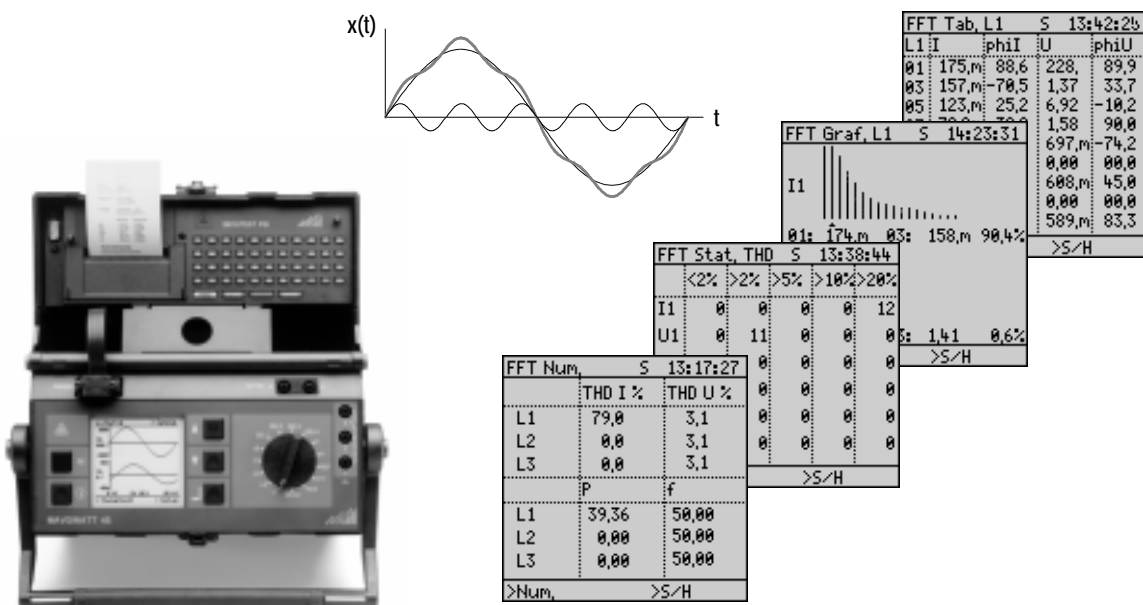


# MAVO-FFT

## Harmonics analysis through SW-Update for energy analyzer MAVOWATT® 45

3.348.763.03  
2/7.96



The image shows a MAVOWATT 45 energy analyzer with several data overlays. On the left is the physical device. In the center is a graph of a signal  $x(t)$  over time  $t$ . On the right are several data tables and a bar chart.

**FFT Tab, L1 S 13:42:25**

L1	I	phiI	U	phiU
01	175,m	88,6	228,	89,9
03	157,m	-70,5	1,37	33,7
05	123,m	25,2	6,92	-10,2
07	70,8	70,8	1,58	90,0
09			6,97,m	-74,2
11			0,00	00,0
13			0,00	45,0
15			6,00,m	00,0
17			5,89,m	83,3

**FFT Graf, L1 S 14:23:31**

I1

01: 174,m 03: 158,m 90,4%

**FFT Stat, THD S 13:38:44**

	<2%	>2%	>5%	>10%	>20%
I1	0	0	0	0	12
U1	0	11	0	0	0

06: 141 06%

**FFT Num, S 13:17:27**

	THD I %	THD U %
L1	79,0	3,1
L2	0,0	3,1
L3	0,0	3,1

**P f**

	P	f
L1	39,36	50,00
L2	0,00	50,00
L3	0,00	50,00

**>Num, >S/H**

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# 1 Installation

## 1.1 Allocation of a password prior to installation

With the use of a DOS PC, the MAVO-FFT option is activated as follows:

- Note the serial number of your unit, see label on the bottom of the case
- If the serial number on the label is not accessible or illegible, proceed as follows:
  - Connect the unit to the line voltage.
  - Switch the unit on; note the LC display. The serial number is shown under the company logo when the unit is switched on.
- Enter the serial number in the attached registration card.
- Return the filled-in registration card to the given address and/or fax number.  
The password for installation of the MAVO-FFT option which we enter in the registration card will then be forwarded to you.

## 1.2 Initial installation of the MAVO-FFT option

Transfer the actual equipment software from the PC to the energy analyzer MAVOWATT 45 before you enter the password for the execution of the MAVO-FFT software. To do this, proceed as follows:

- ⇒ Disconnect the printer.
- ⇒ Connect the energy analyzer to the line without switching it on.
- ⇒ Connect the interface marked RS-232 to the serial port of your PC (e.g. COM 1) via the interface cable included with the supply.
- ⇒ Switch the energy analyzer on.
- ⇒ After initializing, set the switch to L1.
- ⇒ Insert the disk included with the supply into the disk drive of your PC.
- ⇒ Change to the drive in which the program disk is inserted.



### Note

Start the program from the DOS level!

---

- ⇒ Start the transfer of the program from the PC with **LOAD <Enter>**.

The progress of the initializing routine is shown on the screen of the PC by ; ; ; ; . The transfer of the program is shown on the screen by continuous dots ( . . . . . ) on several lines. When the transfer is ended, the cursor rests at the prompt of the actual disk drive. The energy analyzer is restarted.

- ⇒ Set the switch on the energy analyzer to FFT.

## Enable the option MAVO-FFT

- ⇨ Start the recognition routine on the PC with the **FFTKEY** <Enter>. Shortly thereafter you are prompted to enter the password. This is a multidigit number, eventually with sign.
- ⇨ Enter the password made known to you. Press <Enter>.

After enable, the information "FFT unlocked" appears on the monitor of your PC.

- ⇨ Switch the energy analyzer off.
- ⇨ Connect the printer in place of the interface cable.  
After switching the energy analyzer on again, it is ready for operation.



### Note

Future updates do not require to again enable the MAVO-FFT option.

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### Note

After the transfer, check the measuring and equipment parameters. They could have been changed because of the transfer!

---

## Setting the measuring and equipment parameters after the transfer

When transferring the software to the MAVOWATT 45, equipment parameters and measuring parameters that cannot be correlated are set back to their basic values.

That is why we recommend to successively check the parameters after transfer and/or set them as follows:

### 1. Screen contrast

- ⇨ Switch the unit off.
- ⇨ Set the function switch to *MENU*.
- ⇨ Switch the unit on.

When the run of the start program is ended, the cursor automatically flashes at the first setting position for the contrast so that you can directly change it with the  $\Delta$  or  $\nabla$  key.

- ⇨ Confirm the setting with *Enter*.

### 2. Equipment parameters

Contrast:	60 (see above for setting)
Language:	German
Time:	Actual Central European Time
Date:	Actual date
System type:	2/4-wire
Tariff 1 from:	06:00     ↓: 0,000
Tariff 1 from:	06:00     ↑: 0,000
Tariff 2 from:	22:00     ↓: 0,000
Tariff 2 from:	22:00     ↑: 0,000
Tariff 3 from:	06:00     ↓: 0,000
Tariff 3 from:	06:00     ↑: 0,000

### 3. Measuring parameters

#### Switch positions L1, L2 and L3

Sample: 0002  
Iratio: 1,000  
Uratio: 1,000  
Printer: off  
Interval: 30

#### Switch positions E and P:

Period: 0900  
Zconst.: 750  
Sync.: Zeit  
Pfset: 0,9  
Printer: off  
Delete: no

Measured quantities at the corresponding switch position

SEL 1	SEL 2	SEL 3	SEL 4
U1	U1	U1	U1
U2			
U3			
I1			
I2			
I3			

## 2 Applications

In power engineering, there is a strive for pure sinusoidal waveforms of voltage and current. Here, harmonics cause additional heat losses in machines and transducers laid out for the fundamental.

In addition, harmonics can cause resonant effects on lines. Moreover, consumers having a non-linear current/voltage characteristic as well as capacitive resistances cause waveform distortions on the systems.

Thus, there is a need for producers, distributors and large customers of electrical energy as well as for the manufacturers of machines and equipment, to detect, analyze and eliminate harmonic sources.

An evaluation of systems with the MAVOWATT 45 analyzer allows for an inference from the influences on electrical facilities in their electromagnetic environment. For this purpose, the measuring signals are simultaneously scanned with a fixed frequency of 50 kHz (no multiplexing) and stored in the data memory.

Via the Fast Fourier Transform (FFT), fundamental and harmonics of current and voltage are continuously and completely (real time) acquired, computed and evaluated according to specified directives. It is the goal of the evaluation to value the occurring harmonic amplitudes by a comparison with the maximum permissible values according to IEC 555-2 and/or EN 60 555, part 2 (harmonic currents) as well as to value the waveform of the supply voltage in public utility systems according to DIN EN 50 160 (total harmonic distortion THD).

The measured results can directly be documented on the integrated printer, stored on the PC card (in general in real time), or transferred to a PC for further processing.

### 2.1 Legend of short designations

Character	Measured quantity	Meas. unit	Meaning
f	Line frequency	Hz	Hertz
I	Current	A	Ampere
P	Active power	W	Watt
phi	Phase angle for current	°	Degree
phu	Phase angle for voltage	°	Degree
Single	Evaluation method, see page 9		
THDU	Total distortion factor for voltage	%	Percent
THDI	Total distortion factor for current	%	Percent
Tvs	Evaluation method, see page 9		
Tsh	Evaluation method, see page 9		
U	Voltage	V	Volt

### 3 Description

The signal to be analyzed is filtered across a low-pass filter to avoid alias effects\*. The MAVOWATT 45 is suited for frequencies up to 20 kHz so that the 50th harmonic can be acquired in electrical systems up to 400 Hz. The DC component of voltage and current is simultaneously captured. The signal sampled with a fixed frequency of 50 kHz undergoes analog/digital conversion and is stored. FFT is performed via a rectangular window the width of which corresponds to 16 times the determined fundamental. To determine the phase position, sampling rate and width of window are synchronized with the fundamental frequency. The FFT computer first calculates the orthogonal Fourier coefficients of those 50 spectral lines that correspond to the harmonic orders  $n = 0, 1 \dots 50$ . Harmonic amplitude and phase position result from the following arithmetic calculation. The contents are compared with the limits for harmonic voltages and/or currents specified by relevant standards, and evaluated accordingly.

#### 3.1 Valuation of the harmonics (calculation modes)

##### 3.1.1 Valuation of disturbances in supply systems according to DIN VDE 0838 and/or EN 60555-2

###### a) Quasi-stationary harmonics

The measurement is made continuously. Harmonics measured and valuated accordingly are displayed in a set sample time and printed in settable sample time intervals and/or stored to the PC card (option). Aiming at a reduction of the amount of data to the required extent, transfer of the measured data to the PC card is made according to quantitative criteria and selective.

###### b) Varying and rapidly changing harmonics

The amplitude spectrum of the harmonics calculated via the FFT is stored for current and voltage together with the phase angle "by windows". The measurement is continuous. Choose the storage capacity of the PC card in such a way that the values of 5,000 windows can be recorded. The selected method (rectangular window) maintains the required synchronization between fundamental frequency, sampling rate and width of window.

Evaluation is "by windows" for the recorded period of time. For this purpose, the windows are successively worked off, valuated accordingly and displayed. For temporary events (particularly during switching), better smoothing is desired. Averaging of successive windows in the time domain and/or averaging of the coefficients in the frequency domain over defined time ranges can be made via a PC software.

\* If the sampling theorem is not satisfied that is, the sampling intervals are too long, the amplitude signals overlap and the output curve can no longer be determined. This causes so-called alias effects in which case a lower frequency than the actually existing higher frequency is measured. A low-pass filter permits the periodic contents of the signal to be filtered out.



### 3.1.2 Valuation of voltage characteristics according to EN 50 160

The total harmonic distortion THD for current and voltage is continuously captured in real time together with the actual power and the fundamental frequency. Storing of the measured results to the PC card is also made in real time so that it is possible to perform a complete evaluation in conjunction with a PC software. The 10-minute average of the continuously and completely captured signal can thus be formed, for example, as is mentioned in the standard.

Table 1 and/or 2 of EN 50 160 list percentage values up to the 25th harmonic which must not be exceeded. Harmonics of higher order are recorded but not valued. But the entirety of the harmonics up to the 40th order (THD) must not exceed 8 %.

### 3.2 Evaluation method

- Single:** Recording of harmonics within the selected interval and/or when preset limits are exceeded. The data captured via a rectangular window (that is, 16 periods) are valued and recorded according to selectable criteria.
- Tvs:** Continuous recording of the average of the total harmonic distortion for voltage and current as well as the harmonic contents over a very short time (3 seconds, that means 10 rectangular windows at a fundamental frequency of 50 Hz). The recording serves to value long-term influences of harmonics. Classification of the harmonic contents without a comparison with default limits.
- Tsh:** Continuous recording of the average of the total harmonic distortion for voltage and current as well as harmonic contents over a short time (10 minutes, that means 1,875 rectangular windows at a fundamental frequency of 50 Hz) for determination of the cumulative frequency function. Comparison of the harmonic contents up to the 25th harmonic with default limits.

### 3.3 Presentation and documentation

Presentation and documentation are made according to different, selectable criteria. To evaluate quasi-stationary harmonics, the total harmonic distortion THD and the amplitude spectrum in current and voltage are displayed in different types of presentation within preselected sample times. This allows for a quantitative valuation of harmonics.

Recording of the total harmonic distortion THD as well as the quantitative analysis of standard-specified limits of the harmonic amplitude of current and voltage is made in real time. As trigger criteria (count criteria), the limits of the harmonic amplitude contents specified in the standard are compared with the actual amplitudes of the harmonic contents. When making a hardcopy on the integrated printer, evaluation is made in the selected recording interval.

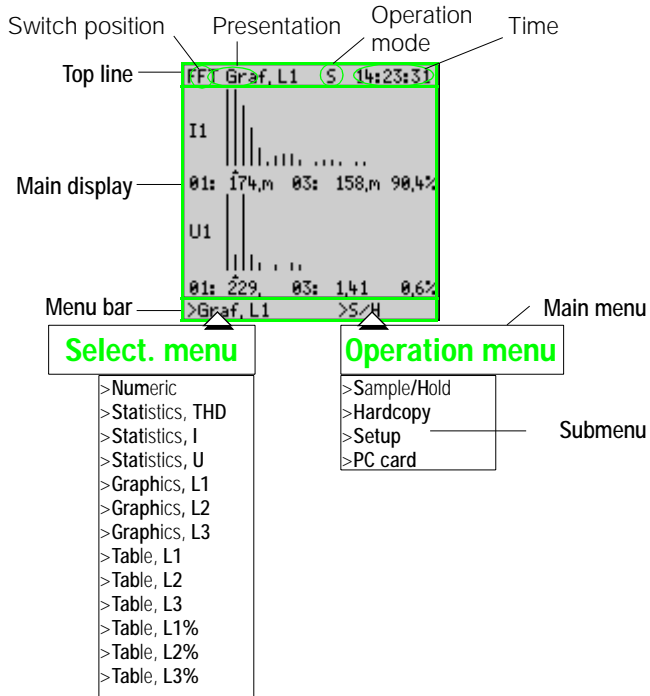
For an analysis of varying and rapidly changing harmonics via a PC software, the samples are continuously stored to the PC card (option), and also the total harmonic distortion THD and the quantitative valuation in real time. The signal is clearly reproducible from the recorded absolute values and the phase location of the harmonic contents.

*Remarks:* Valuation of the waveform of the supply voltage in public utilities systems according to EN 50 160 requires continuous recording of the average of the total harmonic distortion THD as well as the harmonic contents over a defined observation period. The average is formed over a defined time interval of 10 minutes, the observation time is fixed to one week. Along this evaluation method requires a relatively large storage capacity. In addition thereto, further sample time intervals and observation periods (up to one year!) are specified in the relevant standards. Comprehensive viewing is thus left to an own option.



## 4 Types of presentation with the switch set to FFT

### 4.1 Presentation of evaluations on the LC display



#### Note

In numeric presentation, the total harmonic distortion for current (THDI) and voltage (THDU), the actual phase power and the calculated fundamental frequency are shown on the LC display simultaneously for all three phases. Moreover, continuous and complete transfer to the PC card (option PC card) is possible. Further evaluations in the scope of harmonics analysis can only be shown for one phase at a time. When a transfer is made to the PC card, there is a choice to store one phase or all three phases.

#### NUMERIC (distortion factor, power, frequency)

Presentation of the actual total harmonic distortion for current and voltage as well as power and frequency on the individual phases. In **Sample** mode, the display is updated in the preselected sample time.

In **PC card** mode, the measured values are stored to the PC card in real time. In **Hardcopy** mode, the screen contents can be stored.

In **Hold** mode, the measurements available in the memory are held. The memory contents can be shown on the LC display in successive order.

FFT Num.	THD I %	THD U %
L1	79,0	3,1
L2	0,0	3,1
L3	0,0	3,1
	P	f
L1	39,36	50,00
L2	0,00	50,00
L3	0,00	50,00
>Num,	>S/H	

### General information on the statistics presentations

In **Sample** mode, counting starts after selection and confirmation of this mode. The number of violations in the selected sample time intervals is displayed.

The counter reading at a time can be stored to the **PC card**. After the time laps and storage of the counted values, counting starts again in the next sample time interval.

In **Hold** mode, the sample time intervals can be called up in successive order.

### STATISTICS THD (harmonics distortion statistics)

*Number of violations* of a preset total harmonic distortion THD in percent for current and voltage, starting after selection of the type of presentation and within the selected time interval.

FFT Stat, THD S 13:38:44					
	<2%	>2%	>5%	>10%	>20%
I1	0	0	0	0	12
U1	0	11	0	0	0
I2	11	0	0	0	0
U2	11	0	0	0	0
I3	11	0	0	0	0
U3	11	0	0	0	0
>Stat, THD		>S/H			

### STATISTICS-I (amplitude statistics)

*Number of violations* of the preset maximum values of the current amplitudes of harmonics, starting after selection of the type of presentation and in the selected time interval.

FFT Stat, I S 13:39:37	
Limits: C	
I1	0
I2	0
I3	0
>Stat, I	>S/H

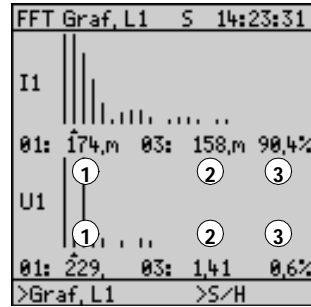
### STATISTICS-U (amplitude statistics)

*Number of violations* of the preset maximum values of the voltage amplitudes of harmonics, starting after selection of the type of presentation and in the selected time interval.

FFT Stat, U S 13:40:09	
EN 50160	
U1	0
U2	0
U3	0
>Stat, U	>S/H

## GRAPHICS (frequency spectrum)

Graphic presentation of the harmonic contents up to the 50th harmonic for odd and even harmonics of a selected phase for current and voltage. Scaling is automatic in accordance with the highest absolute value of all harmonic contents; the fundamental is cut off.



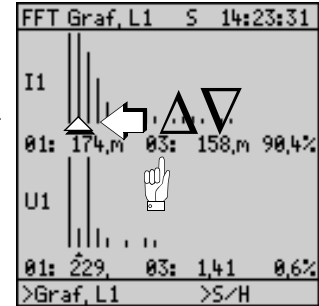
At the same time, the following is shown in numeric form:

- ① The absolute value of the fundamental
- ② The absolute value of the harmonic marked with the cursor
- ③ The percentage value of the marked harmonic referred to the fundamental.

## Number of harmonic contents for the GRASPICS and TABLE presentation

Use the  $\Delta$  and  $\nabla$  keys to move the cursor shown on the frequency axis to the position of the harmonic the characteristic values of which are to be displayed. A number appearing at the same time shows the selected harmonic.

If even and/or odd harmonics are selected here, only even and/or odd harmonic contents are listed in the **phi** and **%** tables.



### TABLE phi (amplitude and phase angle)

Numeric presentation of the harmonic contents and the associated phase angle for current and voltage as a function of the frequency of odd and/or even harmonics of a phase.

Use the  $\Delta\nabla$  keys to scroll between the fundamental and the 49th and/or 50th harmonic.

FFT Tab, L1 S 13:42:26				
L1 I	phiI	U	phiU	
01	175,m	88,6	228,	89,9
03	157,m	-70,5	1,37	33,7
05	123,m	25,2	6,92	-10,2
07	78,8m	-38,8	1,58	90,0
09	37,2m	63,3	697,m	-74,2
11	9,50m	55,0	0,00	00,0
13	19,4m	-29,7	608,m	45,0
15	24,5m	77,6	0,00	00,0
17	20,1m	21,2	589,m	83,3
>Tab, L1		>S/H		

### TABLE % (amplitude and percentage content of the fundamental)

Numeric presentation of the harmonic contents and the percentage content of the harmonics from the fundamental in current and voltage for odd and/or even harmonics of a phase.

Use the  $\Delta\nabla$  keys to scroll between the fundamental and the 49th and/or 50th harmonic.

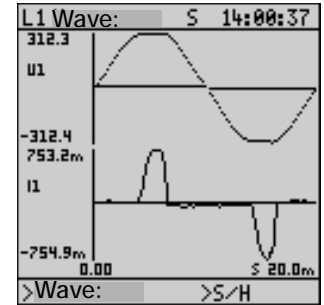
FFT Tab, L1 % S 13:42:26				
L1 I	%	U	%	
01	175,m	100,0	228,	100,0
03	157,m	90,4	1,37	0,6
05	123,m	68,3	6,92	2,3
07	78,8m	53,2	1,58	0,5
09	37,2m	27,2	697,m	0,3
11	9,50m	9,8	0,00	0,0
13	19,4m	11,7	608,m	0,3
15	24,5m	13,2	0,00	0,0
17	20,1m	12,4	589,m	0,4
>Tab, L1 %		>S/H		

### WAVE (oscillogram)

Presentation of the waveform of the current and voltage of a phase and/or the three-phase system.

With the switch set to position L1, L2 or L3, the presentation of the actual sample over a period duration T can be selected.

To reproduce the trace on a PC, amplitude and phase angle are stored to the PC card. Visualization can be made via a PC program.



## 5 Operation

### 5.1 General information

Prior to starting a signal analysis exceeding the internal possibilities of the harmonic analysis, the PC card (option) is required. How to insert the PC card is described in the operating instructions of the mainframe (section 4.7.2).

### 5.2 Measuring connections



#### Note

For the presentation of the quantitative analysis values in real time it is required to connect the voltage paths of all three phases (in parallel) even if a single-phase measurement is made. This ensures that the width of the window of the fundamental frequency corresponds to the phase to be tested.

See the operating instructions of the mainframe, section 5, for the connections.

Contrary to the mainframe, also the frequency measurement of the fundamental is independently made on all three phases when the switch is set to the FFT position. The beginning of a window for the measurement exactly follows the zero crossing of the signal. This prevents marginal disturbances which cause erroneous results.

Presentation of the measured values is made common for all three phases. The width of the window is 16 periods. The width of the window is a function of the lowest detected frequency. Thus, the readout time from LC display or PC card depends on the lowest detected frequency of all three phases. If as frequency cannot be detected, the readout time is correspondingly long.

### 5.3 Selecting the presentation

FFT Num	S	13:17:27
THD I %		THD U %
3,1		3,1
3,1		3,1
3,1		3,1
f		f
36		50,00
00		50,00
00		50,00
>S/H		>S/H



⏻ Set the *rotary switch* to the FFT position. The display shows the actual total harmonic distortion of current and voltage, the phase power and the frequency of all three phases.

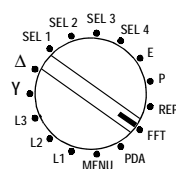
M Press the *M* key. The flashing cursor  $\triangleright$  moves to the *selection menu type of presentation* in the menu bar.

$\Delta \nabla$  Select the desired type of presentation with the *cursor* keys.

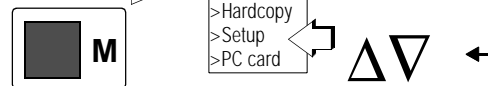
↵ Confirm the selection by pressing the *Enter* key.  
After pressing the *M* key (eventually several times) in the actual type of presentation, the cursor  $\triangleright$  flashes in the selection menu type of presentation. Now press the  $\Delta \nabla$  *cursor* keys several times until desired type of presentation and phase are displayed. Confirm with ↵ *Enter*.

FFT Num,	S 13:17:27	
	THD I %	THD U %
L1	79,0	3,1
L2	0,0	3,1
L3	0,0	3,1
	P	f
L1	39,36	50,00
L2	0,00	50,00
L3	0,00	50,00
>Num,	>S/H	

## 5.4 Selecting the operation mode



FFT Num,	S 13:17:27	
	THD I %	THD U %
L1	79,0	3,1
L2	0,00	3,1
L3	0,00	3,1
	P	f
L1	39,36	50,00
L2	0,00	50,00
L3	0,00	50,00
>Num,	>S/H	



⏻ Set the *rotary switch* to FFT. The display shows the total harmonic distortion in the actual calculation mode.

M Press the *M* key *twice* until the cursor  $\triangleright$  flashes in the Mode menu.

$\Delta \nabla$  Select the desired mode with the *cursor* keys.

↵ Press the *Enter* key. The desired mode is confirmed. The display changes to the corresponding menu.

## 5.5 Setting the measuring parameters for the harmonics analysis

Δ∇ Select **Setup** mode with the *cursor keys*.

↵ Press the *Enter* key. **Setup** mode is confirmed. The display changes to the menu for parameter setting.

Δ∇ Select the desired parameter with the *cursor keys*.

↵ Confirm the parameter by pressing the *Enter* key. The first setting position flashes.

Δ∇ With the *cursor key*, perform the setting in the first field.

↵ Confirm the setting by pressing the *Enter* key.

FFT Setup	H
> Sample	0001
Printer	off
Interval	0030
Limits:	C
Urated:	230,00
>Num.	>Setup

If several fields are available for setting, the next field at a time flashes after confirmation. Perform all settings as described. After confirmation of the setting in the last entry position, the cursor moves back to the parameter concerned.

Δ∇ Select the next parameter with the *cursor keys*.

### How to exit the Setup menu

Press the *M* key. The flashing cursor moves to the *selection menu type of presentation*. The *cursor keys* Δ∇ can now be used to again select the type of presentation.

## 5.6 Printing via PSI module

### Printing the actual display

When pressing the PRINT key on the integrated printer module SECUTEST PSI, the actual display is printed out on roll paper. The display is stored to an own screen memory. The unit continues to be available for data acquisition (Sample mode) while printing takes place.

### Printing in the selected time interval

With the printer switched on (*Printer On*), the measured values of the actual type of presentation are printed out in the preselected interval. At the same time, the actual values can be stored to the PC card within the set interval time. The unit continues to be available for data acquisition (Sample mode).



#### Note

The printer requires about 20 sec to print out the actual LC display. If the selected interval is shorter than the time needed for the printout, the next printout is started immediately after the end of the printout.

---

### Hardcopy printout

The printout corresponds to the LC display.

## 5.7 Recording a FFT measuring sequence on the PC card



### Note

Recorded are those measured values that are shown on the actual LC presentation. That is why the desired LC presentation must be selected prior to recording. Exceptions are the presentations Tab L2 and Tab L3. With Tab L2, the actual measured values of phases one and two are recorded, *and* with Tab L3 the actual measured values of all three phases that is, also those of the phases not shown. This makes it possible to unambiguously reproduce and process the trace via a PC software (e.g. presentation of all six traces, analysis of the signal amplitudes and angular ratio in the time domain).

M Press the *M* key twice. The flashing cursor moves to the *Operation* menu.

Δ∇ Select the **PC card** mode with the *cursor keys*.

↵ Confirm the **PC card** mode by pressing the *Enter* key. The LC display changes to the menu for the setting of parameters for the recording.

FFT Tab, L1		S 13:42:25	
L1 I	phi I	U	phi U
01	175,m	88,6	228, 89,9
03	157,m	-70,5	1,37 33,7
05	123,m	25,2	6,92 -10,2
07	78,8m	-38,8	1,58 90,0
09	37,2m	63,3	697,m -74,2
11	9,50m	55,0	0,00 00,0
13	19,4m	-29,7	608,m 45,0
15	24,5m	77,6	0,00 00,0
17	20,1m	21,2	589,m 83,3
>Tab, L1		>S/H	

### Selecting the recording parameters

M With the switch set to the *FFT position*, press the *M* key once. The flashing cursor moves to the selection menu *type of presentation*.

Δ∇ With the *cursor keys* select the type of presentation containing the desired recording parameters. For **Tab L2** and **Tab L3** see the note above.

↵ Confirm the type of presentation by pressing the *Enter* key.

FFT Num <sub>m</sub>		S 13:17:27	
	THD I %	THD U %	
L1	79,0	3,1	
L2	0,0	3,1	
L3	0,0	3,1	
	P	f	
L1	39,36	50,00	
L2	0,00	50,00	
L3	0,00	50,00	
>Num <sub>m</sub>		>S/H	

## Setting the sample time

Δ∇ With the *cursor keys*, move the flashing cursor > to the parameter *Beg ....* and/or *End ....* (Start and/or End)

↵ Confirm the parameter *Beg ....* and/or *End ...* by pressing the *Enter* key. The first entry position starts to flash.

Δ∇ Perform the setting at the first entry position with the cursor keys.

↵ Confirm the setting at a time by pressing the *Enter* key. The next entry position starts to flash. Perform the setting for all positions in the same way. After the last entry, the cursor either flashes in front of the actual parameter or in front of the parameter *Store*.

FFT Num,	H
> Store	no
Read	00
Interval	0001
Start time	09:46:26
Start date	23,07,1992
End time	03:58:41
End date	24,07,1992
Delete	no
Run	0
>Num,	>PC-Card

## Starting the FFT measuring sequence

Δ∇ In the PC card selection menu, move the flashing cursor > to the submenu *Store*.

↵ Confirm the submenu *Store* by pressing the *Enter* key. The flashing cursor moves to the *Yes/No* entry field.

Δ∇ Select *Store Yes* with the cursor keys.

↵ Confirm the selection by pressing the *Enter* key.

The activated recording is shown at the right of the top line.

E The measurement is activated at the selected time (Enable)

M Recording takes place (Memory)

FFT Num,	H
> Store	no
Read	00
Interval	0001
Start time	09:46:26
Start date	23,07,1992
End time	03:58:41
End date	24,07,1992
Delete	no
Run	0
>Num,	>PC-Card

## 5.7.1 Stopping a recording



### Note

When leaving the FFT switch position, the other functions of the unit can only be addressed with the recording stopped. This is of importance because an active recording which is to be complete (that is, real-time recording) must not be stopped accidentally (e.g. by misadjustment).

Therefore, it is not useful to switch from the FFT switch position to another one during the recording. To stop the recording, the switch must be set to the FFT position. Call the PC card mode menu and stop the recording.

M With the switch set to the FFT position, press the *M* key twice. The flashing cursor moves to the menu for mode selection in the menu bar.

Δ∇ Select the *PC card* mode with the cursor keys.

↵ Confirm the *PC card* mode by pressing the *Enter* key. The LC display changes to the menu for parameter setting for the recording.

FFT Num,	H
> Store	no
Read	00
Interval	0001
Start time	09:46:26
Start date	23.07.1992
End time	03:58:41
End date	24.07.1992
Delete	no
Run	0
>Num,	>PC-Card

## Stopping a recording automatically

### Lapse of time

The recording is automatically stopped when the set time has elapsed.

The marking **M** on the top line disappears.

FFT Num,	H
> Store	no
Read	00
Interval	0001
Start time	09:46:26
Start date	23.07.1992
End time	03:58:41
End date	24.07.1992
Delete	no
Run	0
>Num,	>PC-Card

## Stopping a recording manually

Δ∇ In the setting menu PC card, move the flashing cursor > to the field *Store* using the cursor keys.

↵ Confirm the menu by pressing the *Enter* key. The cursor > moves to the *Yes/No* selection field.

Δ∇ Select *No* with the cursor keys (stop measurement)

↵ Confirm Stop Measurement by pressing the *Enter* key.

## 5.8 Replaying a FFT recording on the LC display

M With the switch set to the FFT position, press the *M* key twice. The flashing cursor moves to the Mode menu.

FFT Num,	S 13:17:27	
	THD I %	THD U %
L1	79,0	3,1
L2	0,0	3,1
L3	0,0	3,1
	P	f
L1	39,36	50,00
L2	0,00	50,00
L3	0,00	50,00
>Num,	>S/H	

Δ∇ Select the **PC card** mode with the *cursor keys*.

↵ Confirm the **PC card** mode by pressing the *Enter* key. The LC display changes to the menu for parameter setting for recording and replay.

Δ∇ Set the flashing *cursor* to the **Read** parameter.

↵ Confirm the **Read** parameter by pressing the *Enter* key. The flashing cursor moves to the setting field.

Δ∇ With the *cursor keys*, select the desired *measuring sequence\** (*Run No.*).

↵ Confirm the selection by pressing the *Enter* key.

FFT Num,	H
> Store	no
Read	00
Interval	0001
Start time	09:46:26
Start date	23,07,1992
End time	03:58:41
End date	24,07,1992
Delete	no
Run	0
>Num,	>PC-Card

The measured values are stored together with the mask information so that a replay is made on the LC display which is equivalent to the hardcopy.

Δ∇ Use the Δ∇ *cursor keys* to scroll through the recordings.

R The Read mode of a recording is displayed at the right of the top line.

23,03,1992		R 10:55:30	
L1 I	phi I	U	phi U
03 175,m	100,0	228,	100,0
05 157,m	90,4	1,37	0,6
07 123,m	68,3	6,92	2,3
09 78,8m	53,2	1,58	0,5
11 37,2m	27,2	697,m	0,3
13 9,50m	9,8	0,00	0,0
15 19,4m	11,7	608,m	0,3
17 24,5m	13,2	0,00	0,0
19 20,1m	12,4	589,m	0,4
Run: 05	>PC-Card		

### 5.8.1 Exiting the menu replay of a FFT recording

M With the switch set to the FFT position, press the *M* key 3 times. The flashing cursor moves to the menu for selection of the type of presentation in the menu bar.

Δ∇ Select the desired type of presentation with the *cursor keys*.

↵ Confirm the type of presentation by pressing the *Enter* key. The LC display changes to the selected type of presentation. Reading is stopped.

23,03,1992		R 10:55:30	
L1 I	phi I	U	phi U
03 175,m	100,0	228,	100,0
05 157,m	90,4	1,37	0,6
07 123,m	68,3	6,92	2,3
09 78,8m	53,2	1,58	0,5
11 37,2m	27,2	697,m	0,3
13 9,50m	9,8	0,00	0,0
15 19,4m	11,7	608,m	0,3
17 24,5m	13,2	0,00	0,0
19 20,1m	12,4	589,m	0,4
Run: 05	>PC-Card		

\* The **Run** parameter shows the number of actually stored measuring sequences.

## 5.8.2 Selecting a setting menu while a FFT recording is replayed

- M** With the switch set to the FFT position, press the *M* key twice. The cursor flashes in front of the Read parameter.
- Δ∇** Select the desired parameter with the cursor keys.
- ↵** Confirm the selected setting menu by pressing the *Enter* key. The cursor moves to the selected setting menu. Reading is stopped.

FFT Num,	H
> Store	no
Read	00
Interval	0001
Start time	09:46:26
Start date	23,07,1992
End time	03:58:41
End date	24,07,1992
Delete	no
Run	0
>Num,	>PC-Card



### Note

It is possible to store and read simultaneously, when first setting the *Store* mode and then setting the LC display to *Read*.

**RM** (Read/Memory) and/or **RE** (Read/Enable) is shown at the right of the top line.





## 6 Appendix

Harmonic currents according to DIN EN 61 000 part 3-2, 05.94  
(equipment input current < 16 A per conductor)

### Limits of class A and B

Harmonic order [n]	Highest permissible harmonic current [A]	
	Class A	Class B <sup>1)</sup>
<b>Odd harmonics</b>		
3	2.30	3.45
5	1.14	1.71
7	0.77	1.16
9	0.40	0.60
11	0.33	0.50
13	0.21	0.32
15 ≤ n ≤ 49	0.15 x 15/n	0.23 x 15/n
<b>Even harmonics</b>	<b>Class A</b>	<b>Class B <sup>1)</sup></b>
2	1.08	1.62
4	0.43	0.65
6	0.30	0.45
8 ≤ n ≤ 50	0.23 x 8/n	0.35 x 8/n

<sup>1)</sup> The limits of class B correspond to 1.5 times of class A.

### Limits of class C

Harmonic order [n]	Highest permissible harmonic current expressed as a percentage of the fundamental
2	2
3	30 x PF*
5	10
7	7
9	5
11 ≤ n ≤ 49	3

\* PF = P/S; PF = power factor, P = active power, S = apparent power

### Grenzwerte der Klasse D

Harmonic order [n]	Highest permissible harmonic current	
	per Watt in mA/W	in A
3	3.4	2.30
5	1.9	1.14
7	1.0	0.77
9	0.5	0.40
11	0.35	0.33
13	0.30	0.21
15 ≤ n ≤ 49	3.85/n	0.15 x 15/n

### Harmonic currents according to DIN EN 60555 part 2, 06.87 Limits for TV and radio receivers

Harmonic order [n]	Highest permissible harmonic current [A]
<b>Odd harmonics</b>	
3	0.80
5	0.60
7	0.45
9	0.30
11	0.17
13	0.12
15 ≤ n ≤ 39	0.10 x 15/n
<b>Even harmonics</b>	
2	0.30
4	0.15
DC current	0.05

Limits of the harmonic voltage  
 according to DIN EN 50160 / VDE 0839 part 160, 01.94  
 in public utility systems


Odd harmonics				Even harmonics	
Non-multiples of 3		Multiples of 3			
Order	$U_h / \%$	Order	$U_h / \%$	Order	$U_h / \%$
5	6.0	3	5.0	2	2.0
7	5.0	9	1.5	4	1.0
11	3.5	15	0.5	$6 \leq n \leq 24$	0.5
13	3.0	21	0.5		
17	2.0				
19	1.5				
23	1.5				
25	1.5				

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