level**

The specified compatibility level for line voltage variations are taken from the standard DIN EN 61000-3-3. For the relevant measurement quantities, the limits can be recognized with the function FSA. Higher line voltage regulations are assessed as voltage drops and/or overvoltages. They are subject to other evaluation criteria.

- The Pst-value must not exceed 1, determined with the tolerance limit ± 5%.
  (Measurements up to Pst = 3 are available).
- The Plt-value must not exceed 0,65.
- The maximal relative voltage change must not exceed 4%
  (Amplitude range of voltage change max. 5%).
- The relative constant voltage deviation dc must not exceed 3%.
- The relative voltage change progress (t) during a voltage change must not exceed 3% for more than 200ms.

For an assessment conforming to standard EN 50160, under normal operating conditions the long-term flicker severity shall not exceed the value Plt = 1 during 95% of a week interval.

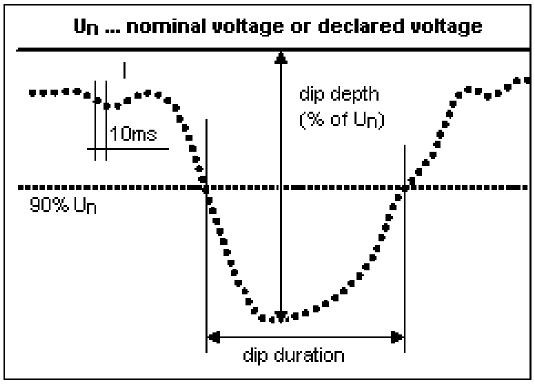
Furthermore, for non public and industrial networks, all Pst-values exceeding the value 1 for less than 95% of the daily values shall be recorded separately for all three phases. The highest value is retained as daily value.




Pst =1 – curve for rectangular equidistant voltage changes

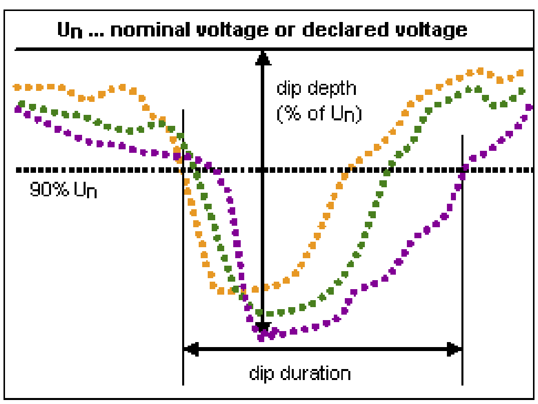
### C 3.6 Voltage Dips

Voltage dips are defined as sudden reduction in r.m.s line voltage to a value between 90% and 1% of the nominal line voltage followed by a voltage rise to the given limits within a short period. The duration of a voltage dip is defined as dip of 10ms and 1 minute.




***Single phase dip***

The duration of a voltage dip is the period measured from the moment the r.m.s voltage of at least one phase drops below 90% of nominal line voltage to when the r.m.s. voltage of all three phases rise above 90% of nominal voltage. Accordingly, the measurement of the 10ms values performs continuously and gapless. In addition to the dip depth the dip duration is defined.




***Three phase dip***

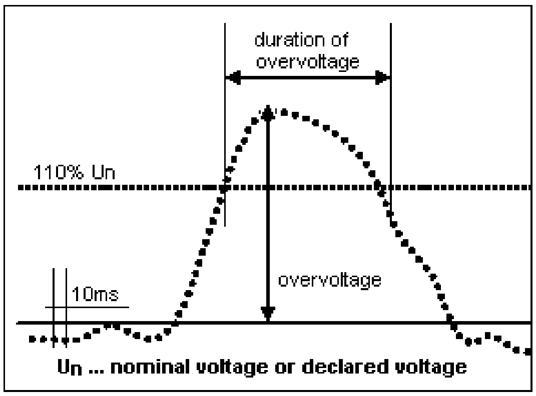
As assessment parameters (limit value of compatibility) the standard EN 50160 defines the maximum permissible number of voltage dips per year. This is considered as provisional value. Furthermore the EURELECTRIC study publishes a classification of the dips between 90% and 99% of nominal (declared) value. This classification can be considered in an analysation software for
POWER1000.

A voltage dip exceeding 99% of Un is classified as voltage drop.

**Note:** The standard IEC EN 61000-4-30 defines the signal period $\mathbf{u}_{rms(1/2)}$ as shortest time duration for a voltage dip. It consists of two consecutive half periods. Every half period the first half cycle is replaced by the next one (gliding period). This method of measurement deviates fundamentally from the accumulation period required in EN 50160 (10 ms) and therefore, is not realised with POWER1000.

### C 3.7 Temporary Mains Frequent Over voltage (swell)

According to IEC 61000-4-30 mains frequent short-term overvoltage is characterised through an increase of the mains voltage to a value exceeding 110% of the nominal voltage Un (and/or the declared voltage; Uc in medium-voltage networks), followed by a drop to the permitted limits of the nominal (declared) voltage after a short time.




The voltage swell is measured from the moment the r.m.s voltage of at least one phase rises above 110% of the nominal line voltage to when the r.m.s. voltage of all three phases drops under 110% of nominal voltage. Accordingly, the measurement of the 10ms values performs continuously and gapless. In addition to the swell magnitude the swell duration is defined.

***Note:***

Short-term overvoltages and transients are distinguishes through the frequency-bond accuracy of swells, while transients in general are characterized through the rise time. The shorter time period of the transients signal requires another procedure for acquisition (e.g. du/dt trigger).

***Note:***

In accordance with EN 50160, mains frequent overvoltage can achieve the value of the phase voltages on account of the possible shift of the neutral point in the 3-phase system. A classification indicated in the UNIPEDE publication is no more considered in newer documents.

### C 3.8 Transient Overvoltage

Transient overvoltages are short-term and normally strong damped overvoltages, having some milliseconds duration or less. They are in general caused by effect of lightning, on and off switching actions and release from protection devices (fuses). The raise time of transient overvoltages varies in a wide field of less than a microsecond up to some milliseconds; the magnitude usually does not exceed 6 kV.

***Note:***

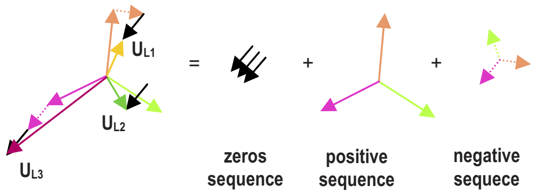
The basic version of the POWER1000 allows for measurement of transient overvoltage up to 1300Vpeak. According to technical report TRS 60 266 the probability of a transient occurrence exceeding the double of the mains voltage is one per annum. Therefore, a measurement which is to be carried out in accordance with EN 50160 over the period of a week supplies no statement for the voltage quality.

Considerably for recording of retrospective mains effects in the field of short-term phenomena less than 10 ms are the periodic short-term dips occurring in power converters. They are summarized under the term commutating dips. Since they are neither described in EN 50160 nor in the standard IEC 61000-4-30, they are not registered by POWER1000 in basic version (acquisition requires a du/dt trigger).

### C.3.9 Voltage Unbalance

Voltage unbalance in a polyphase system arises when the magnitudes of the phase voltages or the relative phase displacements of the phases or both are not equal.

For evaluation the polyphase system under consideration can be represented by the sum of three symmetrical systems. Voltage unbalance is usually expressed as a percentage of the ratio between the negative sequence voltage and the positive sequence voltage.




For calculation, the synchronous measurement of the 200ms r.m.s value of each phase of the line voltages follows the equation (IEC 61000-4-30):

$$U_B = \sqrt{\frac{1-\sqrt{3-6\beta}}{1+\sqrt{3-6\beta}}}$$

$$\text{for } \beta = \frac{U_{12h[1]}^4 + U_{23h[1]}^4 + U_{31h[1]}^4}{\left(U_{12h[1]}^2 + U_{23h[1]}^2 + U_{31h[1]}^2\right)^2}$$

$U_{12h[1]}$, $U_{23h[1]}$ und $U_{31h[1]}$

Fundamental line-to-line voltage

The measurement performs gapless, i.e. each 200ms interval is recorded and from this the 10min root-mean-square values are calculated for the assessment period of 7 continuous days.

The assessed levels comply with the EN 50160 standard when under normal operating conditions the 10 min root-mean-square value of the positive sequence voltage does not exceed 2% of the negative sequence voltage for 95% of the assessment period of 7 continuous days.

For industrial standards (e.g. NRS-048-2) for each 24 h day (00:00 to 24:00), the highest 10 min root-mean-square value of unbalance which is not exceeded for 95% of the assessment period is recorded and the highest is retained as daily value.

### C.3.10 Harmonic Voltage

The widespread applications of electronic devices with non-linear current / voltage characteristic lead to harmonics marked currents those influence the waveform of the voltage via the mains impedance. This kind of the net retrospective effect represents a seriously increasing problem for the power utilities. On account of current regulations they are responsible for compliance with limit values at the junctions of the network.

In accordance with the standard IEC EN 61000-4-7, probes were taken for each phase over the time interval of 200msec and for each harmonic voltage the r.m.s. value is calculated. The mean values are derived from it over 10 minutes and recorded over a period of at least 1 week. Moreover, the time sum of all 10-minute intervals which exceed the given limits are recorded.

The assessed levels comply with the EN 50160 standard when under normal operating conditions the 10 min root-mean-square value of each harmonic does not exceed the compatibility level for 95% of the assessment period of 7 continuous days. The given values are stated in the following table.

On account of differing information in the individual relevant standards, no regard is taken to deviations to EN 50160. Even for reasons of the considerable reduction of adjusting parameters, the limits are fixed.

| odd harmonics | | | | even harmonics | |
|---|---|---|---|---|---|
| non-multiple of 3 | | multiple of 3 | | | |
| order h | $u_h$ in % | order h | $u_h$ in % | order h | $u_h$ in % |
| 5 | 6,0 | 3 | 5,0 | 2 | 2,0 |
| 7 | 5,0 | 9 | 1,5 | 4 | 1,0 |
| 11 | 3,5 | 15 | 0,5 | 6 | |
| 13 | 3,0 | 21 | 0,5 | 8 | |
| 17 - 49 | A | 27 - 45 | 0,2 | 10 - 50 | B |

A = 2,27 x (17/h) - 0,27 B = 0,25 x (10/h)) + 0,25

Moreover, the harmonic distortion THD is calculated according to EN 50160 after the formula

$$THDu = \sqrt{\sum_{h=2}^{40} (u_h)^2}$$

The assessed levels comply with the EN 50160 standard when under normal operating conditions the 10 min root-mean-square value of the THD does not exceed 8% of the assessment period of 7 continuous days.

For industrial standards (e.g. NRS-048-2) for each 24 h day (00:00 to 24:00), the highest 10 min root-mean-square value of THD which is not exceed 8% for 95% of the assessment period is recorded and the highest is retained as daily value.

**Note:** For the standard IEC 61000-4-30 harmonics distortion does not apply. Instead the harmonic sup group $C_{sg,n}$ is required.

See also chap. B spectral analyses

### C.3.11 Interharmonic Voltages

For interharmonics the same formation rules are valid as for the harmonic voltage. Via the FFT-procedure (fast Fourier- transformation) the spectrum lines of 5 hertz distance are calculated (they also include the harmonic parts), and from it the 200ms r.m.s values and the 10min mean values are derived. The observation interval is one week.

For the standard EN 50160, no further determination performs for absence of secured empirical values.

The standard EN 61000-4-30 refers to the centred interharmonic subgroups Cisg,n, described in the standard IEC 61000-4-7 Ed.2. The indication of limit values for interharmonics in IEC 61000-2-2 leads to the informative appendix B of this standard. On account of this situation, the function PQ allows for recording of centred inter-harmonic subgroups groups Cisg,n, however, an automatic recognition of limit violations was not planned.

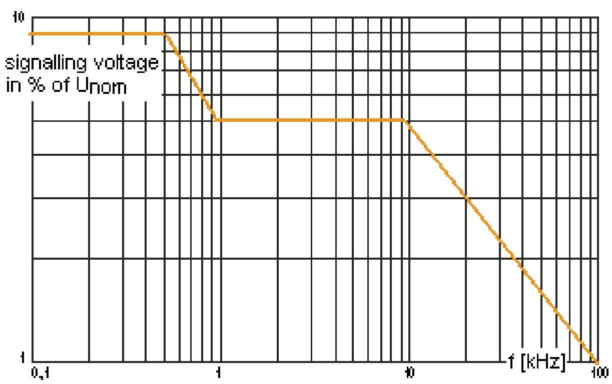
See also appendix, chap. B spectral analyses

### C.3.12 Signalling Voltages

In order to avoid troubles in communications systems interconnected with energy supply, in general frequencies between two harmonic frequencies, i.e. interharmonics are used for signalling.

For signal frequencies be lying between two interharmonics, the standard IEC 61000-4-30 indicates an approximation method, after that the voltages of two directly adjacent interharmonics are observed. Its value is a measure of the occurring signal voltage. If the carrier frequency is known, the signal voltage can be distinguished from the disturbance.

From 10/12 -period mean values (50 / 60Hz, according to IEC 61000-4-30), the 3- second mean values are calculated in accordance with EN 50160. The assessed level complies with the EN 50160 standard when the 3sec mean value of the signalling voltage does not exceed the values represented in the figure for 99% of the assessment period of one day (source: EN50160).



***Note:***

On account of the increasing electro smog, the receive quality of the current used control systems (e.g. DCF 77) is disturbed more and more. Therefore, since short time power utilities use a new clock control system based on satellite navigation (e.g. Wienenergie since 2002). The importance of recordings of signalling voltages decreases considerably. From that fact the approximation procedure stated in the standard IEC/EN 61000-4-30 is replaced through the measurement of interharmonic subgroups.

## C.4 Characteristics table after EN 50160, Status January 2006

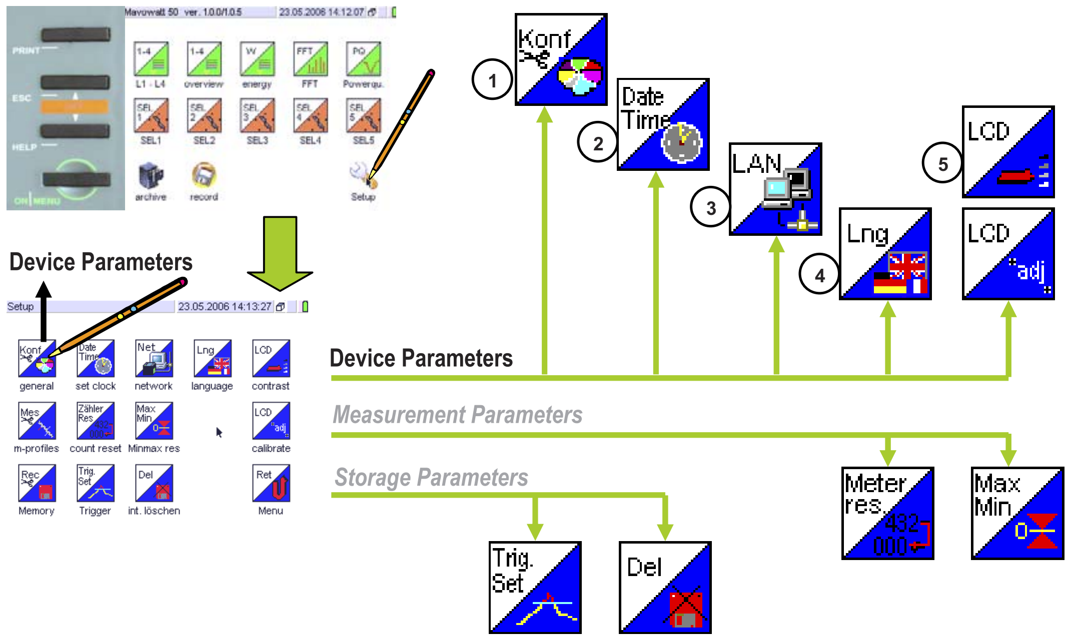
| characteristic of supply voltage | limit values and / or value range | | measuring and assessment parameters | | | |
|---|---|---|---|---|---|---|
| designation | low voltage system | medium voltage system | basis value | Integration interval | observation period | percentage |
| Frequency (in connection with an interconnected system) | 49.5 Hz up to 50.5 Hz<br>47 Hz up to 52 Hz | | mean value | 10s | 1 week | 95%<br>100% |
| Slow voltage fluctuations | 230 V ± 10 % | $U_c$ ± 10 % | r.m.s value | 10min | 1 week | 95% |
| Fast voltage changes | 5%<br>max. 10 % | 4%<br>max. 6 % | r.m.s value | 10ms | 1 day | 100% |
| Flicker severity (stated only for long-term flicker) | $P_{lt} = 1$ | | flicker-algorithm | 2h | 1 week | 95% |
| Voltage dips ( ≤ 1min) | some 10 up to 1000 per year (below 85% $U_c$) | | r.m.s value | 10ms | 1 year | 100% |
| Short supply interruptions ( ≤ 3 min) | some 10 up to some 100 per year (below 1 % $U_c$) | | r.m.s value | 10ms | 1 year | 100% |
| Random long supply interruptions ( > 3 min) | some 10 up to 50 per year (below 1% $U_c$) | | r.m.s value | 10ms | 1 year | 100% |
| Temporary mains frequent overvoltage (phase-to-earth) | In general < 1,5 k V | 1.7 up to 2.0 (according to star point configuration) | r.m.s value | 10ms | no details | 100% |
| Transient overvoltage (phase-to-earth) | In general < 6 kV | According to isolation coordination | peak magnitude | none | no details | 100% |
| Voltage unbalance (ratio positive / negative sequence) | In general 2 %, in special cases up to 3 % | | r.m.s value | 10min | 1 week | 95% |
| Harmonic voltage (reference: $U_n$ or $U_c$) | - total harmonic distortion (THD) < 8 %<br>- harmonic oscillation $U_{H2}$ ... $U_{H25}$<br>Limits according to table EN 50160: 1999 | | r.m.s value | 10min | 1 week | 95% |
| Interharmonic voltage | Values in consideration | | Values in consideration | | | |
| Signalling voltages (reference: $U_n$ or $U_c$) | Range 9kHz up to 95 kHz in consideration | | r.m.s value | 3s | 1 day | 99% |

# Annex M Menu Structure

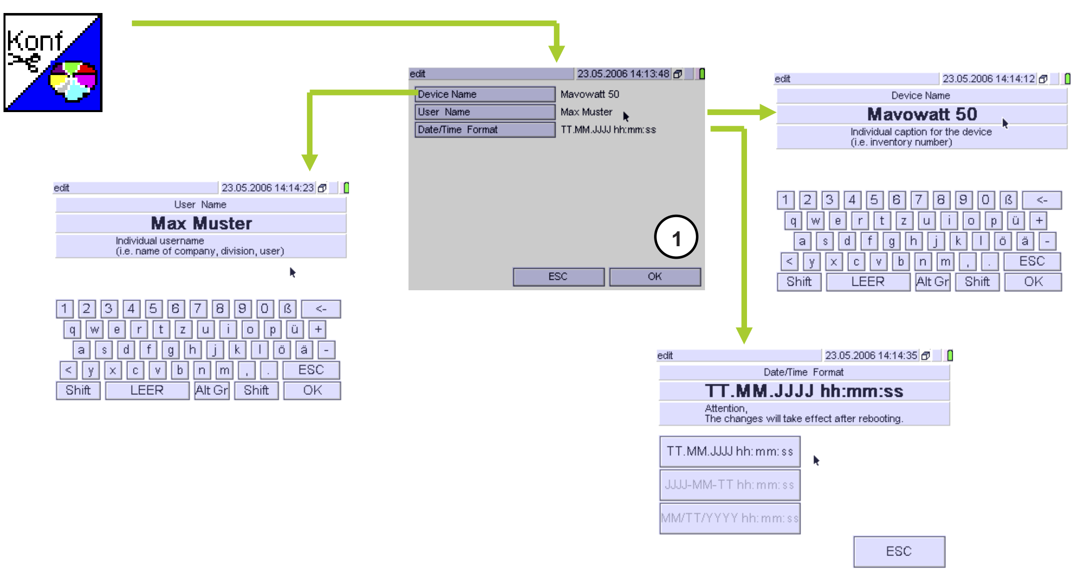
## M 1 Menu Structure Setup

### M 1.1 Device Parameters

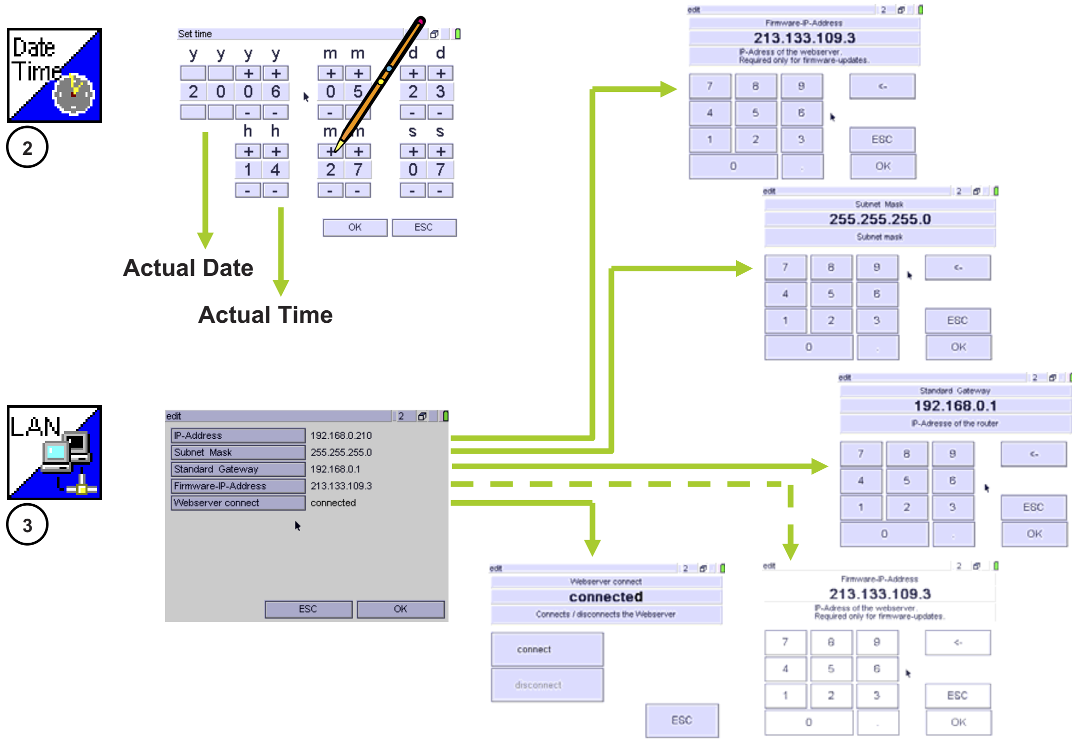
ON|MENU →Setup → [Device Parameters]



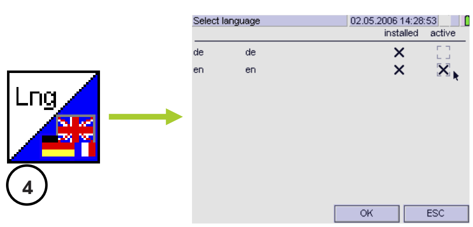

Device Parameters 1 → edit



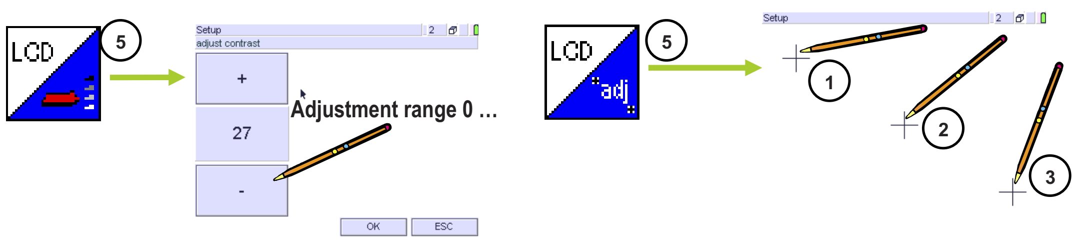
## Device Parameters 2-3 → edit



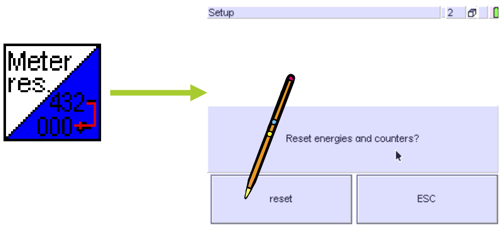

## Device Parameters 4 → select

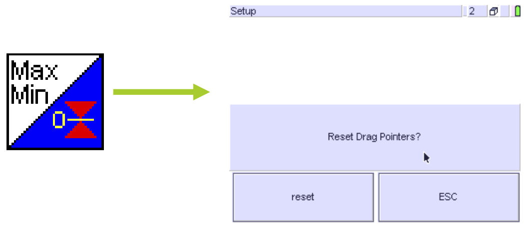


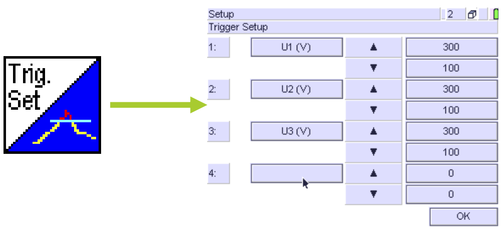

## Device Parameters 5 → adjust

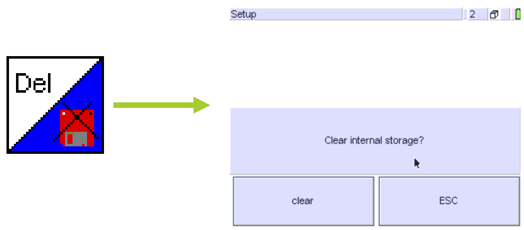


## Device Parameters → set



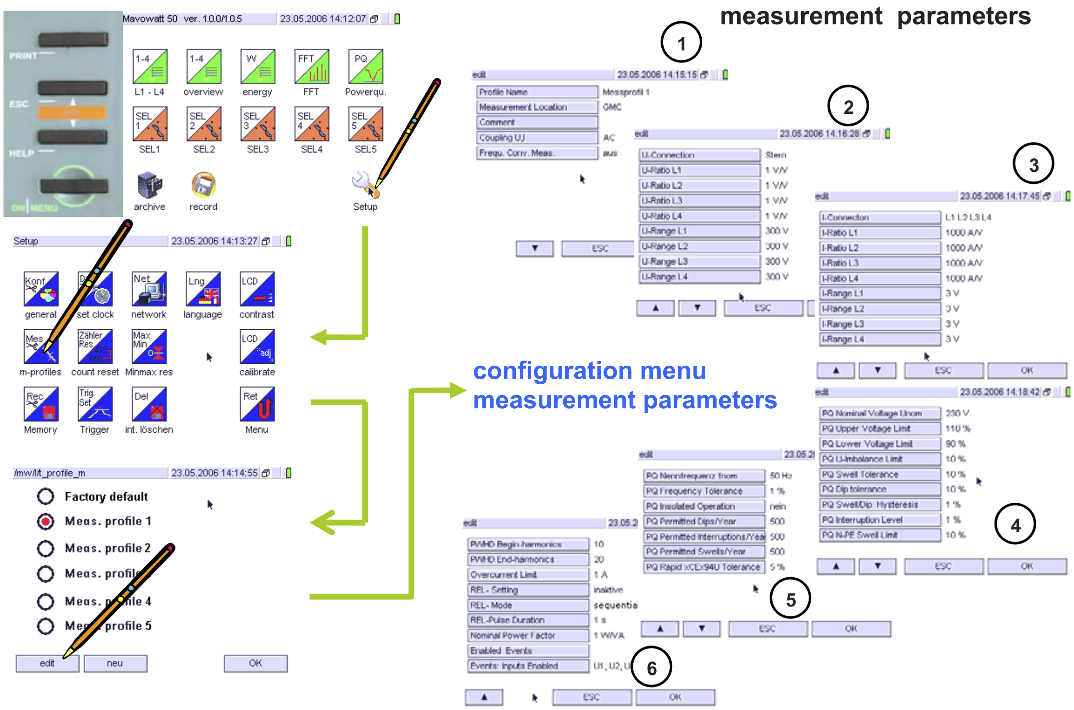



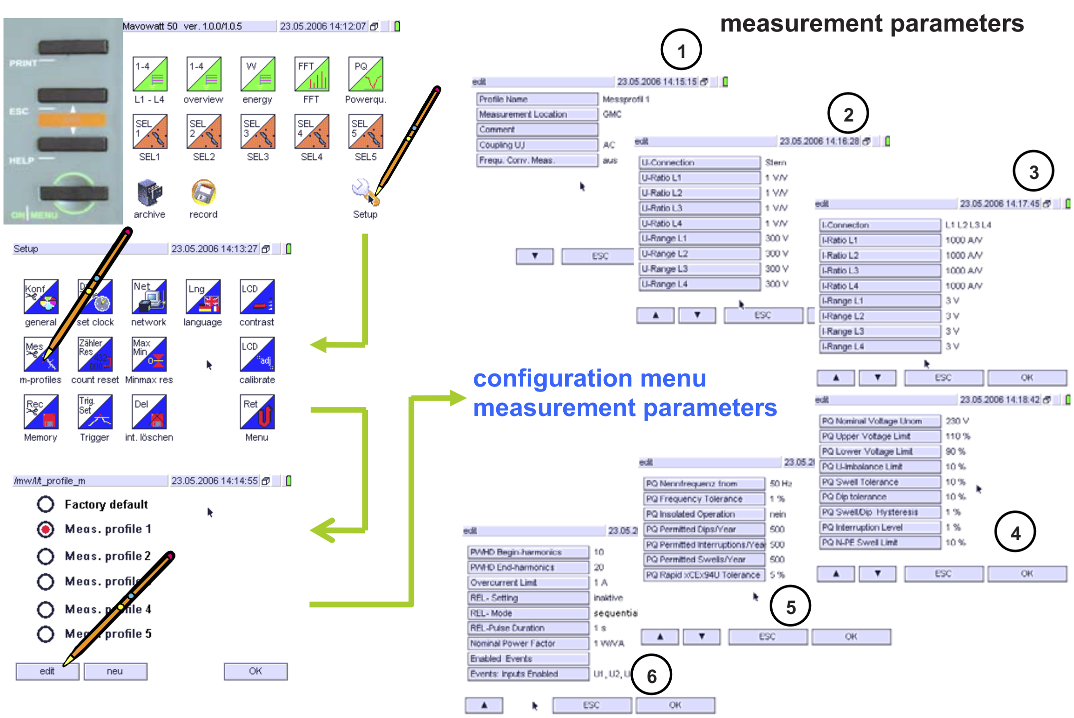



## M 1.2 Measurement Parameters

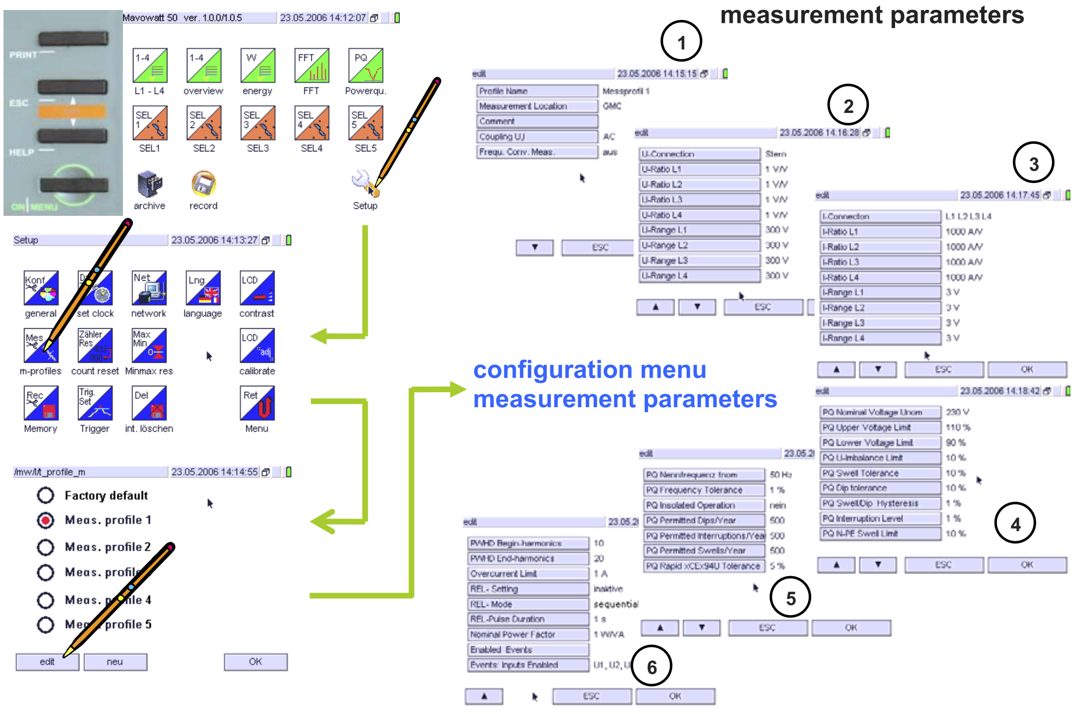
**ON|MENU → Setup → Measuring Parameters**



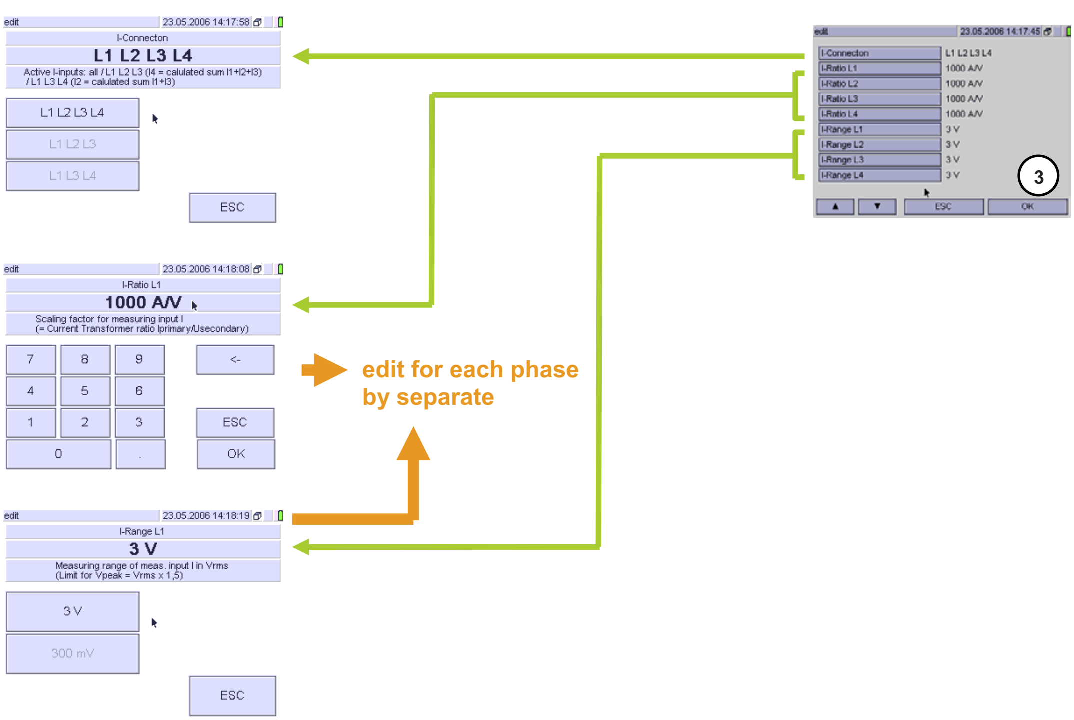

**Measuring Parameters 1 → edit**



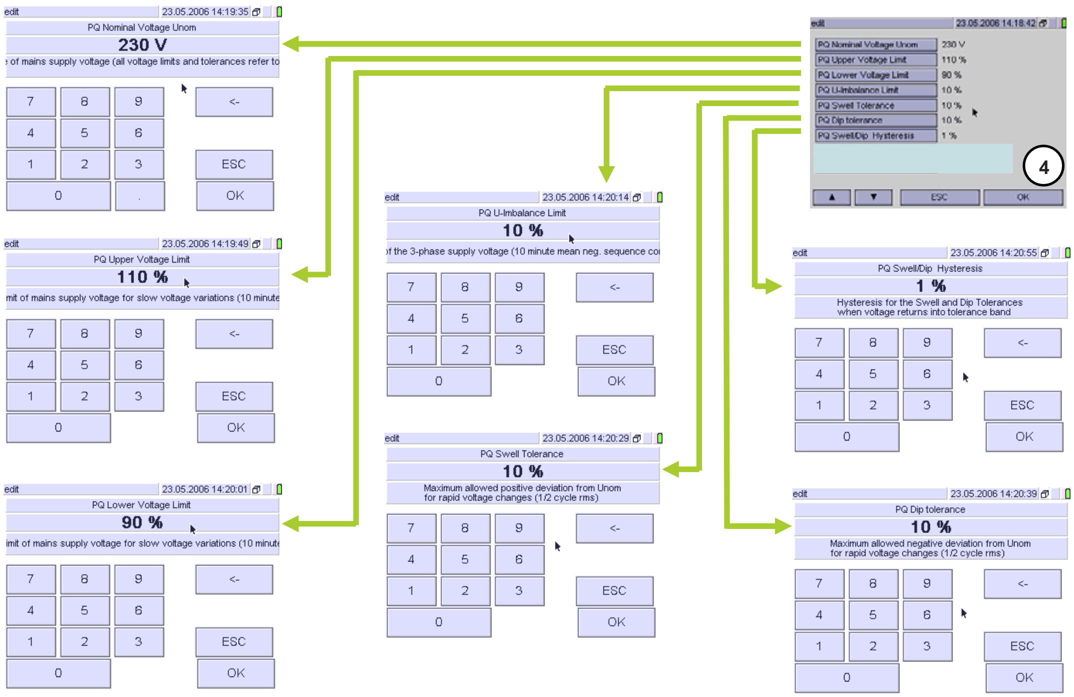
## Measuring Parameters 2 → edit

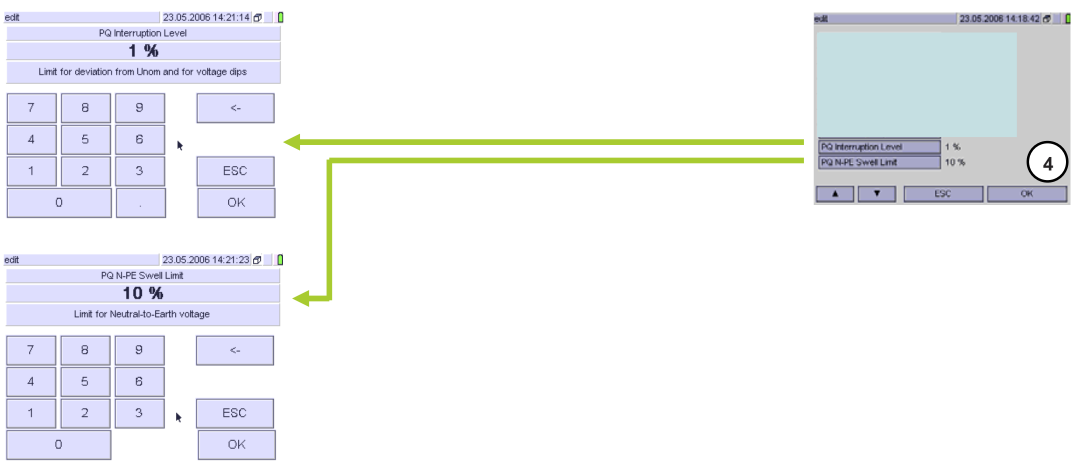



## Measuring Parameters 3 → edit

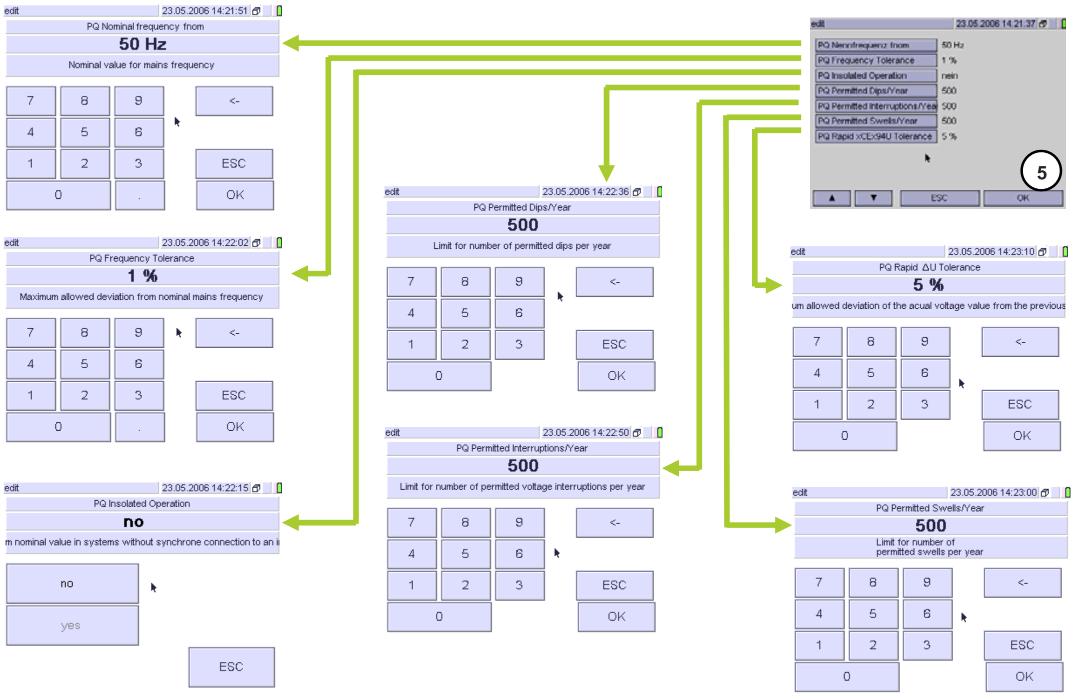


## Measuring Parameters 4 → edit

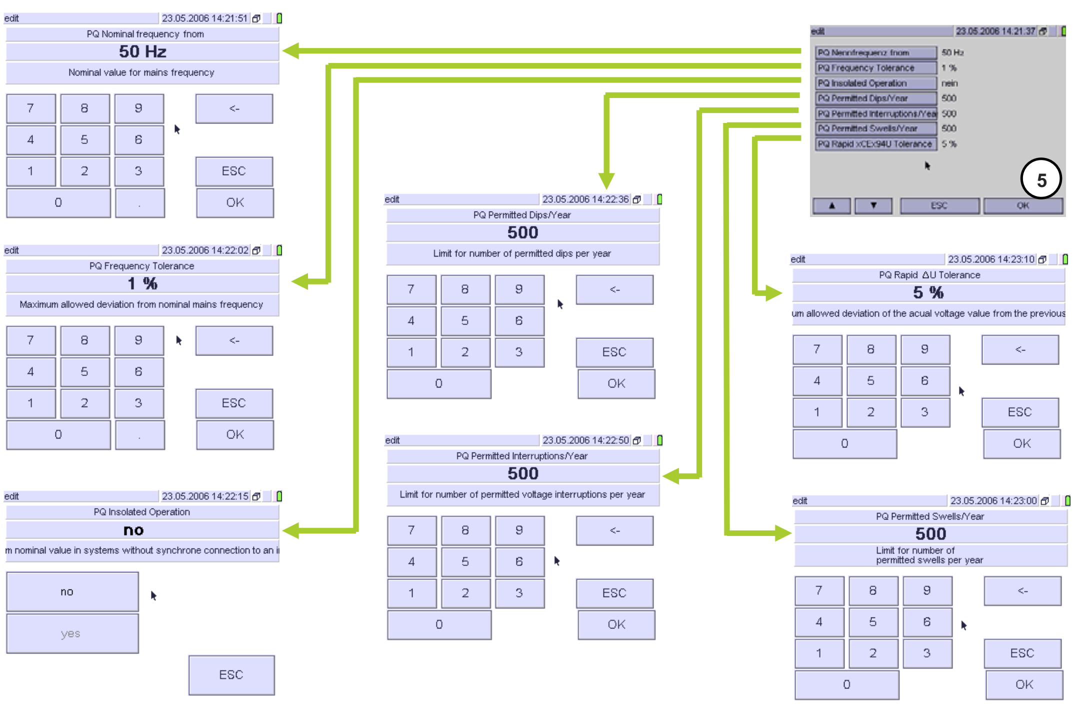


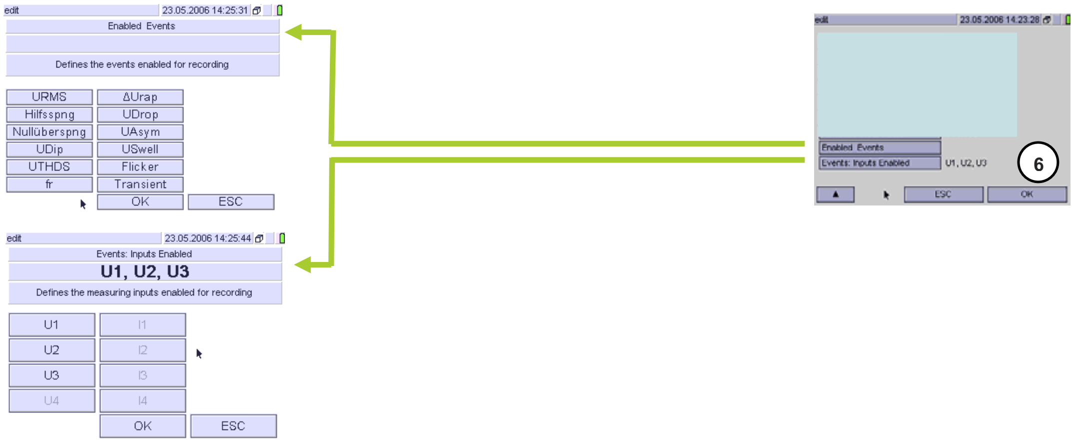
## Measuring Parameters 5 → edit




## Measuring Parameters 6 → edit

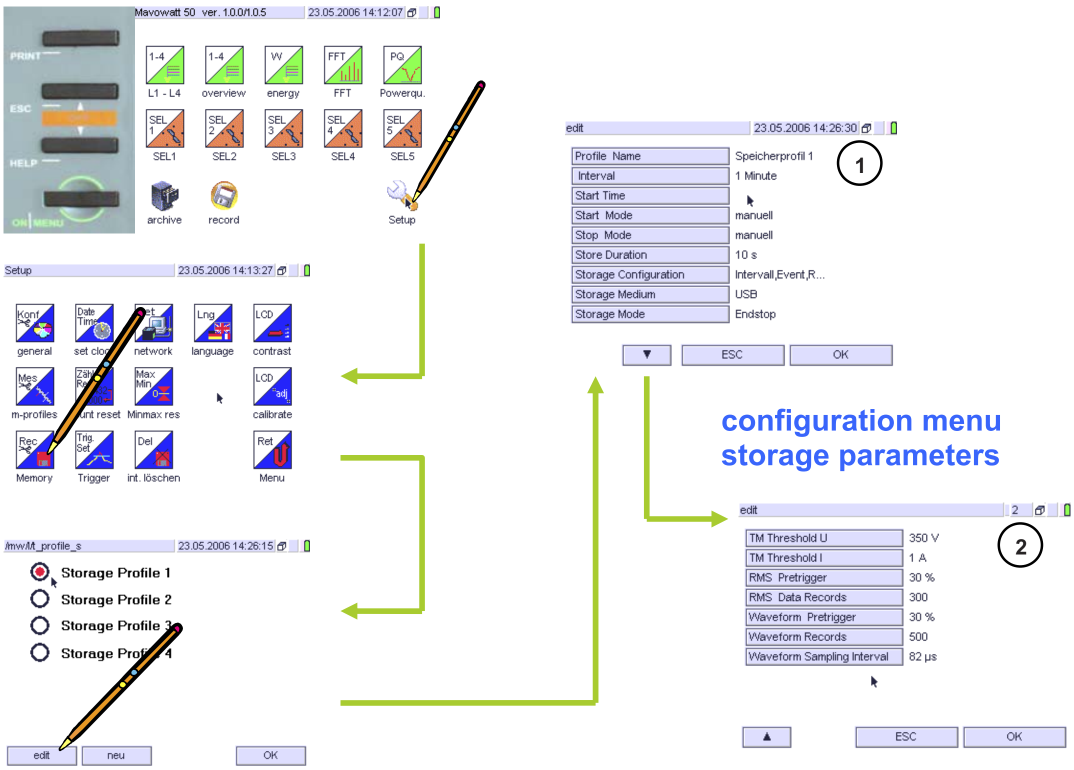


**Measuring Parameters 6 → edit**

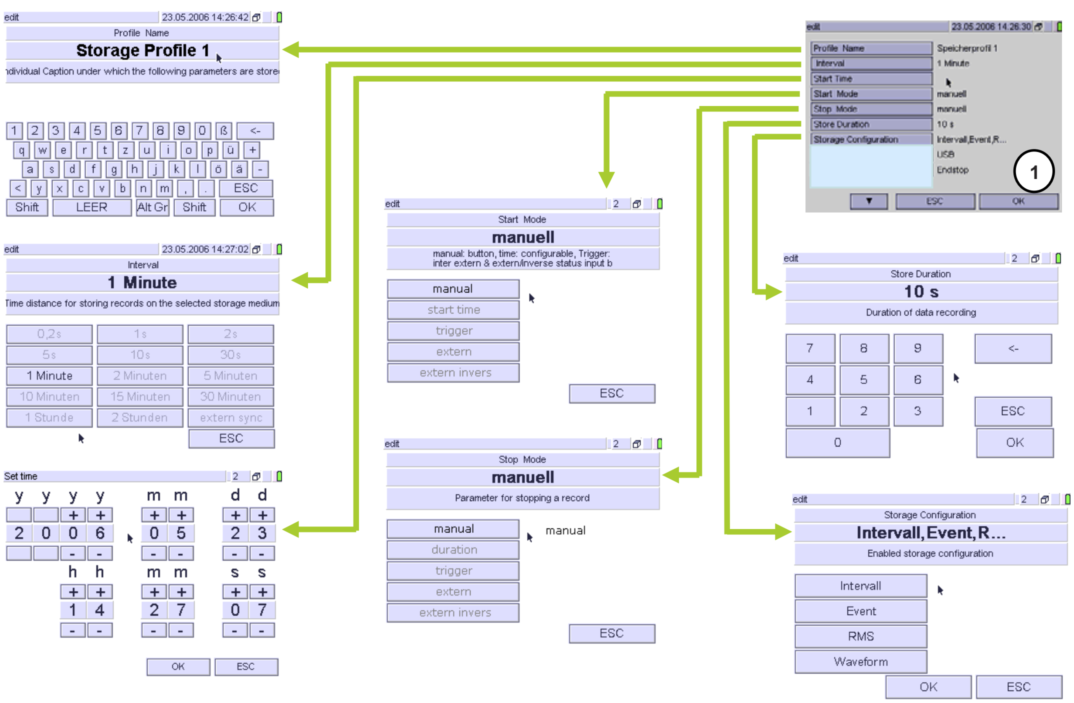


## M 1.3 Storage Parameters

### ON|MENU → Setup → Storage parameters

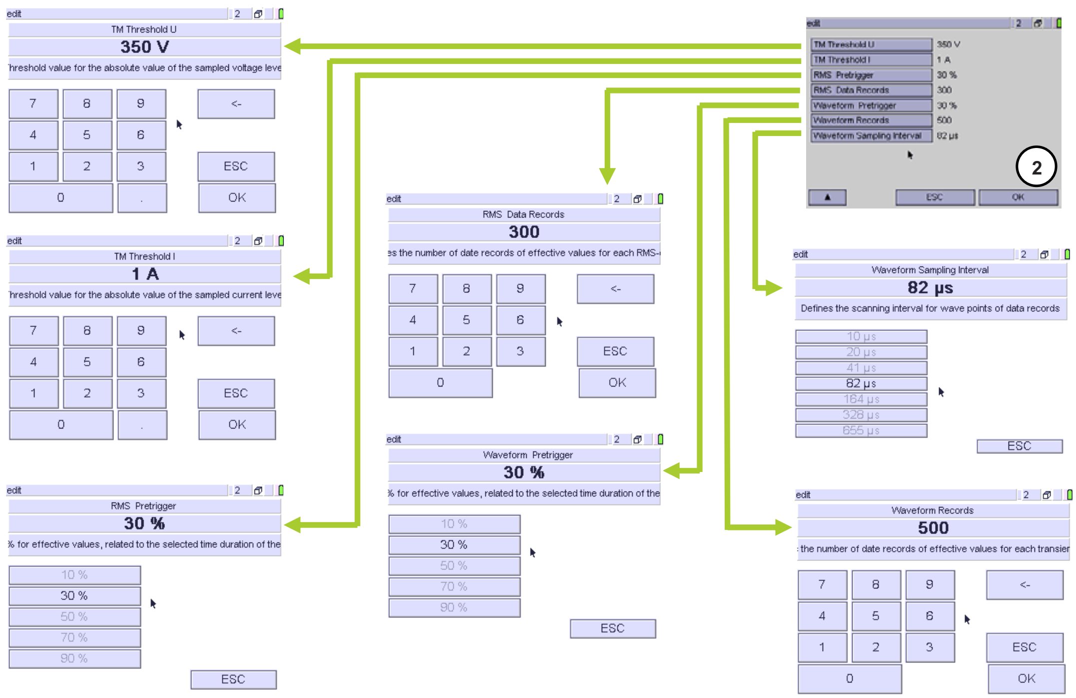



### Storage parameters 1 → edit



## Storage parameters 1 → edit

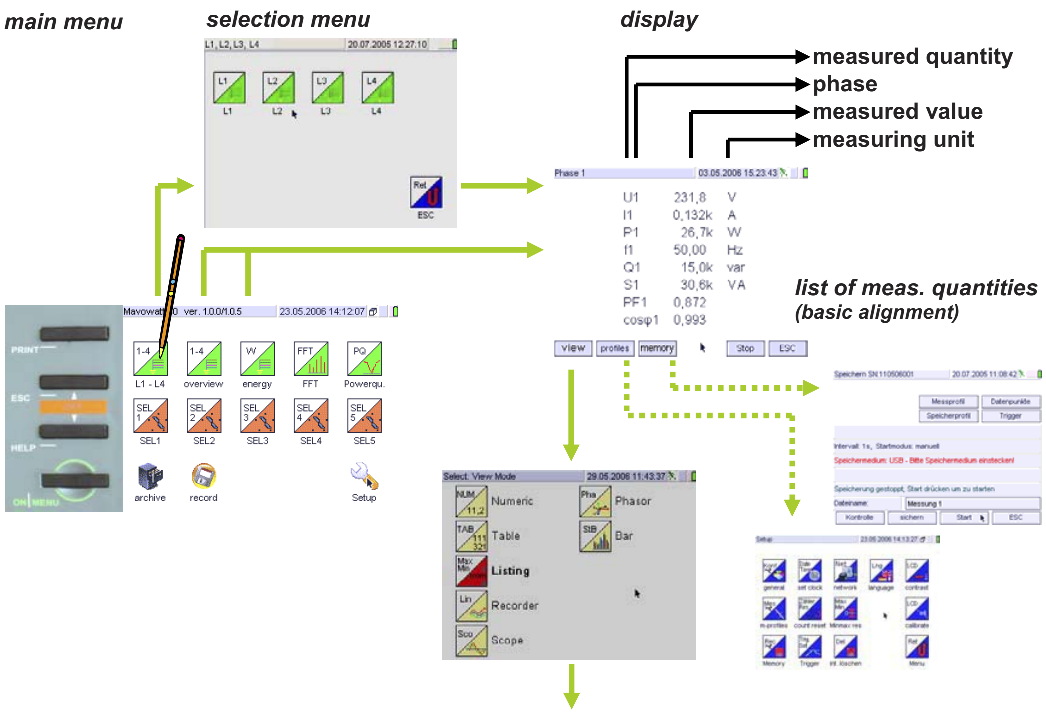

## Storage parameters 2 → edit



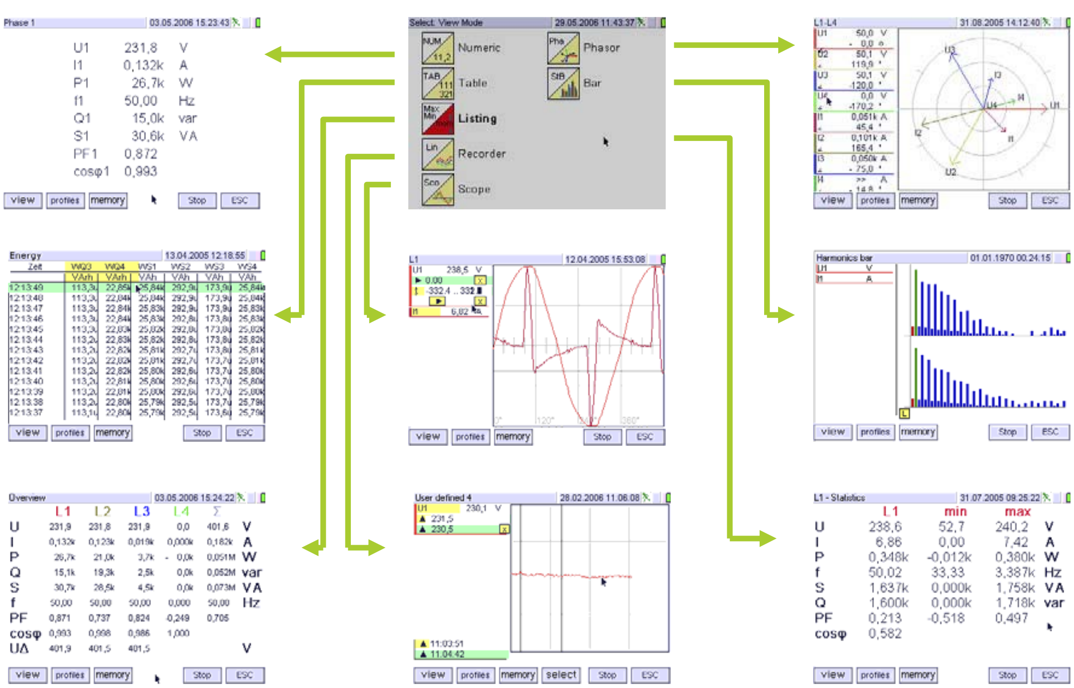
## M 2 Menu Structure Measurement Functions

### M 2.1 Menu Basic Measurement Functions (U, I, P, W, …)

**ON|MENU → L1-L4 → Select**
**→ Overview / Energy**

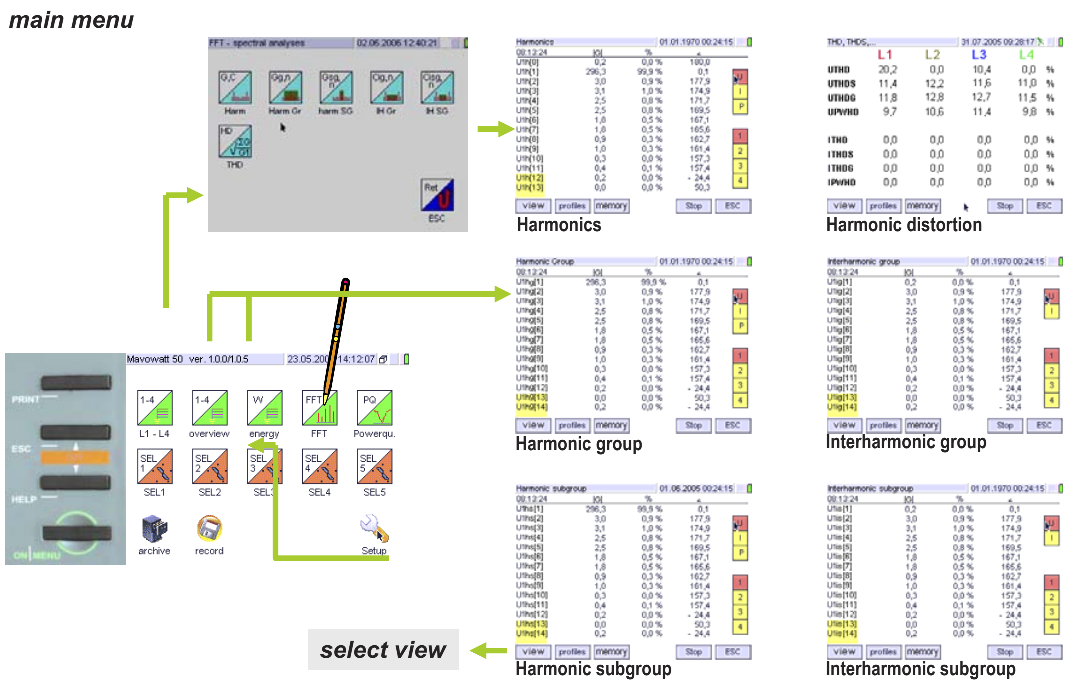



### Display → Select



## M 2.2 Menu Spectral Analysis

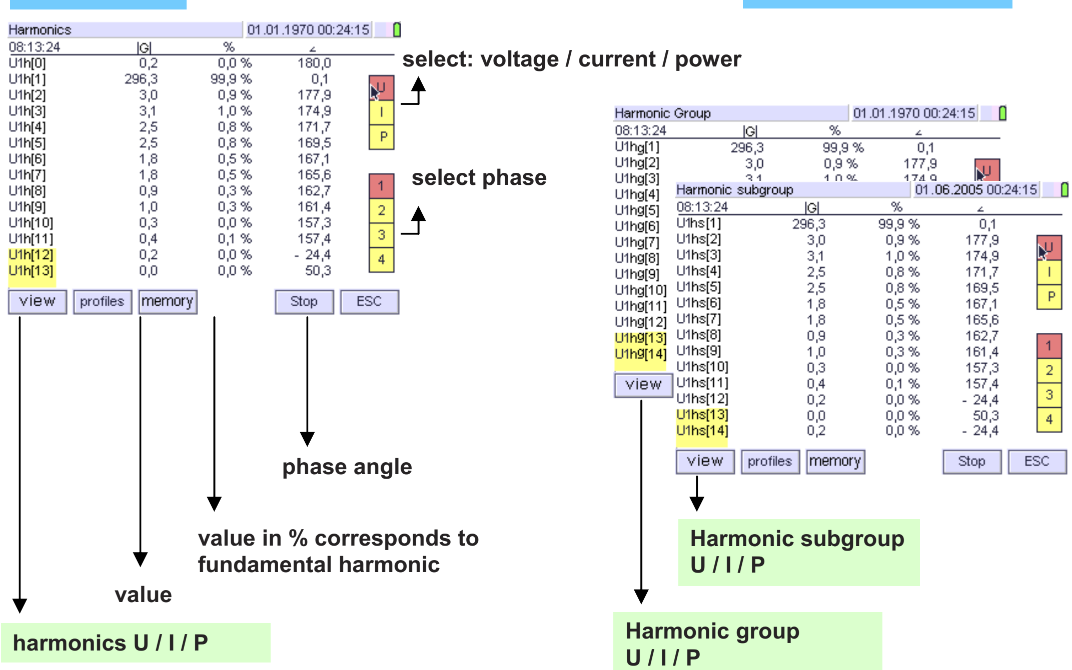
**ON|MENU → FFT → select**




**ON|Menu → FFT → Select [harm. function]**

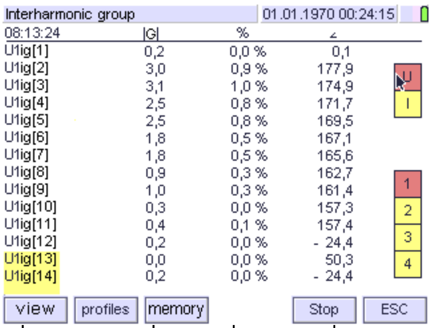
## Harmonics

## Harmonic shares



ON|Menu → FFT → Select [harm. function]

## Interharmonic shares




select: voltage / current

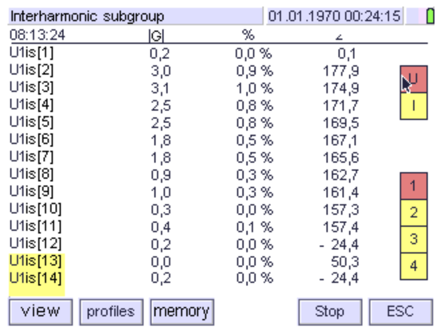
select phase

phase angle

value in % corresponds to fundamental harmonic

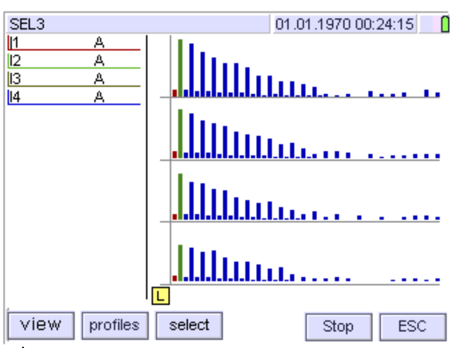
Wert

interharmonc group
voltage / current / power




interharmonic subgroup
voltage / current / power

Menu → FFT → Display → Select [harm. bar]




Selection of spectral shares to be viewed occurs in superordinate views

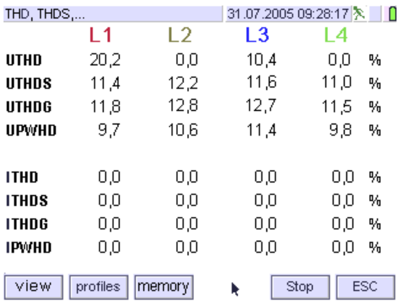
spectral shares

basic harmonic

measured value corresponds to position of vertical cursor

measured quantity U / I / P

**ON|Menu → FFT → Select THD**



THD, THDS,... 31.07.2005 09:28:17

| | L1 | L2 | L3 | L4 | |
|---|---|---|---|---|---|
| UTHD | 20,2 | 0,0 | 10,4 | 0,0 | % |
| UTHDS | 11,4 | 12,2 | 11,6 | 11,0 | % |
| UTHDG | 11,8 | 12,8 | 12,7 | 11,5 | % |
| UPWHD | 9,7 | 10,6 | 11,4 | 9,8 | % |
| ITHD | 0,0 | 0,0 | 0,0 | 0,0 | % |
| ITHDS | 0,0 | 0,0 | 0,0 | 0,0 | % |
| ITHDG | 0,0 | 0,0 | 0,0 | 0,0 | % |
| IPWHD | 0,0 | 0,0 | 0,0 | 0,0 | % |

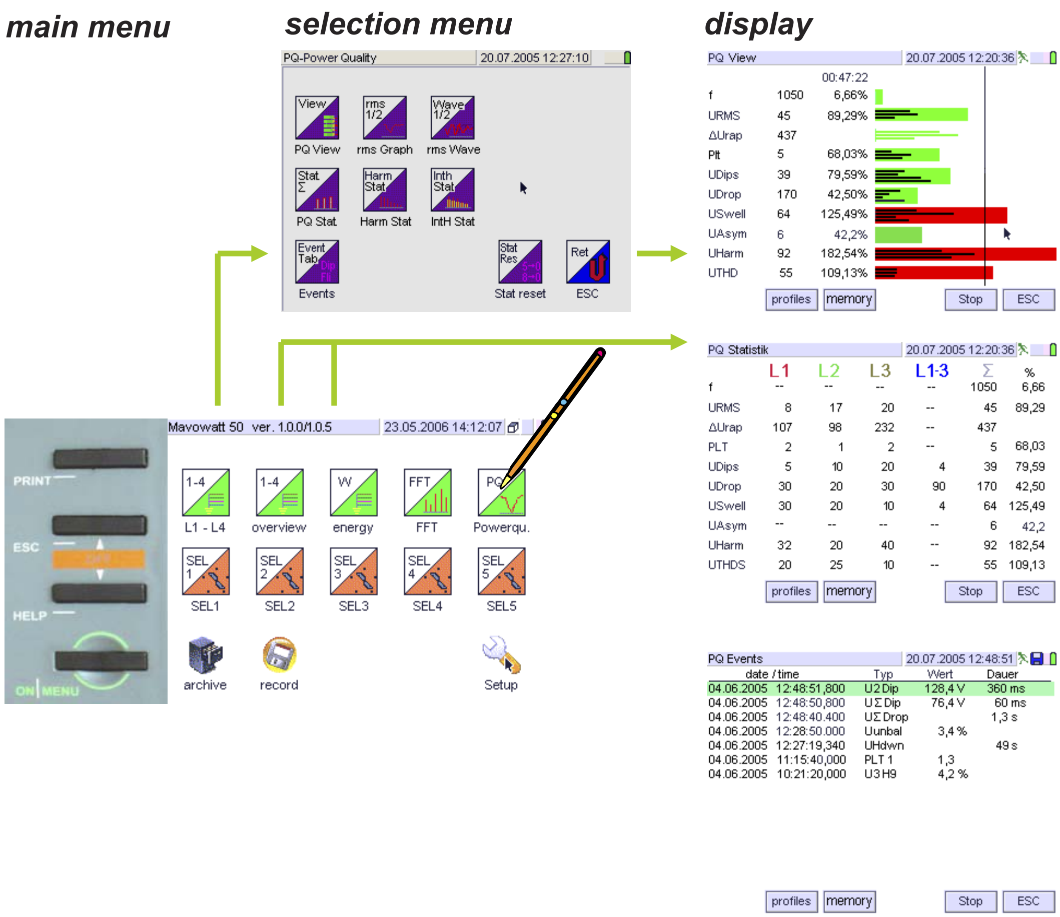
view profiles memory Stop ESC

**Ratio of sum of spectral shares or part of them without fundamental harmonic to effective value of the fundamental harmonic.**
**All viewed data in %**

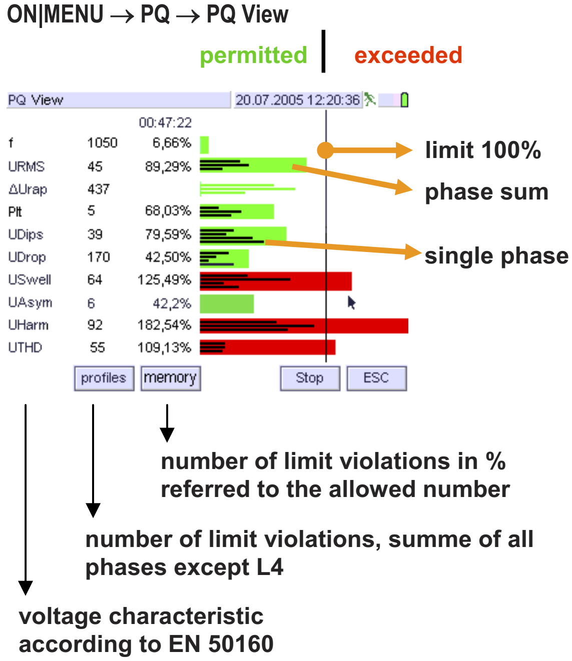
**Spectral Shares:**
**THD:**
**sum of all harmonics**
**THDS:**
**sum of all harmonic shares inclusive the just off contiguous interharmonics shares**
**THDG:**
**sum of all harmonic shares inclusive the contiguous interharmonics**
**PWHD:**
**sum of harmonic shares of a selected group of successive harmonics inclusive the contiguous interharmonics**

## M 2.3 Menu Power Quality

**ON|MENU → PQ → Select [PQ-function]**



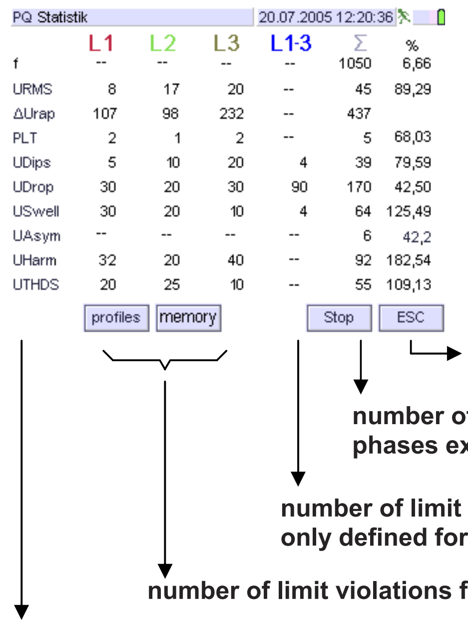

**ON|MENU → PQ → PQ View**




**Overview:**
**voltage Quality over defined charac-trerictics**

- **Frequency**
- **Slow voltage fluctuations**
- **Fast voltage fluctuations**
- **Flicker**
- **Voltage dips**
- **Voltage drops**
- **Voltage swells**
- **Valtage unbalance**
- **Voltage harmonics**
- **Voltage distortion**

**ON|Menu → PQ → PQ Statistics**



PQ Statistik 20.07.2005 12:20:36

| | L1 | L2 | L3 | L1-3 | Σ | % |
|---|---|---|---|---|---|---|
| f | -- | -- | -- | -- | 1050 | 6,66 |
| URMS | 8 | 17 | 20 | -- | 45 | 89,29 |
| ΔUrap | 107 | 98 | 232 | -- | 437 | |
| PLT | 2 | 1 | 2 | -- | 5 | 68,03 |
| UDips | 5 | 10 | 20 | 4 | 39 | 79,59 |
| UDrop | 30 | 20 | 30 | 90 | 170 | 42,50 |
| USwell | 30 | 20 | 10 | 4 | 64 | 125,49 |
| UAsym | -- | -- | -- | -- | 6 | 42,2 |
| UHarm | 32 | 20 | 40 | -- | 92 | 182,54 |
| UTHDS | 20 | 25 | 10 | -- | 55 | 109,13 |



**number of limit violations in % referred to the allowed number**
**< 100%: permitted; > 100%: exceeded**

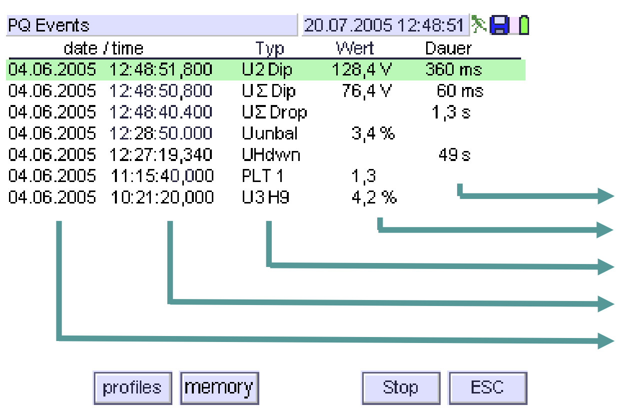
**number of voltage violations, sum of all phases except L4**

**number of limit violations – multiphase failures only defined for short term events dips, drops, swells**

**number of limit violations for the single phases**

**voltage characteristic according to EN 50160**

**ON|Menu → PQ → PQ Events**



PQ Events 20.07.2005 12:48:51

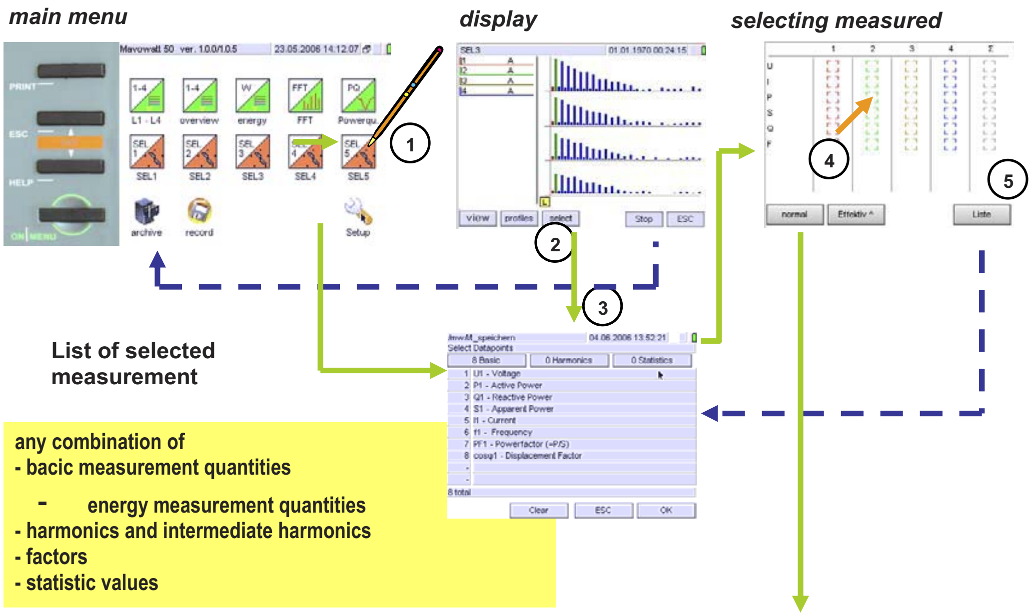
| date / time | | Typ | Wert | Dauer |
|---|---|---|---|---|
| 04.06.2005 | 12:48:51,800 | U2 Dip | 128,4 V | 360 ms |
| 04.06.2005 | 12:48:50,800 | UΣ Dip | 76,4 V | 60 ms |
| 04.06.2005 | 12:48:40.400 | UΣ Drop | | 1,3 s |
| 04.06.2005 | 12:28:50.000 | Uunbal | 3,4 % | |
| 04.06.2005 | 12:27:19,340 | UHdwn | | 49 s |
| 04.06.2005 | 11:15:40,000 | PLT 1 | 1,3 | |
| 04.06.2005 | 10:21:20,000 | U3 H9 | 4,2 % | |



**duration of event**
**max - / min value**
**event type**
**beginn time of event**
**date of event**

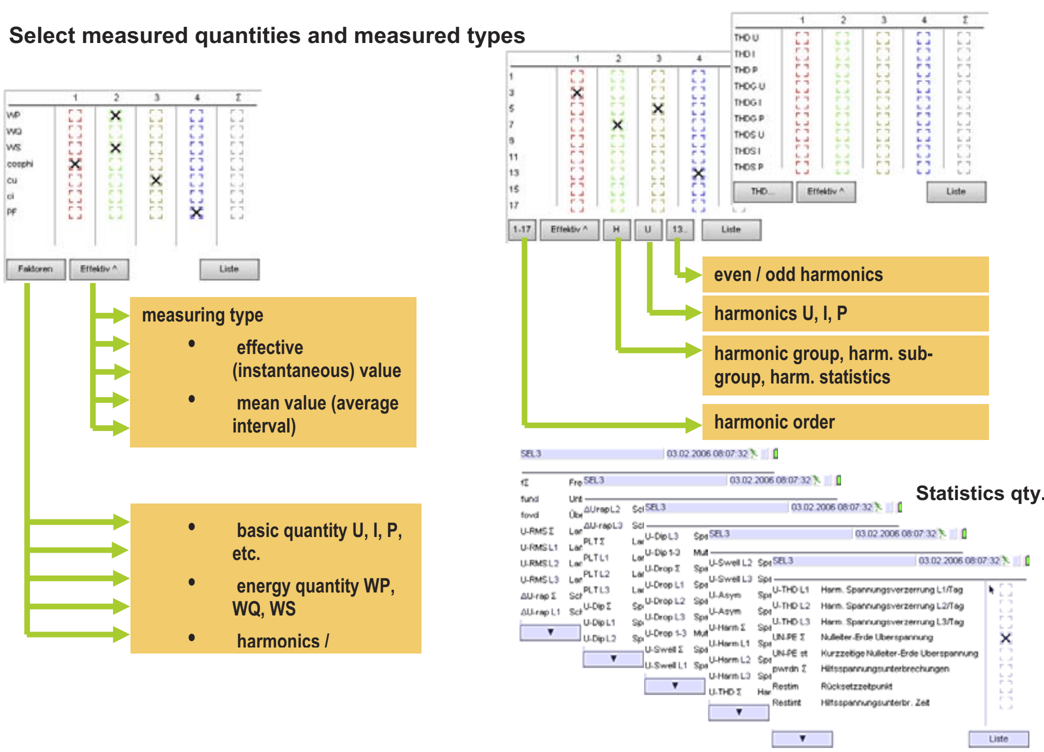
## M 2.4 Menu Assigning Measured Quantities

**ON|MENU → SEL 1-5 → Display**
**↳ Selection of Measured Quantities**



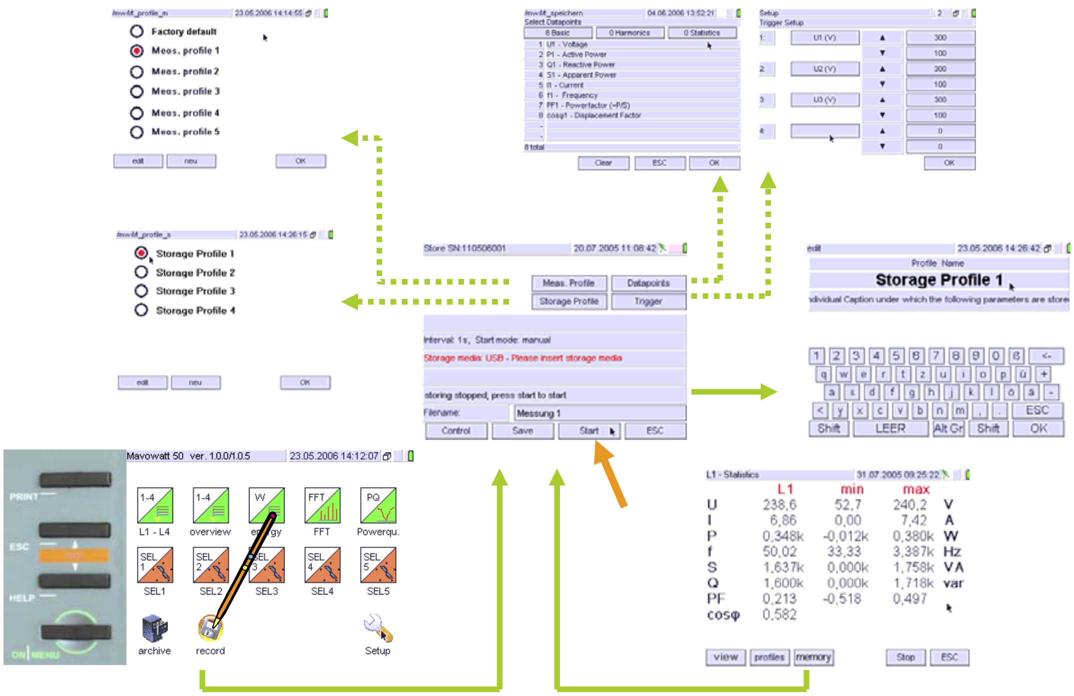

**ON|MENU → SEL1-5 → Select**

**Select measured quantities and measured types**



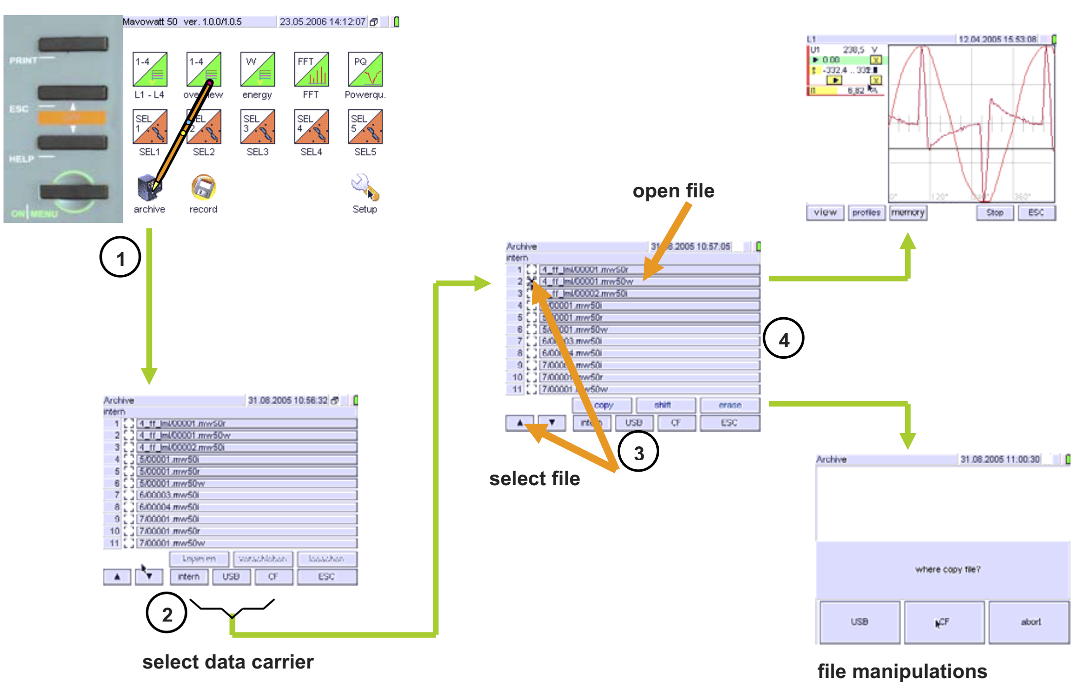
## M 2.5 Menu Store

**ON|MENU → Store → (profile name)**
**Display → Store → (profile name)**




## M 2.6 Menu Archives

**ON|MENU → Archives → Select → open**
**↳ file manipulation**



**Product Support**

When you need service, please contact:

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