GOSSEN METRAWATT CAMILLE BAUER

MAVO-TCM

Transient Measurement and Measurements at Frequency Converters
Optional Function for MAVOWATT® 45 Energy Analyzer

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CONTENTS

1 Installation

1.1 Requesting a Password

In order to unlock the optional MAVO-TCM function, a password is required which is linked to the device serial number. You will receive your password after submitting the completed registration card. Please request your password as follows:

- Make a note of the device serial number (see the serial plate at the base of the housing).

- If the serial number in the serial plate is not accessible or is illegible, please proceed as follows:

  - Connect the instrument to mains voltage.

  - Switch the instrument on and observe the LC display. The serial number appears at the LC display beneath the company logo during initialization.

- A registration card is included with the option package. Enter the device serial number into the appropriate field.

- Send the completed registration card to the address or the telefax number indicated in the card.

- The registration card will be returned to you with your password.

1.2 Preparation for Installation

A computer which runs under DOS is required for installation of the MAVO-TCM option.

- Connect the MAVOWATT 45 to the mains.

- Disconnect the printer module (Secutest PSI) from the instrument.

- If a memory card (PC card) has been inserted into the MAVOWATT 45, it must be removed as well.

- Connect the interface port at the MAVOWATT 45 labeled »RS232« to the COM1 serial port at your PC. Use the signal cable included with the instrument for this purpose (extension cable, 9-pole socket to 9-pole plug, 1:1 through-connected, no zero-modem cables!).

- Switch the MAVOWATT 45 on and make certain that the printer function is deactivated: Setting: *Printer Off* in MENU > Limits and L1 > Setup.

- If your computer is currently running under a different operating system, exit this system and enter the DOS mode. Close all other applications in order to avoid interruptions during uploading.

- Insert the installation disc into the floppy disc drive at your PC and activate the disc drive (e.g. A:).

1.3   Installing the Firmware Update

The firmware update must be installed if your instrument is running firmware version 2.xx or less.

Instruments running version 3.15 or higher do not require a firmware update for activation of the TCM option. If this is the case, please continue as of chapter 1.4.

Note: The firmware version installed to the MAVOWATT 45 appears at the display after the instrument has been switched on (e.g. REV. 2.07).

ATTENTION!

Do not overwrite the firmware installed to the MAVOWATT 45 with an older version from the floppy disc!

- Turn the function switch at the MAVOWATT 45 to the L1 position.

- Start program uploading by entering LOAD and <Enter>.

- The initialization routine is displayed at the PC monitor represented as a series of semicolons (; ; ; ;). Subsequent uploading of the program is represented by consecutive points (. . . .) in several lines at the monitor. Uploading lasts for several minutes and may not be interrupted.

  If an error occurs during uploading, the installation procedure must be repeated, perhaps using a different PC.

- After uploading has been completed, the cursor reappears at the DOS entry prompt.

- The MAVOWATT 45 is automatically restarted.

ATTENTION!

Please check measuring and instrument parameters after uploading (language, time, date, system type, rate times etc.). These may have been changed during uploading!

The display contrast setting may also have been reset, so that the display is illegible. If this is the case, proceed as follows:

- Switch the instrument off.

- Set the function switch to MENU.

- Switch the instrument on.

- After initialization is complete, an acoustic signal sounds and the cursor blinks at the first *contrast* setting position. Contrast can now be adjusted with the scroll keys, even if nothing is visible at the display.

- Acknowledge the desired *contrast* setting with the ⏎ key.

1.4   Unlocking the MAVO-TCM Option

In order to unlock the option, the password protected firmware components are uploaded to the MAVOWATT 45 from the included floppy disc.

- Start the recognition routine by entering TCMKEY <Enter>.
- When requested to do so by the program, enter your [Password] (if necessary with preceding sign). Press the <Enter> key.
- Successful activation is indicated at the monitor with "TCM unlocked".

Note: The option remains activated at the instrument even if a firmware update is uploaded at a later point in time.

- Switch the energy analyzer off.
- Connect the PSI module to the data interface.
- The MAVOWATT 45 is ready for operation as soon as it is switched back on.

With the function switch in the MENU position, the configurations menu for general instrument parameters now includes an entry for *TCM* with the setting options *on* / *off*.


```
menu general
> contrast    70
  language    english
  time        16:39:59
  date        21.11.1997
  mains       2/4-Wire
  TCM         on



>general
```

2   Function and Applications

The MAVO-TCM option expands the scope of functions as well as the applications possibilities for the MAVOWATT 45 through the inclusion of two special utilities for systems measurement technology:

- On the one hand, this option allows for the logging of short, transient events which occur in alternating or direct voltage systems, and at load components driven by such systems.

- On the other hand, the instrument is equipped with the capability of ascertaining the measurement quantities, which are included in the basic functions for power and energy analysis also at the outputs of frequency converters.

The Measurement of Transients

Transient overvoltages which occur within the electrical power supply system are short duration, and as a rule, greatly damped overvoltages with a duration of several milliseconds or less. They are generally caused by lightning, on and off switching operations and the blowing of fuses. Transient overvoltage rise-time varies within a wide range from less than one microsecond to several milliseconds.

The MAVO-TCM option allows for logging of voltage transients with a duration of at least 20 µs, and measurement of transients of up to 1500 Vs.

Transient measurement with the MAVO-TCM option emphasizes recording of the signal shape after a given trigger criterion has been fulfilled (represented as a graph). In addition to the logging of sporadic line voltage faults, this type of representation is also well suited for the recording of current and voltage signal characteristics when load components are switched on (e.g. motor start-up).

An *Events* list can be used for the recording of rapid, consecutive trigger events. Up to approximately 40 events per second are recorded in order of occurrence with date, time, cause of triggering, measurement magnitude and sampled or slope measurement value.

The **MAVO-PDA option** is available for uninterrupted logging, classification and quantification of events. Comparison with limit values is not performed until after the RMS value has been established (after 2 to 16 AC signal cycles). Trigger criteria for the logging of voltage or current fluctuations, phase imbalances, harmonic content and frequency deviations can be selected as well. Recorded events can be represented in four different display modes for evaluation purposes.

Frequency Converter Measurements

The frequency converters which are currently used for the control of electric motor speed are usually equipped with a high frequency square-wave output voltage which is pulse-width modulated by means of motor frequency. Measurement signals of this type require a special measuring process, by means of which the converter operating frequency is filtered out, and which is capable of determining the effective modulation frequency (fundamental frequency) at the motor. The MAVOWATT 45 can derive all of the power and energy analysis measurement magnitudes based on signals which have been conditioned in this fashion.

Prerequisite: The operating frequency must be greater than 1200 Hz and the fundamental frequency must lie within a range of 10 to 100 Hz.

3   Measuring Transients

3.1   Functions Description

3.1.1   Trigger Criteria

As opposed to the MAVO-PDA option with its RMS value trigger criteria, trigger parameters for the registration of line faults are based upon sampled values when the TCM function is active. The time interval between two consecutive sampling operations, and thus the minimum duration of recognizable events, can be selected in six steps ranging from 20 μs to 648 μs (setting parameter: *Sample*).

Two trigger criteria can be selected for both voltage and current:

- Level Triggers U_p and I_p
  The trigger parameter is derived from a comparison of the sampling value quantity and the set limit value.

- Slope Triggers dU/dt and dI/dt
  The trigger parameter results from a comparison of the rate of rise or fall of two consecutive sampled values and the set limit value (V/ms or A/ms).
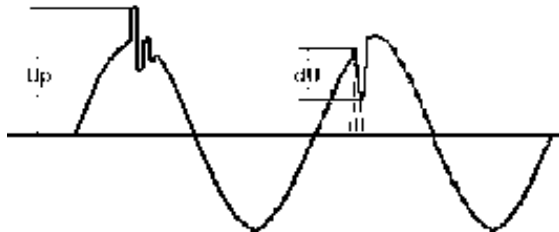
3.1.2   Trigger Modes: Roll Mode / Single Mode

Two different trigger modes can be used for the recording and representation of events:

- In the *roll mode*, the current display remains until the memory is overwritten with the next event. If the PC card has been activated, the event, and thus the current display, is not overwritten until uploading to the PC card has been completed. The instrument does not respond to events which occur during uploading of data to the PC card (uploading takes about 6 seconds).

- In the *single mode*, memory is activated manually for logging of the next event (*Treset*). In this case as well, no further events can be logged until the current event has been uploaded from main memory (RAM) to the PC card, if the card has been activated.

3.1.3   Display Modes: Graph / Event

Two different display modes are available for the representation and recording of transient events:

- Graphic Representation

After an event has been recognized in the graph display mode, approximately 3900 sample values (corresponds to 78 ms to 2.5 s of recording time) for current and voltage of the concerning phase are stored to memory and displayed as a characteristic curve with indication of the cause of triggering under consideration of the percentage value selected for the *Pre-Trigger*. This display remains until the memory has been overwritten by the next event.

Note

If long sampling intervals are used, an effect known as "monitor aliasing" occurs due to the minimal number of pixels available at the LCD. Similar to "true" aliasing, which results in signal alienation due to an excessively slow sampling rate, signal distortion occurs during display due to the minimal number of pixels. The approximately 3900 scanning spots which are stored for each signal are displayed with a resolution of about 95 pixels. In a representation of the entire recording time period, every 40th scanning spot is displayed. If a long sample interval has been selected, the number of pixels per period is reduced which results in a distorted representation at the LCD. In such cases, actual signal characteristics are better represented by using a sufficiently small portion of the signal (zoom function with *single mode* triggering).

Example: Aliasing Effect at the LCD
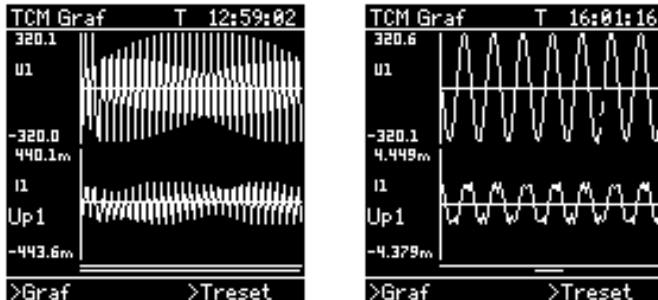
Recording time period is equal to about 2560 milliseconds. Scanning spots are stored at an interval of 648 μs. Every 40th spot is displayed at the LCD, i.e. the virtual scanning spot interval is greater than 25 ms. At the third zoom level, the curve can be displayed without the aliasing effect.

- **Events List Display**

The *event* display mode can be used for the recording of rapid, consecutive trigger events. Recognized events are listed in tabular form in order of occurrence along with time, cause of triggering and sampled or slope value. The date is also stored if recording is conducted in conjunction with a PC card.

If limit values are continuously exceeded, recording is performed with the shortest possible interval which is equal to approximately 25 ms. This assures that events of like type and of lengthy duration, as well as events of various types which occur in a rapid, consecutive fashion, are all recorded.

3.2   Transient Measurement Settings

Knowledge of the basic parameter setting procedures as described in the operating instructions for the basic instrument is assumed for the settings described below.

3.2.1   Activating the TCM Functions

The recording of transient events is performed with the function selector switch in the PDA position. First activate the TCM option (*TCM on*) with the function switch in the MENU position (*Menu, General*), and then rotate the function switch to the PDA position.

```
menu general
   contrast   70
   language   english
   time       16:39:59
   date       21.11.1997
   mains      2/4-Wire
 > TCM        on


>general
```

Event controlled measurements with the TCM and PDA options are performed with the function switch in the PDA position. If both options have been installed, selection can be made in the *General* menu with the function switch in the MENU position:

  TCM off   ⇒ measurement with PDA functions
  TCM on   ⇒ measurement with TCM functions

Simultaneous measurement with both MAVO-TCM and MAVO-PDA functions is not possible.

Note: The MAVO-TCM option is only displayed after it has been unlocked (→chapter 1).

3.2.2   Setting the Operating Parameters

Setting of operating parameters for the measurement of transients is accomplished in Setup with the function switch in the PDA position.

The Setup menu for parameter settings is distributed over two pages. The settings on page 1 (can be called up from the *Event* display mode) and page 2 (can be called up from the *Graf* display mode) are performed independently of one another, and are equally valid for both display modes. Thus it makes no difference in which order the settings are carried out (first page 1 and then page 2, or vice versa).

```
TCM Setup    E  16:41:39
 > Up / V        400.00
   dU / V/ms     150.00
   Ip / A        .00000
   dI / A/ms     .00000
   sample / us   40
   printer       off
   interval      0001



>event          >setup
```

Setup menu, page 1, queried from the Event display mode

```
TCM Setup    H  09:17:06
 > display       singlemode
   rangeU        600V·Uratio
   rangeI        1A·Iratio
   phases        1
   Pr.Trigger    10 %




>graf           >setup
```

Setup menu, page 2, queried from the Graf display mode

Refer to the following tables for explanations of the operating parameters.

Operating Parameters in the Setup Menu called up from the Event Display Mode

Parameter	Description	Setting Range	Unit	Comment
Up	Trigger threshold for the absolute value of the voltage sampling level	*.01000 … 99999* *.00000* (=inoperative)	V	Applies equally to both positive and negative sampling levels under consideration of *Uratio*, as well as to all monitored voltage measurement inputs defined by the *phases* parameter.
dU	Trigger threshold for the absolute value of the voltage rate of change	*.01000 … 99999* *.00000* (=inoperative)	V/ms	Applies equally to both positive and negative flanks under consideration of *Uratio*, as well as to all monitored voltage inputs defined by the *phases* parameter.
lp	Trigger threshold for the absolute value of the current sampling level	*.01000 … 99999* *.00000* (=inoperative)	A	Applies equally to both positive and negative sampling levels under consideration of *Iratio*, as well as to all monitored current measurement inputs defined by the *phases* parameter.
dI	Trigger threshold for the absolute value of the current rate of change	*.01000 … 9999,9* *.00000* (=inoperative)	A/ms	Applies equally to both positive and negative flanks under consideration of *Iratio*, as well as to all monitored current measurement inputs defined by the *phases* parameter.
sample	Sampling interval	*20 | 40 | 81 | 162 | 324 | 648*	μs	Time interval between two consecutive samplings, and thus the shortest recognizable event
printer	Disable / enable printer function (event controlled in this case)	*off | on*		When the printer is enabled, the current LCD is printed out immediately after an event occurs. The setting is valid for all measuring functions, is however independent upon the setting *printer on / off* in the **MENU** > *limits* (alarm print-out) (see also manual for basic instrument).
interval	Time interval for periodic storage or print-out of measurement values; no consequence for the measurement of transients because the printer function and storage to PC card are event controlled.	*0001 … 1800*	s	Setting is also active for other measuring functions (see also operating instructions for basic instrument).

Operating Parameters in the Setup Menu called up from the Graph Display Mode

Parameter	Description	Setting Range	Unit	Comment
display	Triggering and Display Modes *single mode* = only records the first occurring event after manual reactivation of the trigger with *treset* *roll mode* = continuous recording of all recognizable events with automatic reactivation of the trigger	*single mode* | *roll mode*		Mainly significant for the *Graf* display mode: The characteristic curve displayed at the LCD for voltage and current can only be expanded along the time axis if the *single mode display* setting has been activated in order to make details within the recording visible (zoom function).
rangeU	Fixed Voltage Measuring Range [1] (autoranging is inactive)	*12V•Uratio* (=21V_p• Uratio) *100V•Uratio* (=195V_p• Uratio) *600V•Uratio*(=1500V_p• Uratio)	V	Valid for all voltage measurement inputs under individual consideration of *Uratio*.
rangeI	Fixed Current Measuring Range [1] (autoranging is inactive)	*0.12A• Iratio* (=0.29A_p• Iratio) *1A• Iratio* (=2.4A_p• Iratio)	A	Valid for all current measurement inputs under individual consideration of *Iratio*.
phases	Defines which phases are to be monitored (analog measurement inputs L1, L2, L3)	*1| 2| 3| 1+2| 1+3| 2+3|* *1+2+3*		
pre-trigger	Pre-Trigger = Trigger position relative to time expressed in % in relationship to the overall recording time for an event in the *Graf* display mode	*10| 30| 50| 70| 90*	%	

[1] Because measurements cannot be performed by means of automatic measuring range selection (autoranging) where event controlled measurements are concerned (due to the necessarily short reaction time), fixed measuring ranges must be selected, which are below anticipated measurement values. The nominal values of the measuring ranges make reference to RMS values. The maximum possible absolute sampling values are indicated in each case in parentheses.

Notes

In addition to the above mentioned measuring and recording parameters, settings for the operating parameters which are relevant to all of the measuring functions included with the MAVOWATT 45 must also be observed. These include:

− Phase selective settings for the weighting factors *Uratio* and *Iratio* for the analog measurement inputs in the Setup menus under L1 / L2 / L3.
− All parameters in the General Menu, except for *mains* type. *Mains* setting is of no consequence here, because all of the relevant signals must be directly acquired for transient measurement, which cannot be used with derived (calculated) measurement magnitudes (e.g. I2 for power analysis at a *3-Wire mains* system).

The *cycle time* and *interval* parameters are of no significance for the measurement of transients, because these measurements are event controlled.

Example for the Determination of Trigger Criteria

Task: Monitoring of a 230 V system for sporadically occurring voltage peaks or dips.

The following applies in general to sinusoidal alternating voltage U_{rms}:

- peak voltage U_p $= U_{rms} \bullet \sqrt{2}$
- max. voltage slope dU/dt $= 2 \bullet \pi \bullet f \bullet U_p$.

Thus where U_{rms} = 253 V (= 230 V +10%) and f = 50 Hz:
- peak voltage U_p = 358 V
- max. voltage slope dU/dt   = 112 V/ms.

$\Rightarrow$ Reasonable trigger thresholds for the logging of transients:
  Up = 370 V,   *dU $\geq$ 150* V/ms.

3.3 Performing Transient Measurements

3.3.1 Measuring Set-Up for Transient Measurements

The following characteristics must be taken into consideration for the connection of the measuring circuit for transient measurements:

• Voltage Measuring Set-Up

Alternating as well as direct voltage signals can be monitored and measured.

The voltage measurement inputs can be connected to either neutral point displacement voltage (L to N) or to phase-to-phase voltage (e.g. L1 to L2).

Neutral point displacement voltage can be measured with either true or virtual neutral point (by interconnecting the three LOW terminals).

Theoretically, any phase sequence can be used for measurement, because no magnitudes are derived from the phase angle of the three voltages.

• Current Measuring Set-Up

Alternating as well as direct current signals can be monitored and measured.

The zero point (DC offset) must be precisely adjusted when using active DC clip-on probes. This is best accomplished under L1/L2/L3 in the *wave* display mode.

3.3.2   Measurements in the Event Display Mode (events table)

Events (i.e. the violation of set limit values) are listed in the events table in the order in which they are recognized. The display includes time of occurrence, cause of triggering and the relevant measurement value.

When the *Event* display mode is first entered, the events list is empty. An » E « (enabled) at the right side of the header indicates that the trigger is active. After the trigger criterion has been fulfilled, the corresponding event is displayed.

```
TCM Event            E 12:47:11




12:42:47  Up1       306,7
12:42:48  Up1       844,4
>Event              >S/H
```

Roll Mode – Continuous Event Recording

The *roll mode* is selected in the setup menu for the *Graf* display mode.

The current event is displayed in the last line of the LCD immediately after the trigger criterion has been fulfilled. The previous events all roll up to the next highest line. The trigger is then reset automatically.

```
TCM Event            E 16:41:14

16:38:39  Up1       404,7
16:38:39  Up1       416,3
16:38:39  Up1       449,5
16:38:39  dU1       153,5
16:40:05  Up1       409,6
16:40:05  Up1       417,4
16:40:05  Up1       449,3
16:40:06  dU1       154,3
16:40:38  dU1       420,3
>Event              >Treset
```

The last 10 events are displayed in tabular form at the LCD. Previously occurring events can only be queried if they have been stored to the PC card (→chapter 3.5).

After an event has been logged, the instrument requires approx. 25 ms to process the data for display, and to store them to memory if required. The instrument does not respond to further events which occur during this time. If selected trigger criteria are fulfilled at several measurement inputs simultaneously, the following priority sequence applies: I1 – U1 – I2 – U2 – I3 – U3.

Single Mode – Recording of the First 10 Events

The *single mode* is selected in the setup menu for the *Graf* display mode.

The first 10 events are displayed at the LCD in the order in which they were recognized. Subsequent events are ignored until the trigger has been manually reset.

```
TCM Event            H 10:17:27
10:15:24  dU1       31,28
10:15:24  dU1       96,32
10:15:25  dU1       53,62
10:15:25  dU1       48,66
10:15:26  dU1       91,36
10:15:26  Up1       319,9
10:15:27  dU1       2,093k
10:15:27  dU1       57,59
10:15:28  dU1       101,8
10:15:28  dU1       38,23
>Event              >S/H
```

An » E « (enabled) is displayed at the right side of the header as long as fewer than ten events have been recognized. The display changes to » T « (terminated) after the tenth event has been recorded.

This display remains until the trigger has been manually reset. In order to reset the trigger, select *treset* in the menu bar at the right and acknowledge with the ↵ key.

3.3.3   Measurements in the *Graf* Display Mode (curve display)

When the *Graf* display mode is first entered, no measurement values are displayed. The main display field is dark.
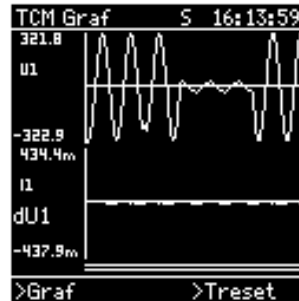
An » E « (enabled) at the right side of the header indicates that the trigger is active.

Roll Mode – Automatic Overwriting of the Last Event

Voltage and current waveforms are represented as a Y-t graph with scaled Y axis after an event has been recognized.

This display remains until it has been overwritten by the next event. The trigger is reset automatically and the limit values are continuously monitored.


An » S « (sample) at the right side of the header indicates that events have been recognized and that the trigger has been reactivated. Previously recorded events can only be queried if they have been stored to the PC card (→chapter 3.5).

After an event has been recognized, the instrument requires approx. 1s to process data for display in this display mode, and 5s to store data to the PC card if required. The instrument does not respond to further events which occur during this time. If selected trigger criteria are fulfilled at several measurement inputs simultaneously, the following priority sequence applies: I1 – U1 – I2 – U2 – I3 – U3.

Single Mode – "Freezing" the Last Event

The display remains until the trigger has been manually reset. In order to reset the trigger, select *treset* in the menu bar at the right.

An » E « (enabled) at the right side of the header indicates that the trigger is active. The display changes to » T « (terminated) after an event has been recognized, and the time of triggering is displayed to the right.
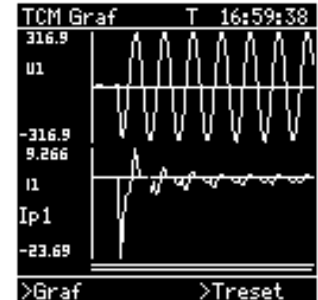

Independent of trigger criteria (U or I), always current and voltage waveforms are displayed with scaled Y axis. The cause of triggering is displayed to the left of the current curve.

The zoom function described below can be used in this mode.

Zoom Function

For more accurate examination, an isolated portion of the curve can be displayed at the LCD in several steps expanded along the time axis.

The zoom function is only available in combination with *single mode* triggering.

```
TCM Graf        T  17:00:48
309.9
U1


-300.5
9.334
I1
Ip1
-24.63
>Graf            >Treset
```
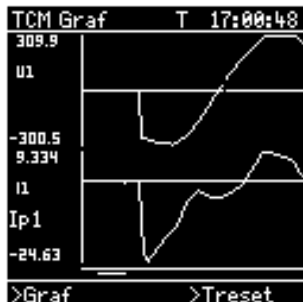
↵   Press the Enter key. The LCD changes to the time display with the next highest resolution. The bar underneath the displayed graphic identifies the time range of the selected zoom level in relationship to overall recording time.

▲▼ The desired time range is selected with the scroll keys.

↵   The display is shifted to the next highest zoom level with each activation of the Enter key. When the smallest possible time range has been reached, the LCD shifts to the overall view if the Enter key is activated again.

Notes:

−   See also chapter 3.1.3 for the interpretation of graphic representations, especially if a slow *sample* rate is used.

−   The selected zoom level remains active, even after the trigger has been reset (*treset*).

Treset – Resetting the Trigger

M 2x After the M key has been activated twice, the blinking cursor moves to the right hand side of the menu bar (*treset*). If an operating mode other than *treset* is displayed, select *treset* with the scroll keys.

↵   The current display is deleted by pressing the Enter key. An » E « appears at the right in the header, which indicates that the trigger has been reactivated.

3.4   Printing via the PSI Module

3.4.1   Manually Activated Print-Out

A copy of the current LCD display can be printed out onto a papertape by pressing the PRINT key on the integrated SECUTEST PSI printer module.

The display is temporarily stored to memory at the printer so that the instrument is available for continued events recording during printing.

3.4.2   Event Controlled Printing

When the printer is activated (parameter: *printer on* in TCM *Event* setup), the recorded event is printed out as a copy of the LCD display immediately after occurrence.

The printer requires approximately 20 seconds to print out the current LCD display. If further events occur during this time they are displayed at the LCD, but they cannot be printed out.

Note: The *interval* parameter included in the *Event* setup menu has no significance for either printing or memory functions in the transient measurement mode.

3.5   PC Card – Logging and Read-Out of Transient Events

The procedures for use of the PC card are described in detail in the operating instructions for the basic instrument. Thus only the special characteristics involved with the logging and read-out of transient signals are included here.

3.5.1   Storage to the PC Card

Events which have been logged by means of transient measurement can be stored to the PC card (memory card) in the respectively selected display mode, *Event* or *Graf*:

$\Rightarrow$ Activate the TCM option ($\rightarrow$chapter 3.2.1).

$\Rightarrow$ Set the function selector switch to the PDA position.

$\Rightarrow$ Select the desired operating parameters in the two Setup menus (*Event* and *Graf*) ($\rightarrow$chapter 3.2.2).

$\Rightarrow$ Select the desired display mode, *Event* or *Graf*.

$\Rightarrow$ Open the *PC Card* menu via the menu bar.

$\Rightarrow$ If the start of recording is to be delayed, enter the desired *start time* and *start date*.

$\Rightarrow$ Start recording by acknowledging the parameter selection, *save yes*.

$\Rightarrow$ Return to the selected display mode with the menu bar.

After recording has been started, events are stored to the PC card in the order of their occurrence.

As opposed to the logging of a series of measurements for power and energy analysis, storage does not occur continuously at a fixed interval, but rather sporadically as events occur. Thus:

- The *interval* setting is of no significance.
- The *end time* and *end date* which are automatically displayed by the instrument do not correspond to maximum possible recording time. The total number of events which can be stored varies greatly depending upon which of the two display modes has been selected. It can, however, be roughly estimated as follows:
  – *Event* Display Mode: approx. 50,000 events / Mbyte;
  – *Graf* Display Mode: approx. 30 events / Mbyte.

The selection of *single mode* or *roll mode* triggering also applies to the storage of events to the PC card.

S*ingle mode* triggering is suitable if only single events are to be recorded, which will occur within a foreseeable amount of time after manual activation of the trigger via *treset*, e.g. logging the inrush current of electrical load components.

Temporary Recording Stop

⇒ A running recording can be stopped temporarily by acknowledging the *S/H* operating mode in the menu bar, and is resumed with a second acknowledgement.

Interrupting Recording

If supply voltage to the MAVOWATT 45 fails during recording, current recording is interrupted, and is resumed automatically after power has been restored, but a new record file (run) will be created on the PC Card.

Ending Recording

⇒ In order to end current recording, open the *PC Card* menu, select *save no* and acknowledge with <Enter>.

3.5.2 Reading Out a Recording

⇒ Open the *PC Card* menu via the menu bar.
⇒ Enter the number of the desired record file (run) at *read ##* and acknowledge with <Enter>.
⇒ The first stored event from the selected recording appears at the LCD. Backward and forward scrolling within the recording is possible with the scroll keys ▼▲.
⇒ The display is returned to the *PC Card* menu via acknowledgement with the M key.

The record is displayed in the display mode that was used during recording.

The zoom function for the *Graf* display mode is not available for the read-out of stored recordings. Detailed analysis with enhanced time resolution are thus only possible at the PC with METRAwin 45 software.

3.5.3   Uploading Measurement Data to a PC

METRAwin® 45 Software for Windows® is available for upload-ing measurement data stored at the PC Card to a PC. It also allows for detailed analysis, as well as documentation, archiving and export of measurement data to other programs.

The RS232 interface at the MAVOWATT 45 must be connected to one of the COM ports at the PC with the included signal cable for the uploading of measurement data. Data transfer via modem is in preparation.

Due to the high speed at which measurement data are made available during transient measurement, online data transfer is not possible, i.e. data must first be stored to the PC Card and subsequently uploaded to the PC.

METRAwin 45 version 4.20 or higher is required for accurate analysis of transient measurements. Recordings made in the *Graf* display mode where *sample* $\neq$ 20 μs result in incorrect time axis scaling with earlier software versions.

Additional tips for operation can be queried via the help menu included with the software.

4   Frequency Converter Measurements

4.1   General Information

Converter controlled three-phase motors offer considerable advantages as opposed to DC motors despite the increased expenses involved with the converter. A wide range of applications has been opened up for DC link converters thanks to the availability of electronic components which are suited for relatively high load current and off-state voltage. Single or three-phase alternating voltage which is applied to the input of the frequency converter is first rectified by means of electronic power converters and conditioned in the DC link. Direct voltage at the intermediate circuit is distributed to the individual phases of the motor with electronic switches (e.g. FETs or GTOs) such that a rotating field is generated with the desired rotational speed.
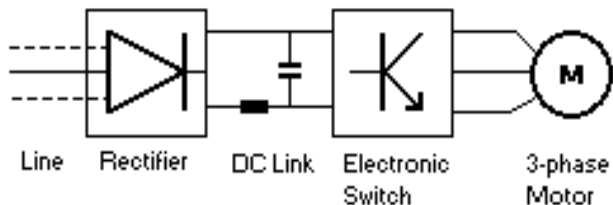

Fig. 4.1a: Schematic Diagram: Electronic Frequency Converter

Output voltage amplitude and frequency are altered by means of the mark-to-space ratio of the pulse frequency (also known as the chopper frequency). Furthermore, the duty factor between positive and negative voltage values is selected such

that a sine function results as the 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 motor is controlled.
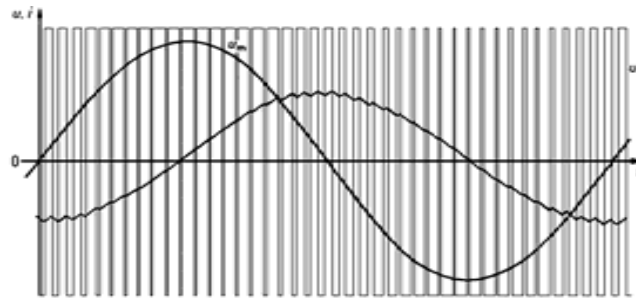

Fig. 4.1b: Time curve for output voltage u, its mean value u_m and for current i with pulse-width modulated signals

The representation demonstrates the characteristics for one phase of the frequency converter with a no-loaded motor. A sinusoidal current curve with a somewhat saw-toothed shape suggests high motor inductivity in relationship to pulse frequency (asynchronous motor).

This theoretical representation may greatly deviate from the actual curve.

For the measurement of electrical magnitudes at frequency converters, the direct true rms value of output voltage does not lead to the desired results. Nor does the pulse frequency provide us with clues concerning frequency regulation. It is primarily the mean value, u_m, that demonstrates amplitude and frequency response, which is required for the measurement of the existing operating conditions of voltage and frequency. However, neither of these measurement magnitudes can be acquired by means of simple voltage and frequency measurement.

Current has an almost sinusoidal shape due to the inductivity of the motor. Thus current measurement can be performed with standard measuring methods up into the highest frequency range of the instrument (20 kHz).

Motor voltage is fed through a digital filter with a corner frequency of approximately 120 Hz and damping of greater than 70 dB at 500 Hz for voltage and frequency measurement with the MAVOWATT 45. The filtered signal provides us with two basic alternating voltage measurement magnitudes, from which voltage and initial rotary field frequency can be calculated.

Because valuable information is thus provided regarding the operating condition of the three-phase motor, the characteristic waveforms for current and voltage are based upon the filtered signal.

Calculation of active power and effective current is performed with the unfiltered signal. Thus all harmonic content up to 20 kHz is taken into consideration in the measurement results. This leads to accurate conclusions concerning mechanical power and temperature rise at the windings.

The product of filtered voltage and unfiltered motor current is used for the calculation of apparent power ($S = U_{rms} \bullet I_{rms}$).

Power factor and reactive power are calculated with the well known formulas

$$PF = P/S \quad \text{and} \quad Q = \sqrt{(S^2 - P^2)}.$$

Harmonics cause ohmic loss and interference in electrical supply lines. From a mechanical standpoint they may also cause vibratory forces which generate heat, and which have no positive effect on useful torque. The MAVO-FFT option is available for the measurement of harmonics.

With MAVO-FFT harmonics can be measured at the line input side of frequency converters, but not at the output side.

4.2   Measuring Set-Up for Frequency Converters

4.2.1   General Notes

The measuring set-up for converter circuits depends to a great extent upon the type of converter to be measured. Interference caused by frequency sidebands and neutral point characteristics must be carefully considered for the measuring set-up. However, in most cases frequency converter performance characteristics are only known to a limited extent, or entirely unknown. The following sample measuring set-ups are recommended for this reason, which lead to good results for most measurements.

In general, the following apply for measurements within converter circuits with the MAVOWATT 45:

- (Clip-on) current transformers must be used for current measurement. Current measurement cannot be performed by means of shunt resistors in the motor power supply line due to the poor signal-to-disturbance ratio.

- Voltage measurement must always be taken at a neutral point, in order to ascertain true phase relationships, as well as correct measurement values for the derived magnitudes. The voltage measurement inputs may only be connected between the phase conductors if the numeric values for directly measured voltage and current are the only magnitudes that need to be determined.

  As a rule, measurement must be performed with an artificial neutral point, because there is generally no neutral point available at the converter output, and if there is a neutral point connection at the motor, it is usually inaccessible. Due to the high-impedance internal resistors (approx. 6 MΩ) at the voltage measurement inputs, the neutral point created

by interconnecting the LOW terminals is frequently too "soft", which leads to unstable measurement values. Furthermore, converters may demonstrate excessively steep switching slopes which influence measuring results. Good measuring results can be obtained in such cases through the use of neutral point resistors with a value of less than 100 kΩ, or HF filters in the voltage circuits.

A suitable combination including neutral point resistor (60 kΩ, 0.5%) and HF filter is available as an accessory. The HF Filter Module is provided as an encapsulated unit which can be conveniently plugged into the voltage measurement input of the MAVOWATT 45. It can be used for voltages of up to 400 V$_{rms}$ (corresponds to 700 V$_{rms}$ line-to-line voltage) and offers a practical and electrically safe solution for these problem cases. A total of three filter modules are required – one for each voltage measurement input.
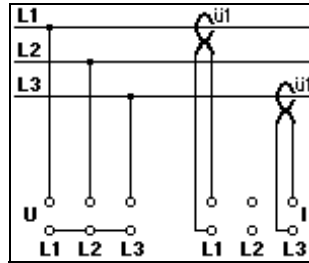
4.2.2   Recommended Set-Ups

Example A:

Two-wattmeter method

Voltage measurement with artificial neutral point

Current measurement via clip-on current transformer with voltage output

- *Mains* is set to *3-Wire* with the function selector switch in the **MENU** position.
- *Uratio* is set to *1* in **Setup** for selector switch positions L1 through L3.
- *Iratio* corresponds in each case to the transformation ratio of the current transformer in use.

Example: Output = 1mV/A $\Rightarrow$ *Iratio* = *1000* A/V.
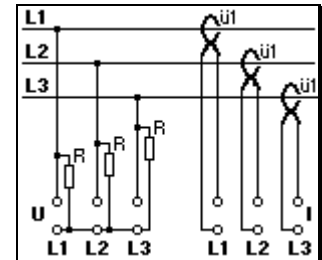
The use of HF filter modules (accessory) in the voltage circuit is recommended in case of unstable measurement values.

Example B:

Two-wattmeter method

Voltage measurement with artificial neutral point

Current measurement via clip-on current transformer and shunt resistor
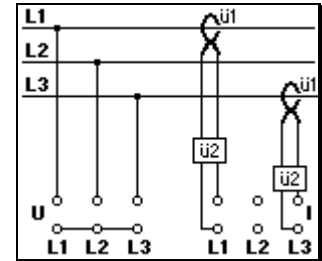
- *Mains* and *Uratio* are selected as in example A.
- *Iratio* corresponds to the product of the clip-on current transformer transformation ratio and the shunt resistor.

Example: current transformer 200A / 5A $\Rightarrow$ ü1 = 40; shunt (50mΩ) 5A / 250mV $\Rightarrow$ ü2 = 20; *Iratio* = ü1 • ü2 = *800*.

The use of HF filter modules (accessory) in the voltage circuit is recommended in case of unstable measurement values.

Example C:

Three-wattmeter method

Voltage measurement with artificial, reinforced neutral point

Current measurement via clip-on current transformer with voltage output

- *Mains* is set to *2/4-Wire* with the function selector switch in the **MENU** position.

- *Uratio* and *Iratio* are selected as in example A.

An artificial, rigid neutral point is created with resistors R if greatly fluctuating symmetry relationships should occur at the neutral point. The use of HF filter modules (accessory) is recommended in such cases.

Example D:

Three-wattmeter method

Voltage measurement with artificial, reinforced neutral point

Current measurement via clip-on current transformer and shunt resistor
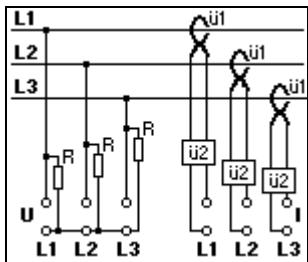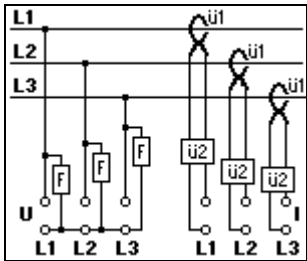

- *Iratio* corresponds to the product of the clip-on current transformer transformation ratio and the shunt resistor (see example B).

- Remaining settings correspond to the above example.

Example E:

Three-wattmeter method

Voltage measurement with artificial neutral point and HF filter

Current measurement via clip-on current transformer and shunt resistor

Interference may occur in some cases which influences measurement results. Good measurement results can be obtained in such cases through the use of filters in the voltage circuit. The use of HF filter modules (accessory) is recommended to this end.

Example F:

Power measurement in balanced load three-phase current systems via clip-on current transformer with voltage output
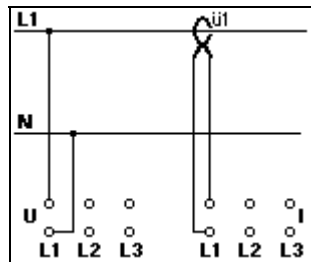
- *Mains* is set to *2/4-Wire* with the function selector switch in the MENU position.

- *Uratio* is set to *1* in Setup for selector switch positions L1 through L3.

- *Iratio* is equal to 3 times the transformation ratio of the clip-on current transformer (*Iratio* = 3 • ü1).

The use of HF filter modules (accessory) in the voltage circuit is recommended in case of unstable measurement values.

Product Support

If required, please contact:

> GOSSEN-METRAWATT GMBH
> Product Support Hotline
> Telephone +49 911 8602-112
> Telefax +49 911 8602-709