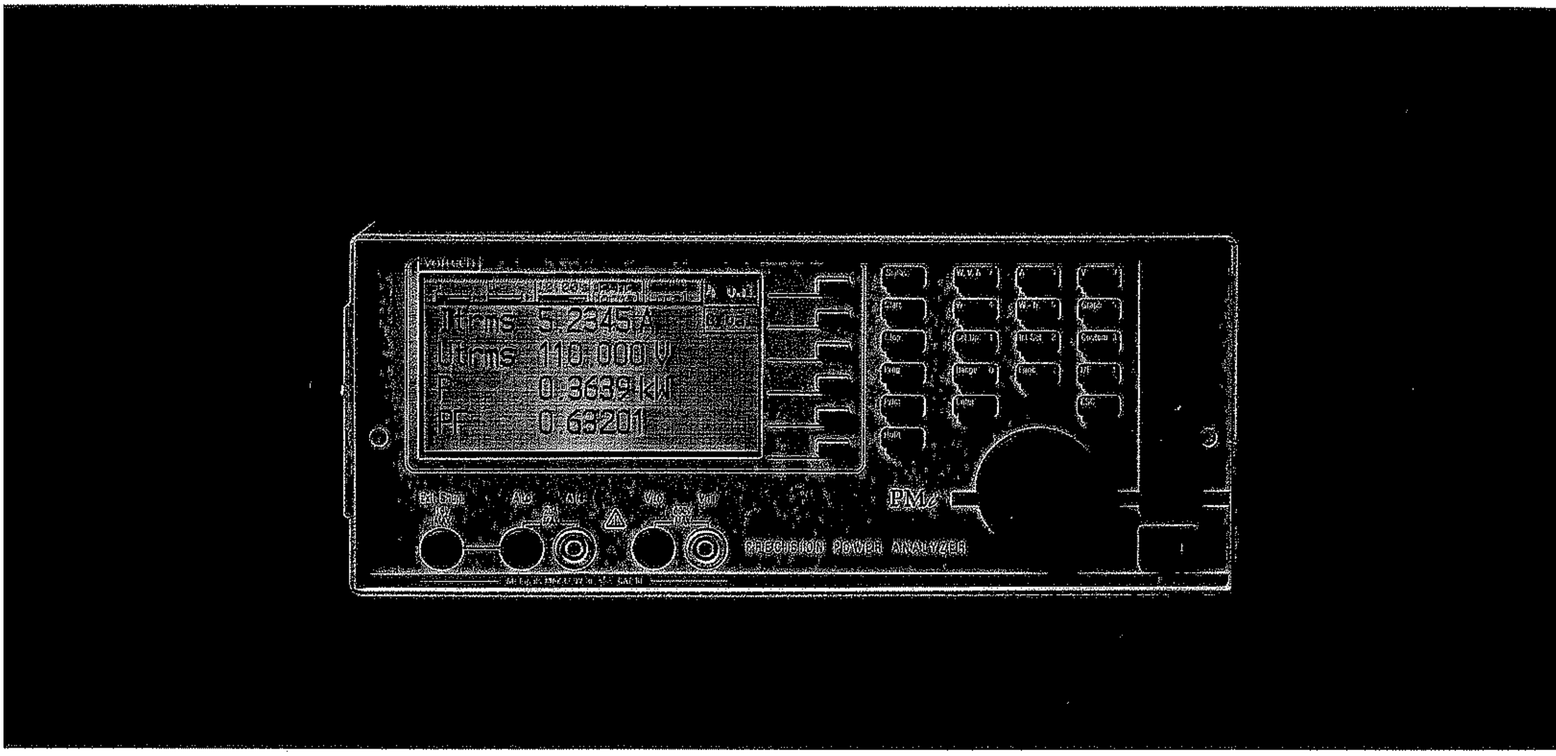
PMi

Power Analyzer



User Manual

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Voltech™

THE WORLD'S MOST POPULAR POWER ANALYZERS

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Table of Contents

1 General Description

1.1 Safety Precautions

Electrical devices can constitute a safety hazard. It is the responsibility of the user to ensure the compliance of the installation with any local acts or bylaws in force. Only qualified personnel should install this equipment, after reading and understanding this user guide. These operating instructions should be strictly adhered to. If in any doubt, consult your supplier.

The PMℓ is constructed in compliance with the requirements of IEC61010-1, concerning the protection of electrical instrumentation, and as such ensures the safety of the meter and the user when normal precautions are followed.

- The power source should be inserted in a socket with a protective ground contact.
- The power source should be inserted before connections are made to measuring or control circuits.
- Do not attempt to remove the outer cover without first disconnecting auxiliary and test power supplies. When the instrument is removed from its case, hazardous voltages are present. It must only be serviced by qualified personnel who understand the danger of shock hazards.
- The signal leads must be in good condition with no damage.
- Fuses may only be replaced with the correctly rated and recommended types.

If you are at all unsure of how to install or operate the PMℓ, please do not hesitate to contact your Voltech Instruments supplier for advice.

This equipment is supplied under warranty conditions, in force at the time of purchase from your supplier. Contact your supplier for details. Any attempt to disassemble or modify the unit will render any warranty agreement invalid.

1.2 Getting Started

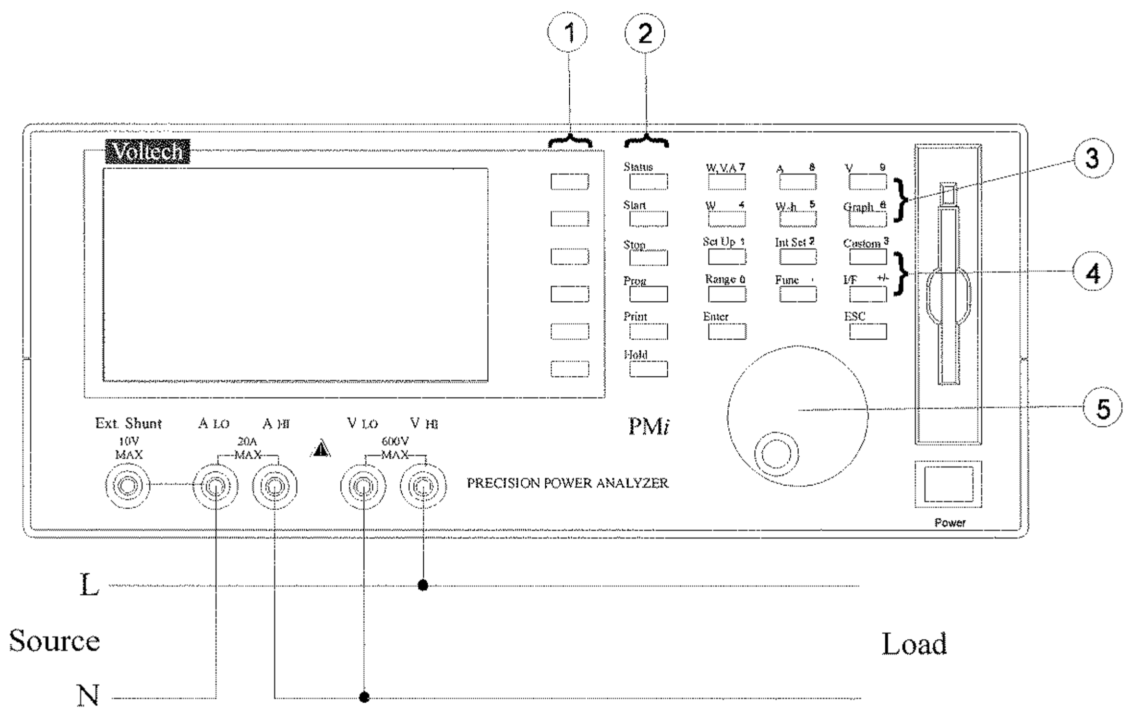
The instrument is supplied with an earthed power lead to suit the local power supply. The safety ground connection must always be made when the instrument is in use.

Turn the power on at the front of the instrument.

The display will show the start-up screen while initialization takes place, followed by the display below.

Press the **W,V,A** key to display some measured values. Test connections may now be made to the PMi, and the control and settings experimented with. Each feature is described in detail in the relevant section of the manual.

Where possible, examples have been used throughout the manual. Chapter 6 details how to use the PMi for specific applications. This chapter assumes a working knowledge of the settings and operation of the instrument, as described in the earlier parts of the manual.



Instrument controls and standard connections

The main control features of the instrument are briefly described here.

1. Softkeys

The right-hand side of the display shows the functions of each of these keys. They are used for the rapid setting-up of measurements.

2. Special function keys

These allow control of the instrument functionality, such as printing and integration.

3. Menu keys

Select different measurement displays.

4. Function keys

Allow access to menus, which configure the instrument set-up.

5. Rotary knob

This is used in many menus to select items from lists, scroll windows or cursors, and to change value settings.

1.3 Measuring Modes

The PMɩ has up to five measurement modes, depending on the options purchased. Each is optimized for specific uses, and can configured from the **Set Up** menu.

Normal mode

This is the usual mode for making standard measurements. Large ranges of measured values are available under the various menus.

CE-harmonics mode

The PMɩ acts as a compliant harmonic power analyzer, capable of comparing the equipment under test to EN61000-3-2, including amendment 14, measuring fluctuating harmonics and comparing them to their limits.

CE-flicker mode (optional)

This mode is used to measure the compliant voltage flicker over timed intervals of operation, according to the standard EN61000-3-3.

100-harmonics mode (optional)

The PM*e* acts as a high-precision harmonic analyzer, calculating the first 100 harmonics of voltage, current, and power.

Transient mode (optional)

This is used to monitor for certain events in the signals. The waveform is captured whenever limits in value or slew-rate are exceeded. This option requires a 4 MB memory module to be installed. See Voltech option OP-06.

1.4 Features

The Voltech PM*e* is a very powerful instrument with many useful features.

Accurate measurements of voltage and current can be obtained over a wide range of values, allowing both high and low power uses.

The exceptionally good common mode rejection allows the instrument to measure high frequency signals at up to 600V relative to earth. This is particularly important for measurements in inverter and rectifier circuits, and in switch-mode power supplies.

Measurements to IEC standards may be performed easily and quickly with the built-in CE-harmonics feature. The optional CE-flicker feature increases these possibilities still further.

The large display is used to make powerful menus available, and allows the graphical functions to be accessed. This provides a rapid interpretation of results and detailed analysis of the waveforms.

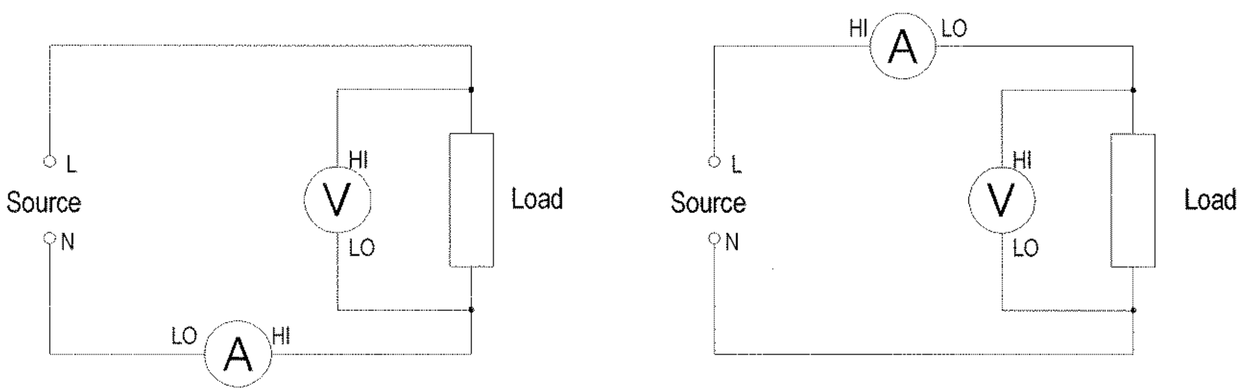
The interface options allow the measurements taken by the PM*e* to be analyzed and output in forms suitable for the user's purposes. Control over the communications interface allows remote use of the instrument, and automatic operation by software running on a PC.

1.5 Applications

The powerful features described above allow the Voltech PMℓ to be used in almost any power analysis application. Settings and advice for common uses are described in Chapter 6, under the following sections:

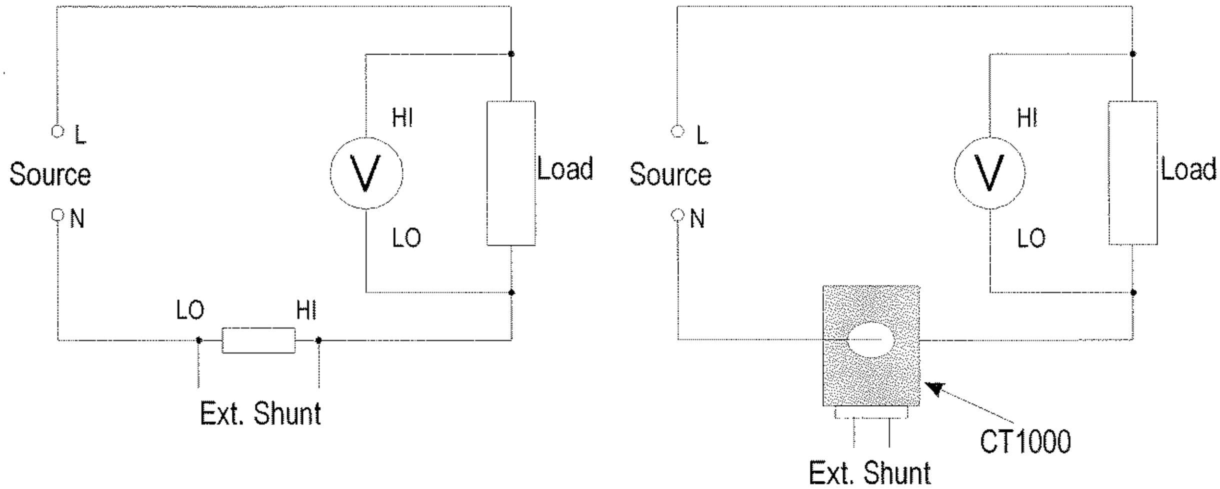
1.6 Connections

The voltage and current channels are isolated from each other, and so any connection arrangement is possible. The usual arrangement is given below.



Normal operating connections

It is also possible to use the external shunt inputs of the PMℓ. The illustrations below show how to connect an external shunt in a measuring circuit. See section 7.1 for the configuration of external shunts.



Uses of the external shunt input

The following Voltech accessories may be used to enhance the current range of the PM*e*:

CL100 and CL1000

The CL100 and CL1000 are clamp-on current transformers, which extend the AC current capability to 100A rms and 1000A rms respectively. Each has a close tolerance turns ratio and carefully controlled magnetic circuit, giving a measurement accuracy of better than 1%.

CT1000

The CT1000 is a toroidally wound AC current transformer which extends the range of Voltech power analyzers to 1200A. Close tolerance turns ratios provide a measurement accuracy of better than 0.2%, making it suitable for precision-grade measurements.

1.7 Troubleshooting

Technical support may be obtained by contacting Voltech Instruments at:

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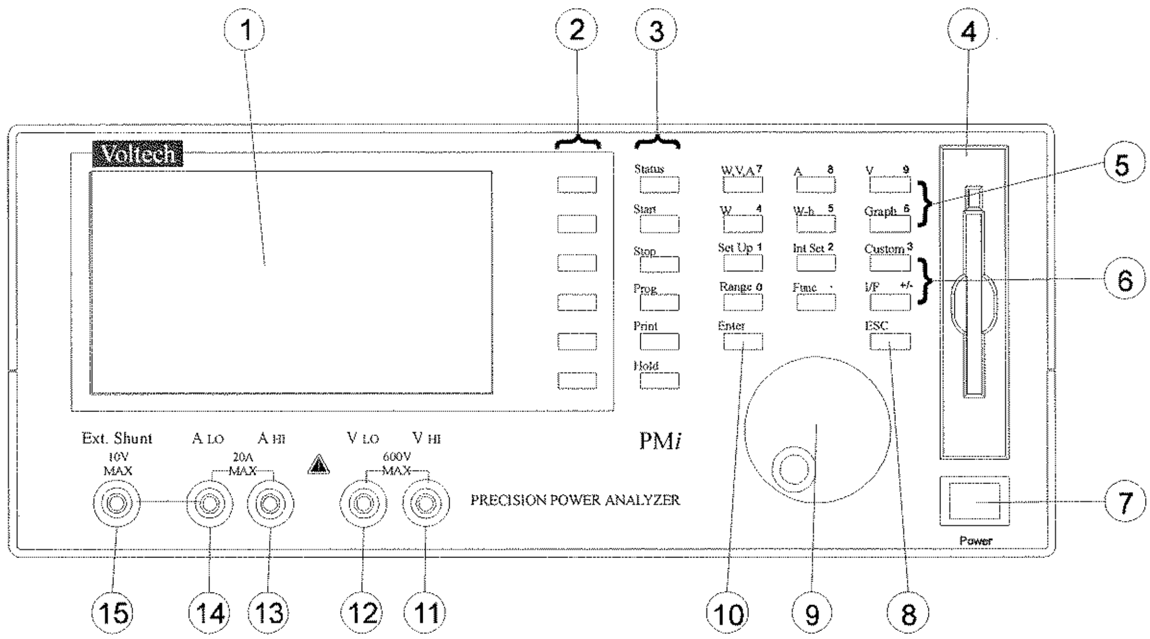
2 Operation

2.1 Instrument Controls

2.1.1 Front Panel



Front panel layout

1 **Graphical display**

2 **Softkeys**

The functions of these are shown on the display, and change with each menu.

3 **Special function keys**

Status Gives information about reported errors.

Start Begins time-dependent measurements, such as integration.

Stop Ends time-dependent measurements.

Prog Saves and recalls user configurations (Section 3.1).

Print Used to print the screen or to log data (*see 5.3 Printing and Logging*).

Hold Holds or enables the display.

4 **PCMCIA card slot** (option OP02) includes a 64 K Memory card

5 **Menu selection keys**
These keys select the different measurement displays. They are also used to enter digits when in a number-entering mode.

6 **Function keys**
These keys are used to configure the set-up of the instrument. They may also be used to enter digits when in a number-entering mode.

7 **Power switch**

8 **ESC key**

9 **Rotary knob**
This is used for selecting items from lists, and for moving the cursors or window.

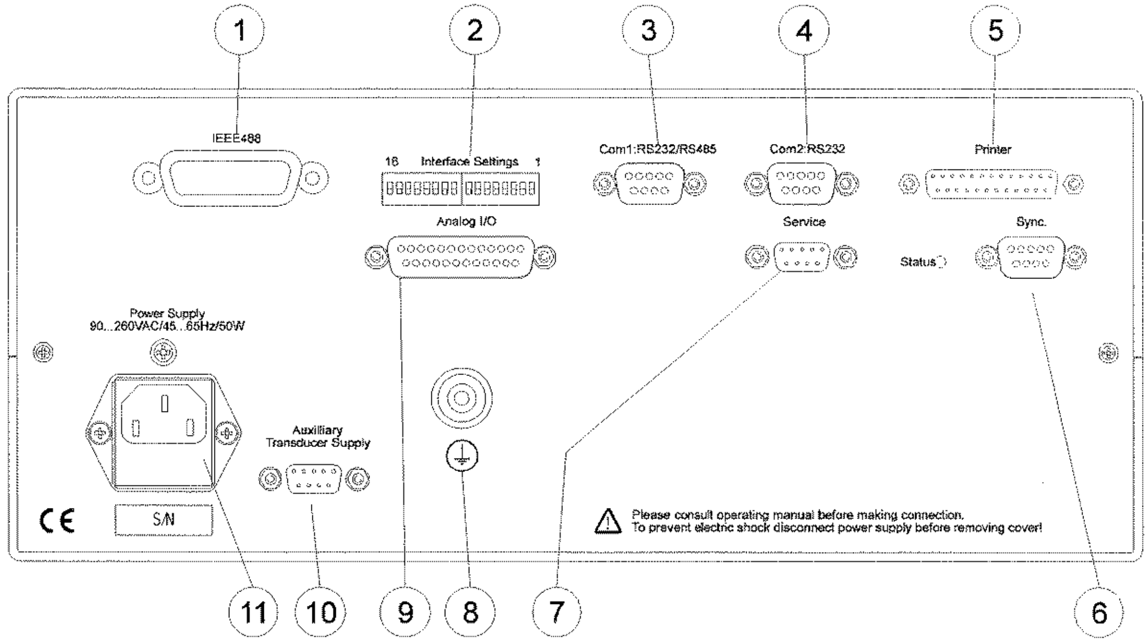
10 **Enter key**

11, 12 **V_{HI} and V_{LO} input sockets**

13, 14 **A_{HI} and A_{LO} input sockets**

15 **External Shunt Input**
Input for voltages from external shunts or transformers (see section 1.6).

2.1.2 Rear Panel



Rear panel layout

1 **IEEE488** (Section 5.1.3)

2 **DIP switches** (Section 5.2.1)
These switches are used to set the comms device and parameters.

3 **COM1: Serial RS232/RS485 interface** (Section 5.1.1)

4 **COM2: Serial RS232 interface** (Section 5.1.2)

5 **Printer connector** (Section 5.1.4)

6 **Synchronization connector** (Section 7.5)
Socket for external synchronization and time control of the PMι

7 **Service**
This socket is reserved for servicing the instrument.

8 **Ground stud**
This may be used for additional earthing.

9 **Analog I/O** (optional) (Section 3.6.6)
The connector for the Processing Signals Interface.

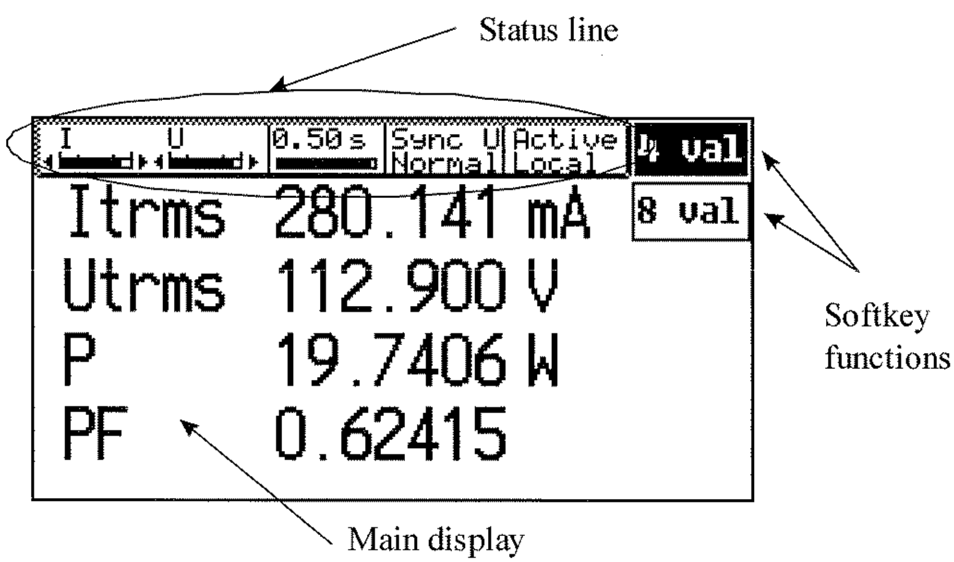
10 **Auxiliary transducer supply** (Section 7.4)
Additional supply voltages of ±15V for external sensors

11 **Power input**
Fused chassis plug with fuse-holder. Input voltage 90...260V, 45...65Hz, 50W. Use Microfuse T1A/250V, 5x20mm, DIN41662.

2.2 Display

The display is divided into three regions:

- The functions of the softkeys are displayed on the right-hand side of the display, next to the corresponding key.
- The status line is always visible at the top of the display. Its elements are described in section 2.2.1 below.
- The main display for measured values and menus.



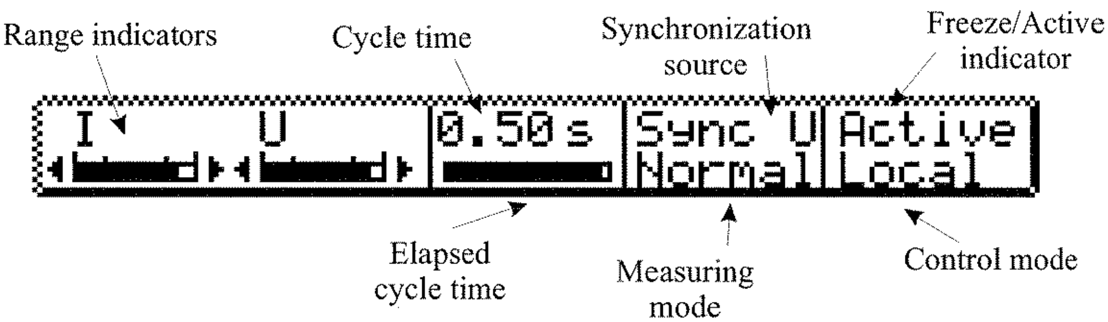
Display regions

2.2.1 Status Line

The status line has the following regions:

- **Signal level indicators**. These show how much of the range is being used by the signal. The letters 'LF' indicate that the signal is filtered. If the arrow to the left or right is blinking, then a lower or higher range should be used.
- **Cycle time.** This states the present cycle time of the instrument. The bar below this number shows how much of the cycle time is over.
- **Synchronization source and measuring mode indicators**. A black background means that a valid synchronization signal could not be found.

- **Freeze and remote indicator**, and the control source. *Freeze* indicates a frozen display. *Active* shows that the display is continually updated. The control source may be either *Local* or *Remote*.



Status bar regions

2.3 Function Keys

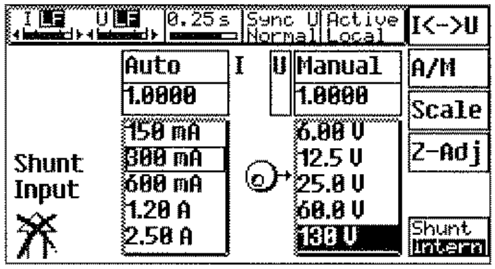
The six function keys are used to configure the set up of the instrument. Most are available in every measuring mode.

2.3.1 Set-up

This is the main function key. It allows the measuring mode to be selected and configured. See the set-up details of each measuring mode in Chapter 4:

Measuring Mode **page**

2.3.2 Range



Range menu

The **Range** menu is available in every measuring mode, although the auto-ranging feature is available in selected modes only. See section 9.3.4 for the technical specification of each range.

The uses of the softkeys are as follows:

I<->U Switches between setting the current and voltage channels. Where I represents current and U represents voltage

A/M Selects either manual or auto-ranging.

Scale Allows the scaling value to be set. This scaling is applied to all readings taken. In the example above 1.0000 is the scale factor being used.
If, for example, you need to use a CL100 with the PM6, you press the **Scale** softkey, press the **Clr** softkey which will clear the scale factor for current, and then key in 100, using the alphanumeric key pad, followed by **Enter**.
The scale factor will now be kept at 100 until you choose to change it again.

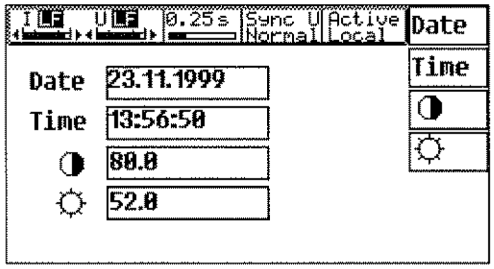
Z-Adj Begins the Z-Adj setting of the instrument. See section 7.3 before using this function.

Shunt Switches between internal and external shunts for the current input. The shunt input on the left of the display also indicates this setting.

2.3.3 Int Set

This menu is used to configure the integrator feature. See section 3.5 for more details.

2.3.4 Func



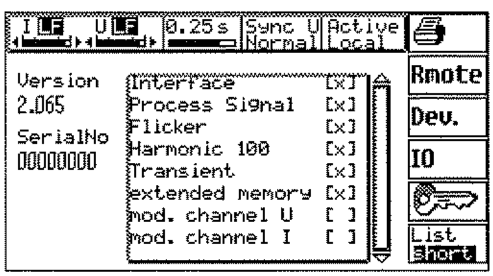
Function menu

The **Function** menu is available in every measuring mode. It allows the instrument date (format: 'dd.mm.yy') and time to be set, as well as the display contrast and brightness. The PMℓ will retain these settings on power cycle.

2.3.5 Custom

The **Custom** menu is a powerful feature of the PMℓ that allows user variables to be set-up and manipulated by the user. It also allows access to the Formula editor, as detailed in section 3.4.

2.3.6 I/F



I/F menu

This menu allows the interface options to be set-up. The features installed on the instrument are displayed checked [x] in the list. A more detailed list can be obtained by pressing the 'List' softkey. Should you decide to purchase an option at a later time, a new 24-character hex pass key will be provided. Once you install the new password and revisit this screen, you will find it is now checked.

Each of the other softkeys leads to another menu, described in the sections referred to below.

Printer	Section 5.3
Rmote	Section 5.2
Dev.	Section 5.1
IO	Section 3.6
Key	Section 3.7

2.4 Entering Text and Identifiers in Menus

Some menus require text to be entered. This may involve words, a numerical value, or identifiers for measurements taken by the PMε; this section describes how to enter these most efficiently. The available keys and identifiers depend on the present menu.

2.4.1 Softkeys

The softkeys, which may be available, are:

«	Moves the cursor one position to the left.
»	Moves the cursor one position to the right.
↵	Enters a carriage return.
←	Deletes the character to the left of the cursor.
del	Deletes the character to the right of the cursor.
ins	Changes between insert and overwrite modes.
clr	Clears the text box.
End	Completes the operation and returns to the previous menu.
Mode	Cycles between *copy*, *move*, and *line* modes. These control the effect of the rotary knob. See section 2.4.3 for more details.

2.4.2 Numerical Values

In text boxes used to enter numerical values only, the menu keys with numeric labels should be used. Magnitude suffixes may be entered by scrolling the cursor to the far right using the rotary knob. The suffixes k, M, μ, and m appear.

When entering a time, the colon separator may be obtained by pressing the '.' key.

2.4.3 Entering Text

To enter text, the **Mode** softkey should be used to select **copy**. The rotary knob may now be used to move the copy cursor in the character box in the top-right of the display. Select the desired character and press **Enter**. The character will be entered in the location of the main cursor in the text box.

Press the **Mode** softkey to change to **move** mode. Now the rotary knob will control the position of the main cursor. Pressing **Mode** again to select **line** will move the main cursor line by line with the rotary knob.

2.4.4 Entering Identifiers

Identifiers are the values measured by the PMℓ during operation, such as *Vdc*, *Itrms*, and *var0*. Pressing a menu key will give a pop-up list of available identifiers. The desired one may be selected with the rotary knob and set with the **Enter** key. The **ESC** key exits the menu.

Identifiers which end in [:] require an additional parameter. For example, the 5th voltage harmonic may be addressed by Uh[5].

Note that only measurements taken under the present measuring mode are updated during operation. For example, formulae involving Uh[98] will only be valid if the measuring mode is set to *100-harmonics*.

Example 1: To enter '*Utrms*', press the **V** key. On the resulting list, scroll down to select '*Utrms*' and press **Enter**.

Example 2: To enter '*var7*', one of the user variables, press the **Custom** key. Then select '*var7*' from the list and press **Enter**.

The table below shows which identifiers are available from each menu in normal mode.

A	V	W	W-h	Graph	Set Up	Custom	Func	I/F
F	f	f	q	Wave_i	DisCyc	var0	abs()	Ain:
Iac	OvrU	P	EP	Wave_p	Cycle	var1	acos()	DigFreq
Icf	Uac	PF	EQ	Wave_u	Per	var2	asin()	
Idc	Ucf	PHI	ES		Rcyc	var3	bell()	
Itrms	Udc	Q	Pm			var4	cos()	
Iff	Utrms	Rser	Qm			var5	freeze()	
Ipkp	Uff	S	Sm			var6	log()	
Ipkn	Upkp	Xser				var7	ln()	
Ipp	Upkn	Z					sin()	
Irect	Upp						unfreeze()	
RngI	Urect						if();fi	
OvrI	RngU						2.7182818	
							3.1415927	
							1.2566e-6	
							8.854e-12	

Notes *1* The list obtained by the **W, V, A** key contains all those from the **W**, the **V**, the **A**, and **Custom** lists.

2 The definitions of some of these values are given in section 9.1.

3 The meaning and purposes of the constants are stated below.

Constant	Symbol	Definition
2.7182818	e	The base of natural logarithms
3.1415927	π	Ratio of circumference to diameter of a circle
1.2566e-6	μ_0	Permeability of free space
8.854e-12	ε_0	Permittivity of free space

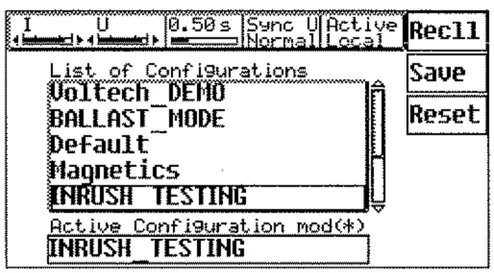
3 Features

3.1 Storing Configurations

The function key **Prog** allows measuring configurations to be stored and recalled. Up to eight different set-ups may be stored, and all data such as formulae, ranges and measuring settings are saved.

The field '*Active configuration mod( )*' displays the name of the selected set-up. If '*mod(*)*' is displayed, then one or more settings have been changed.

The display below shows example names for user configurations.



'Prog' menu

3.1.1 Restoring a Configuration

Select the desired set-up name with the rotary knob and press **Recll**. All present settings are overwritten with those of the new configuration.

The manufacturer defaults can be restored as follows:

- Hold down the lower two softkeys while switching on the instrument.
- After a few seconds, a beep will be heard and the softkeys may be released.

3.1.2 Saving a Configuration

With the rotary knob, select the desired location to save the configuration. The item selected will be overwritten with the new set-up. Press **Save** and enter a name for the configuration. Press **End** when completed.

3.2 Display Hold

Values shown on the display may be frozen with the **Hold** key. When this function is in operation, **Freeze** is shown blinking in the status bar. The **Hold** key may be used again to return to normal operation.

While in Freeze mode, the menus may still be used to display different values, or change the settings. Printing will produce the values presently frozen.

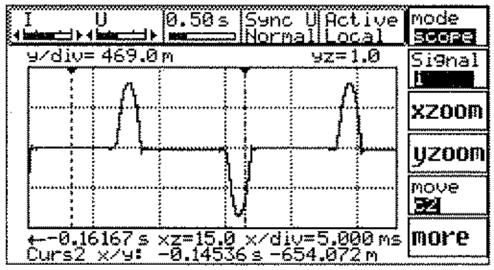
The formula editor may also be programmed to freeze and unfreeze the display, see section 3.4.

3.3 Graphical Display

The graphical display is a powerful feature of the PM*e*, which allows it to display measured data in several forms. The displays available depend on the measuring mode presently selected.

3.3.1 Scope Function

The operation of the instrument in this mode is very similar to a conventional oscilloscope. The scope function is only available in normal measuring mode.



Scope Function

The softkeys available in this function are:

Signal Selects which signal is displayed. The available waves may be changed under the **more** menu.

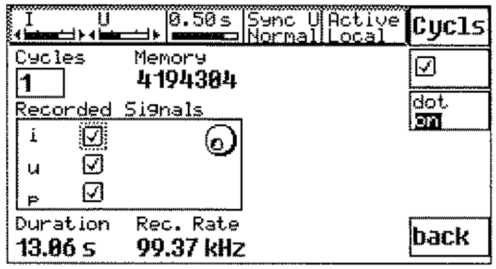
xzoom Controls the zoom on the time (x) axis. The rotary knob or softkeys may be used to adjust the zoom value. This allows you to view more or fewer cycles.

yzoom Controls the zoom on the y axis. This allows you expand the height of the signal viewed.

move This allows the cursors (c1 or c2) or window to be moved with the rotary knob. Note that, when a cursor is selected, its coordinates are displayed on the bottom line of the screen. When 'c1&c2' is selected, the differences between cursor positions are stated.

Pressing the **move** softkey will go through the following sequence of choices: c1, then c2, c1 & c2, x-pos, and then back to c1.

The menu under **more** allows the user to select which signals are enabled to be viewed. The number of signals to be viewed is limited by the memory available. The record rate and duration of stored signals are automatically determined.



Scope Function

This screen shows that all three signals—current, voltage, and power—are enabled to be viewed. The overall memory available is 4,194,304 bytes in depth. The PMℯ, in this case, will be digitizing at the rate of 99.37 kHz and therefore can acquire a maximum record for 13.06 seconds.

Select signals with the rotary knob and use the '√' softkey to select each signal required.

i, u, p Directly measured signals (no filter or only the anti-aliasing filter selected).

i fil, u fil, p fil Signals as measured with selected filters, if any.

Cycles Allows the user to set the minimum duration of signal to be captured. It is expressed in multiples of the cycle time. The duration and record rate are automatically determined for the available memory.

dot If set to *on*, then successive sample points are joined with straight lines.

Example: To display a 120V, 60Hz signal.

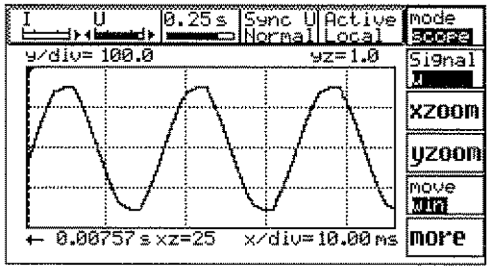
Ensure that the measuring settings are as below:

Set Up Normal measuring mode, suitable filter (if any), Sync on U, coupled to AC+DC.

Range Voltage range 130V (or auto-ranging enabled).

- Enter the **Graph** menu and select **scope** mode.
- Set the **signal** to **u**, if necessary entering the **more** menu to select **u** as a recorded signal.

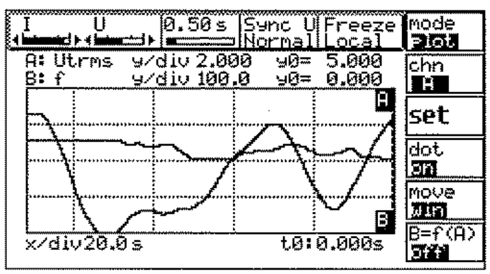
- Change the **yzoom** to 1.0.
- Change the **xzoom** to at least 10 to display a whole period.
- If no wave is visible, change **move** to **win** and scroll to time 0.



Display for example above

3.3.2 Plot Function

This function is available only in *normal measuring mode*. It shows a scrolling display of two waveforms against time, or it can be used to plot one waveform against another.



Plot of Utrms and f against time

The purpose of each softkey is given below:

chn Selects which channel, A or B, is to be **set**.

set Allows the parameters of the channel to be changed:

Signal	Sets which of the values measured by the PMℓ is displayed.
y/div	Allows the vertical axis scaling to be changed.
y0	Sets the value of the middle of the graph.

Example: Select **y0**=200V and **y/div**=20V, then the range 180V to 220V will be displayed in the graph window.

dot If *on*, then successive sample points are joined with a straight line.

move Select the cursors or window to be moved. The positions of the cursors are read out at the bottom of the screen, when selected.

B=f(A) Switches this mode on and off. See below for more details.

3.3.2.1 B=f(A) mode

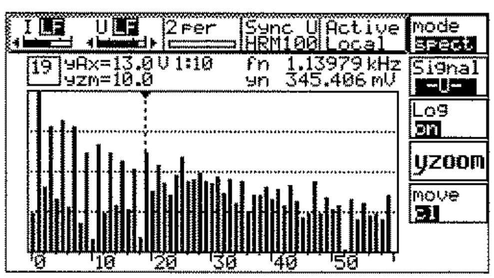
When enabled, this mode allows two waveforms to be plotted against each other. Signal A is plotted on the X-axis, and B on the Y-axis.

This function is most easily used by first capturing the waveforms with B=f(A) turned *off*. Freeze the display by pressing the **Hold** key, and place the cursors either side of the area of interest. Now enable the B=f(A) mode to display the relationship between the waveforms.

Combined with the formula editor and user variables, this feature can be a very powerful utility in analyzing almost any electrical system.

3.3.3 Spectrum Display

The **Graph** key may be used to display the spectrum of a signal when in either *CE-harmonics mode* or *100-harmonics mode.*



Voltage spectrum, taken in 100 harmonics mode

The following settings may be configured:

Signal Selects the signal to be displayed

Log Switches between logarithmic and linear scales for the vertical axis.

yzoom Allows the scaling of the vertical axis to be changed.

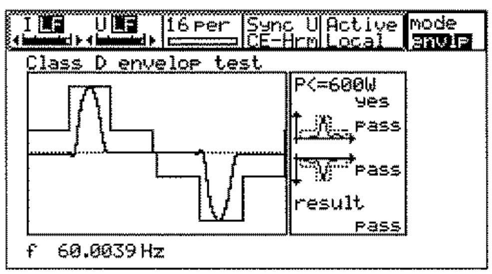
move The cursor may be moved to select individual harmonics. The data at the top of the screen relates to the selected harmonic, and depends on the measuring mode.

3.3.4 Envelope Display

This function is available only in *CE-Harmonics mode*, and it relates to the current signal of Class D equipment. The waveform is displayed, along with the envelope, as specified by the standard. The PMℓ checks that:

- The waveform is within the positive and negative envelopes for at least 95% of the time and the power is less than or equal to 600W.

A pass/fail indication is given for each condition.



Class D envelope detection

3.4 Formula Editor

The formula editor is a powerful function of the PMℓ that allows the user to define variables calculated from the measured values. Values specific to any application can be evaluated from the base measurements of the instrument.

The formula editor can also be used in conjunction with the graph feature to display these values or with the processing signals interface to control external systems.

3.4.1 General

The formula editor is accessed through the **Custom** menu by pressing the **Forml** softkey. **Set** is used to enter the edit mode. Refer to *2.4 Entering Text and Identifiers in Menus*.

The editor is similar to a programming language. Instructions and statements are entered line-by-line, and are executed in consecutive order. Execution takes place at the end of each measuring cycle.

- Instructions must be separated by ';'.
- Spaces, linefeeds and carriage returns do not affect the operation, but must not be placed within keywords or identifiers.
- A line feed may be forced with the '\' symbol.

Changes may be canceled by pressing the **ESC** key. Press **End** to leave the editor mode. The program is checked for correct syntax, and any errors are reported. It is then saved to memory.

The formula editor window may be cleared by pressing the '←' softkey while the cursor is in the far top-left position.

3.4.2 Instructions

3.4.2.1 Variables

Values measured by the PMɛ may be read but not set, while the user variables may be both read and set.

3.4.2.2 Conditional Instruction

This instruction may be used to alter the program flow depending on the result of an expression. The following syntax is used:

```
if (expression)
    instruction1;
    instruction2;
fi
```

There may be any number of instructions between the if and fi commands. Nesting is possible to produce a logical AND:

```
if (expression1)
    if (expression2)
        instruction;
    fi
fi
```

3.4.2.3 Functions

The following functions are available from the **Func** menu:

`abs(x)`	Returns the absolute value of x.
`sin(x)`	
`cos(x)`	
`asin(x)`	
`acos(x)`	
`log(x)`	
`ln(x)`	Returns the natural logarithm of x.
`bell()`	Generates a short sound on the internal speaker.
`freeze()`	Freezes the display (equivalent to **Hold** key).
`unfreeze()`	Reactivates the display after a `freeze()` instruction.

3.4.2.4 Constants

The valid range for constants is ±3.4E-34 to ±3.4E+34. Constants are always stored as floating point, and can be entered in normal or scientific notation.

3.4.2.5 Operators

In order of priority (highest to lowest):

:	Index operator, e.g. U:5 returns the 5th voltage harmonic
( )	Function calls and forcing evaluation priority
-	Negation
^	Exponent
/	Division
*	Multiplication
+	Addition
-	Subtraction
<	Less than comparator
>	Greater than comparator
==	Equality comparator
=	Setting a value

3.4.3 Examples

Example 1

The following are all equivalent formulae:

```
var0 = Uh[5] ^ ((2+1)*3);
var0 = (Uh[5]) ^ (9);
var0 = Uh[5] ^ 9;
```

Example 2

When testing transformers, it may be required to calculate the peak magnetic flux density. From theory, this is given by:

$$Bpk = \frac{Urect}{4.f.n_2.A_{fe}}$$

where				
	Bpk	=	Peak magnetic flux density	*to be calculated*
	Urect	=	Mean rectified voltage value	*measured value*
	f	=	Signal frequency	*measured value*
	n_2	=	Secondary number of turns	*transformer constant*
	A_{Fe}	=	Effective magnetic area of core	*transformer constant*

This should be entered in the formula editor as below, with suitable numerical values for n_2 and A_{Fe}. The identifier 'Bpk' is stored in a user variable, and displayed under the **Custom** menu.

```
Bpk = Urect / (4*f*(100)*(0.00005));
```

The PMℓ utitlity software program has already incorporated the custom measurements of Bpk, H and others; please refer to it.

Example 3

This program measures the highest and lowest trms voltage values since the last reset. The identifiers 'Uhigh' and 'Ulow' are stored in the user variables, and are displayed in the **Custom** menu.

```
if (Utrms > Uhigh)
     Uhigh = Utrms;
fi
if (Utrms < Ulow)
     Ulow = Utrms;
fi
```

Example 4

This program gives the signed reactive power, defined as positive for inductive loads, and negative for capacitive loads.

```
Qsign = Q;
if (PHI < 0)
     Qsign = -Q;
fi
```

Example 5

The following program calculates the mean Utrms since the user variables were last reset. 'count' gives the number of cycles averaged over.

```
count = count+1;
sum   = sum+Utrms;
mean  = sum/count;
```

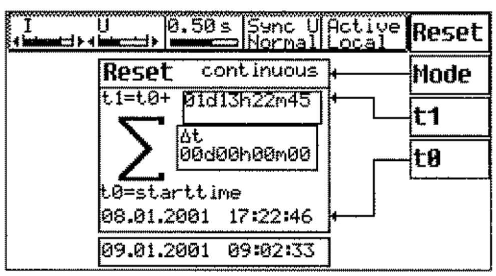
Example 6

This program can be used to count the number of times the power rises above 10W. The variable 'r' is used as a flag so that 'count' cannot be incremented again until the power has dropped below the limit.

```
if (P>10)
   if (r==0)
      count = count+1;
      r=1;
   fi
fi
if (P<10)
   r=0;
fi
```

3.5 Integrator

The integrator function is used in the *Normal Measuring mode* to evaluate energy flow to the system under test. The values obtained may be displayed under the **W-h** menu.



Int Set menu

The **Int Set** menu key allows the integration to be configured.

Integration may be controlled in any of four ways:

- Automatically, using the system clock,
- Manually, by means of the keys on the front panel,
- Remotely, by communications control,
- By signals applied to the sync connector.

Integrals can only be evaluated over an integer number of cycles. Therefore, after starting the integration by any of the ways shown above, the evaluation does not occur until the beginning of the next cycle. Similarly, after stopping the integration, evaluation continues until the end of the present cycle.

The integration state may be one of the following:

Reset Integration is stopped and all energy measurements are set to zero.
Wait The PMℓ is waiting until the start time is reached to begin the integration.
Start The integration has been started, but evaluation will not begin until the next cycle.
Run Integral evaluation is taking place.
Stop The integral has been ended, but evaluation is continuing until the present cycle has been completed.
Hold The integration process has finished, and the final values are being held.

The **mode** can be in any of five settings. When set to *off*, no integration may be performed. The functions of the other modes are described below.

	Resets W-h values at start	Stops when time is t1	Stops by Stop key or external signal	Updates display every:
Continuous	√	X	√	Cycle
Interval	√	√	√	Cycle
Periodic	√	*See note*	√	Interval t_1-t_0
Summing	X	X	√	Cycle

Note: After each interval of t_1-t_0, values are displayed and evaluation of the next interval begins.

3.5.1 Setting Automatic Integration

Integration may be set to occur automatically, controlled by the system clock of the instrument. Note that the clock format is dd:hh:mm:ss

To set up this function, the parameters **t0** and **t1** are used:

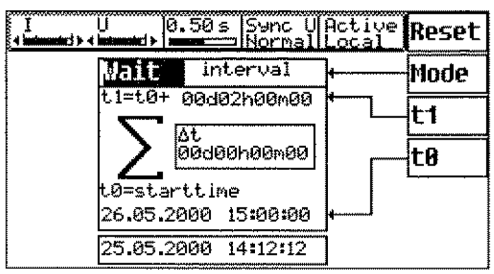
t0 This is the start time, and it is specified as a date and time.
t1 Sets the stop time. It is expressed as the sum of **t0** and a user-definable term.

For automatic integration to be carried out, it is necessary to trigger the integration before the start time is reached. The instrument will remain in **Wait** mode until that time.

Example:

To set an automatic integration for two hours, beginning at 15:00 on 26 May 2000:

- Press **Int Set** to enter the integral menu.
- Ensure that integration is in Reset mode by pressing the **Reset** softkey.
- Press **Mode** until *interval* is selected.
- Now press the softkey **t0** followed by **Date**. Enter '26.05.2000', and then **Enter**.
- Use the softkey **Time** to enter '15:00:00'.
- Press **t1** to enter the integral duration as '00d02h00m00'.
- Press the **Start** function key. **Wait** will be displayed, and integration will proceed at the start-time. The screen should be similar to the one below.



Set-up for example

3.5.2 Setting Manual Integration

To carry out integration controlled only by the **Start** and **Stop** keys on the front panel, it is necessary to set **t0** to a date and time earlier than the current time. The mode should be set to *continuous*, *periodic*, or *summing*, as required.

When ready to begin or end the integration, press the **Start** or **Stop** key as required. The bottom line of the display depicts the current date an time, the line above it depicts the date and elapsed time.

3.5.3 Using the Sync Connector

The sync connector may be used to simulate the pressing of the **Start** or **Stop** key on the front panel. See section 7.5 for further details. It has been provide for user integration into a test set or other bench application where another event may become the trigger to start the PMć integration.

3.5.4 Using Remote Communications

The effect of pressing **Start** may be simulated over remote communications. The integration may be set up using the `:CALC` command, or manually with the keys on the front panel. The integration may be started and ended with the `:TRIG:START` and `:TRIG:STOP` commands.

For further details on setting up and using communications, see chapter 5. The command set is explained in section 8.

NOTE: In any of the programming examples, it is recommended to send capital letters, so that this conversion does not have to occur internal to the PMć.

Example:

To set an automatic integration for two hours (or 7,200 seconds), beginning at 15:00 on 26 May 2000, send the following commands over the communications interface:

```
REN
:CALC:INTE:INTM 2
:CALC:INTE:INTD 2000,05,26
:CALC:INTE:INTT 15,00,00
:CALC:INTE:INTI 7200
:TRIG:START
```

Integration should now take place automatically at the specified start time.

3.6 Analog I/O Signals or Process Signals Interface (Option OP04)

The analog I/O signals interface offers increased control of the PMć and systems connected to it.

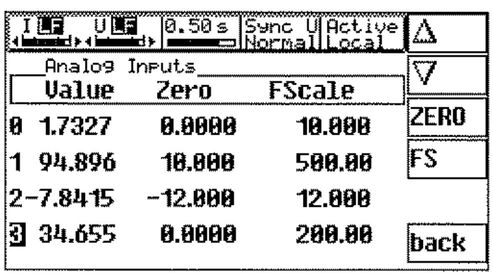
The outputs may be used to output processed data from the PMć, controlling external circuits such as monitoring systems, data loggers, and warning alarms. The inputs allow extra control of the instrument through the formula editor and its direct interface to a rotational speed converter.

3.6.1 Settings

The analog I/O signals interface may be set up by pressing the menu key **I/F**, followed by the softkey **IO**. The softkey **Modul** allows the user to cycle through and configure the four types of input and output.

3.6.2 Analog Inputs (Module A_In)

Four analog inputs are available, with one common ground. Each input is sampled at 1kHz, and the average within each measuring cycle is displayed.



Analog input settings

The following functions are available:

⇧⇩ These may be used to select the input channel. The rotary knob may also be used.

ZERO This sets the value that will be displayed for a 0V input.

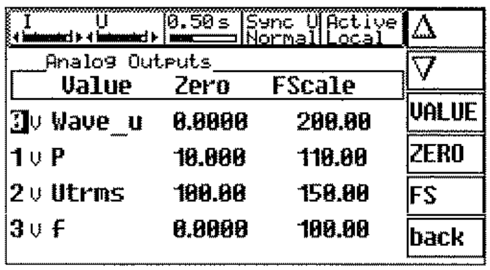
FS This sets the value that will be displayed for a 10V input.

Example With **ZERO** '30' and **FS** '120', a 0V input will give a displayed value of 30, a 10V input gives 120, and a –10V input gives –60.

The values of the analog inputs may be accessed in some text boxes with the identifiers Ain:0 to Ain:3 (see *2.4.4 Entering Identifiers* for more details).

3.6.3 Analog Outputs (Module A_Out)

There are four analog outputs with one common ground. They are updated once every measuring cycle, except the 'Wave_u', 'Wave_i' and 'Wave_p' values, which are updated at the sample rate.



Analog output settings

The following settings are available:

VALUE Sets which measurements the output is to depend upon, such as 'Vdc'. Note that the values 'Wave_u', 'Wave_i' and 'Wave_p' can only be used once each.

ZERO This sets the signal value that will give an output of 0V.

FS This sets the signal value that will give an output of 10V.

Example 1 Select **VALUE** 'Utrms', **ZERO** '200' and **FS** '250'. When Utrms=200V, an output of 0V will be given; with Utrms=250V, an output of 10V; and with Utrms=230V, an output of 6V.

Example 2 Select **VALUE** 'Wave_u', **ZERO** '0' and **FS** '100'. The sampling values of the voltage are now given on the output. An instantaneous value of 100V will be output as 10V.

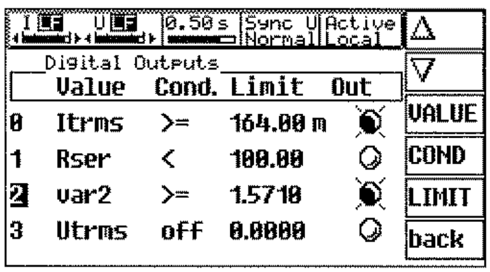
3.6.4 Digital Inputs (Module D_In)

The present state of each of the six digital inputs is shown in this menu. Inputs 1 to 4 may only be used for state indicating. Inputs 5 and 6 may be used as state indicators or for frequency and direction inputs. In this case, input 5 is used to measure the frequency, and input 6 the direction.

The measured frequency is multiplied by the **Scale** value and displayed under **Frequency**. A negative frequency indicates a reverse direction of rotation. Pressing **Set** and **SCALE** may change the scaling.

3.6.5 Digital Outputs (Module D_Out)

The four digital outputs are open collector outputs and require an external pull-up arrangement. The maximum load is 100mA at 30V.



Digital output settings

The following settings are available:

VALUE Sets which measurements the output is to depend upon, such as Vdc.

COND The threshold condition is set here.

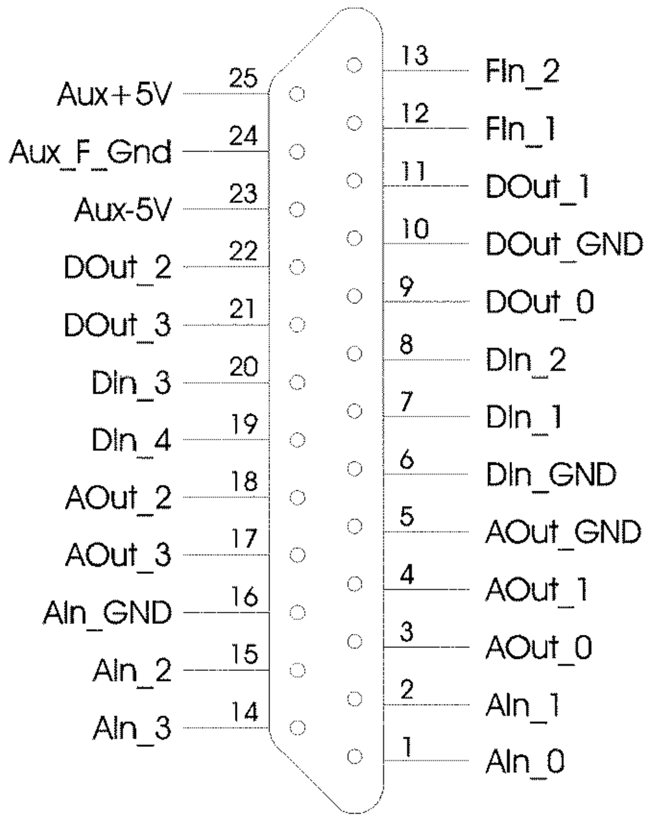
- on The output is always high.
- off The output is always low.
- >= The output is high only if the **VALUE** is greater than or equal to **LIMIT**.
- < The output is high only if the **VALUE** is less than the **LIMIT**.

LIMIT Sets the threshold limit to be compared to **VALUE**.

Example Select 'Itrms >= 164.00mA'. The output will be high impedance, whenever the trms current is greater than or equal to 164mA.

3.6.6 Connector

All connections are made through the 25-way D-type socket, marked **Analog I/O** on the rear panel of the instrument.



Pin-out of the analog I/O connector

3.7 Installing New Options

Some new options may be purchased and enabled without returning the unit to the manufacturer. For this purpose, a software key will be given that can be entered into the PMι and enables the option in the software.

Option keys are 24-character long hex values.

To enable a new option:

- Press the **I/F** key.
- Press the **Key** softkey.
- Press the **Key** softkey again.
- Enter the software key exactly as printed.
- Press **End**, and the new option will be installed.

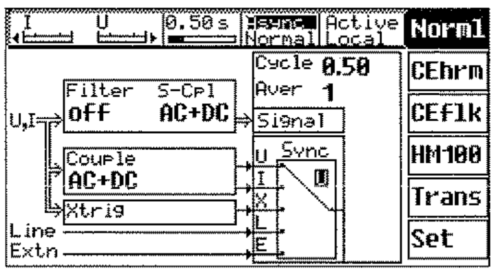
Contact Voltech if you encounter any problems (contact details in section 1.7).

4 Measuring Modes

4.1 Normal Measuring Mode

The normal measuring mode is the usual mode for making standard measurements. It can be selected and configured under the **Set Up** menu.

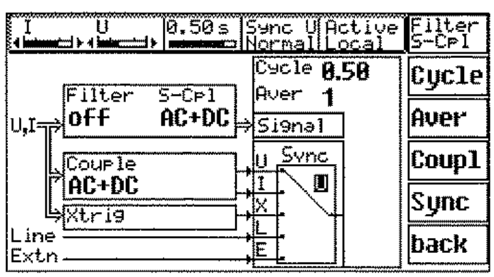
4.1.1 Settings



Normal measuring mode set-up

After selecting normal measuring mode in the **Set Up** menu, a schematic is displayed showing how the synchronization and signal waveforms are manipulated.

By pressing the **Set** softkey, you will see the following display. The meanings of the settings are given below.



Normal measuring mode set-up

Cycle Time At the end of each cycle time, the measured values are calculated from the sample values, and the display is updated. The cycle time must be greater than the period of the measured signal, and between 0.05 and 60 seconds. This is the reading update rate.

Aver The averaging sets how many measuring cycles are averaged on the display. This setting may be used to smooth out fluctuations, but may result in a slow response to changes in inputs.

Couple If the voltage or current inputs are used for synchronization, then the coupling may be used to modify the waveform.

AC+DC The signal is directly coupled.

BP A band-pass filter is applied, passing only components between 10 and 300Hz.

AM The signals are demodulated and the envelope of the waveform used.

Sync Selects the signal used for synchronization of measurements. The period of this signal will be used for the calculation of other values. Synchronization may be set to the voltage or current channels, the line frequency, or to an external input.

Filt/S-Cpl Selects which filters are active. The filters do not affect synchronization. See section 9.3.6 for the filter specifications. S-Cpl is the synchronization coupling and can be either AC+DC or just AC.

4.1.2 Display of Values

The menu keys may be used to display the values measured by the PMε. The table below shows which values are displayed under each menu.

W, V, A	A	V	W	W-h	Custom
Itrms	Itrms	Utrms	P	EP	var0
Utrms	Iac	Uac	Q	EQ	var1
P	Idc	Udc	S	ES	var2
S	Ipp	Upp	PF	q	var3
Q	Irect	Urect	f	Pm	var4
PF	Icf	Ucf	Z	Qm	var5
f	Iff	Uff	Rser	Sm	var6
z	Iinr	f	Xser	t	var7

Notes *1* The **W-h** menu is used in conjunction with the integrator feature. Refer to section 3.5 for more details.

2 The values under the **Custom** menu may be redefined by the user to have different names.

3 Definitions of all values listed may be found in section 9.1.1.

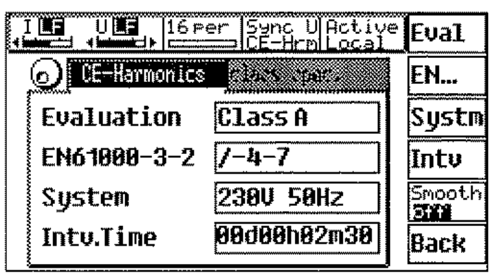
The **Graph** menu may be used in scope or plot modes.

For further details, refer to:

4.2 CE-Harmonics Measuring Mode

In this mode, the PMℓ acts as a precision harmonic analyzer, capable of comparing the equipment under test to IEC61000-3-2 including the prA14 amendments now published in the *Official Journal for the EMC, Low Voltage, and Machinery Directives* (OJ). Refer to section 6.2 for further details on how to test compliance to IEC standards.

4.2.1 Settings



CE-harmonic mode settings

In this mode, the synchronization is fixed to the voltage input. The other settings may be configured under the **Set Up** menu. The PMℓ will also be set to the proper manual range; auto-ranging is not allowed.

Eval Selects the class the equipment is to be tested to. Classes A, B, C or D may be used. Use the rotary knob to select the class you want to test to.

EN Chooses which published EN standard you can test to in accordance with the versions of the standard published between 1993 and 1997.

Systm This should be set to the supply voltage and frequency used.

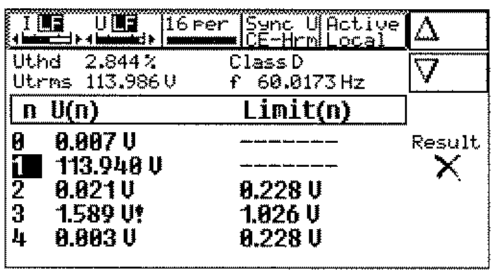
Intv Sets the observation time for a fluctuating harmonics test. The minimum compliant observation time is 2:30 minutes.

Smoth When selected, a 1.5s low-pass filter is enabled. This should be selected for compliant analysis.

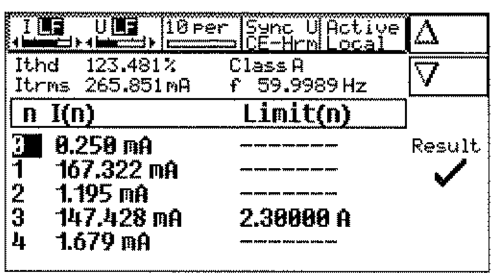
Note that auto-ranging is not possible in this measuring mode, because continuous measuring is required by the standard. It is important to select the correct range carefully before carrying out tests.

4.2.2 Instantaneous Fluctuating Harmonics Analysis

The first 40 harmonic components of voltage and current may be displayed under the **V** and **A** menus. The limit for each harmonic is calculated according to the IEC standard and class set in the **Set Up** menu. The measurements may be printed out using the **Hold** and **Print** keys.



Display of voltage harmonics



Display of current harmonics

A '!' indicates that the measured value exceeds its limit. A '?' indicates that the harmonic is between 100% and 150% off the limit, which may lead to a fluctuating harmonics failure.

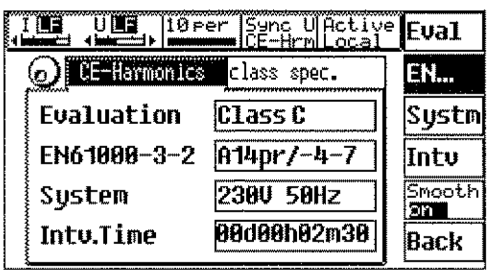
Note:
If no limit applies, then it is displayed as '-------'. This will be displayed if the current harmonic is less than 0.6% of Rms or 5mA, whichever is greater.

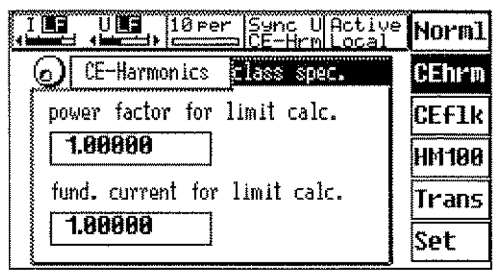
A summary pass/fail is indicated by a '√' or 'X' under **Result**.

4.2.3 Timed Fluctuating Harmonics Analysis

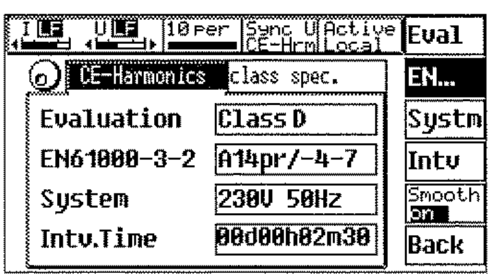
Fluctuating harmonics testing requires that the PMℓ monitors the harmonics over a suitable interval. In order to view this mode, press the W-h key and when you are ready, press the **Start** key. The analysis will then run for the keyed-in observation time, usually 2:30 minutes. At the end of this analysis, one can verify each harmonic that has been detected. The harmonics displayed now are the arithmetic average of the measured values for each DFT time window over the entire observation period.

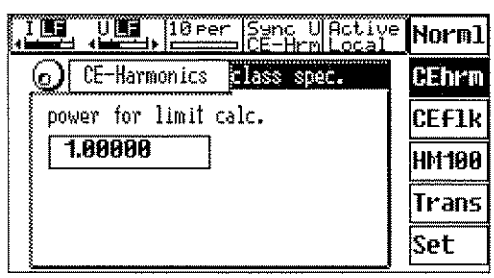
If you are testing to Class C, and you select A14 pr/-4-7, you can then further enter the power factor and fundamental current for limit calculations by rotating the knob switch once to the right. If you have selected Class C and A14pr/-4-7, the following screen is where these values are independently entered.





If you have selected Class D, then the following screens will be viewed.





One clockwise rotation on the rotary knob gets you to the second screen, where the limits for either power factor and fundamental current or power for class D are entered. Once you have entered those values, go back to the set-up screen by one counterclockwise rotation of the rotary knob.

Note: Be aware that when testing your product, you must allow at least ten seconds before you press **Start**. This guarantees that the inrush current will not affect your test results. For compliant testing, you should now go to the harmonic analysis screen by pressing the **W-h** key and allowing 10 seconds. To transition after you power your device on, press **Start** and allow the observation time to completely run down to zero seconds.

The time interval may be configured in the **Set Up** menu, the **Start** and **Stop** keys on the front panel, or remotely through communications control timing.

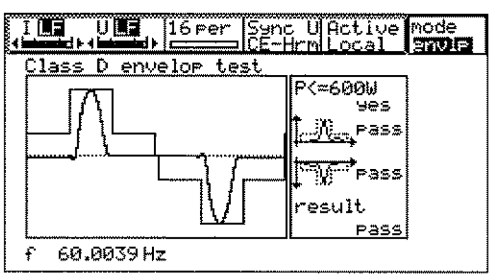
The harmonic order or # n is indicated on the left side. You can scroll through the results by using the rotary knob. Failing harmonics for either current or voltage are indicated via a "**!**" in the two columns on the right-hand side of the display.

These test results can be printed by connecting a parallel printer to the printer port on the back of the PM*e* and selecting ASCII format from the logging menu.

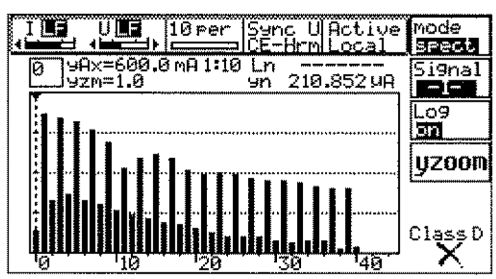
4.2.4 Viewing CE Harmonic Bar Spectrum via Graphical Display

The graphical function may be used to display the harmonic spectrum. It can also be used to show the current waveform and envelope for Class D equipment.

The **Graph** menu key accesses the graphical mode, and the **mode** softkey switches between spectrum and envelope displays.



Class D envelope detection



Harmonic bar spectrum

One can view the harmonic voltage spectrum with or without limits as well as the harmonic current spectrum with or without limits by repeated presses of the **Signal** softkey. The rotary knob can be used to position the harmonic order # cursor on the harmonic in question. As you move this cursor to the next harmonic, you will view the actual measured value (yn) or the limit for it (Ln) just above the bar spectrum. In the example above, the full scale of the x axis is 600 mA, which is the y axis value. You may also view the bar spectrum with the log on function selected or off.

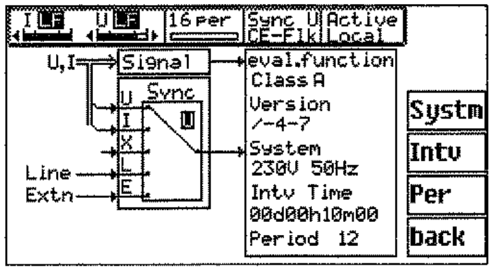
For further details, refer to:

4.3 CE-Flicker Measuring Mode (Option OP01)

This instrument mode enables pre-compliance testing of equipment for flicker to EN61000-3-3, in accordance with IEC868 / IEC6100-4-15 flicker meter design specification.

The PMɛ monitors the equipment for flicker over several short intervals, normally ten minutes. This time interval may be configured in the **Set Up** menu, the **Start** and **Stop** keys on the front panel, or remotely through communications control timing. By pressing the **W-h** button, the values for pst, plt, dc, dmax and elapsed time can be viewed. Pressing the start key initializes the testing. After starting, there is a 20-second delay before timing begins and readings are taken. The test will end automatically, but may be stopped early by the user.

4.3.1 Settings

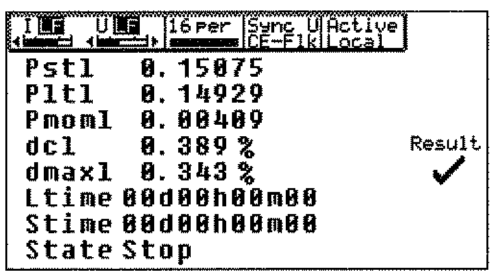


CE-flicker mode settings

The synchronization is fixed to the voltage input. The other settings for this mode may be configured under the **Set Up** menu.

Systm This should be set to the supply voltage and frequency used.
Intv Sets the duration of a short-term test.
Per Edits the number of short-term intervals in a long-term interval.

Note that auto-ranging is not possible in this measuring mode, because continuous measuring is required by the standard. It is important to select the correct range carefully before carrying out tests.



CE-flicker mode results

In the example above, the PMℓ period was set to 2, so two independent Pst values were generated and ultimately plt could be analyzed; 0.14929 in this example. The period for plt is normally set to 12, and the pst observation time is ten minutes, so plt normally is a two-hour event. Results can be printed or saved to the PCIM memory card, if installed.

Meaning of flicker values

Pst Short-term perceptibility
Plt Long-term perceptibility
Pmom Instantaneous flicker
dc Relative steady-state voltage change
dmax Maximum relative voltage change
Ltime Time remaining for the long-term test
Stime Time remaining for present short-term test
State State of the evaluation; may be *reset*, *starting*, *running*, or *stop*

4.3.2 Display of Measured Values

The menu keys may be used to display the values measured by the PMč. The table below shows which values are displayed under each menu.

W, V, A	A	V	W	W-h	Custom
Itrms	Itrms	Utrms	P	Pst	var0
Utrms	Ithd	Ithd	Q	Plt	var1
P	F	F	S	Pmom	var2
S			PF	dc	var3
Q			f	dmax	var4
PF			Z	Ltime	var5
f			Rser	Stime	var6
z			Xser	State	var7

Notes *1* The **W-h** menu displays the flicker results and fluctuating results for the entire observation period.

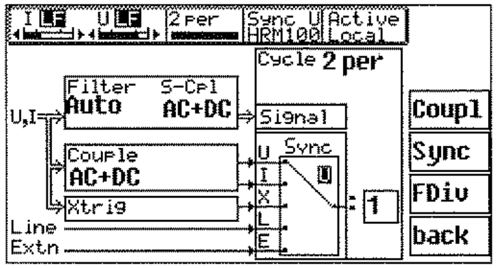
2 The values under the **Custom** menu may be redefined to have user-defined names.

3 Definitions of the values listed may be found in section 9.1.1.

4.4 100 Harmonics Measuring Mode (Option OP05)

In this mode, the PMč acts as a precision harmonic analyzer, calculating the first 100 harmonics of voltage, current, and power.

4.4.1 Settings



100 harmonics mode settings

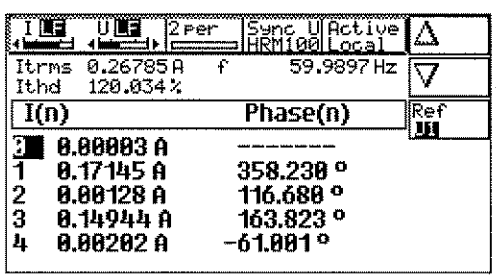
The settings may be configured under the **Set Up** menu.

Coupl If the voltage or current inputs are used for synchronization, then the coupling may be used to modify the waveform.

- **AC+DC** The signal is directly coupled.
- **BP** A band-pass filter is applied, passing only components between 10 and 300Hz.
- **AM** The signals are demodulated and the envelope of the waveform used.

Sync Selects the signal used for synchronization of measurements. The period of this signal will be used for the calculation of other values. Synchronization may be set to the voltage or current channels, the line frequency, or to an external input.

FDiv Defines the frequency division of the basic wave.



100 harmonics mode settings

Once you have selected all of the set-up conditions in 100 harmonics mode, you can then view current harmonics by pressing **A**, voltage harmonics by pressing **V**, and power harmonics by **W**.

Example When **FDiv** is set to 1, and the frequency of the input wave is equal to 50Hz, the frequencies of the harmonics will be:

Harmonic order	1	2	3	4	5	6	...
Frequency	50	100	150	200	250	300	...

If, however, **FDiv** equals 2 and the same synchronization is used, the frequencies of the harmonics will be:

Harmonic order	1	2	3	4	5	6	...
Frequency	25	50	75	100	125	150	...

The filter to be used is automatically selected, based on the basic wave frequency. See section 9.1.4 for more details.

4.4.2 Display of Measured Values

The **W, V, A** and **Custom** keys give the same lists of measured values as in other modes.

The **A** and **V** keys list the first 100 harmonics, giving both magnitude and phase. A softkey has been added to the 100^{th} harmonics set-up screen to allow the user to define the reference signal as being either the voltage or current. If for example **U1** was selected as the reference, then you will see the phase angle associated to the fundamental as being zero degrees. If you press the **Ref** softkey again, where **I1** is now selected, you will see a phase angle for the voltage fundamental other than zero. Based on your application, you may want to set **I** as the reference.

The **W** menu can be used to display the harmonics of P, Q, or S. The **List** softkey is used to select between P, Q and S harmonics.

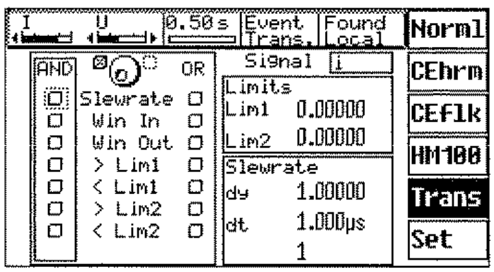
The **Graph** menu may be used to display the spectrum graphically. See *3.3.3 Spectrum Display* for more details.

4.5 Transient Measuring Mode (Option OP03)

The transient mode allows the PM*ε* to monitor for particular events in the signal. The graphical display can then be used to investigate the waveform before and after the event.

After setting up the search, it may be started by pressing the **Start** button. The PM*ε* is now armed, awaiting the event to cause the trigger capture. Pressing the **Stop** key will end the search.

When an event has been detected, **Found** will be displayed. The **Graph** function may then be used to investigate the waveform (see *3.3.1 Scope Function*).

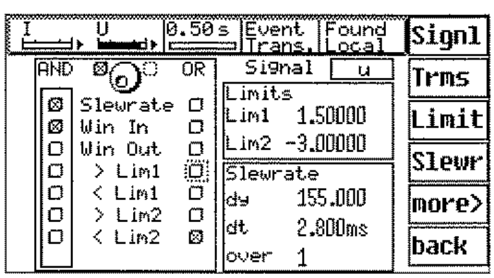


Transient Mode Selection

4.5.1 Settings

The transient mode can be set up with the **Set Up** menu key, followed by the **Trans** and **set** softkeys.

Note that the voltage and current ranges must be set manually in this measuring mode.



Transient settings

The window on the left of the display shows the requirements for an event to occur. An event will be raised, when all conditions in the **AND** column or any in the **OR** column are found. These conditions may be selected with the rotary knob and the **Enter** key.

The condition **Win In** and **Win Out** refer to the window with upper limit **Lim1** and lower limit **Lim2**.

The settings may be configured as follows:

Signl Selects the signal to be monitored. Available options are: *i, i*i, u, u*u, p, ifilt, ufilt, pfilt.*

Trms Allows the filter, synchronization and coupling options to be changed. These are described in section 4.1.1.

Limit Sets the limit values.

Slewr This sets the slew rate limits. There are three values that may be configured:

- **dSig** The required change in signal level.
- **dt** The time interval over which the change must occur.
- **overx** Where x is the minimum number of sample values over which the slew rate must occur. This reduces the possibility of the slew rate occurring over only a small number of samples.

Example It is required to capture the voltage waveform when a rise time of 3.5V in 450µs is observed. Set **dSig** to 3.5 and **dt** to 450µs. Whenever a rate of change of 7.777V/ms is observed, the PMε will capture the waveform. However, it is possible for noise to cause the same rate of change between two successive samples. The **overx** value can be used to prevent an event from occurring over a low number of samples.

Tdur Sets the minimum duration for which a condition must be met before an event is raised.

Example If the duration is set to 5ms and the PMx is set to check for values over **Lim1**, an event will only occur when the signal has been greater than **Lim1** for at least 5ms.

TRec Allows the recording time to be set. This may be limited by available memory.

PreTr Sets the percentage of memory that is reserved before the event occurs.

Example If the pre-trigger is set to 30%, and the record time is 0.50s, then 0.15s of signal before the event occurs will be stored, and 0.35s afterwards.

5 Communications (Option PMι-com or OP-10)

This chapter is divided into four sections:

The communication command sets, which the PMι uses, are detailed in section 8.

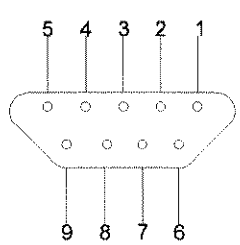
5.1 Devices

The devices are the different types of interface available for communication between the PMι and an external system. They may be set in the **I/F** menu with the softkey **Dev** softkey.

The **Dev** softkey cycles through the available interfaces and allows the settings of each one to be configured.

5.1.1 COM1 RS232/RS485

To connect COM1 to a standard PC, a 1:1 cable should be used. The rear-panel connector is a nine-way Sub-D socket.



COM1 pin-out

RS232 connections

Pin	1	2	3	4	5	6	7	8	9
Connection	n/u	TxD	RxD	n/u	GND	n/u	CTS	RTS	n/u

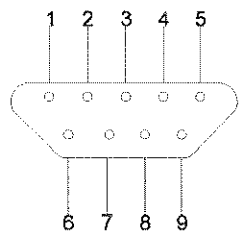
RS485 connections

Pin	1	2	3	4	5	6	7	8	9
Connection	TA	n/u	n/u	RA	n/u	TB	n/u	n/u	RB

n/u denotes 'not used'. These pins should not be connected when using this communications standard.

5.1.2 COM2, RS232

To connect COM2 to a PC, a null-modem cable must be used. The connector is a nine-pin Sub-D plug.



COM2 pin-out

RS232 connections

Pin	1	2	3	4	5	6	7	8	9
Comment	DCD	RxD	TxD	DTR	GND	DSR	RTS	CTS	RI

5.1.3 GPIB

The GPIB interface is based on the IEEE488.2 standard. The PMι address may be set in the **I/F** menu, when selected under **Dev**. Any values between 1 and 30 are valid.

The ending character used is <lf> (linefeed, hex 0A, decimal 10). At the end of a transmission by the PMι, the <lf> ending char is sent and the EOI line is set.

At the end of a data transmission to the PMι, either the <lf> itself must be sent, or the EOI line must be set with the last data byte.

The connector used is a standard 24-pin micro-ribbon socket.

5.1.4 Parallel Port

The pin-out is the same as a standard parallel port on a PC. It is a parallel printer compatible, 25-way Sub-D socket.

5.2 Remote Control

The PM*c* may be fully controlled over its communications interface. Details about the command sets are given in section *8.1 Remote Control.*

The settings for remote mode can be found under the **I/F** menu, by pressing the **Remote** softkey. The resulting menu has two settings:

Device Sets over which device remote control is to be established. *Note that a device may not be used for both logging and remote control.*

Mode Shows the present control mode. The softkey may be used to toggle between local and remote.

These settings can be automatically loaded when the instrument is powered up by use of the DIP switches (see below).

5.2.1 Set-up Using DIP Switches

The DIP switches located on the rear panel may be used to configure the remote control settings of the instrument.

Bit	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
IEEE	1	0	1	Mode		x	x	x	x	x	x	IEEE Address				
Other	Device			Mode		x	x	Echo	Protocol		EOS			Baud		

'x' denotes that a bit is not used.

Device

Bit 16	15	14	
0	0	0	Set-up only from menu. All other switches are ignored.
0	0	1	Select COM1 with RS232 levels
0	1	0	Select COM1 with RS485 levels
0	1	1	Select COM2 with RS232 levels
1	0	1	Select IEEE488 port

Mode

Bit 13	12	
0	0	Local mode
1	0	Remote mode

Echo

Bit 9	
0	Echo off
1	Echo on

Protocol

Bit 8	7	
0	0	No Protocol
0	1	RTS/CTS

EOS

Bit 6	5	4	
0	0	0	<lf>
0	0	1	<cr>
0	1	0	<cr><lf>
0	1	1	Terminal

Baud rate

Bit 3	Bit 2	Bit 1	
0	0	0	1200
0	0	1	2400
0	1	0	4800
0	1	1	9600
1	0	0	19200
1	0	1	38400
1	1	0	57600
1	1	1	115200

IEEE Address

Bits 5 to 1: Specify the IEEE address of the PMι. Binary value, with bit 5 as the most significant bit.

Example 1 It is required that the instrument start up with remote control on COM1, RS232, remote mode, echo on, no protocol, terminal EOS at 57,600 baud. The DIP switches should be set to:

Bit: 16... ...1
Settings: 0 0 1 1 0 x x 1 0 0 0 1 1 1 1 0

Example 2 Set IEEE and local control with the PMι at address 10:

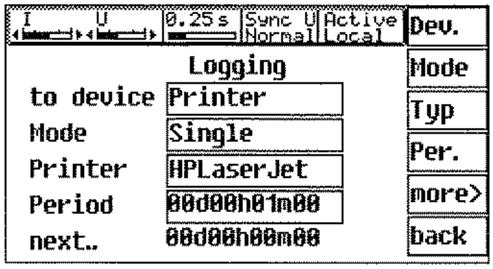
Bit: 16... ...1
Settings: 1 0 1 0 0 x x x x x x 0 1 0 1 0

5.3 Printing and Logging

All menus, measured values and graphs can be stored to a printer or memory card, if installed, or sent to the serial communications ports.

5.3.1 Settings

Logging can be configured in the **I/F** menu, by pressing the **printer** softkey.



Logging menu

The purpose of each setting in this menu is given below.

Dev. Sets the device to which data should be logged. **Note that a device may not be used for both remote control and logging.**

Mode Selects the logging mode from the following:

Single	Data is stored only when requested.
Cycle	Data is stored at the end of each measuring cycle.
Integral	Data is stored at the end of an integration interval.
Periodic	Data is stored at periodic intervals.

Typ Changes the printer driver.

Per. Defines the period for periodic logging.

next Shows the time remaining until the end of the period.

Head Sets the header text, shown at the top of all logged data.

If the required printer driver is not available, ASCII format may still output correctly. Formats can be selected after pressing the **Print** key (see below).

5.3.2 Printing

Select the menu required and press the **Print** function key. The logging window appears showing the current state and settings.

Three softkeys are available:

Form Selects the output format (see below).
formf Ejects the paper from the printer.
linef Produces a single-line feed.

If there is a print job currently running, it may be canceled with the **Enter** key. Otherwise, printing may be started by pressing the **Enter** key.

5.3.3 PCMCIA (Option OP02)

If the output device is the PCMCIA slot, then different functions are available. Some of the functions require that no job is running.

File Sets the file name used for logging. Up to eight characters may be used. The file name automatically ends with '.100', for the first file to be logged with that name, '.101' for the second, and so on.

List Switches between displaying directory and status information.

dir Displays a list of files on the memory card is displayed.

state Shows information about the memory card: write protect status, battery state, format type and free space available.

Del* Deletes the marked files.

Mark* Marks or unmarks the selected file. Marked files are shown shaded.

Form Selects the format to use (see above).

Erase Re-formats the memory card. All data on the card will be lost.

5.3.4 Data Formats

There are five data formats available in the PM*e*:

ASCII The data is output as text, with no special characters.

Bitmap The output is formatted in bitmap format for uses such as screen capture.

Table See definition below.

Binary See definition below.

Graphic The data is formatted according to the selected printer driver.

The **Table** and **Binary** formats are very similar; they both have several lines of ASCII header information, but the representation of the data itself differs. The meaning of each variable is described below:

REM The header text, as entered under the **I/F printer** menu, is shown here.

TYPE Specifies the type of stored values:
Normal values
Harmonic values
Normal samples

DATE Date when logging started (dd.mm.yy).

XN Shows in which column the time is given.

X0 Time when logging started (hh.mm.ss).

FREQ Frequency of the signal, when storing sample values.

YCOLn Describes the data in column 'n', as shown on the display. (Value/Units)

DX Time interval between loggings, in seconds. DX is not stated when XN is given.

VAL_LEN Defines how many ASCII characters are used to state each measured value.

YFACT The factor by which sampling values should be multiplied to obtain the real values.

DATA_BINARY In this case, the data is expressed in ASCII format of each hex digit. The data is a stream of characters; the length of each measured value is stated in **VAL_LEN** above.

Example
The byte <3Fh> is represented by <33h><46h>, the ASCII representation of the characters '3' and 'F'.

DATA_ASCII Data is given as floating point values in ASCII. Values taken at the same time are separated by one or more spaces, while values taken at different times are separated with <CR><LF>.

Example
The following is the same data printed out in *table* and *binary* formats. Shown are the first four values of the **Custom** menu.

In *table* format:

```
REM
TYPE=NORMAL
DATE=23.11.1999
XN=0
X0=12:29:48
DX=0.0E+00
YCOL0=Itrms/A
YCOL1=Utrms/V
YCOL2=P/W
YCOL3=PF/
DATA_ASCII=
 2.79694E+00  115.663E+00  202.834E+00  626.993E-03
```

In *binary* format:

```
REM
TYPE=NORMAL
DATE=23.11.1999
XN=0
X0=12:29:48
DX=0.0E+00
YCOL0=Itrms/A
YCOL1=Utrms/V
YCOL2=P/W
YCOL3=PF/
VAL_LEN=8
DATA_BINARY= 4033010E42E753A0434AD5963F20829D
```

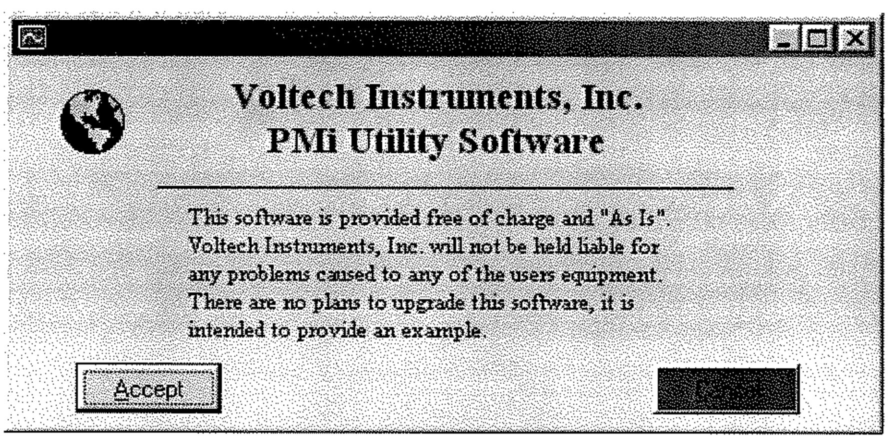
5.4 Examples

Many of the examples, which follow, use the PMi utility software.

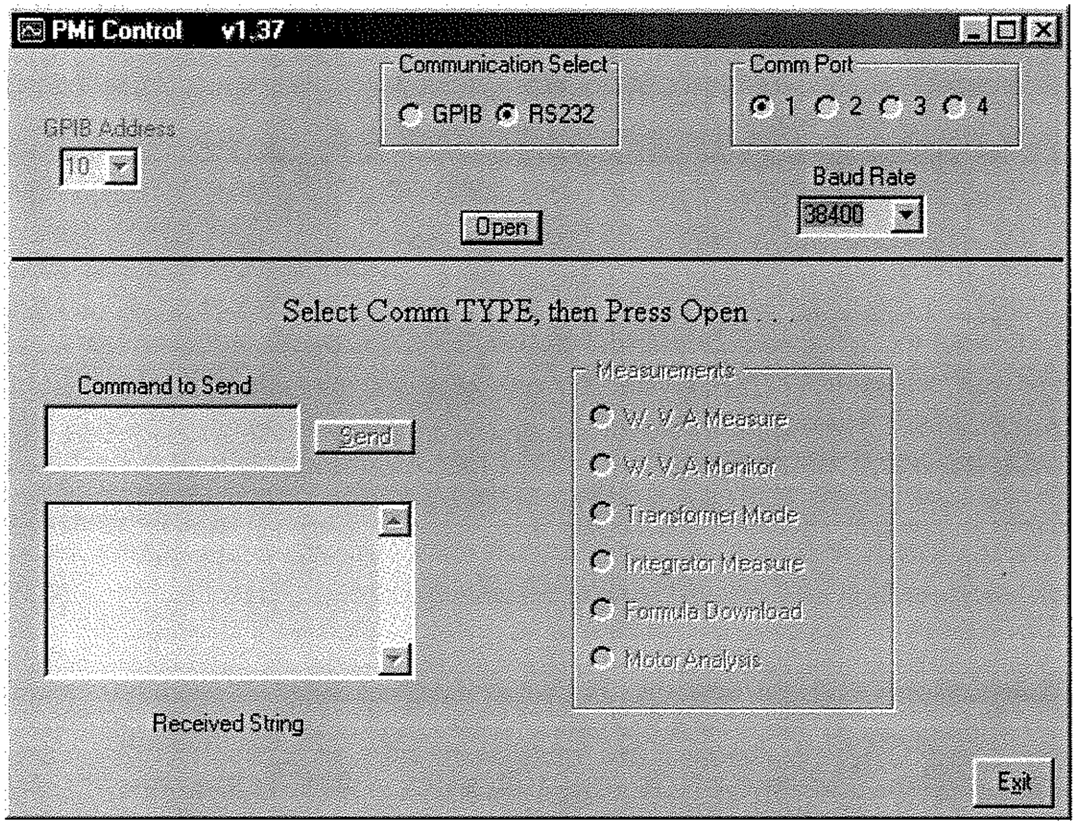
Example 1: Testing Communications

To test the communications between a PC and the PMi, it is recommended that Voltech's PMi utility software be used. The software can be downloaded from the Voltech Web site at www.voltech.com.

After installing the software and executing the desktop icon, the following screen will come up.

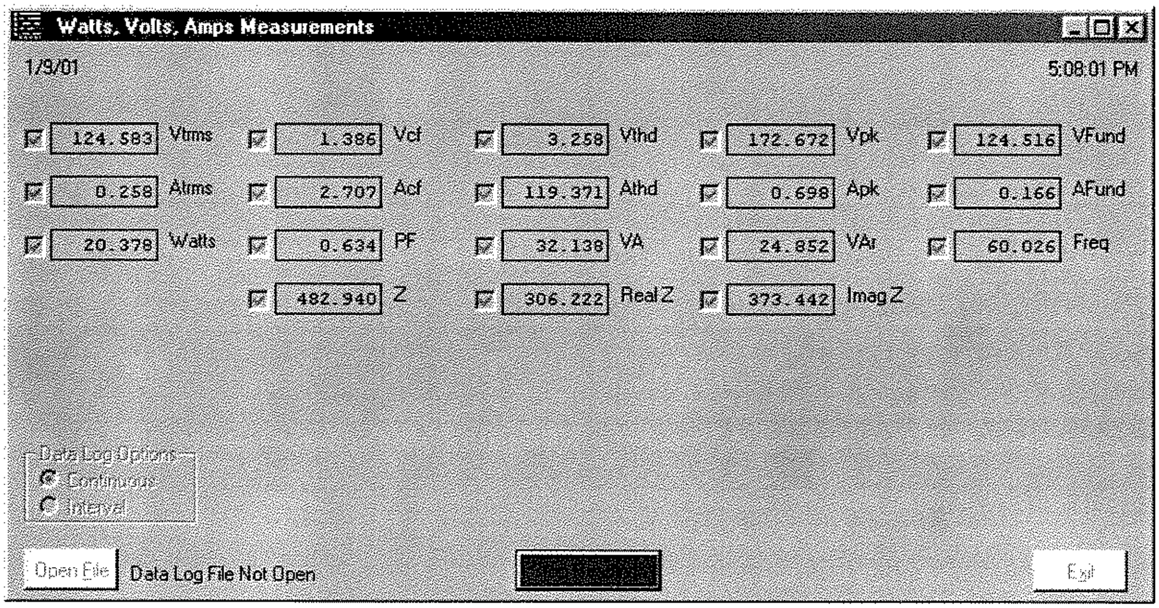


After pressing the **Accept** button, the following screen will appear.

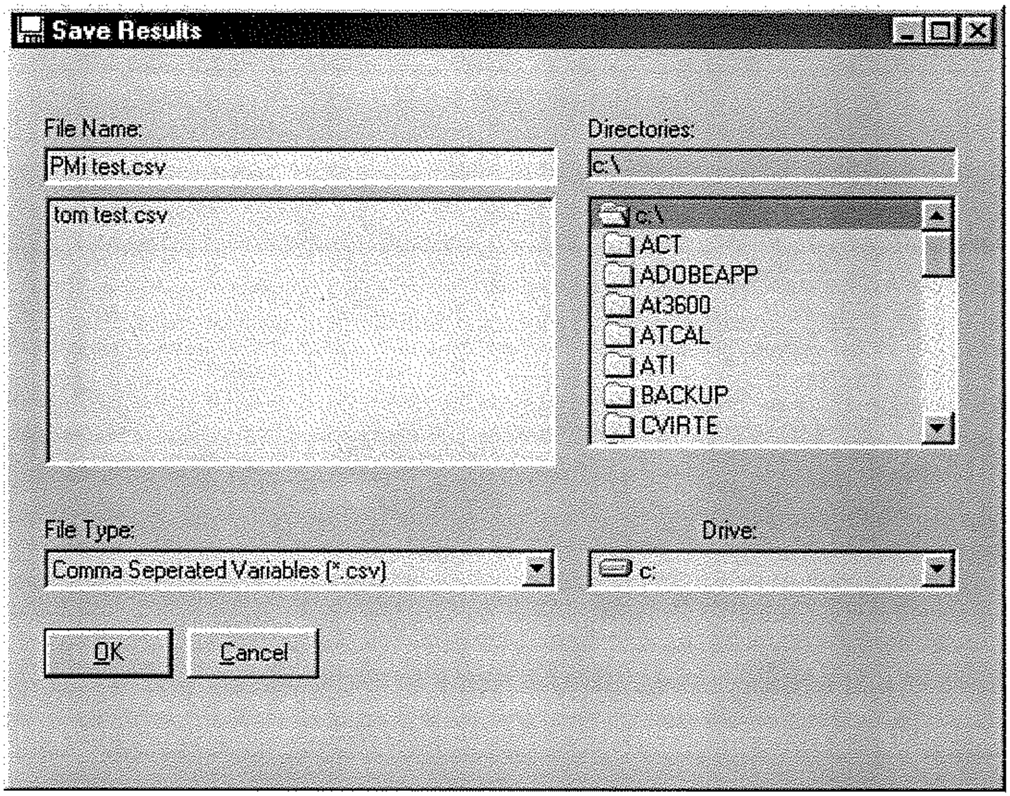


Pressing the **Open** button, after having selected COM port 1 and baud rate, the display will show that the PMί is now in remote mode. The PMί utility program provides an easy way to perform many PMί-related tasks, including saving results back to the PC in a .csv file format, recognizable by Excel or other spreadsheet programs. There are six different modes or screens that you can measure for. The program is written in Visual Basic, and it could be enhanced further by the end user, if required.

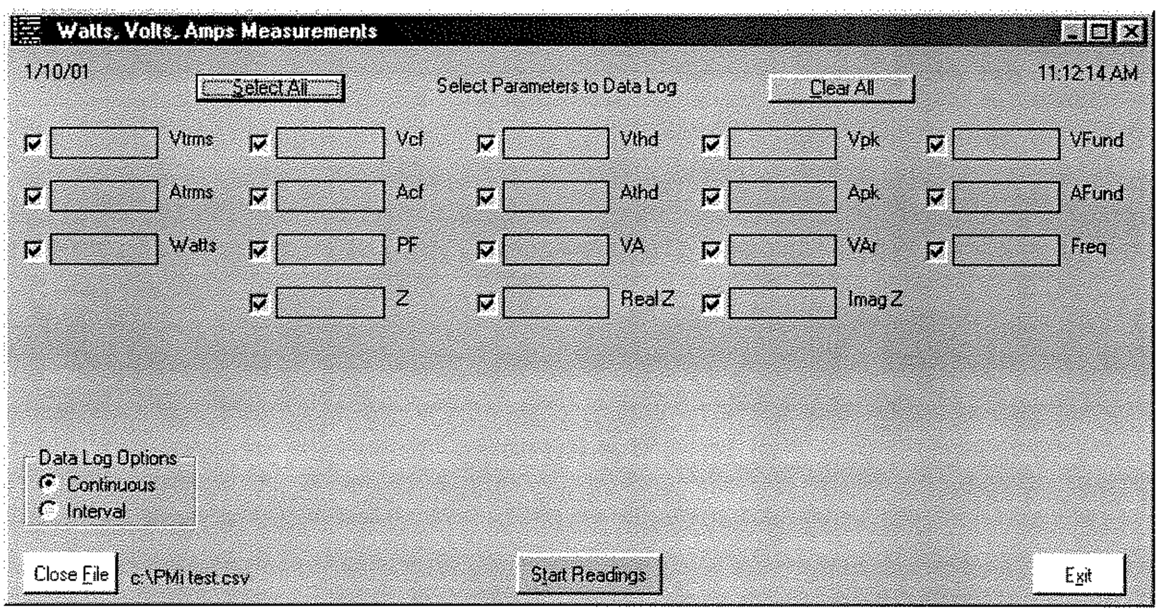
Example 2: Logging to a PC



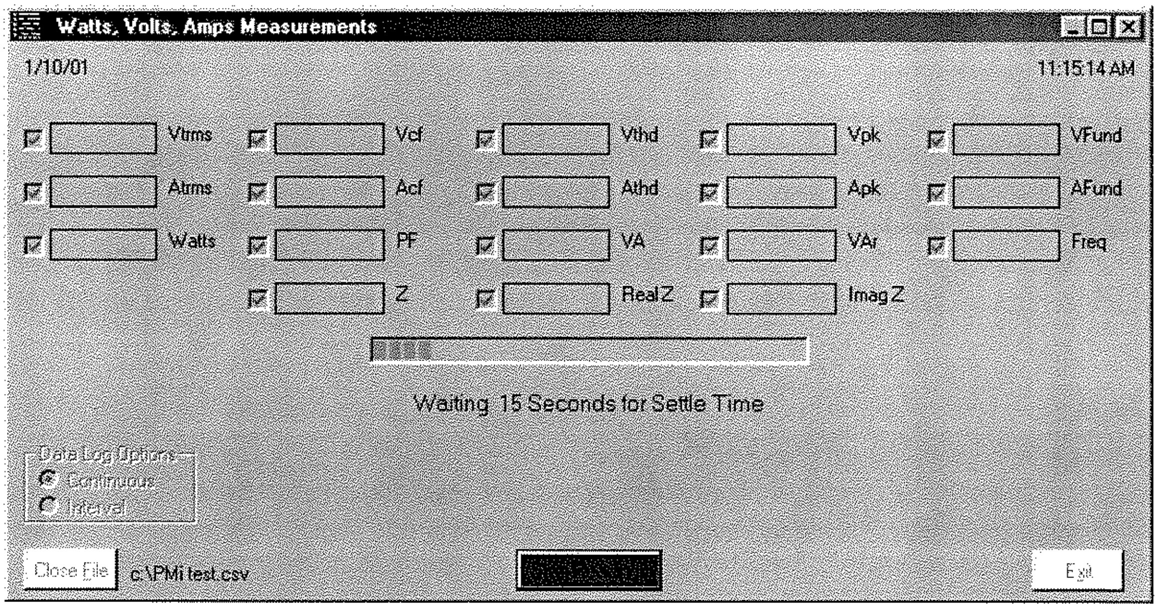
To store PMi measurements directly into a PC file, select the **Open File** button on the lower left portion of the screen. The following screen will appear. Type in a file name of your choice. This file will be your data log file. In this axample, **PMi Test.csv** was typed in as the file name, then press OK.



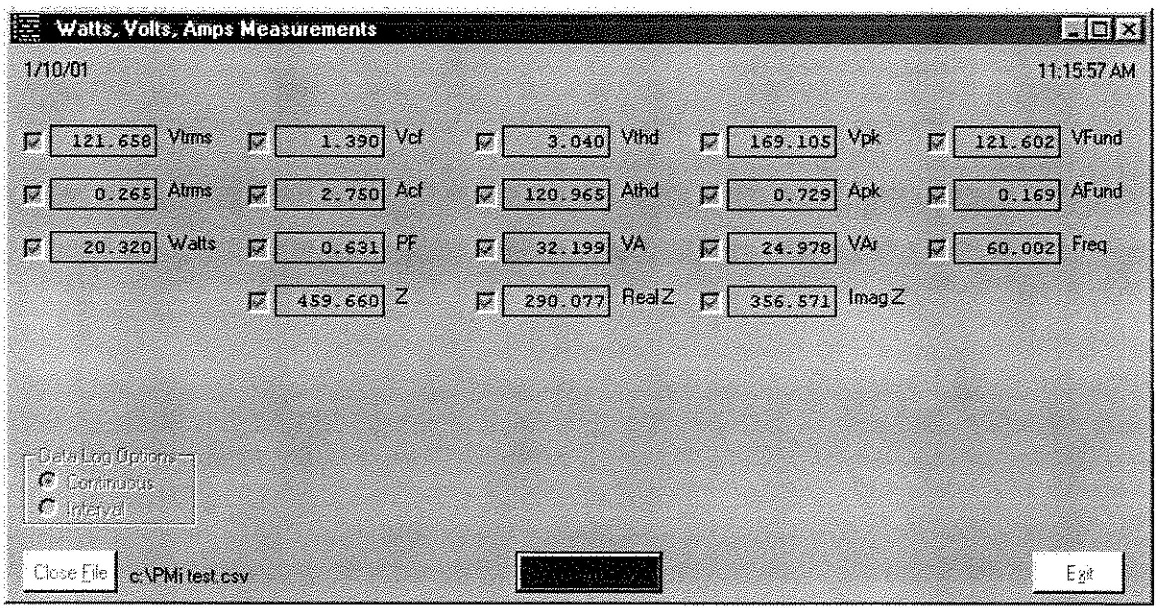
Now select the measurements you wish to log and choose **Continuous**. Your screen will look like this:



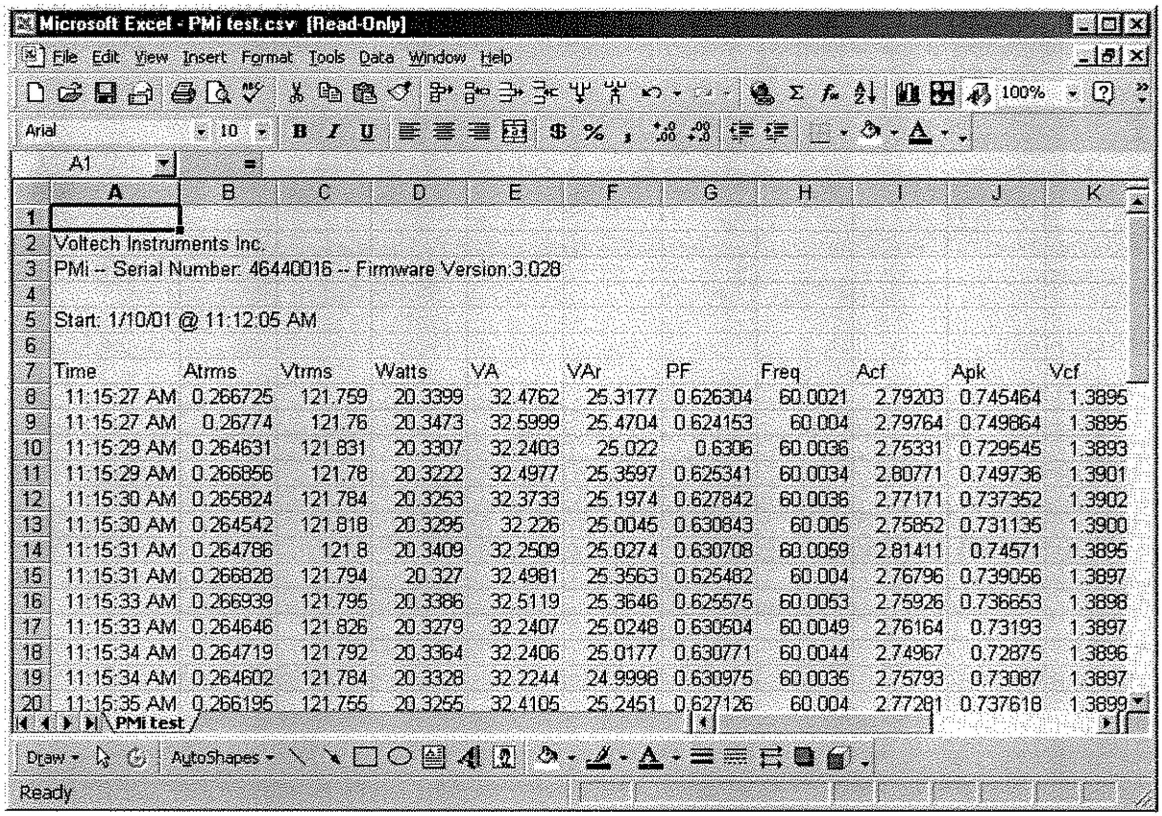
When ready, connect the unit under test (UUT) and press the **Start Readings** button. The following screen will appear:



After about 15 seconds, you will see measurements appear in the boxes you selected.



When you have acquired enough data, press **Stop Readings**. The data file we were logging to looks like this:



Microsoft Excel - PMi test.csv [Read-Only]

Voltech Instruments Inc.

PMi -- Serial Number: 46440016 -- Firmware Version:3.028

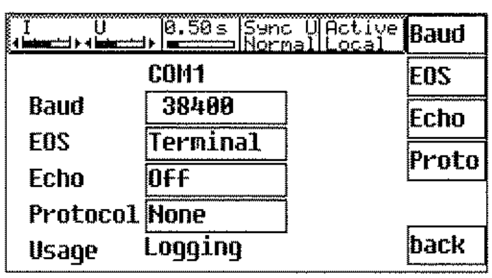
Start: 1/10/01 @ 11:12:05 AM

Time	Atrms	Vtrms	Watts	VA	VAr	PF	Freq	Acf	Apk	Vcf
11:15:27 AM	0.266725	121.759	20.3399	32.4762	25.3177	0.626304	60.0021	2.79203	0.745464	1.3895
11:15:27 AM	0.26774	121.76	20.3473	32.5999	25.4704	0.624153	60.004	2.79764	0.749864	1.3895
11:15:29 AM	0.264631	121.831	20.3307	32.2403	25.022	0.6306	60.0036	2.75331	0.729545	1.3893
11:15:29 AM	0.266856	121.78	20.3222	32.4977	25.3597	0.625341	60.0034	2.80771	0.749736	1.3901
11:15:30 AM	0.265824	121.784	20.3253	32.3733	25.1974	0.627842	60.0036	2.77171	0.737352	1.3902
11:15:30 AM	0.264542	121.818	20.3295	32.226	25.0045	0.630843	60.005	2.75852	0.731135	1.3900
11:15:31 AM	0.264786	121.8	20.3409	32.2509	25.0274	0.630708	60.0059	2.81411	0.74571	1.3895
11:15:31 AM	0.266828	121.794	20.327	32.4981	25.3563	0.625482	60.004	2.76796	0.739056	1.3897
11:15:33 AM	0.266939	121.795	20.3386	32.5119	25.3646	0.625575	60.0053	2.75926	0.736653	1.3898
11:15:33 AM	0.264646	121.826	20.3279	32.2407	25.0248	0.630504	60.0049	2.76164	0.73193	1.3897
11:15:34 AM	0.264719	121.792	20.3364	32.2406	25.0177	0.630771	60.0044	2.74967	0.72875	1.3896
11:15:34 AM	0.264602	121.784	20.3328	32.2244	24.9998	0.630975	60.0035	2.75793	0.73087	1.3897
11:15:35 AM	0.266195	121.755	20.3255	32.4105	25.2451	0.627126	60.004	2.77281	0.737618	1.3899

Example 3: Printing Measurements

1. Setting up the PMі

- Under **I/F**, **printing**, set the device to **COM1 RS232**, and the **Mode** to **Single**. Other settings are not relevant in this case.
- Under **I/F, Dev**, configure COM1 as follows:



2. Logging data

Enter the **V menu** and select **4 val**. To log values, press the **Print** function key. The message 'com1 state: Ready' should be displayed. Press the **Form** softkey, until the format is set to **ASCII** and press **Enter**.

The measured values of Utrms, Uac, Udc and Upp should be displayed in the terminal window as shown:

```
Utrms= 115.498 V
Uac= 115.498 V
Udc=-0.017 V
Upp= 320.977 V
```

If this does not work correctly, check the settings of the PMι and your PC. Ensure that a 1:1 cable connects the COM1 port of each and that no connections are broken or missing.

Example 4: Logging to the PCMCIA Card

To log P, Q, S and PF to the PCMCIA card.

- Under **I/F, logging**, select the **Device** as memory card and set the **Mode** to cycle.
- Insert the memory card.
- Select the **W menu**, with **4 val** display.
- Press the **Print** function key.
- Check that the card details are correct and that write-protect is turned off.
- Enter the **file name** to save to.
- Select the desired format, such as ASCII or table.
- Press **Enter** to start logging.

To finish logging, press the **Print** key and **Enter**.

Should you encounter problems during this operation, check that the memory card you are using is available under the **I/F** menu's detailed list. Ensure that the memory card is inserted and recognized correctly before the **Print** key is pressed.

6 Applications

This chapter gives details and advice on how to set up the PMε for application-specific measurements. It is intended to be a starting point to allow the user to get accurate and reliable results with minimal set-up time.

The following applications are covered:

6.1 Measuring Inrush Current

Inrush current can be measured using the following procedure.

1. Place the PMε into normal mode by selecting the **Norm** softkey from the **Setup** menu. By pressing the **Set** softkey, assure that the following are set: **Couple AC+DC, Filter off, Cycle 0.5, Average 1, Sync U.**
2. Press the **A** key and place the PMε into **8 Val** mode. You will notice that the **Inrsh** is blank. This is where the inrush measurement will appear.
3. Press the **Range** key and place both the **I** and **U** channels into manual range mode. Select the appropriate range for each based on the UUT requirements. For the current range, select a peak range that is high enough for the inrush you expect.
4. You can now go back to the **A** key, press the **Inrsh** softkey, and turn the UUT power on. The stabilized reading you will see is the inrush current of the UUT. If no reading occurred, verify that you have selected the appropriate peak range, keeping in mind that the highest peak range you may select is 960 A_{pk}.
5. Once you have successfully completed the inrush measurements, go back to the **Range** key and reset the voltage and current ranges from before. Then place the unit in auto range mode for both U and I.

It is recommended that the following settings be used:

Range V manual, I manual, set according to expected peak value.
Set Up Couple AC+DC, Filter off, Cycle 0.5, Average 1, Sync U.

6.1.1 Making Better Inrush Measurements With the PS1000

The Voltech PS1000 is a solid-state switch that controls the turn-on of an AC supply to allow accurate measurement of inrush current into an AC load. The turn-on point of the AC supply can be selected at either zero-degree crossing (for linear power supply front- end) or 90-degree crossing (for switch-mode supply front-ends).

To use a PS1000 with the PMℓ, refer to the PS1000 instructions. Having connected the PS1000 as shown in the instructions, the same settings may be used as in either mode above. Instead of powering up the UUT, press the **RUN** push-button of the PS1000. The inrush current will be captured in the same way as described above.

6.2 IEC Testing

The Voltech PMℓ has been carefully designed to meet all requirements to perform measurements according to the standards EN61000-3-2, EN61000-3-3, and EN61000-3-11.

6.2.1 Classes

The EN61000 standard defines several classes of equipment, each with different value limits.

Class A Balanced, three-phase equipment and all other equipment except those stated in one of the following classes.

Class B Portable tools.

Class C Lighting equipment, including dimming devices.

Class B Portable tools.

Class C Lighting equipment, including dimming devices.

Class D Equipment having an input current with a 'special wave shape', as defined in the standard, and an active input power P ≤ 600W. Whatever the wave shape of their input current, Class B, Class C, and provisionally motor-driven equipment with phase angle control are not considered Class D equipment.

6.2.3 Setting Up

The standard requires that the UUT be powered from an AC source that meets certain conditions. The PMℓ ensures that the harmonic content requirements of the standard are met, with its pass/fail indication of voltage steady-state harmonics.

6.2.4 EN61000 3-2 Fluctuating Harmonics Mode

To measure CE harmonics:

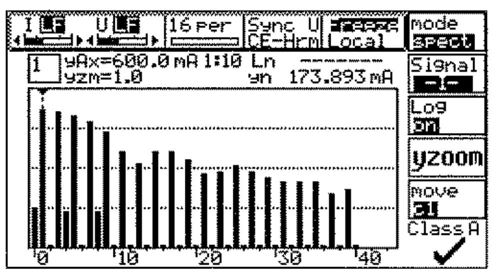
- Select **CE-hrm** measuring mode from the **Setup** key and then select the **Set** softkey.
- Select the class evaluation by pressing the **Eval** softkey and using the rotary knob to select either **A**, **B**, **C**, or **D**.
- If **C** or **D** are selected, additional information, like power factor and fundamental current for Class C and power for Class D, will need to be entered. To get to those screens, either class C or D need to be selected. You then turn the rotary knob one click clockwise, enter the required values via the alphanumeric keypad, and then press the **Enter** key. Once the values have been entered in either of these classes, a one-click turn of the rotary knob counter-clockwise will return you to the main **CE Hrm** set-up screen.
- Next, select the revision of the EN61000 standard that you wish to test to by pressing **EN**. The PMℓ currently supports even the new A14 pr amendments 1, 2, 3 and 4 to the EN61000 standard.
- Next, select the voltage system you will be testing on by selecting the **Systm** softkey. Pressing this softkey subsequently will show you the choices. Entering a choice will automatically set the proper voltage range. It should be noted that no range changes occur during this analysis.

- Next select the **Intv** softkey and define the observation period you wish to test to. The default is 2:30 minutes. Please note that the time protocal is dd:hh:mm:ss. The "." from the alphanumeric key pad inserts the ":" properly.
- Next, select the **Smooth** softkey, so that it is on. This envokes the 1.5 seconds constant filter, providing smoothing per the standard.

The **A menu** displays the measured current harmonics and their limits. A summary pass/fail indication for the UUT is given.

The **V menu** displays the measured voltage harmonics of the supply. A fail indication shows that the supply is not satisfactory for testing to the standard.

To run the CE Hrm test for the observation period you specified, press the **W-h** key and then press the **Start** key. The results given at the end of this process will be the harmonic answers with respect to the legal limits for the class that your product false into. You may send those results to a printer, as previously described.
The **Graph menu** can be used to display bar graphs of the results and limits (see *3.3.3 Spectrum Display*).



Graphical display of current harmonics

6.2.5 Flicker Meter

PM6 option OP01 is required to carry out flicker tests.

- Select **CE-flk** measuring mode.
- Set the correct **ranges** for the equipment supply. (Auto-ranging may not be used in this mode.)
- Set the **system** supply used.
- **Interval time** is the duration of a short-term test. The standard should be ten minutes, except in the case of an exception as detailed in the standard.

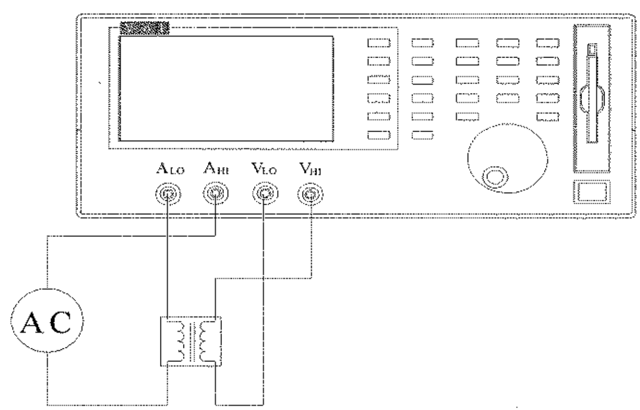
- **Period** is the number of short-term tests that make up a long-term test. This should be set to 12.
- Switch on the UUT and enter the **W-h** menu.
- Press **Start** to begin the test. There will be a 20-second delay before timing begins and results are being taken.

The test will be ended automatically, and a pass/fail indication given.

6.3 Testing Magnetic Cores

The graphical display and formula editor make the PMℓ an ideal instrument for analyzing the behavior of electronic components. By performing logical and mathematical operations, the formula editor can be used to derive many measurements specific to the application. The graphical display can then be used to show the variation of these measurements.

Measuring the characteristics of soft ferrite cores is an ideal application of these powerful features. Although different connection methods are possible, the connections shown below are suitable for most measurements.



Connections to test a transformer core

This circuit has the advantage of measuring the ferrite core dissipation without the copper losses. The primary peak current is proportional to the peak magnetic field strength (H_{pk}), and the rectified mean voltage of the open-circuited secondary is proportional to the peak magnetic flux density (B_{pk}). The integration of the hysteresis loop is equivalent to the derived true power.

The total dissipation of a wound component consists of its hysteresis power, the eddy current losses, and winding losses. Using the circuit above, the voltage drop of the copper resistance in the primary has no effect on the measured current. To measure the magnetizing voltage, the secondary side is used open-circuited.

6.3.1 Equations

$$P_{Fe} = P\frac{n_1}{n_2}$$

$$X_L = \frac{U_{ac}^{\ 2}}{Q}$$

$$\tan\delta = \frac{P_{Fe}}{Q}$$

$$L = \frac{X_L}{2\pi f}$$

$$B_{pk} = \frac{U_{rect}}{4fn_2A_{Fe}}$$

$$A_L = \frac{X_L}{2\pi f n_2}$$

$$H_{pk} = \frac{n_1 I_{pp}}{l_{Fe}}$$

$$A_L = \frac{\mu_0\mu_r A_{Fe}}{l_{Fe}}$$

$$\mu_r = \frac{B_{pk}}{\mu_0 H_{pk}}$$

$$L = \frac{\mu_0\mu_r A_{Fe} n_2}{l_{Fe}}$$

Device values

n_1 Primary number of turns (no units)
n_2 Secondary number of turns (no units)
A_{Fe} Effective magnetic cross-sectional area (m^2)
l_{Fe} Effective magnetic length (m)

Values measured in PMℓ

- P Active power (W)
- I_{trms} Effective current (A)
- Q Reactive power (VAR)
- U_{rect} Rectified value of voltage (V)
- f Frequency (Hz)
- I_{pp} Peak value of current (A)
- U_{ac} AC component of voltage (V)
- I_{dc} DC component of current (A)

Values calculated in formula editor

- P_{Fe} Core loss (W)
- $\tan\delta$ Loss factor of core (no units)
- B_{pk} Peak value of magnetic flux density (T)
- H_{pk} Peak value of magnetic field strength (A/m)
- μ_r Relative permeability (no units)
- X_L Reactive impedance (Ω)
- L Inductance (H)
- A_L Inductance per turn (H)

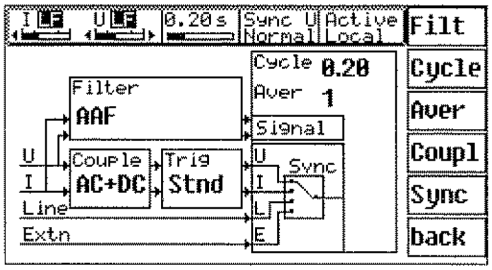
6.3.2 Example

A transformer with the following parameters was connected as shown above.

n_1	240
n_2	24
A_{Fe}	0.0016 m^2
l_{Fe}	0.24 m

The instructions that follow, detail the settings used and the results obtained when analyzing this transformer.

1. Select the normal measuring mode and the configurations below.



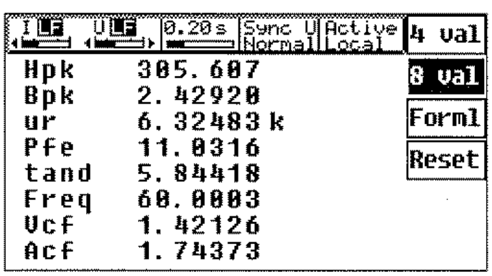
2. Set appropriate voltage and current ranges. Auto-ranging may normally be used.

3. Enter the required equations into the formula editor.

```
Hpk=1000*Ipp;
Bpk=6.51*Urect/f;
ur=5180*Urect/f/Ipp;
Pfe=P*10;
tand=Pfe/Q;
Freq=f;
Vcf=Ucf;
Acf=Icf;
```

4. Set the AC source to a suitable frequency and output range.

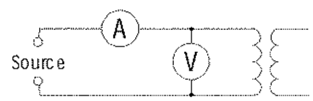
5. The **Custom** menu can be used to view the required values in real-time.



6.3.3 No-load Losses in Transformers

The PMℓ is able to measure the no-load losses of large (e.g. 10 to 20 kVA) power transformers. The 'no-load' losses include core loss, dielectric loss, conductor loss in the winding, due to excitation current, and conductor loss, due to the circulating current in parallel windings. The core loss is usually the most important; it is a function of the magnitude, frequency and waveform of the input voltage, and it also varies significantly with temperature.

The method of testing for no-load losses is specified in the standards IEC76-1 and IEEE C57. The circuit below is an example of a single-phase test circuit.



Connections for measuring no-load losses

Other test circuits are shown in the standards, involving both current and voltage (instrumentation) transformers, and three phases.

IEEE C57 also uses the formulae:

$$P_{Fe}(T_m) = \frac{P_m}{P_1 + kP_2} \qquad k = \left(\frac{E_r}{E_a}\right)^2$$

where:

	T_m	=	temperature
	$P_c(T_m)$	=	the no-load losses corrected for waveform at temperature T_m
	P_m	=	the measured no-load losses at temperature T_m
	P_1	=	the ratio of hysteresis loss to total iron losses
	P_2	=	the ratio of eddy current loss to total iron losses
	E_r	=	the rms test voltage
	E_a	=	the mean voltage

'k' may be calculated by the PMℓ formula editor, and $P_c(Tm)$ estimated, by using a value of 0.5 for both P_1 and P_2.

6.4 Lighting Ballast Measurements

The PMє may be used to aid the designing and testing of a range of lighting applications, including electronic ballasts.

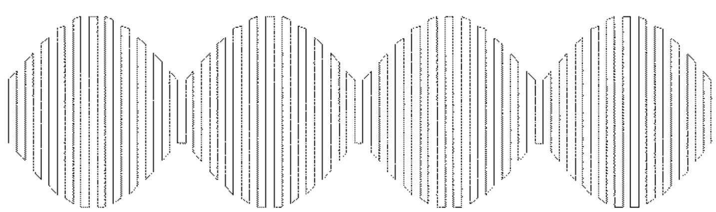
In situations where high-frequency voltage and current waveforms are heavily modulated by mains-borne frequencies, careful set-up is required to make accurate measurements, because the high-frequency sampling must be synchronized to the low-frequency modulation.

It is recommended that, for high-frequency applications, the 400kHz PMє (option PMє-hf) be used.

6.4.1 Electronic Ballasts

Electronic ballasts use a switching frequency of at least 25kHz to drive the lamp. This is because the efficiency of a fluorescent tube is greater when driven at higher frequencies, and the electronic components are physically smaller, lighter and more efficient.

The output waveform is a carrier with a frequency of typically 25 to 50kHz modulated at a line frequency of 50 or 60Hz.



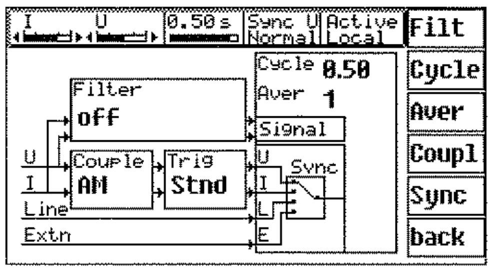
Typical waveform of a ballast output

In order for the PMє to synchronize to this type of signal, **AM** coupling should be used. Any input filter selected should pass the high-frequency component of the signal.

The following configuration is recommended for testing electronic ballasts:

- Enter the **Set Up** menu.
- Select **Normal** and press **Set**.
- With the **Filt** softkey, select Filter **off**.
- Enter a **Cycle** time of 0.50.
- Set **Averaging** to 1.
- Press **Couple** until **AM** is selected.
- Use **Sync** to select either **U** or **I** synchronization.

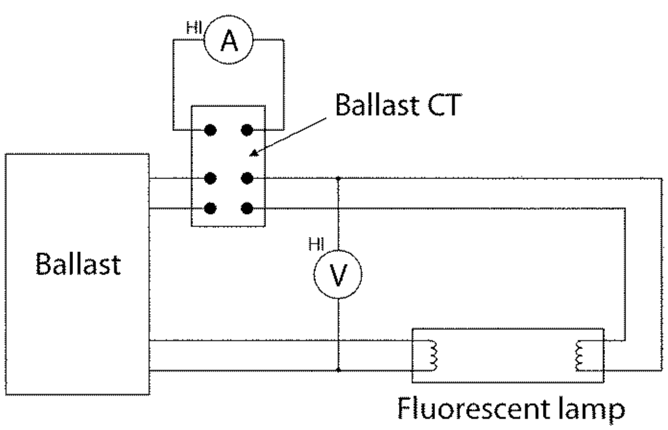
The PMε should now trigger correctly to the envelope of the waveform to give stable and reliable results.



Configuration for ballast measurements

6.4.2 Voltech Ballast CT

The Voltech Ballast CT is a freestanding module that simplifies the measurement of output power and tube current in high-frequency electronic ballasts. Designed specifically for lighting applications, this device overcomes problems that are usually found when using conventional or Hall effect CTs.



Typical use of a Ballast CT

6.4.3 Ultrasonics

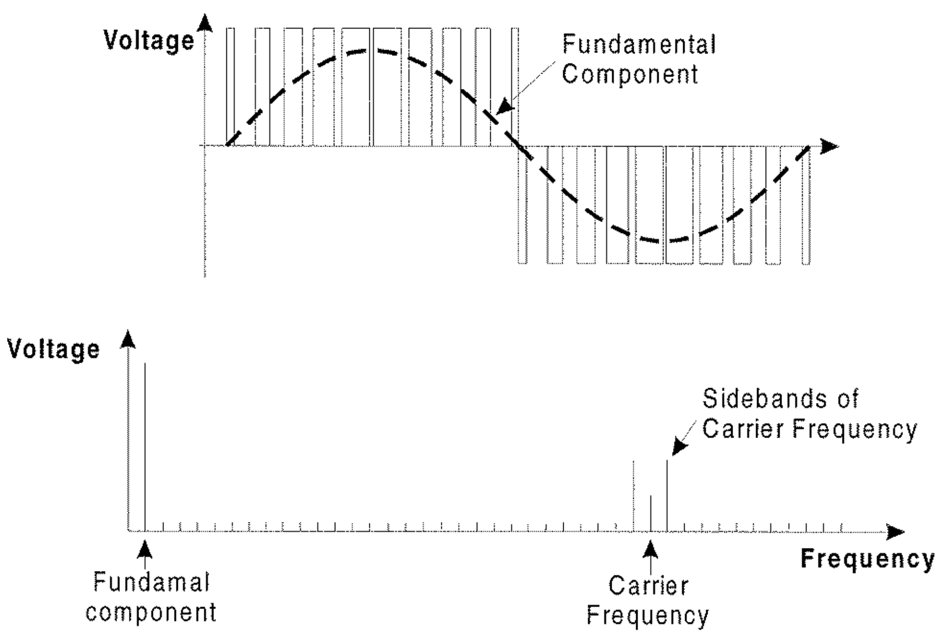
Signals in ultrasonics applications are often modulated in the same way as those in ballasts. The same configurations may be used.

The high-frequency version PMι (option PMι-hf) is recommended for ultrasonics applications.

6.5 Measurements on Variable Speed Drives

The PMι may be used to take measurements on a variable speed drive: on its input, a single phase of its output, the DC-bus, and on the motor shaft output.

The output of a variable speed drive is very complex, often using pulse-width modulation (PWM). This consists of a mixture of high-frequency components due to the carrier, and components at low frequency due to the fundamental. The only useful power delivered to the motor is at the fundamental frequency; any power associated with the harmonics or carrier frequency represents losses in the motor.



Typical inverter output and spectrum

The problem this poses for most power analyzers is that they can either measure at high frequencies, in which case low-frequency information in the waveform is lost; or they filter the PWM waveform to measure at low frequencies, in which case high-frequency data is lost.

The difficulty occurs because the waveform is being modulated at low frequency. High frequency measurements, such as trms voltage, true power etc, must therefore be made at high frequency, but over an integral number of cycles of the low frequency component in the output waveform.

The Voltech PMé overcomes these problems with its coupling and signal filter options.

6.5.1 Settings

The **BP** coupling option passes only components in the range of 10 to 300Hz. Therefore, using this setting, the instrument will synchronize to the fundamental frequency as required.

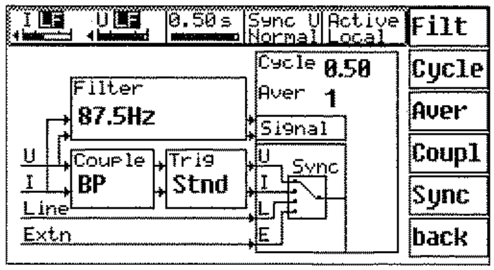
The **input filter** should be selected according to the required measurements. For example, to measure the fundamental values, it should be set to cut off frequencies significantly above this value.

The voltage and current **ranges** may be set to auto-ranging in most cases.

To enter this configuration:

- Enter the **Set Up** menu.
- Press the **Normal** and **Set** softkeys.
- Press **Filt** until the required filter is selected.
- Press **Couple** until **BP** coupling is selected.
- Select either **U** or **I** synchronization with the **Sync** softkey.
- Enter the **Range** menu.
- Set ranging to **Auto**.
- Press the **I↔V** softkey.
- Set the ranging to **Auto**.

Suggested values for the **Cycle** and **Average** options are 0.50 and 1 respectively.

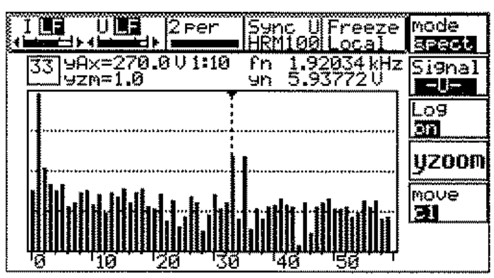


Configuration in set-up menu

6.5.2 Harmonic Analysis

The harmonic content of the inverter output may be analyzed in the **100-hrm** mode of the PM*ε*. The graphing feature may be used to display bar graphs of the harmonic magnitudes.

- Enter the **Set Up** menu.
- Select the **100-hrm** mode and press **Set**.
- Set the coupling to **BP** with the **Coupl** softkey.
- Select **U** synchronization with **Sync**.
- Ensure that **FDiv** is set to 1.
- Enter the **V**, **A** or **W** menus to display lists of the harmonics.
- Press **Graph** to show the bar graph display.
- Use the **Signal** softkey to toggle between voltage and current harmonics.
- The scale of the vertical axis may be changed with the **yzoom** softkey.

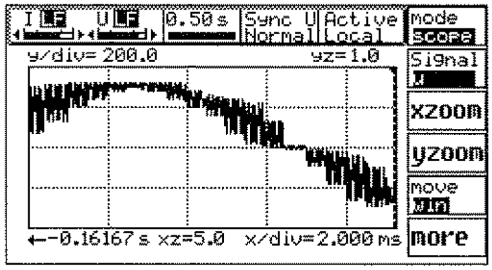


Harmonic content of PWM drive

Note that in the example above, the carrier frequency side bands may be seen clearly. A fundamental of 58Hz and carrier of 2kHz were used.

6.5.3 Graphical Representation

In **Normal** measuring mode, the **Graph** menu **scope** mode may be used to display the waveforms. An example of the voltage waveform of an inverter output is given below.



Scope display of inverter output

6.5.4 Transducer Inputs

The processing signals interface (PMć option OP04, see section 3.6) allows additional transducers to be connected to the PMć.

The digital inputs offer a frequency counter and direction indicator designed for the purpose of analyzing the operation of motors. The configuration of this may be carried out as follows:

- Select the **I/F** menu.
- Press the **IO** softkey.
- Press **Module** until the **D_In** menu is displayed.

Refer to section 3.6.4 for more details.

The analog inputs may be used to monitor the output of analog transducers, such as speed and torque. To access the configuration menu:

- Select the **I/F** menu.
- Press the **IO** softkey.
- Press **Module** until the **A_In** menu is displayed.

Details of how to use these settings are given in section 3.6.2.

Example

A transducer is to be used that produces 2.5V per hp.
It is to be connected to the analog input 0 of the Processing Signals Interface, and scaled appropriately with a full-scale of 4 hp.

Connect the transducer output to pin 1 and its ground to pin 16 of the Analog I/O connector on the rear panel.

- Enter the **I/F** menu and press the **IO** softkey.
- Press **Module** until the **A_In** menu is displayed.
- Press **Set** and select input 0.
- Set **Zero** as 0.0000 and **FS** as 4.000.

The directly scaled value will be displayed under the **I/F**, **IO** menu. It may also be accessed in the formula editor with the 'Ain:0' identifier.

7 Miscellaneous

7.1 Use of External Shunts

To use an external shunt with the PMℓ, an input socket is provided on the front panel. It is necessary to calculate the shunt conductance and enter this as the current scaling of the instrument.

$$G = \frac{I}{V}$$

where G = Conductance (A/V or Ω^{-1})
I = Current value (A)
V = Voltage output (V)

Example

To use a shunt that gives an output voltage of 5.00 V for a current of 100mA, carry out the following operations:

- Calculate the shunt conductance from the equation above. In this case,
  $G = 0.100 / 5.00 = 0.020\ \Omega^{-1}$.
- Enter the **Range** menu.
- Select the **I** channel with the **I↔V** softkey.
- Press **Scale**.
- Type 0.020 and **Enter**.
- Select the external shunt with the **Shunt** softkey.
- Connect the shunt terminals to the 'Ext Shunt' and 'A_{LO}' sockets on the PMℓ front panel.

All values measured on the PMℓ will now be scaled to give the correct readings for the shunt used.

7.2 Calibration

It is recommended that the PMℓ is calibrated at Voltech Instruments, Inc.

7.3 Zero Adjustment

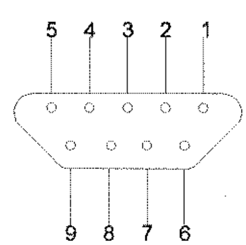
The DC components of the PMℓ can be adjusted without sending the instrument back to the manufacturer. Follow these steps to adjust the instrument:

1. Remove ALL measuring cables from the instrument.
2. Short-circuit the voltage input and the external shunt input with the shortest length wire possible.
3. Warm the instrument up for a minimum of two hours.
4. Press **Range** and then the **Z-Adj** softkey.
5. Answer the warning with **Enter**, if the instrument is set-up correctly.
6. After about one minute, the instrument is adjusted and a message appears.

Never switch the instrument off while it is adjusting, as this will cause incorrect measurements.

7.4 Auxiliary Transducer Supply

The 9-way D-type socket on the rear panel, marked **Auxiliary Transducer Supply**, may be used to supply external sensors and circuits with a ±15V DC supply.



Connections of the auxiliary transducer supply

Pin	Use
1, 2, 6	-15V
3, 7, 8	GND
4, 5, 9	+15V

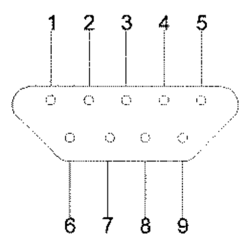
The technical specifications are given in section 9.3.9.

7.5 External Synchronization

The synchronization connector on the rear panel may be used for two purposes:

- External synchronization of the PMℓ (pins 1 and 2).
- Controlling the energy measurement (pins 6, 7 and 9).

The connector is a 9-pin Sub-D plug.



Synchronization Connector

Pin	Use
1	Ground for external synchronization
2	Input for external synchronization
6	Ground for control
7	Control out
9	Control in

All other pins should not be connected.

The **external sync** is used to synchronize the PMℓ measuring cycles. The rising edge simulates a positive zero crossing and the falling edge a negative zero crossing.

The **Control In** is a 5V input, used to control the energy measuring of the PMℓ. The falling edge simulates a pressing of the **Start** button; the rising simulates the **Stop** button.
The **Control Out** indicates when integration is taking place. It is in the low-impedance state while the PMℓ is integrating, and high impedance otherwise.

8 Appendix 1

Interfaces

The data interface is used for two general purposes:

Logging: Logging means that selected values are being transferred to a physical device (serial port, printer, memory card, etc.) either once or in periodic intervals. The transfer is controlled from the front panel of the PMε.

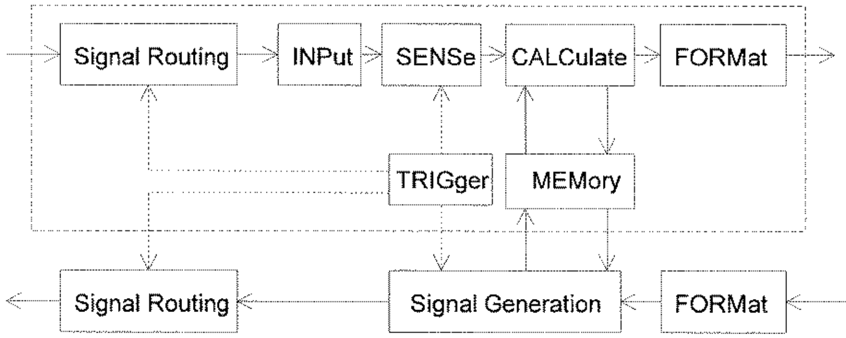
Remote control: Remote control means the PMε is connected to a computer by a physical device (serial port, parallel printer port, GPIB). The computer can be used to set up the instrument as well as read out values. The computer controls the data transfer.

8.1 Remote Control

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

8.1.1 SCPI

The SCPI command set has been developed to standardize the use and remote control of different devices from different manufacturers. The standard command makes it possible to control different devices with the same commands. The SCPI Consortium has defined commands to control some basic devices, like digital meters, power supplies, RF and microwave sources and signal switches. All devices have a specific signal routing that looks like the following:



SCPI functional model

For a measurement instrument, only the upper blocks are necessary. The command set is built in a tree structure, based on the proposals of Appendix A of IEEE Standard 488.2-1992. The tree structure is comparable to the structure of computers running the DOS operating system and its directory structure. There is a root directory (e.g., drive C:\), followed by subdirectories and, again, subdirectories. At the bottom, you find the complete command that can be used to request values from the measurement device or to change parameters. All headers are separated by a colon. The first colon (:) is at the root, followed by the first header, which defines in which direction to go. The PM*e* has the following root headers:

:CALCulate
:DISPlay
:FETCh
:FORMat
:INITiate
:INSTrument
:MEMory
:READ
:SENSe
:SOURce
:STATus
:SYSTem
:TRIGger

The 'Display' header directs to the set-up commands concerning the display. The 'Measure' header directs to the headers asking the device for measurement values.

The 'Sense' header directs to the set-up of ranges, and so on. When a header is directly followed by a question mark (?), a value is requested. The instrument looks for the value (a measurement value or even a simple parameter) and sends it back to the interface. If there is no question mark (?) at the end of a header, a command or a parameter change (e.g., the range) is sent. It is possible to send more than one command to the instrument. Several headers have to be separated by semicolons (;).

Example: To change the range and ask the device for the DC voltage.

:SENSE:VOLTAGE:RANGE:UPPER 2;:FETCH:VOLTAGE:DC

The first command sets the instrument to the voltage range for 2V measurements, and the second command asks the instrument for the DC voltage value. Note that, at the beginning of a command string, there must be a colon (:). When starting another command (or demand) within one string, there must be a semicolon (;) to separate the commands, followed by a colon (:) to start the next command from the root within the SCPI system. If there is no colon (:) then the SCPI parser tries to find the next command, while keeping in mind the last position within the SCPI tree.

It is possible to ask for the DC voltage value and the AC voltage value in the following manner:

:FETCH:VOLTAGE:DC?;AC?

It is also possible to send:

:FETCH:VOLTAGE:DC?;:FETCH:VOLTAGE:AC?

This command needs more evaluation time. There is also a short form of each command. It is possible to send the following to the instrument:

:FETC:VOLT:DC?;AC?

The short form is shown in the manual by capital letters and small letters like this:

FETCh, or VOLTage

The spelling has no effect on the commands. It is possible to send commands in either small or capital letters, or even mixed.

Note: **To speed up evaluation, send capital letters. The commands are internally converted to capital letters.**

8.1.2 Transfer Buffer Size

The buffer size is fixed to 512 bytes. The PMℓ starts parsing the incoming data as soon as the first bytes come in. That means it is possible to send data to the PMℓ with more than 512 bytes. The same applies to the output buffer. The PMℓ is using FIFOs—a kind of ring buffer. Using a 512-byte FIFO, it becomes possible to transfer sample values with, for example, 20,000 bytes to a computer because the PMℓ is generating a constant data flow over each interface. While it is reading in some data, it starts evaluating the first command. While it is putting the evaluated data into the output FIFO, a connected computer can read out the same data.

8.1.3 Ending Characters

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

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

8.1.4 Settings in the PMℓ

It is possible to set all values that can be set via the keyboard via the remote interface. To prevent a double entering from both sources, the instrument is set to remote mode with the **ren** command using IEEE488.2. When using the RS232 interface, the first incoming character forces the interface into remote mode. Remote mode MUST be enabled to set any values via that interface.

8.1.5 Registers

The PMε uses the standardized register structure to follow all requirements. There are three different register sets. The first register set is defined in IEEE488.2 and is called **Standard Status Data Structure**. The other two stes , which are defined in SCPI specifications, are called **Questionable Status Register Structure** and **Operation Status Register Structure**.

8.1.5.1 Standard Status Data Structure

The central register is the **status byte register**. This register collects the main events. It can be read out with the demand *STB? . This register is read-only. When the register is read out by the *STB? demand, bit 6 will be the **MSS** (Master Summary Status).

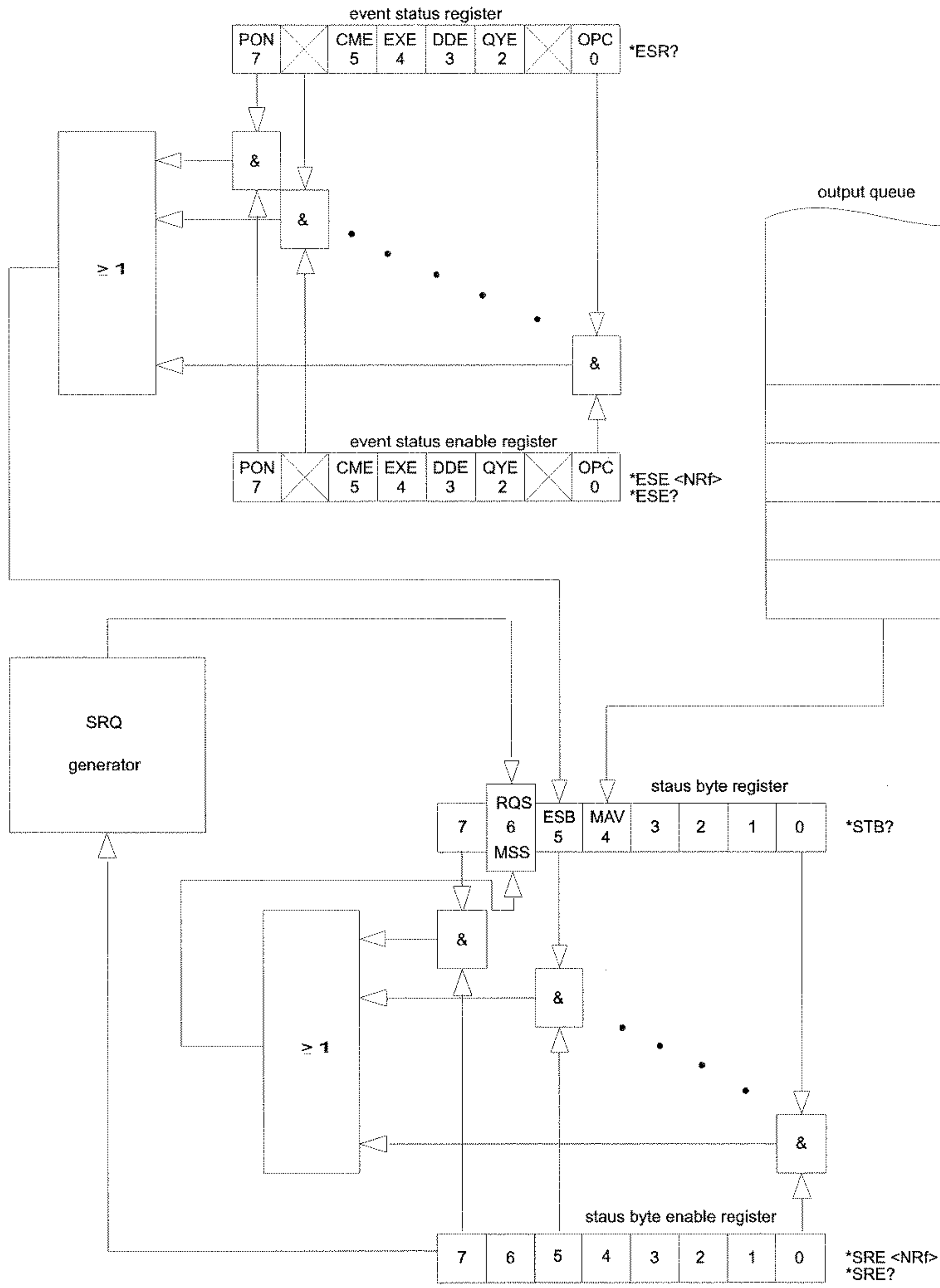
The **status byte register** can be read out by a *serial poll* on the GPIB bus.

Bit 7 is the summary message of the **Operation Status**.
Bit 6 is the **RQS** (Request Service Bit), coming from the service request generation.
Bit 5 is the **ESB** (Event Status Bit). It shows any occurred event registered by the **event status register**, but **only** when the corresponding bit in the **event status enable register** has been set. The event status register can be read out by the *ESR? demand. It can be set with the *ESE <NRf> command, where <NRf> stands for a decimal number.
Bit 4 is the **MAV** (Message Available Bit). It is used to signal any data in the output buffer of the PMε.
Bit 3 is the summary message of the **Questionable Status**.
Bit 7 is the **PON** (Power On Bit). It indicates an off-to-on transition in the power supply of the device.
Bit 5 is the **CME** (Command Error Bit). It is used to indicate errors detected by the parser, while examining the incoming commands.
Bit 4 is the **EXE** (Execution Error Bit). It indicates that a <Program Data> element, following a header, was evaluated by the device as outside of its legal input range, or that valid program message could not be properly executed.
Bit 3 is the **DDE** (Device-Specific Error Bit). It indicates that the detected error is not a command error, a query error or an execution error.

Bit 2 is the **QYE** (Query Error Bit). It indicates that an attempt is being made to read data from the output queue when no output is present or pending, or data in the output queue has been lost.

Bit 1 is the **RQC** (Request Control Bit), never used by the PMɩ, because this device will never become active controller in the GPIB bus system.

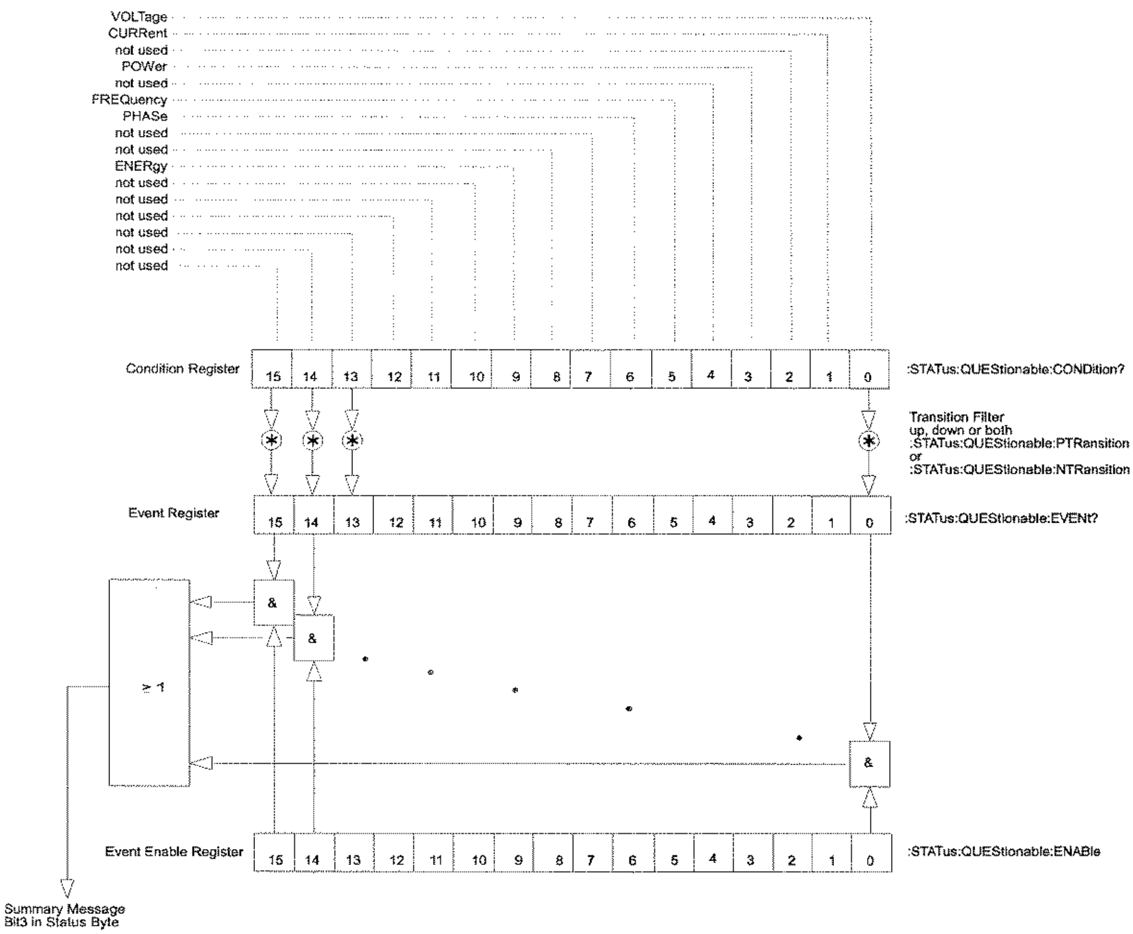
Bit 0 is the **OPC** (Operation Complete Bit). It indicates that all commands before the *OPC command have been executed. This bit will only be set, when the *OPC command has been received by the PMɩ.



Standard Status Data Structure

8.1.5.2 Questionable Status Register Structure

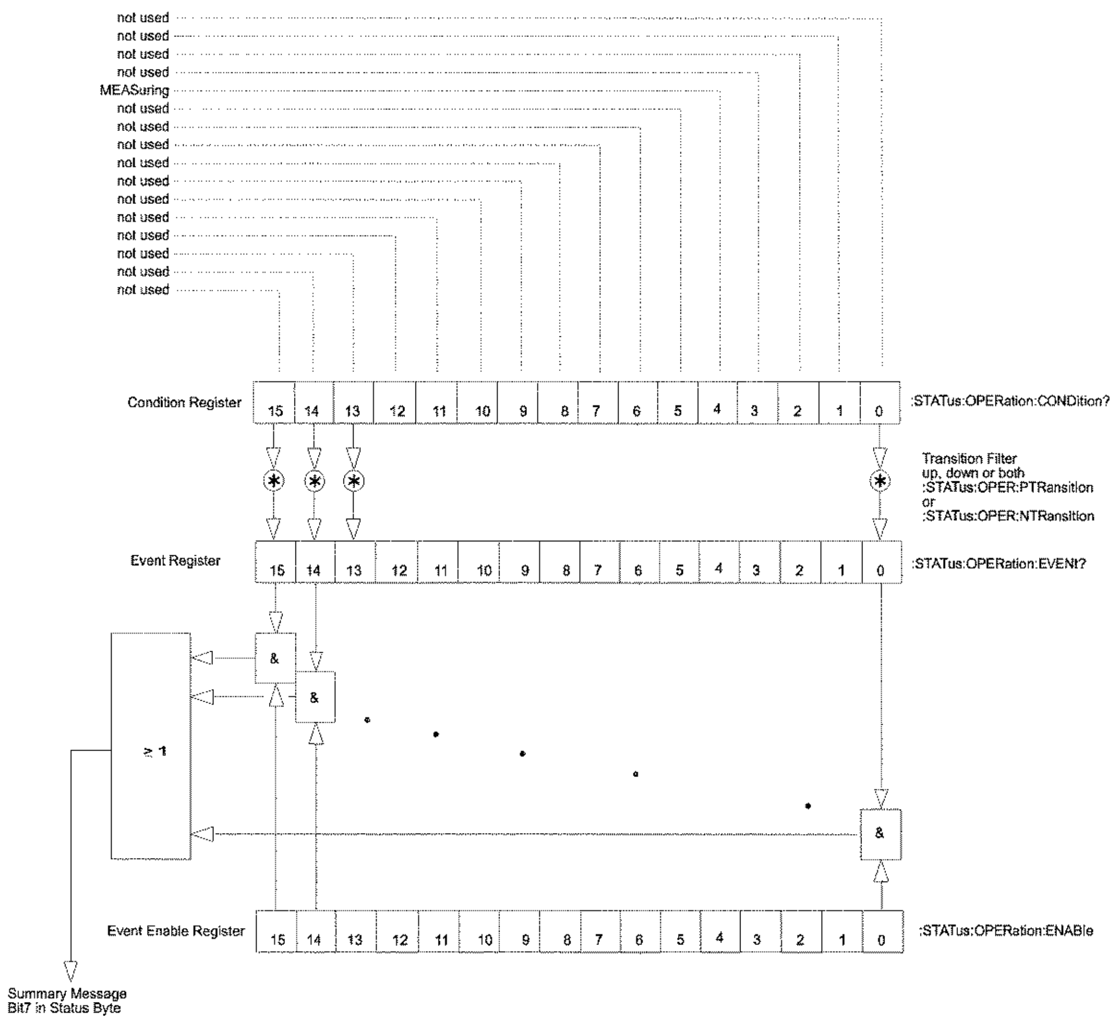
The Questionable Status shows which values the device measures. Whenever one type of value becomes valid, the corresponding bit in the **Condition Register** changes to high. A transition filter can be set up to get only specific events into the **Event Register**. It is possible to detect only positive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



Questionable Status Data Structure

8.1.5.3 Operation Status Data Structure

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



Operation Status Data Structure

8.1.6 Syntax

The SCPI command set cannot be parsed very fast. The SCPI command tree is very complex and large. This means fast applications can become impossible. Therefore a SHORT command set with shorter commands has been implemented that is much faster. For further differences between the SCPI and SHORT command sets, also see 8.2.4, :FETCh and :READ Commands. It is not possible to enter a SHORT command without switching to the short command set. To change from the SCPI command set to the other, it is necessary to use the command: SYST:LANG SHORT. This command tells the parser now to use the compatibility command set (SHORT command set). To get back to the SCPI command set, send the command: LANG SCPI.

Explanation of syntax:

- Commands starting with an asterisk (*) are IEEE488.2 common commands.
- Brackets [..] show an optional part of commands.
- /qonly/ indicates that this is a value that can only be demanded, but not set. Do not send the /qonly/ string to the device. For example, a measuring value cannot be sent.
- /nquery/ indicates that this value can only be set, not demanded. Do not send the /nquery/ string to the device. For example, a trigger command cannot be requested.
- All commands without /qonly/ and /nquery/ can be read and set.
- All parameters following the commands have to be separated from the command with a space character.

Examples

Command for reading the TRMS value:
:FETCh:CURRent:TRMS?

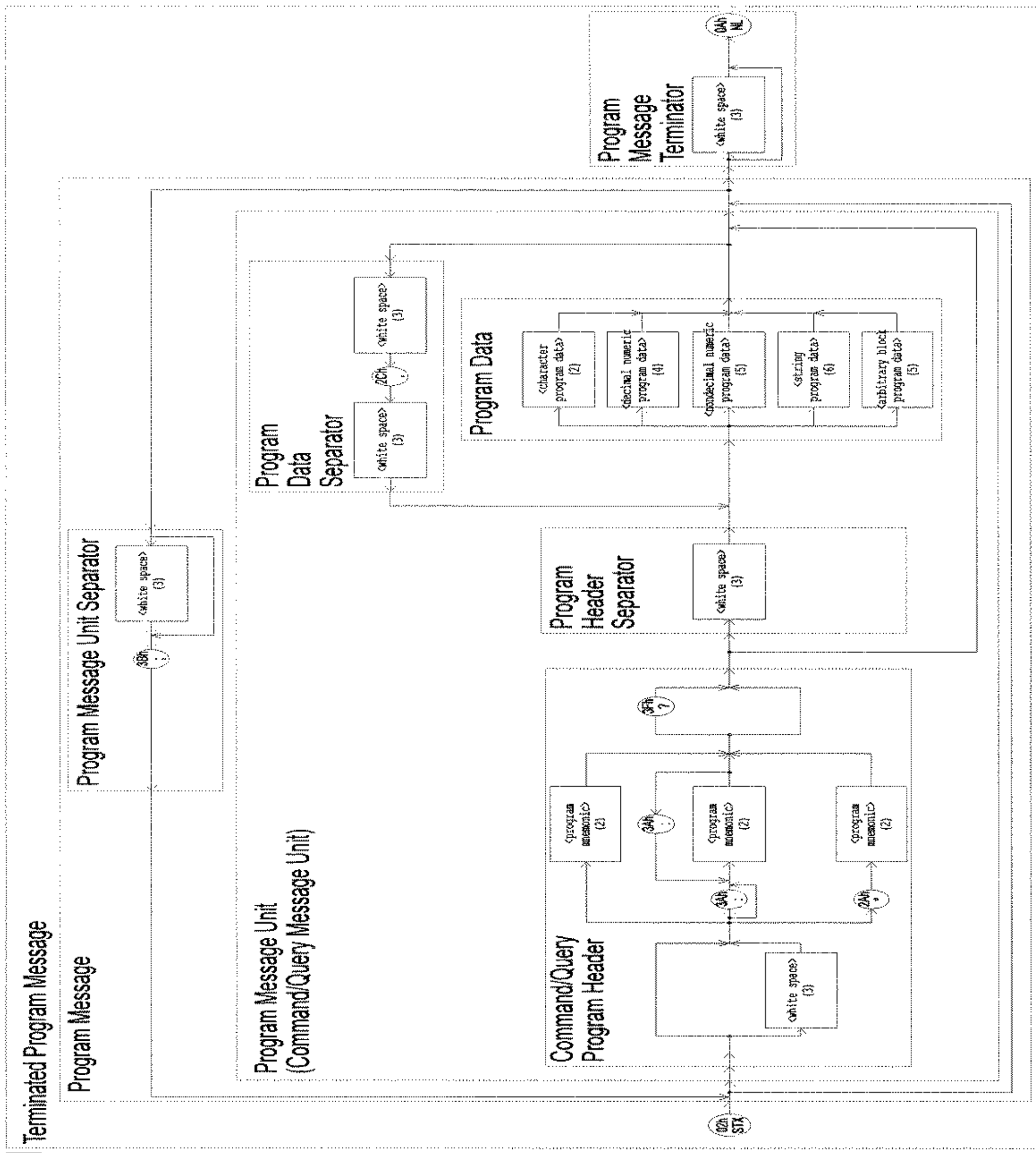
Command for reading the harmonic voltages from the 2nd to the 4th harmonic:
:FETC:HARM:VOLT:AMPL? (2:4)
Notice that there is a space after the question mark.

Command for setting the 250V range:
:SENS:VOLT:RANG 250
Notice that there is a space before 250.

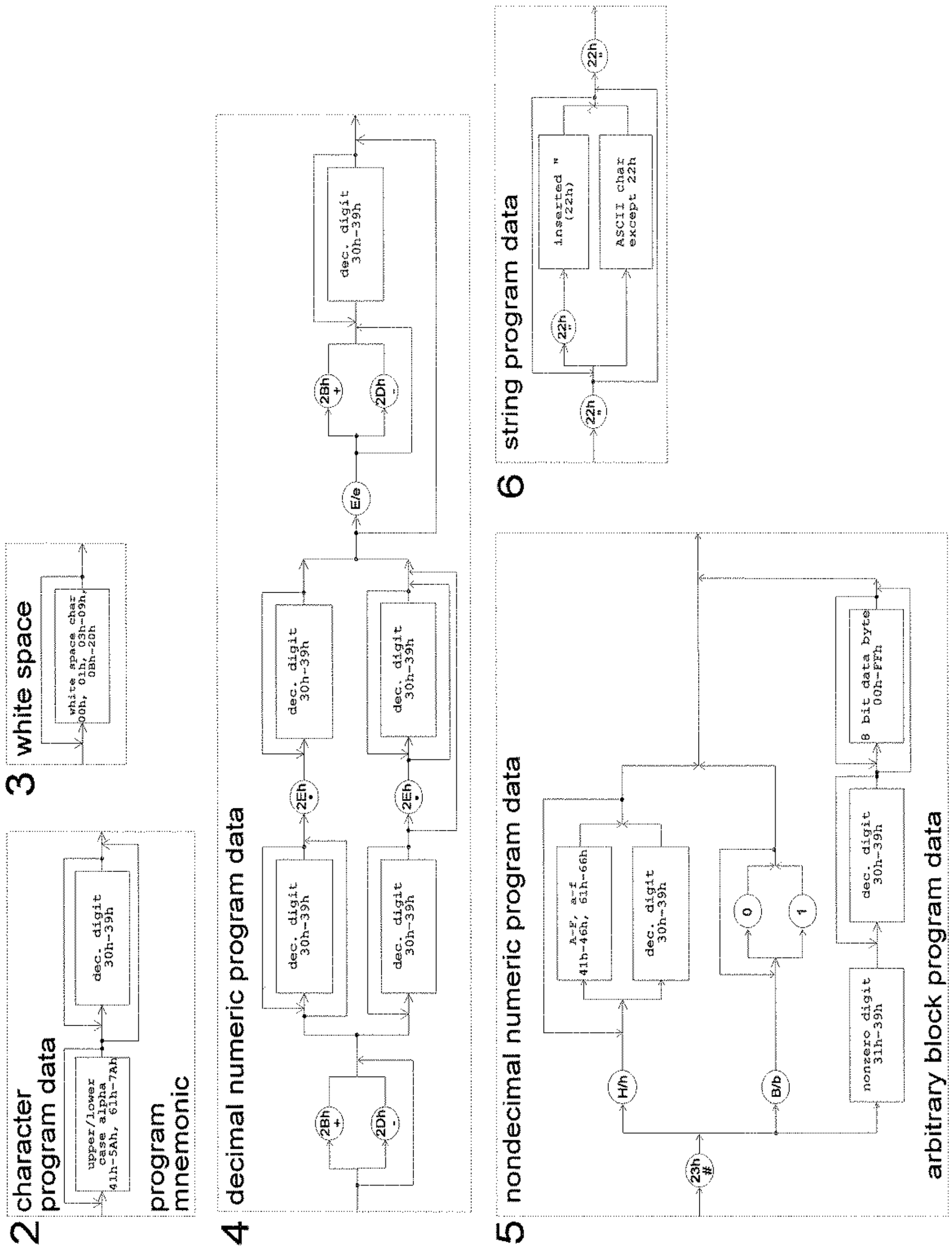
The commands are ordered in SCPI root structure.

8.1.6.1 Syntax for Sending Commands to the Instrument

The following syntax diagram shows what can be sent to the PM¿.



Program messages



Program messages

8.1.6.1.1 <NRf> Data

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

8.1.6.1.2 <NRi> Data

<NRi> is a flexible numeric format. It follows the rules of box 2 in the character program data illustration OR box 4 in the decimal numeric program data illustration OR box 5 in the non-decimal numeric program data illustration.

8.1.6.1.3 <list> Data

<list> stands for (<NRf>:<NRf>). With this construct, several values can be requested and stored in an array, for example harmonic values. To get the 3rd to 11th harmonic, (3:11) is written.

8.1.6.1.4 Character Program Data

These are character data that are a synonym for a numerical value. The following strings are defined (upper or lower case letters can be used):

String **OFF, ON**
Value 0, 1

String **MANUAL, AUTO**
Value 0, 1

String **INT, EXT**
Value 0, 1

String **ASCII, PACKED**
Value 0, 1

String **NORML, CEHRM, CEFLK, HRMHUN, TRANS**
Value 0, 1, 2, 3, 4

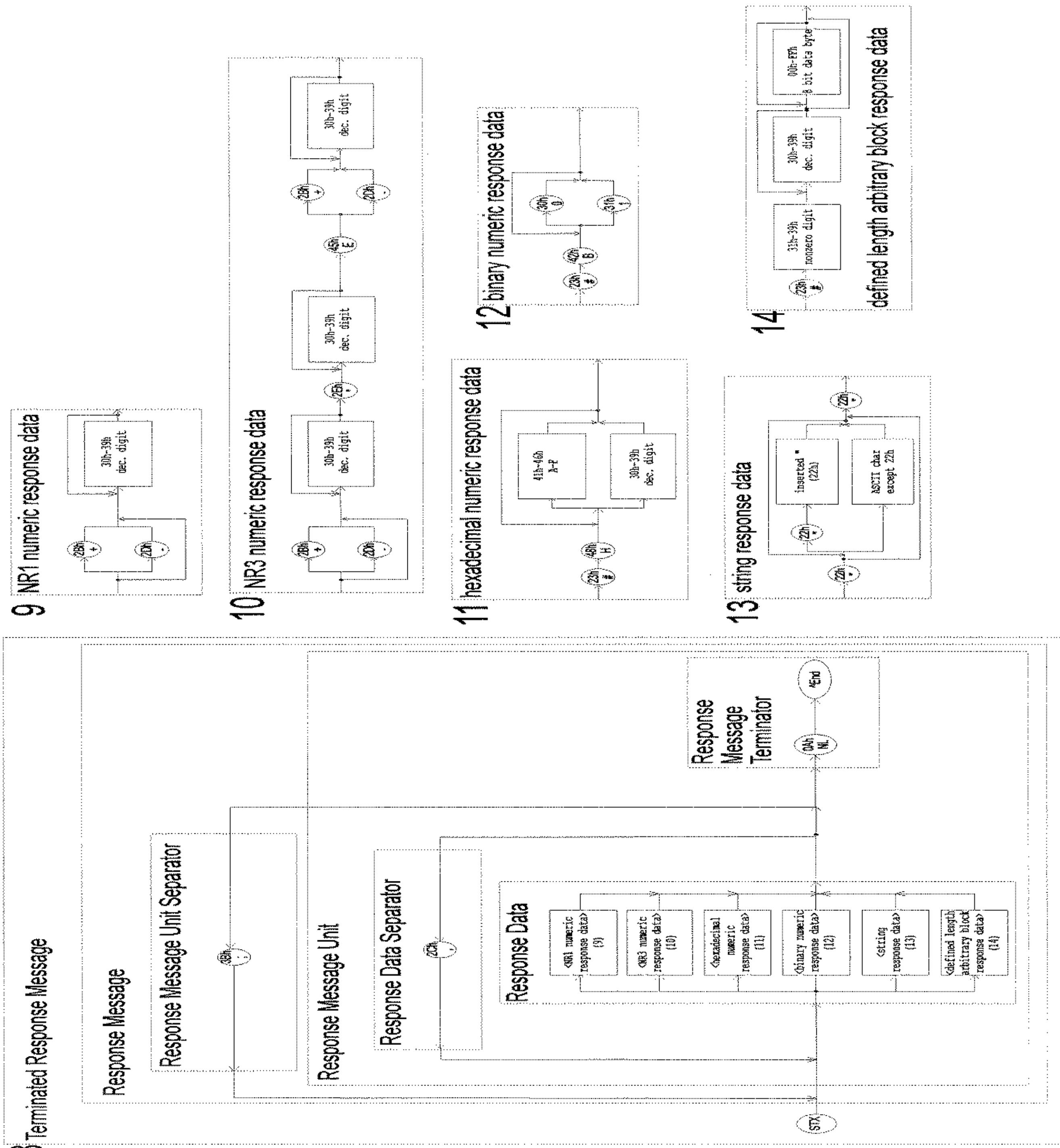
String **SCPI, SHORT**
Value 0, 1

String **LINE, EXTS, U, I**
Value 0, 1, 2, 3

String **ACDC, BP, AM**
Value 0, 1, 2

It is equal to write SYST:LANG 1, SYST:LANG shORt or SYST:LANG ACDC.
The last one works, but it does not make any sense.

8.1.6.2 Syntax for Answers from the Instrument



Response messages

8.1.6.2.1 Defined Length Arbitrary Block Response Data

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

If a float number is desired as the response, the number '-2.31234e-3' might be returned. This requires 11 bytes to be transferred. The same data transferred in the defined-length arbitrary block response data, the number '#14xxxx' might be returned, where each 'x' represents one data byte of the 32-bit float number, and only 7 bytes to transfer. So, there are several advantages:

- Less data bytes to transfer.
- The instrument needs no time to convert the float number to an ASCII string.
- The PC needs no time to convert the ASCII string to a float number.
- The value is returned with the full resolution, not with just six digits, so there is better accuracy.

In the defined-length arbitrary block response data format, the first character is always a '#'. The following digit specifies the number of digits of following data. The sequence '#40008' specifies that the length information is four digits wide.

8.2 Commands

The following is a list of all the commands the instrument can use. Additionally there are commands called IDs. They are used in the formula editor. Please note that, with newer software versions, command menus might change. So, a sequence of pressed keys to get a special function can change. Currently valid key sequences are defined below.

8.2.1 IEEE488.2 Common Commands

8.2.1.1 *CLS

SCPI: *CLS/nquery/
SHORT: *CLS/nquery/
ID: no ID defined

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

8.2.1.2 *ESE

SCPI: *ESE <NRi>
SHORT: *ESE <NRi>
ID: no ID defined.
Used to set up or read out the Event Status Enable Register.

8.2.1.3 *ESR?

SCPI: *ESR?/qonly/
SHORT: *ESR? /qonly/
ID: no ID defined
Reads out and clears the Event Status Register.

8.2.1.4 *IDN?

SCPI: *IDN?/qonly/
SHORT: *IDN? /qonly/
ID: no ID defined
Reads out the identification of the device. There are four fields, separated by commas:
Field 1 Manufacturer
Field 2 Model
Field 3 Serial number
Field 4 Firmware level

8.2.1.5 *IST?

SCPI: *IST?/qonly/
SHORT: *IST? /qonly/
ID: no ID defined
Individual Status Query. This returns the status of the 'ist' local message in the device. See 8.1.5 *Registers*. Possible values are '0' or '1' (30h or 31h).

8.2.1.6 *OPC

SCPI: *OPC/nquery/
SHORT: *OPC/nquery/
ID: no ID defined
Causes the device to set the operation complete bit in the Standard Event Status Register, when all pending selected device operations have been finished.

8.2.1.7 *OPC?

SCPI: *OPC?/qonly/
SHORT: *OPC?/qonly/
ID: no ID defined
Causes the device to place a "1" in the output queue, when all pending selected device actions have been finished (= operation complete).

8.2.1.8 *PRE

SCPI: *PRE <NRi>
SHORT: *PRE <NRi>
ID: no ID defined
Used to set up or read out the Parallel Poll Enable Register.

8.2.1.9 *RST

SCPI: *RST/nquery/
SHORT: *RST/nquery/
ID: no ID defined
This performs a device reset. A lot of internal settings are set to their default values. In this chapters the default value is indicated by '[*RST Default value]'. All time-dependent measurements are stopped (e.g., energy, flicker, harmonics).

8.2.1.10 *SRE

SCPI: *SRE <NRi>
SHORT: *SRE <NRi>
ID: no ID defined
Sets or queries the Service Request Enable Register.

8.2.1.11 *STB?

SCPI: *STB?/qonly/
SHORT: *STB? /qonly/
ID: no ID defined
Queries the Status Byte Register.

8.2.1.12 *TRG

SCPI: *TRG/nquery/
SHORT: *TRG/nquery/
ID: no ID defined
Triggers the same action as sending DT1 via IEEE488.1 interface or'&TRG<cr><lf>' via RS232 interface. Actually nothing is performed.

8.2.1.13 *TST?

SCPI: *TST?/qonly/ <NRi>
SHORT: *TST?/qonly/ <NRi>
ID: no ID defined.
Initiates a self test. Returns a value depending on <NRi>. This command should only be used by Voltech and not by customers.

8.2.1.14 *WAI

SCPI: *WAI/nquery/
SHORT: *WAI/nquery/
ID: no ID defined
Waits until all pending selected device operations have been finished. Note: The instrument handles commands in a queue, so when executing the *WAI all previous commands have been executed. Therefore, the instrument is not processing any commands when receiving the *WAI command. This command has been implemented to follow the standard IEEE488.2.

8.2.2 :CALCulate Commands

Here you find commands that influence the calculation of formulae or limits.

8.2.2.1 :FORMula

8.2.2.1.1 [:DEFine] FORM

SCPI: :CALCulate:FORMula[:DEFine] <string program data>
SHORT: FORM <string program data>
ID: no ID defined.
Sets or reads the formula of the formula editor. There is no *RST default value.
For example, 'FORM "a=1;"<lf>' sets the internal variable a to 1.

8.2.2.2 :LIMit:

8.2.2.2.1 :VERSion

SCPI: :CALCulate:LIMit:VERSion
SHORT: EDIT
ID: no ID defined
Sets the edition of the harmonic standard:
0: IEC61000-4-7:1993 [*RST default value]
1: IEC61000-4-7:1997.

8.2.2.2.2 :CLASs

SCPI: :CALCulate:LIMit:CLASs <Nri>
SHORT: EVAL <NRi>
ID: no ID defined
Sets or reads the evaluation of the harmonics in the CE mode:
0: Harmonics class A [*RST default value]
1: Harmonics class B
2: Harmonics class C
3: Harmonics class D

8.2.2.2.3 :FCURrent

SCPI: :CALCulate:LIMit:FCURrent
SHORT: ISO
ID: no ID defined
Sets or reads the fundamental current for the EN61000-3-2/A14 limit calculation in the CE mode. The *RST default value is 1.0.

8.2.2.2.4 :PFACtor

SCPI: :CALCulate:LIMit:PFACtor
SHORT: PFSO
ID: no ID defined
Sets or reads the power factor for the EN61000-3-2/A14 limit calculation in the CE mode. The *RST default value is 1.0

8.2.2.2.5 :POWer

SCPI: :CALCulate:LIMit:POWer
SHORT: PSO
ID: no ID defined
Sets or reads the power for the EN61000-3-2/A14 limit calculation in the CE mode. The *RST default value is 1.0

8.2.2.2.6 :SYSTem

SCPI: :CALCulate:LIMit:SYSTem
SHORT: SYSD
ID: no ID defined
Sets or reads the supply system for the EN61000-3-2 limit calculation in the CE mode:
0: 230V/50Hz [*RST default value]
1: 230V/60Hz
2: 120V/50Hz
3: 120V/60Hz

8.2.2.2.7 VERSion

SCPI: :CALCulate:LIMit:VERSion

SHORT: EDIT

ID: no ID defined

Sets or reads the edition of the harmonic standard:

0: EN61000-3-2 EN61000-4-7 [*RST default value]

1: EN61000-3-2 prEN61000-4-7

2: EN61000-3-2/A14 EN61000-4-7

3: EN61000-3-2/A14 prEN61000-4-7

8.2.3 :DISPlay Commands

8.2.3.1 :BRIGhtness

SCPI: :DISPlay:BRIGhtness <NRf>

SHORT: DISB <NRf>

ID: no ID defined

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

8.2.3.2 :CONTrast

SCPI: :DISPlay:CONTrast <NRf>

SHORT: DISC <NRf>

ID: no ID defined

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

8.2.4 :FETCh and :READ Commands

These commands are used to obtain measuring values from the instrument. :FETCh gets the values that are in the buffer for the interface. :READ executes two internal commands: :INITiate:IMMediate and :FETCh (see 8.2.6.3 *:IMMediate INIM* for further details).

If you request measuring values with two :READ commands (e.g. :READ:DC?;:READ:DC?), you get two different values from two different cycles. This can cause problems, for example, with the following request.

:READ:VOLTAGE:DC?;:READ:CURRENT:DC?
Sending this command, you will get values for Udc and Idc that are measured in two different cycles.

On the other hand, if you request measuring values with two :FETCh commands, you get values of the same cycle. For example, :FETC:DC?;:FETC:DC? gets the same value twice.

A usual request looks like this, :READ:VOLTAGE:DC?;:FETC:CURRENT:DC?

In this case, the instrument finishes the current cycle, copies the values for the interface and returns the two requested values. So, the two values are measured in the same cycle.

The SHORT commands perform equal to the :FETCh commands (which means there is no INIM perfomed). So, if you want to perform the last example with SHORT commands, you have to enter:

INIM;UDC?;IDC?

When not specified, the return values are float numbers.

8.2.4.1 [:SCALar]

8.2.4.1.1 :CURRent

8.2.4.1.1.1 :AC?
SCPI: :FETCh[:SCALar]:CURRent:AC?/qonly/ |
:READ[:SCALar]:CURRent:AC?/qonly/
SHORT: IAC?/qonly/
ID: Iac
Reads the AC value of the current.

8.2.4.1.1.2 :CFACtor?
SCPI: :FETCh[:SCALar]:CURRent:CFACtor?/qonly/ |
:READ[:SCALar]:CURRent:CFACtor?/qonly/
SHORT: ICF? /qonly/
ID: Icf
Reads the crest factor of the current.

8.2.4.1.1.3 :DC?
SCPI: :FETCh[:SCALar]:CURRent:DC?/qonly/ |
:READ[:SCALar]:CURRent:DC?/qonly/
SHORT: IDC?/qonly/
ID: Idc
Reads the DC value of the current.

8.2.4.1.1.4 :FFACtor?
SCPI: :FETCh[:SCALar]:CURRent:FFACtor?/qonly/ |
:READ[:SCALar]:CURRent:FFACtor?/qonly/
SHORT: IFF?/qonly/
ID: Iff
Reads the form factor of the current.

8.2.4.1.1.5 :FSCale?
SCPI: :FETCh[:SCALar]:CURRent:FSCale?/qonly/ |
:READ[:SCALar]:CURRent:FSCale?/qonly/
SHORT: FSI?/qonly/
ID: no ID defined
Reads the full-scale value of the current.

8.2.4.1.1.6 :INRush?
SCPI: :FETCh[:SCALar]:CURRent:INRush?/qonly/ |
:READ[:SCALar]:CURRent:INRush?/qonly/
SHORT: IINR?/qonly/
ID: Iinr
Reads the value of the inrush current.

8.2.4.1.1.7 :MAXPK?

SCPI: :FETCh[:SCALar]:CURRent:MAXPK?/qonly/ |
:READ[:SCALar]:CURRent:MAXPK?/qonly/
SHORT: IMAX?/qonly/
ID: Ipkp
Reads the largest sampled value of the current.

8.2.4.1.1.8 :MINPK?

SCPI: :FETCh[:SCALar]:CURRent:MINPK?/qonly/ |
:READ[:SCALar]:CURRent:MINPK?/qonly/
SHORT: IMIN?/qonly/
ID: Ipkn
Reads the smallest sample value of the current.

8.2.4.1.1.9 :PPEak?

SCPI: :FETCh[:SCALar]:CURRent:PPEak? \f if/qonly/ |
:READ[:SCALar]:CURRent:PPEak?/qonly/
SHORT: IPP?/qonly/
ID: Ipp
Reads the peak value of the current.

8.2.4.1.1.10 :RECTify?

SCPI: :FETCh[:SCALar]:CURRent:RECTify?/qonly/ |
:READ[:SCALar]:CURRent:RECTify?/qonly/
SHORT: IREC?/qonly/
ID: Irect
Reads the rectified value of the current.

8.2.4.1.1.11 :RUSed?

SCPI: :FETCh[:SCALar]:CURRent:RUSed?/qonly/ |
:READ[:SCALar]:CURRent:RUSed?/qonly/
SHORT: OVRI?/qonly/
ID: OvrI
Reads the usage of the range in percent.

8.2.4.1.1.12 [:TRMS?]
SCPI: :FETCh[:SCALar]:CURRent[:TRMS]?/qonly/ |
:READ[:SCALar]:CURRent[:TRMS]?/qonly/
SHORT: ITRMS?/qonly/
ID: Itrms
Reads the TRMS value of the current.

8.2.4.1.2 :CYCLe

8.2.4.1.2.1 :COUNt?
SCPI: :FETCh[:SCALar]:CYCLe:COUNt?/qonly/ |
:READ[:SCALar]:CYCLe:COUNt?/qonly/
SHORT: COUNT?/qonly/
ID: no ID defined
Reads an individual number of the measuring cycle counter that is copied into memory. This value runs up to 65535 and then starts again at 0.

8.2.4.1.2.2 :TIME?
SCPI: :FETCh[:SCALar]:CYCLe:TIME?/qonly/ |
:READ[:SCALar]:CYCLe:TIME?/qonly/
SHORT: CYCR?/qonly/
ID: Mtime
Reads the real measuring time of the measuring cycle. This is the time for an integer number of periods of the measured signal (generally, this is the cycle time, but it depends on the signal).

8.2.4.1.3 :DINPut?
SCPI: :FETCh[:SCALar]:DINPut?/qonly/ | :READ[:SCALar]:DINPut?/qonly/
SHORT: DIST?/qonly/
ID: no ID defined
Reads the status of the digital inputs. The bits in the answer have the following meanings:
Bit 0: Input 1
Bit 1: Input 2
Bit 2: Input 3
Bit 3: Input 4
Bit 4: Input 5
Bit 5: Input 6

8.2.4.1.4 :ENERgy

8.2.4.1.4.1 [:ACTive]?

SCPI: :FETCh[:SCALar]:ENERgy[:ACTive]?/qonly/ |
:READ[:SCALar]:ENERgy[:ACTive]?/qonly/
SHORT: EP?/qonly/
ID: EP
Reads the active energy (integrated active power).

8.2.4.1.4.2 :APParent?

SCPI: :FETCh[:SCALar]:ENERgy:APPArent?/qonly/ |
:READ[:SCALar]:ENERgy:APParent?/qonly/
SHORT: ES?/qonly/
ID: ES
Reads the apparent energy (integrated apparent power).

8.2.4.1.4.3 :CHARge?

SCPI: :FETCh[:SCALar]:ENERgy:CHARge?/qonly/ |
:READ[:SCALar]:ENERgy:CHARge?/qonly/
SHORT: EI?/qonly/
ID: q
Reads the charge (integrated DC current).

8.2.4.1.4.4 :REACtive?

SCPI: :FETCh[:SCALar]:ENERgy:REACtive?/qonly/ |
:READ[:SCALar]:ENERgy:REACtive?/qonly/
SHORT: EQ?/qonly/
ID: EQ
Reads the reactive energy (integrated reactive power).

8.2.4.1.4.5 :TIME?

SCPI: :FETCh[:SCALar]:ENERgy:TIME?/qonly/ |
:READ[:SCALar]:ENERgy:TIME?/qonly/
SHORT: INTR?/qonly/
ID: no ID defined
Reads the time of the running integration in ms.

8.2.4.1.5 :FLICker

8.2.4.1.5.1 [:EUTest]
Selects the equipment under test measuring results. They are measured at the voltage input jacks.

8.2.4.1.5.1.1 :APMoment?
SCPI: :FETCh[:SCALar]:FLICker[:EUTest]:APMoment?/qonly/ |
:READ[:SCALar]:FLICker[:EUTest]:APMoment? \f if/qonly/
SHORT: FLMO?/qonly/
ID: Pmoml
Reads the averaged, momentary flicker level of the equipment under test. The value is displayed as 'Pmoml'. It is averaged over 16 periods.

8.2.4.1.5.1.2 :DC?
SCPI: :FETCh[:SCALar]:FLICker[:EUTest]:DC?/qonly/ |
:READ[:SCALar]:FLICker[:EUTest]:DC?/qonly/
SHORT: FLDC?/qonly/
ID: dcl
Reads the DC value of the equipment under test when measuring in the flicker mode.

8.2.4.1.5.1.3 :DELTat?
SCPI: :FETCh[:SCALar]:FLICker[:EUTest]:DELTat?/qonly/ <list>|
:READ[:SCALar]:FLICker[:EUTest]:DELTat?/qonly/ <list>
SHORT: FLDT?/qonly/ <list>
ID: dtl
Reads the d(t) values of the equipment under test. After each measuring cycle, over 16 periods, you can get 32 values. The smallest and largest requestable values in the list are 0 and 31.

8.2.4.1.5.1.4 :DMAX?
SCPI: :FETCh[:SCALar]:FLICker[:EUTest]:DMAX?/qonly/ |
:READ[:SCALar]:FLICker[:EUTest]:DMAX?/qonly/.
SHORT: FLDX?/qonly/
ID: dmaxl
Reads the dmax value of the equipment under test.

8.2.4.1.5.1.5 :HWTRms?

SCPI: :FETCh[:SCALar]:FLICker[:EUTest]:HWTRms?/qonly/ <list>|
:READ[:SCALar]:FLICker[:EUTest]:HWTRms?/qonly/ <list>
SHORT: FLRM?/qonly/ <list>
ID: Ul
Reads the half-wave TRMS values of the equipment under test. This value is displayed as 'Ul'. After each measuring cycle, over 16 periods, you can get 32 values. The smallest and largest requestable values in the list are 0 and 31.

8.2.4.1.5.1.6 :PLT?

SCPI: :FETCh[:SCALar]:FLICker[:EUTest]:PLT?/qonly/ |
:READ[:SCALar]:FLICker[:EUTest]:PLT?/qonly/
SHORT: FLLT?/qonly/
ID: Pltl
Reads the Plt value of the equipment under test.

8.2.4.1.5.1.7 :PMOMentary?

SCPI: :FETCh[:SCALar]:FLICker[:EUTest]: PMOMentary?/qonly/ <list>|
:READ[:SCALar]:FLICker[:EUTest]: PMOMentary?/qonly/ <list>
SHORT: FLMS?/qonly/ <list>
ID: Pml
Reads the momentary flicker level of the equipment under test. This is the value that is displayed as 'Pl'. After each measuring cycle, over 16 periods, you can get 32 values. The smallest and largest requestable values in the list are 0 and 31.

8.2.4.1.5.1.8 :PST?

SCPI: :FETCh[:SCALar]:FLICker[:EUTest]:PST?/qonly/ |
:READ[:SCALar]:FLICker[:EUTest]:PST?/qonly/
SHORT: FLST?/qonly/
ID: Pstl
Reads the Pst value of the equipment under test.

8.2.4.1.5.1.9 :RESult?

SCPI: :FETCh[:SCALar]:FLICker[:EUTest]:RESult?/qonly/ |
:READ[:SCALar]:FLICker[:EUTest]:RESult?/qonly/.
SHORT: FLRE?/qonly/
ID: no ID defined
Reads the result of the flicker measuring at the equipment under test. The result is returned as a long number with the following meaning:

Bit 0: Set if the total evaluation of the flicker fails (i.e., if any of the sub evaluations fail), cleared otherwise.
Bit 1: Set if at least one Pst value was >1.0, cleared otherwise.
Bit 2: Set if the Plt value was >0.65 at the END of the measuring interval, cleared otherwise.
Bit 3: Set if dmax was >4%, cleared otherwise.
Bit 4: Set if d(t) was >3% for more than 200ms, cleared otherwise.
Bit 5: Set if dc was > 3%, cleared otherwise.

8.2.4.1.5.2 :LTRemain?

SCPI: :FETCh[:SCALar]:FLICker:LTRemain?/qonly/ |
:READ[:SCALar]:FLICker:LTRemain?/qonly/
SHORT: FLTR?/qonly/
ID: no ID defined
Reads the remaining long time for the flicker measurement in seconds.

8.2.4.1.5.3 :SOURce

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

8.2.4.1.5.3.1 :APMoment?

SCPI: :FETCh[:SCALar]:FLICker:SOURce:APMoment?/qonly/ |
:READ[:SCALar]:FLICker:SOURce:APMoment?/qonly/
SHORT: FSMO?/qonly/
ID: Pmoms
Reads the averaged, momentary flicker level of the source. This is the value that is displayed as 'Pmoms'. It is averaged over 16 periods.

8.2.4.1.5.3.2 :DC?

SCPI: :FETCh[:SCALar]:FLICker:SOURce:DC?/qonly/ |
:READ[:SCALar]:FLICker:SOURce:DC?/qonly/
SHORT: FSDC?/qonly/
ID: dcs
Reads the DC value of the source.

8.2.4.1.5.3.3 :DELTat?
SCPI: :FETCh[:SCALar]:FLICker:SOURce:DELTat?/qonly/ <list>|
:READ[:SCALar]:FLICker:SOURce:DELTat?/qonly/ <list>
SHORT: FSDT?/qonly/ <list>
ID: dts
Reads the d(t) values of the source. After each measuring cycle over 16 periods you can get 32 values. The smallest and largest requestable values in the list are 0 and 31.

8.2.4.1.5.3.4 :DMAX?
SCPI: :FETCh[:SCALar]:FLICker:SOURce:DMAX?/qonly/ |
:READ[:SCALar]:FLICker:SOURce:DMAX?/qonly/
SHORT: FSDX?/qonly/
ID: dmaxs
Reads the dmax value of the source.

8.2.4.1.5.3.5 :HWTRms?
SCPI: :FETCh[:SCALar]:FLICker:SOURce:HWTRms?/qonly/ <list>|
:READ[:SCALar]:FLICker:SOURce:HWTRms?/qonly/ <list>
SHORT: FSRM?/qonly/ <list>
ID: Us
Reads the half-wave TRMS value of the source. This is the value that is displayed as 'Us'. After each measuring cycle, over 16 periods, you can get 32 values. The smallest and largest requestable values in the list are 0 and 31.

8.2.4.1.5.3.6 :PLT?
SCPI: :FETCh[:SCALar]:FLICker:SOURce:PLT?/qonly/ |
:READ[:SCALar]:FLICker:SOURce:PLT?/qonly/
SHORT: FSLT?/qonly/
ID: Plts
Reads the Plt value of the source.

8.2.4.1.5.3.7 :PMOMentary?
SCPI: :FETCh[:SCALar]:FLICker:SOURce: PMOMentary?/qonly/ <list>|
:READ[:SCALar]:FLICker:SOURce: PMOMentary?/qonly/ <list>
SHORT: FSMS?/qonly/ <list>
ID: Pms
Reads the momentary flicker level of the source. This is the value that is displayed as 'Ps'. After each measuring cycle, over 16 periods ,you can get 32 values. The smallest and largest requestable values in the list are 0 and 31.

8.2.4.1.5.3.8 :PST?

SCPI: :FETCh[:SCALar]:FLICker:SOURce:PST?/qonly/ |
:READ[:SCALar]:FLICker:SOURce:PST?/qonly/
SHORT: FSST?/qonly/
ID: Psts
Reads the Pst value of the source.

8.2.4.1.5.3.9 :RESult?

SCPI: :FETCh[:SCALar]:FLICker:SOURce:RESult?/qonly/ |
:READ[:SCALar]:FLICker:SOURce:RESult?/qonly/
SHORT: FSRE?/qonly/
ID: no ID defined
Reads the result of the flicker measuring at the source. It is returned as long number with the following meaning:

Bit 0: Set if the total evaluation of the flicker fails (i.e., if any of the sub evaluations fail), cleared otherwise.
Bit 1: Set if at least one Pst value was >1.0, cleared otherwise.
Bit 2: Set if the Plt value was >0.65 at the END of the measuring interval, cleared otherwise.
Bit 3: Set if dmax was >4%, cleared otherwise.
Bit 4: Set if d(t) was >3% for more than 200ms, cleared otherwise.
Bit 5: Set if dc was > 3%, cleared otherwise.

8.2.4.1.5.4 :STATe?

SCPI: :FETCh[:SCALar]:FLICker:STATe?/qonly/ |
:READ[:SCALar]:FLICker:STATe?/qonly/
SHORT: FSTA?/qonly/
ID: no ID defined
Reads the status of the flicker measuring. It is returned as a long number with the following meaning:

0: Reset
1: Wait
2: Run
3: Stop

8.2.4.1.5.5 :STRemain?
SCPI: :FETCh[:SCALar]:FLICker:STRemain?/qonly/ |
:READ[:SCALar]:FLICker:STRemain?/qonly/
SHORT: FSTR?/qonly/
ID: no ID defined
Reads the remaining short time for the actual short-term measurement in seconds.

8.2.4.1.6 FREQuency

8.2.4.1.6.1 :FINPut?
SCPI: :FETCh[:SCALar]:FREQuency:FINPut?/qonly/ |
:READ[:SCALar]:FREQuency:FINPut?/qonly/
SHORT: DIFQ?/qonly/
ID: DigFrq
Reads the value of frequency input of the processing signal interface.

8.2.4.1.6.2 :SSOurce?
SCPI: :FETCh[:SCALar]:FREQuency[:SSOurce]?/qonly/ |
:READ[:SCALar]:FREQuency[:SSOurce]? \f if/qonly/
SHORT: FREQ?/qonly/
ID: f
Reads the frequency of the synchronization source.

8.2.4.1.7 :HARMonics

8.2.4.1.7.1 :AMPower?
SCPI: :FETCh[:SCALar]:HARMonics:AMPower?/qonly/ |
:READ[:SCALar]:HARMonics:AMPower?/qonly/
SHORT: HPAV?/qonly/
ID: no ID defined
Reads the maximum smoothed power of the harmonic measuring.

8.2.4.1.7.2 :APFactor?
SCPI: :FETCh[:SCALar]:HARMonics:APFactor?/qonly/ |
:READ[:SCALar]:HARMonics:APFactor?/qonly/
SHORT: HPFM?/qonly/
ID: no ID defined
Reads the maximum smoothed power factor of the harmonic measuring.

8.2.4.1.7.3 :CDResult?

SCPI: :FETCh[:SCALar]:HARMonics:CDResult?/qonly/ |
:READ[:SCALar]:HARMonics:CDResult?/qonly/
SHORT: HENS?/qonly/
ID: no ID defined

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

Bit 0: Set if the total class D evaluation failed (i.e., if any of the sub evaluations failed), cleared otherwise.
Bit 1: Set if the current was for <95% of time under the positive special envelope, cleared otherwise.
Bit 2: Set if the current was for <95% of time under the negative special envelope,cleared otherwise.
Bit 3: Set if P>600W, cleared otherwise.

8.2.4.1.7.4 :CURRent

8.2.4.1.7.4.1 :AAMPlitude?

SCPI: :FETCh[:SCALar]:HARMonics:CURRent:AAMPlitude?/qonly/ <list> |
:READ[:SCALar]:HARMonics:CURRent:AAMPlitude?/qonly/ <list>
SHORT: HIAV?/qonly/ <list>
ID: Iaver

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

8.2.4.1.7.4.2 :AFUNdamental?

SCPI: :FETCh[:SCALar]:HARMonics:CURRent:AFUNdamental?/qonly/ |
:READ[:SCALar]:HARMonics:CURRent:AFUNdamental?/qonly/
SHORT: HIFM?/qonly/
ID: no ID defined

Reads the maximum averaged fundamental current of the harmonics in CE-HRM mode.

8.2.4.1.7.4.3 :AMPLitude?

SCPI: :FETCh[:SCALar]:HARMonics:CURRent:AMPLitude?/qonly/ <list> |
:READ[:SCALar]:HARMonics:CURRent:AMPLitude?/qonly/ <list>
SHORT: HIAM?/qonly/ <list>
ID: Ih
Reads the amplitude of the harmonics of the current . The smallest and largest requestable values in the list are 0 and 40 in CE-HRM mode or 0 and 99 in HRM100 mode.

8.2.4.1.7.4.4 :GFResult?

SCPI: :FETCh[:SCALar]:HARMonics:CURRent:GFResult?/qonly/ |
:READ[:SCALar]:HARMonics:CURRent:GFResult?/qonly/
SHORT: HIGF?/qonly/
ID: no ID defined
Reads the global final result of the current check in CE-HRM mode. It is returned as a long number with the following meaning:.

Bit 0: Set if the total current evaluation failed (i.e., if any of the sub evaluations fail), cleared otherwise.
Bit 1: Set if any of the harmonics was > 100% of the allowed limit, cleared otherwise.
Bit 2: Set if the fluctuating harmonics were for more than 10% of the 2.5 minute window between 100% and 150% of the limit, cleared otherwise.
Bit 3: Set if questionable values (with '?') have occured, cleared otherwise.
Bit 4: Set if measured power was > 110% of defined power, cleared otherwise. This is only a warning, not an error.
Bit 5: Set if measured power factor was > 110% of defined power factor, cleared otherwise. This is only a warning, not an error.
Bit 6: Set if measured fundamental current was > 110% of defined fundamental current, cleared otherwise. This is only a warning, not an error.
Bit 7: Set if measured power was < 90% of defined power, cleared otherwise.
Bit 8: Set if measured power factor was < 90% of defined power factor, cleared otherwise.
Bit 9: Set if measured fundamental current was < 90% of defined fundamental current, cleared otherwise.
Bit 10: Set if any harmonic is > 150% of limits, cleared otherwise.

8.2.4.1.7.4.5 :LIMit?
SCPI: :FETCh[:SCALar]:HARMonics:CURRent:LIMit?/qonly/ <list> |
:READ[:SCALar]:HARMonics:CURRent:LIMit?/qonly/ <list>
SHORT: HILM?/qonly/ <list>
ID: IL
Reads the limit of the harmonics of the current in CE-HRM mode. The smallest and largest requestable values in the list are 0 and 40.

8.2.4.1.7.4.6 :LTResult?
SCPI: :FETCh[:SCALar]:HARMonics:CURRent:LTResult?/qonly/ <list> |
:READ[:SCALar]:HARMonics:CURRent:LTResult?/qonly/ <list>
SHORT: HILT?/qonly/ <list>
ID: no ID defined
Reads the long-time result of the harmonics of the current in CE-HRM mode. This is an array of two long numbers, so you get a 64-bit result, if you read out both elements. Each bit, from 0 to 40, indicates if the corresponding harmonic has at least one time during the measuring violated the limit. The smallest and largest requestable values in the list are 0 and 1.

8.2.4.1.7.4.7:MAMPlitude?
SCPI: :FETCh[:SCALar]:HARMonics:CURRent:MAMPlitude?/qonly/ <list> |
:READ[:SCALar]:HARMonics:CURRent:MAMPlitude?/qonly/ <list>
SHORT: HIMX?/qonly/ <list>
ID: IMax.
Reads the maximum amplitude of the harmonics of the current in CE-HRM mode. The smallest and largest requestable values in the list are 0 and 40.

8.2.4.1.7.4.8 :OLIMit?
SCPI: :FETCh[:SCALar]:HARMonics:CURRent:OLIMit?/qonly/ <list> |
:READ[:SCALar]:HARMonics:CURRent:OLIMit?/qonly/ <list>
SHORT: HIOV?/qonly/ <list>
ID: no ID defined
Reads the over-limit status of the harmonics of the current in CE-HRM mode. This is an array of two long numbers, so you get a 64-bit result if you read out both elements. Each bit from 0 to 40 indicates, if the corresponding harmonic has violated the limit in the actual frame. The smallest and largest requestable values in the list are 0 and 1.

8.2.4.1.7.4.9 :PHASe?
SCPI: :FETCh[:SCALar]:HARMonics:CURRent:PHASe?/qonly/ <list> |
:READ[:SCALar]:HARMonics:CURRent:PHASe?/qonly/ <list>
SHORT: HIPH?/qonly/ <list>
ID: IP
Reads the phase of the harmonics of the current in HRM100 mode. The smallest and largest requestable values in the list are 0 and 99.

8.2.4.1.7.4.10 :POHarmonic?
SCPI: :FETCh[:SCALar]:HARMonics:CURRent:POHarmonic?/qonly/ |
:READ[:SCALar]:HARMonics:CURRent:POHarmonic?/qonly/
SHORT: HPOC?/qonly/
ID: Ipohc
Reads the partial odd harmonic current.

8.2.4.1.7.4.11 :POLimit?
SCPI: :FETCh[:SCALar]:HARMonics:CURRent:POLimit?/qonly/ |
:READ[:SCALar]:HARMonics:CURRent:POLimit?/qonly/
SHORT: HLIP?/qonly/
ID: no ID defined
Reads the partial odd harmonic current that is calculated from the limits at the end of a measuring in CE-HRM mode.

8.2.4.1.7.4.12 :SAVerage?
SCPI: :FETCh[:SCALar]:HARMonics:CURRent:SAVerage?/qonly/ |
:READ[:SCALar]:HARMonics:CURRent:SAVerage?/qonly/
SHORT: HIAS?/qonly/
ID: no ID defined
Reads the smoothed averaged current of the harmonics in CE-HRM mode.

8.2.4.1.7.4.13 :SMOothed?
SCPI: :FETCh[:SCALar]:HARMonics:CURRent:SMOothed?/qonly/ |
:READ[:SCALar]:HARMonics:CURRent:SMOothed?/qonly/
SHORT: HIMA?/qonly/
ID: no ID defined
Reads the smoothed current of the harmonics in CE-HRM mode.

8.2.4.1.7.4.14 :STATe?

SCPI: :FETCh[:SCALar]:HARMonics:CURRent:STATe?/qonly/ |
:READ[:SCALar]:HARMonics:CURRent:STATe?/qonly/
SHORT: HIST?/qonly/
ID: no ID defined

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

Bit 0: Set if the total current evaluation failed (i.e., if any of the sub evaluations failed), cleared otherwise.
Bit 1: Set if any of the harmonics were > 100% of the allowed limit, cleared otherwise.
Bit 2: Set if the fluctuating harmonics were for more than 10% of the 2.5 minute window between 100% and 150% of the limit, cleared otherwise.
Bit 3: Set if questionable values (with '?') have occurred, cleared otherwise.
Bit 4: Set if measured power was > 110% of defined power, cleared otherwise. This is only a warning, not an error.
Bit 5: Set if measured power factor was > 110% of defined power factor, cleared otherwise. This is only a warning, not an error.
Bit 6: Set if measured fundamental current was > 110% of defined fundamental current, cleared otherwise. This is only a warning, not an error.
Bit 7: Set if measured power was < 90% of defined power, cleared otherwise.
Bit 8: Set if measured power factor was < 90% of defined power factor, cleared otherwise.
Bit 9: Set if measured fundamental current was < 90% of defined fundamental current, cleared otherwise.
Bit 10: Set if any harmonic is > 150% of limits, cleared otherwise.

8.2.4.1.7.4.15 :THARmonic?

SCPI: :FETCh[:SCALar]:HARMonics:CURRent:THARmonic?/qonly/ |
:READ[:SCALar]:HARMonics:CURRent:THARmonic?/qonly/
SHORT: HTHC?/qonly/
ID: Ithc

Reads the total harmonic current.

8.2.4.1.7.4.16 :THDistort?

SCPI: :FETCh[:SCALar]:HARMonics:CURRent:THDistort?/qonly/ |
:READ[:SCALar]:HARMonics:CURRent:THDistort?/qonly/
SHORT: HIHD?/qonly/
ID: Ithd
Reads the THD of the current.

8.2.4.1.7.5 [:VOLTage]

8.2.4.1.7.5.1 :AMPLitude?

SCPI: :FETCh[:SCALar]:HARMonics[:VOLTage]:AMPLitude?/qonly/ <list> |
:READ[:SCALar]:HARMonics[:VOLTage]:AMPLitude?/qonly/ <list>
SHORT: HUAM?/qonly/ <list>
ID: Uh
Reads the amplitude of the harmonics of the voltage harmonics. The smallest and largest requestable values in the list are 0 and 40 in CE-HRM mode or 0 and 99 in HRM100 mode.

8.2.4.1.7.5.2 :GFResult?

SCPI: :FETCh[:SCALar]:HARMonics[:VOLTage]:GFResult?/qonly/ |
:READ[:SCALar]:HARMonics[:VOLTage]:GFResult?/qonly/
SHORT: HUGF?/qonly/
ID: no ID defined
Reads the global final result of the voltage check in CE-HRM mode. It is returned as a long number with the following meaning:

Bit 0: Set if the total voltage evaluation failed (i.e, if any of the sub evaluation failed), cleared otherwise.
Bit 1: Set if any of the harmonics were > 100% of the allowed limit, cleared otherwise.
Bit 2: Set if the voltage amplitude was not within the limit, cleared otherwise.
Bit 3: Set if the frequency was not within the limit, cleared otherwise.
Bit 4: Set if the crest factor was not within the limit, cleared otherwise.

8.2.4.1.7.5.3 :LIMit?

SCPI: :FETCh[:SCALar]:HARMonics[:VOLTage]:LIMit?/qonly/ <list> |
:READ[:SCALar]:HARMonics[:VOLTage]:LIMit?/qonly/ <list>.
105
SHORT: HULM?/qonly/ <list>
ID: UL
Reads the limits of the harmonics of the voltage in CE-HRM mode. The smallest and largest requestable values in the list are 0 and 40.

8.2.4.1.7.5.4 :LTResult?

SCPI: :FETCh[:SCALar]:HARMonics[:VOLTage]:LTResult?/qonly/ <list> |
:READ[:SCALar]:HARMonics[:VOLTage]:LTResult?/qonly/ <list>
SHORT: HULT?/qonly/ <list>
ID: no ID defined
Reads the long time result of the harmonics of the voltage in CE-HRM mode. This is an array of two long numbers, so you get a 64-bit result, if you read out both elements. Each bit from 0 to 40 indicates if the corresponding harmonic has, at least one time during the measuring, violated the limit. The smallest and largest requestable values in the list are 0 and 1.

8.2.4.1.7.5.5 :MAMPlitude?

SCPI: :FETCh[:SCALar]:HARMonics[:VOLTage]:MAMPlitude?/qonly/ <list> |
:READ[:SCALar]:HARMonics[:VOLTage]:MAMPlitude?/qonly/ <list>
SHORT: HUMX?/qonly/ <list>
ID: UMax
Reads the maximum amplitude of the harmonics of the voltage harmonics in CE-
HRM
mode. The smallest and largest requestable values in the list are 0 and 40.

8.2.4.1.7.5.6 :OLIMit?

SCPI: :FETCh[:SCALar]:HARMonics[:VOLTage]:OLIMit?/qonly/ <list> |
:READ[:SCALar]:HARMonics[:VOLTage]:OLIMit?/qonly/ <list>
SHORT: HUOV?/qonly/ <list>
ID: no ID defined
Reads the over-limit status of the harmonics of the voltage in CE-HRM mode. This is an array of two long numbers, so you get a 64-bit result, if you read out both elements. Each bit from 0 to 40 indicates if the corresponding harmonic has violated the limit in the actual frame. The smallest and largest requestable values in the list are 0 and 1.

8.2.4.1.7.5.7 :PHASe?

SCPI: :FETCh[:SCALar]:HARMonics[:VOLTage]:PHASe?/qonly/ <list> |
:READ[:SCALar]:HARMonics[:VOLTage]:PHASe?/qonly/ <list>
SHORT: HUPH?/qonly/ <list>
ID: UP
Reads the phase of the harmonics of the voltage in HRM100 mode. The smallest and largest requestable values in the list are 0 and 99.

8.2.4.1.7.5.8 :STATe?

SCPI: :FETCh[:SCALar]:HARMonics[:VOLTage]:STATe?/qonly/ |
:READ[:SCALar]:HARMonics[:VOLTage]:STATe?/qonly/
SHORT: HUST?/qonly/
ID: no ID defined
Reads the actual result of the voltage check in CE-HRM mode. It is returned as a long number with the following meaning:

Bit 0: Set if the total voltage evaluation failed (i.e., if any of the sub evaluations failed), cleared otherwise.
Bit 1: Set if any of the harmonics were > 100% of the allowed limit, cleared otherwise.
Bit 2: Set if the voltage amplitude was not within the limit, cleared otherwise.
Bit 3: Set if the frequency was not within the limit, cleared otherwise.
Bit 4: Set if the crest factor was not within the limit, cleared otherwise.

8.2.4.1.7.5.9 :THDistort?

SCPI: :FETCh[:SCALar]:HARMonics[:VOLTage]:THDistort?/qonly/ |
:READ[:SCALar]:HARMonics[:VOLTage]:THDistort?/qonly/
SHORT: HUHD?/qonly/
ID: Uthd
Reads the THD of the voltage.

8.2.4.1.8 :POWer

8.2.4.1.8.1 :AACTive?

SCPI: :FETCh[:SCALar]:POWer:AACTive?/qonly/ |
:READ[:SCALar]:POWer:AACTive?/qonly/
SHORT: PM?/qonly/
ID: Pm
Reads the average active power.

8.2.4.1.8.2 :AAPParent?

SCPI: :FETCh[:SCALar]:POWer:AAPParent?/qonly/ |
:READ[:SCALar]:POWer:AAPParent?/qonly/
SHORT: SM?/qonly/
ID: Sm
Reads the average apparent power.

8.2.4.1.8.3 [:ACTive]?

SCPI: :FETCh[:SCALar]:POWer[:ACTive]?/qonly/ |
:READ[:SCALar]:POWer[:ACTive]?/qonly/
SHORT: P?/qonly/
ID: P
Reads the active power.

8.2.4.1.8.4 :APParent?

SCPI: :FETCh[:SCALar]:POWer:APParent?/qonly/ |
:READ[:SCALar]:POWer:APParent?/qonly/
SHORT: S?/qonly/
ID: S
Reads the apparent power.

8.2.4.1.8.5 :AREactive?

SCPI: :FETCh[:SCALar]:POWer:AREactive?/qonly/ |
:READ[:SCALar]:POWer:AREactive?/qonly/
SHORT: Q?/qonly/
ID: Qm
Reads the average reactive power.

8.2.4.1.8.6 :FSCale?

SCPI: :FETCh[:SCALar]:POWer:FSCale?/qonly/ |
:READ[:SCALar]:POWer:FSCale?/qonly/
SHORT: FSP?/qonly/
ID: no ID defined
Reads the full-scale value of the power.

8.2.4.1.8.7 :ICAPacity?

SCPI: :FETCh[:SCALar]:POWer:ICAPacity?/qonly/ |
:READ[:SCALar]:POWer:ICAPacity?/qonly/
SHORT: INCA?/qonly/
ID: no ID defined
Reads the status of the inca flag. Shows if the system is inductive or capacitive. It is returned as a long number with the following meaning:
+1 inductive
0 undefined
-1 capacitive

8.2.4.1.8.8 :PFACtor?

SCPI: :FETCh[:SCALar]:POWer:PFACtor?/qonly/ |
:READ[:SCALar]:POWer:PFACtor?/qonly/
SHORT: PF?/qonly/
ID: PF.
Reads the power factor.

8.2.4.1.8.9 :PHASe?

SCPI: :FETCh[:SCALar]:POWer:PHASe?/qonly/ |
:READ[:SCALar]:POWer:PHASe?/qonly/
SHORT: PHI?/qonly/
ID: PHI
Reads the phase between current and voltage.

8.2.4.1.8.10 :REACtive?

SCPI: :FETCh[:SCALar]:POWer:REACtive?/qonly/ |
:READ[:SCALar]:POWer:REACtive?/qonly/
SHORT: Q?/qonly/
ID: Q
Reads the reactive power.

8.2.4.1.9 :RESistance

8.2.4.1.9.1 :ASResist?

SCPI: :FETCh[:SCALar]:RESistance:ASResist?/qonly/ |
:READ[:SCALar]:RESistance:ASResist?/qonly/
SHORT: RSER?/qonly/
ID: Rser
Reads the active serial resistance.

8.2.4.1.9.2 :IMPedance?

SCPI: :FETCh[:SCALar]:RESistance:IMPedance?/qonly/ |
:READ[:SCALar]:RESistance:IMPedance?/qonly/
SHORT: Z?/qonly/
ID: Z
Reads the impedance (apparent resistance).

8.2.4.1.9.3 :RSIMpedance?

SCPI: :FETCh[:SCALar]:RESistance:RSIMpedance?/qonly/ |
:READ[:SCALar]:RESistance:RSIMpedance?/qonly/
SHORT: XSER?/qonly/
ID: Xser
Reads the reactive serial impedance.

8.2.4.1.10 :VARiable?

SCPI: :FETCh[:SCALar]:VARiable?/qonly/ <list> |
:READ[:SCALar]:VARiable?/qonly/ <list>
SHORT: XSER?/qonly/ <list>
ID: The ID is the name a user has defined. If a user has a formula 'abc=Utrms*2;', then the ID would be 'abc'. Reads the value of the defined variables. The smallest and largest requestable values in the list are 0 and 7.

8.2.4.1.11 [:VOLTage]

8.2.4.1.11.1 :AC?

SCPI: :FETCh[:SCALar][:VOLTage]:AC?/qonly/ |
:READ[:SCALar][:VOLTage]:AC?/qonly/
SHORT: UAC?/qonly/
ID: Uac
Reads the AC value of the voltage.

8.2.4.1.11.2 :AINPut?
SCPI: :FETCh[:SCALar][:VOLTage]:AINPut?/qonly/<list> |
:READ[:SCALar][:VOLTage]:AINPut?/qonly/ <list>
SHORT: AIVA?/qonly/ <list>
ID: Ain
Reads the voltage of the analogue input of the processing signal interface. With <list> you specify the required values.

8.2.4.1.11.3 :CFACtor?
SCPI: :FETCh[:SCALar][:VOLTage]:CFACtor?/qonly/ |
:READ[:SCALar][:VOLTage]:CFACtor?/qonly/
SHORT: UCF?/qonly/
ID: Ucf
Reads the crest factor of the voltage.

8.2.4.1.11.4 :DC?
SCPI: :FETCh[:SCALar][:VOLTage]:DC?/qonly/ |
:READ[:SCALar][:VOLTage]:DC?/qonly/
SHORT: UDC?/qonly/
ID: Udc
Reads the DC value of the voltage.

8.2.4.1.11.5 :FFACtor?
SCPI: :FETCh[:SCALar][:VOLTage]:FFACtor?/qonly/ |
:READ[:SCALar][:VOLTage]:FFACtor?/qonly/
SHORT: UFF?/qonly/
ID: Uff
Reads the form factor of the voltage.

8.2.4.1.11.6 :FSCale?
SCPI: :FETCh[:SCALar][:VOLTage]:FSCale?/qonly/ |
:READ[:SCALar][:VOLTage]:FSCale?/qonly/
SHORT: FSU?/qonly/
ID: no ID defined
Reads the full-scale value of the voltage.

8.2.4.1.11.7 :MAXPK?

SCPI: :FETCh[:SCALar][:VOLTage]:MAXPK?/qonly/ |
:READ[:SCALar][:VOLTage]:MAXPK?/qonly/
SHORT: UMAX?/qonly/
ID: Upkp
Reads the largest sample value of the voltage.

8.2.4.1.11.8 :MINPK?

SCPI: :FETCh[:SCALar][:VOLTage]:MINPK?/qonly/ |
:READ[:SCALar][:VOLTage]:MINPK?/qonly/
SHORT: UMIN?/qonly/
ID: Upkn
Reads the smallest sample value of the voltage.

8.2.4.1.11.9 :PPEak?

SCPI: :FETCh[:SCALar][:VOLTage]:PPEak?/qonly/ |
:READ[:SCALar][:VOLTage]:PPEak?/qonly/
SHORT: UPP?/qonly/
ID: Upp
Reads the peak peak value of the voltage.

8.2.4.1.11.10 :RECTify?

SCPI: :FETCh[:SCALar][:VOLTage]:RECTify?/qonly/ |
:READ[:SCALar][:VOLTage]:RECTify?/qonly/
SHORT: UREC?/qonly/
ID: Urect
Reads the rectified value of the voltage.

8.2.4.1.11.11 :RUSed?

SCPI: :FETCh[:SCALar][:VOLTage]:RUSed?/qonly/ |
:READ[:SCALar][:VOLTage]:RUSed?/qonly/
SHORT: OVRU?/qonly/
ID: OvrU
Reads the usage of the range in percent.

8.2.4.1.11.12 [:TRMS?]
SCPI: :FETCh[:SCALar][:VOLTage][:TRMS]?/qonly/ |
:READ[:SCALar][:VOLTage][:TRMS]?/qonly/
SHORT: UTRMS?/qonly/
ID: Utrms
Reads the TRMS value of the voltage.

8.2.5 :FORMat

Here you can set up the output format.

8.2.5.1 :DATA

SCPI: :FORMat:DATA/nquery/ <NRi>
SHORT: FRMT/nquery/ <NRi>
ID: no ID defined
Defines the data output format. Parameter is:
'0' or 'ASCII' for ASCII output [*RST default value].
'1' or 'PACKED' for a packed output.
In the packed output, the data are output as defined-length, arbitrary block response data. If there is more data to be output than buffer memory available, there are several sequential blocks of data. There are three kinds of data in the blocks: ASCII data, long data (4 byte) and float data (4 byte). The numeric data are transferred, so that the receiving PC program can store the data directly in memory. The number 0x11223344 is ordered inside the block as 0x44 0x33 0x22 0x11. This is the order Intel-based computers store the number in. So, if you want to read the number, you can simply use a pointer to the input buffer and read the contents of the pointer.

The output changes after the end of the actual program message.

8.2.6 :INITiate Commands

Here you can start or stop special actions.

8.2.6.1 :CONTinuous

SCPI: :INITiate:CONTinuous <NRi>
SHORT: CONT <NRi>
ID: no ID defined
This activates or deactivates the continuous execution of the string defined with :TRIGger:ACTion or ACTN. The programmer should only use :FETCh commands to be executed because, when switched to 'ON', an :INITiate:IMMediate is executed automatically at the end of each cycle.
Parameters:
'ON' or '1' activates this mode
'OFF' or '0' deactivates this mode [*RST default value]
The standard defines, that instruments with sequential commands can only exit the 'ON' state by the device CLEAR command of the interface. This also works with this instrument. Additionally, however, you can exit the 'ON' state by setting the instrument to 'OFF' with :INITiate:CONTinuouse or CONT.

8.2.6.2 :COPY

SCPI: :INITiate:COPY/nquery/
SHORT: COPY/nquery/
ID: no ID defined
This forces an actualization of the values to be read with the :FETCh commands. The copying of the data is done immediately and not at the end of the measuring cycle (see also 8.2.6.3 *:IMMediate INIM*).

8.2.6.3 :IMMediate

SCPI: :INITiate:IMMediate/nquery/
SHORT: INIM/nquery/
ID: no ID defined
This forces an actualization of the values to be read with the :FETCh commands. In general, the instrument measures continuously. After each cycle the measured values

are copied into the display memory. The values read by the :FETCh commands are taken from another copy of the values. This copy is updated, whenever the :INITiate:IMMediate or INIM command is executed. This assures that all values read with sequential :FETCh commands are from one measuring cycle and belong together. Please note that this command is not executed instantaneously, and it will not be complete until the end of the cycle. This can take up to one complete cycle. Keep this in mind when setting any time-out for expecting the answer of a following command.

8.2.7 :INPut

8.2.7.1 :COUPling

SCPI: :INPut:COUPling <NRi>
SHORT: SCPL <NRi>
ID: no ID defined
Sets or queries the setting of the signal coupling . The *RST default value is 0.
Allowed values are:
'0' or 'ACDC' for AC+DC coupling
'1' for AC coupling

8.2.8 :INSTrument Commands

Here general set-ups of the instrument are done.

8.2.8.1 :SELect

SCPI: :INSTrument:SELect <NRi>
SHORT: MODE <NRi>
ID: no ID defined
Sets or reads the measuring mode:
'0' or 'NORML' for normal measuring mode [*RST default value]
'1' or 'CEHRM' for CE harmonic measuring mode
'2' or 'CEFLK' for CE flicker measuring mode
'3' or 'HRMHUN' for 100 harmonics measuring mode
'4' or 'TRANS' for transient measuring mode

8.2.9 :MEMory Commands

8.2.9.1 :FREeze

SCPI: :MEMory:FREeze <NRi>
SHORT: FRZ <NRi>
ID: no ID defined
Freezes the scope RAM. The scope has too much memory, so it cannot be copied into a buffer each cycle. For this reason, you should set FRZ to ON when you want to read out the sample values of the scope. Parameters:
'ON' or '1' activates the freeze mode
'OFF' or '0' deactivates the freeze mode [*RST default value]

8.2.10 :SENSe Commands

8.2.10.1 :AINPut

8.2.10.1.1 :FSCale
SCPI: :SENSe:AINPut:FSCale <NRf>
SHORT: AIHI <NRf>
ID: no ID defined
Sets or queries the setting of the full scale of the analogue inputs . The *RST default value is 10.

8.2.10.1.2 :ZERO
SCPI: :SENSe:AINPut:ZERO <NRf>
SHORT: AILO <NRf>
ID: no ID defined
Sets or queries the setting of the zero position of the analogue inputs . The *RST default value is 0.

8.2.10.2 :AVERage

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

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

8.2.10.3 :CURRent

8.2.10.3.1 :DETector

SCPI: :SENSe:CURRent:DETector <NRi>
SHORT: IEXT <NRi>
ID: no ID defined
Reads and sets internal or external shunt input:
'0' or 'INT' for internal shunt (current input) [*RST default value]
'1' or 'EXT' for external shunt input (voltage input)

8.2.10.3.2 :RANGe

8.2.10.3.2.1 :AUTO

SCPI: :SENSe:CURRent:RANGe:AUTO <NRi>
SHORT: IAM <NRi>
ID: no ID defined
Reads and sets the status of the auto-range function:
'0' or 'MANUAL' for manual range selection
'1' or 'AUTO' for automatic range selection [*RST default value]

8.2.10.3.2.2 [:UPPER]

SCPI: :SENSe:CURRent:RANGe[:UPPER] <NRf>
SHORT: IRNG <NRf>
ID: RngI
Reads and sets the range for the current measurement. The parameter is the nominal value of the range. There is no *RST default value.

8.2.10.3.3 :SCALe

SCPI: :SENSe:CURRent:SCALe <NRf>
SHORT: ISCA <NRf>
ID: Iscal
Reads and sets the scaling of the current range. The *RST default value is 8.

8.2.10.4 :FILTer

8.2.10.4.1 [:LPASs]

8.2.10.4.1.1 [:STATe]

SCPI: :SENSe:FILTer[:LPASS][:STATe] <NRi>
SHORT: FILT <NRi>
ID: no ID defined
Reads and sets the filter settings:
0: Filter off [*RST default value]
1: AAF on
2: Lowpass '2kHz' on
3: Lowpass '9.2kHz' on
4: Lowpass '60Hz' on
5: Lowpass '18kHz' on
6: Lowpass '6kHz' on.
7: Lowpass '2.8kHz' on
8: Lowpass '1.4kHz' on
11: Lowpass '175Hz' on
12: Lowpass '87.5Hz' on
13: Lowpass '30Hz' on

8.2.10.5 :FINPut

8.2.10.5.1 :SCALe

SCPI: :SENSe:FINPut:SCALe <NRf>
SHORT: DIFS <NRf>
ID: no ID defined
Sets or queries the setting of the scale of the frequency input . The *RST default value is 1.

8.2.10.6 :FLICker

8.2.10.6.1 :PERiods

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

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

8.2.10.6.2 :STIMe

SCPI: :SENSe:FLICker:STIMe <NRf>
SHORT: FTIM <NRf>
ID: no ID defined
Reads and sets the short-term flicker measuring time in seconds. The *RST default value is 600.

8.2.10.7 :HARMonics

8.2.10.7.1 :REFerence

SCPI: :SENSe:HARMonics:REFerence <NRi>
SHORT: HREF <NRi>
ID: no ID defined
Reads and sets the state of the harmonic reference. That determines if the basic wave of U or I is set to 0° as reference for the system.
'0' for U as reference [*RST default value]
'1' for I as reference

8.2.10.7.2 :SMOoth

SCPI: :SENSe:HARMonics:SMOoth <NRi>
SHORT: SMOO <NRi>
ID: no ID defined
Reads and sets the state of the smoothing:
'0' or 'OFF' for direct measuring [*RST default value]
'1' or 'ON' for smoothed measuring

8.2.10.7.3 :TIME

SCPI: :SENSe:HARMonics:TIME <NRf>
SHORT: HTIM <NRf>
ID: no ID defined
Reads and sets the harmonics measuring time in seconds. The *RST default value is 150.

8.2.10.8 :INTegral

8.2.10.8.1 :DATE

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

SHORT: INTD <NRf>,<NRf>,<NRf>

ID: no ID defined

Reads and sets the start date for an energy measurement. Example: INTD 2001,02,09 sets the date to February 9th, 2001.

8.2.10.8.2 :INTerval

SCPI: :SENSe:INTegral:INTerval <NRf>

SHORT: INTI <NRf>

ID: no ID defined

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

8.2.10.8.3 :MODE

SCPI: :SENSe:INTegral:MODE <NRi>

SHORT: INTM <NRi>

ID: no ID defined

Reads and sets the integration mode.

0 = off [*RST default value]

1 = continuous

2 = interval

3 = periodic

4 = summing

8.2.10.8.4 :STATe?

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

SHORT: INTS?/qonly/

ID: no ID defined

Reads the state of the energy measurement. The returned long value means:

0 = Reset

1 = Wait

2 = Start

3 = Run

4 = Stop

5 = Hold

8.2.10.8.5 :TIME

SCPI: :SENSe:INTegral:TIME <NRf>,<NRf>,<NRf>
SHORT: INTT <NRf>,<NRf>,<NRf>
ID: no ID defined
Reads and sets the start time for an energy measurement. Example: INTT 19,26,49 sets the start time to 19:26:49.

8.2.10.9 :SWEep

8.2.10.9.1 :TIME

SCPI: :SENSe:SWEep:TIME <NRf>
SHORT: CYCL <NRf>
ID: Cycle
Reads and sets the cycle time in seconds. The *RST default value is 0.5.

8.2.10.10 :TRANsient

8.2.10.10.1 :ACRegister

SCPI: :SENSe:TRANsient:ACRegister <NRi>
SHORT: TACR <NRi>
ID: no ID defined.
Reads and sets the AND condition register in the transient mode. The *RST default value is 0.
The parameter and the return value are a long number with the following meaning:
Bit 0: slewrate
Bit 1: Win In
Bit 2: Win Out
Bit 3: >Lim 1
Bit 4: <Lim 1
Bit 5: >Lim 2
Bit 6: <Lim 2
The bits are counted from 0 to 7.

8.2.10.10.2 :DURation

SCPI: :SENSe:TRANsient:DURation <NRf>
SHORT: TDUR <NRf>
ID: no ID defined
Reads and sets the duration of the event. The *RST default value is 1ms, which is also the minimum value. The maximum value is 10s.

8.2.10.10.3 :LIMita

SCPI: :SENSe:TRANsient:LIMita <NRf>
SHORT: TLIA <NRf>
ID: no ID defined
Reads and sets the limit 1 of the transient mode. The *RST default value is 0.

8.2.10.10.4 :LIMitb

SCPI: :SENSe:TRANsient:LIMitb <NRf>
SHORT: TLIB <NRf>
ID: no ID defined
Reads and sets the limit 2 of the transient mode. The *RST default value is 0.

8.2.10.10.5 :OCRegister

SCPI: :SENSe:TRANsient:OCRegister <NRi>
SHORT: TOCR <NRi>
ID: no ID defined
Reads and sets the OR condition register in the transient mode. The *RST default value is 0.
The parameter and the return value are a long number with the following meaning:
Bit 0: slewrate
Bit 1: Win In
Bit 2: Win Out
Bit 3: >Lim 1
Bit 4: <Lim 1
Bit 5: >Lim 2
Bit 6: <Lim 2
The bits are counted from 0 to 7.

8.2.10.10.6 :PRETrigger

SCPI: :SENSe:TRANsient:PRETrigger <NRf>
SHORT: TPRE <NRf>
ID: no ID defined

Reads and sets the pre-trigger of the transient mode. The *RST default value is 50%. Allowed values are from 0% to 100%.

8.2.10.10.7 :RTIMe

SCPI: :SENSe:TRANsient:RTIMe <NRf>
SHORT: TREC <NRf>
ID: no ID defined
Reads and sets the record time of the transient mode. The *RST default value is 0.5s. Allowed values are from 10ms to 60s.

8.2.10.10.8 :SIGNal

SCPI: :SENSe:TRANsient:SIGNal <NRf>
SHORT: TSRC <NRf>
ID: no ID defined
Reads and sets the signal source of the transient mode. The *RST default value is 5.
The following parameters are allowed:
1: i^2
3: u^2
5: i
6: u
7: p

8.2.10.10.9 :SRDT

SCPI: :SENSe:TRANsient:SRDT <NRf>
SHORT: TDT <NRf>
ID: no ID defined
Reads and sets the slew rate dt of the transient mode. The *RST default value is 1ms. Allowed values are from 1ms to 1s.

8.2.10.10.10 :SRDY

SCPI: :SENSe:TRANsient:SRDY <NRf>
SHORT: TDU <NRf>
ID: no ID defined
Reads and sets the slew rate dy of the transient mode. The *RST default value is 1.

8.2.10.10.11 :SROVER

SCPI: :SENSe:TRANsient:SROVER <NRf>
SHORT: TDX <NRf>
ID: no ID defined
Reads and sets the slew rate over x value of the transient mode. The *RST default value is 1. Allowed values are from 1 to 15.

8.2.10.11 :VOLTage

8.2.10.11.1 :RANGe

8.2.10.11.1.1 :AUTO

SCPI: :SENSe:VOLTage:RANGe:AUTO <NRi>
SHORT: UAM <NRi>
ID: no ID defined
Reads and sets the status of the auto-range function:
'0' or 'MANUAL' for manual range selection
'1' or 'AUTO' for automatic range selection [*RST default value]

8.2.10.11.1.2 [:UPPER]

SCPI: :SENSe:VOLTage:RANGe[:UPPER] <NRf>
SHORT: URNG <NRf>
ID: RngU
Reads and sets the range for the voltage measurement. The parameter is the nominal value of the range. There is no *RST default value.

8.2.10.11.2 :SCALe

SCPI: :SENSe:VOLTage:SCALe <NRf>
SHORT: USCA <NRf>
ID: Uscal
Reads and sets the scaling of the voltage range. The *RST default value is 1.0.

8.2.10.12 :WAVeform

8.2.10.12.1 :IUPDate

SCPI: :SENSe:WAVeform:IUPDate/nquery/
SHORT: SACT/nquery/
ID: no ID defined

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

8.2.10.12.2 :SATRigger?
SCPI: :SENSe:WAVeform:SATRigger?/qonly/
SHORT: SATR?/qonly/
ID: no ID defined
Reads how many sample values are available after the trigger event. See also ':SENS:WAV:IUPD'.

8.2.10.12.3 :SBTRigger?
SCPI: :SENSe:WAVeform:SBTRigger?/qonly/
SHORT: SBTR?/qonly/
ID: no ID defined
Reads how many sample values are available before the trigger event. See also ':SENS:WAV:IUPD' .

8.2.10.12.4 :SSAMples?
SCPI: :SENSe:WAVeform:SSAMples?/qonly/
SHORT: SSAM?/qonly/
ID: no ID defined
Reads which sample values are stored in the memory. See also ':SENS:WAV:IUPD'.
It is returned as long number with the following meaning:
Bit 3: i
Bit 4: u
Bit 5: p
The bits are counted from 0 to 7.

8.2.10.12.5 :WAVE?

SCPI: :SENSe:WAVeform:WAVE?/qonly/ <NRi>,<list>
SHORT: WAVE?/qonly/ <NRi>,<list>
ID: no ID defined
Reads out sample values specified with <NRi>. It is a long number with the following meaning:
4: i
5: u
6: p
The first value in <list> is the value read by :SENSe:WAVeform:SBTRigger?, the last value is read by :SENSe:WAVeform:SATRigger?

8.2.11 :SOURce

8.2.11.1 :DIGital

8.2.11.1.1 :CONDition

SCPI: :SOURce:DIGital:CONDition <NRi>
SHORT: DOCO <NRi>
ID: no ID defined
Sets or queries the setting of the condition of the digital outputs. The *RST default value is 0.
Possible parameters are:
0: off
1: on
2: >=
3: <

8.2.11.1.2 :LIMit

SCPI: :SOURce:DIGital:LIMit <NRf>
SHORT: DOLI <NRf>
ID: no ID defined
Sets or queries the setting of the limits of the digital outputs. The *RST default value is 0.

8.2.11.1.3 :VALue

SCPI: :SOURce:DIGital:VALue <string>

SHORT: DOIX <string>
ID: no ID defined
Sets or queries the setting of the value of the digital outputs. The *RST default value is 'Utrms'. As <string> you have to enter the same string as you would enter when using the instrument without interface.

8.2.11.2 :VOLTage

8.2.11.2.1 :VALue
SCPI: :SOURce:VOLTage:VALue <string>
SHORT: AOIX <string>
ID: no ID defined
Sets or queries the setting of the value of the analogue outputs. The *RST default value is 'Utrms'. As <string> you have to enter the same string as you would enter when using the instrument without interface.

8.2.11.2.2 :SCALe

8.2.11.2.2.1 :FSCale AIHIAOIX3 "Itrms"
Defines that the trms value of the current should be output on the third analogue output.

8.2.11.2.2.2 :ZERO
SCPI: :SOURce:VOLTage:SCALe:ZERO <NRf>
SHORT: AOLO <NRf>
ID: no ID defined
Sets or queries the setting of the zero position of the analogue output . The *RST default value is 0.

8.2.12 :STATus Commands

8.2.12.1 :OPERation

8.2.12.1.1 :CONDition?
SCPI: :STATus:OPERation:CONDition?/qonly/
SHORT: SOC?/qonly/
ID: no ID defined
Reads the Operation Status Condition Register.

8.2.12.1.2 :ENABle
SCPI: :STATus:OPERation:ENABle
SHORT: SOEN
ID: no ID defined
Reads and sets the Operation Status Enable Register.

8.2.12.1.3 [:EVENt]?
SCPI: :STATus:OPERation[:EVENt]?/qonly/
SHORT: SOE?/qonly/
ID: no ID defined
Reads the Operation Status Event Register and clears it.

8.2.12.1.4 :NTRansition
SCPI: :STATus:OPERation:NTRansition
SHORT: SONT
ID: no ID defined
Reads and sets the Operation Status Negative Transition Register.

8.2.12.1.5 :PTRansition
SCPI: :STATus:OPERation:PTRansition
SHORT: SOPT
ID: no ID defined
Reads and sets the Operation Status Positive Transition Register.

8.2.12.2 PRESet

SCPI: :STATus:PRESet/nquery/
SHORT: PRES/nquery/
ID: no ID defined.
Presets the operation and the query registers. The p-transition registers are filled with 0x7FFF, the n-trasnsition registers with 0x0000, and the enable registers with 0x0000.

8.2.12.3 :QUEStionable

8.2.12.3.1 :CONDition?
SCPI: :STATus:QUEStionable:CONDition?/qonly/
SHORT: SQC?/qonly/
ID: no ID defined
Reads the Questionable Status Condition Register.

8.2.12.3.2 :ENABle
SCPI: :STATus:QUEStionable:ENABle
SHORT: SQEN
ID: no ID defined
Reads and sets the Questionable Status Enable Register.

8.2.12.3.3 [:EVENt]?
SCPI: :STATus:QUEStionable[:EVENt]?/qonly/
SHORT: SQE?/qonly/
ID: no ID defined
Reads the Questionable Status Event Register and clears it.

8.2.12.3.4 :NTRansition
SCPI: :STATus:QUEStionable:NTRansition
SHORT: SQNT
ID: no ID defined
Reads and sets the Questionable Status Negative Transition Register.

8.2.12.3.5 :PTRansition

SCPI: :STATus:QUEStionable:PTRansition
SHORT: SQPT
ID: no ID defined
Reads and sets the Questionable Status Positive Transition Register.

8.2.13 :SYSTem Commands

8.2.13.1 :BEEPer

8.2.13.1.1 :IMMediate

SCPI: :SYSTem:BEEPer:IMMediate/nquery/
SHORT: BEEP/nquery/
ID: no ID defined
Forces the internal beeper to beep a short sound.

8.2.13.2 :DATE

SCPI: :SYSTem:DATE <NRf>,<NRf>,<NRf>
SHORT: DATE <NRf>,<NRf>,<NRf>
ID: no ID defined
Reads and sets the system date. Format is DATE yyyy,mm,dd. Example: DATE 2001,02,09 sets the date to February 9th, 2001

8.2.13.3 :ERRor

8.2.13.3.1 :ALL?

SCPI: :SYSTem:ERRor:ALL?/qonly/
SHORT: ERRALL?/qonly/
ID: no ID defined
Reads all errors out of the error/event queue, including error code and error description, separated by commas out of the error/event queue.

8.2.13.3.2 :COUNt?

SCPI: :SYSTem:ERRor:COUNt?/qonly/
SHORT: ERRCNT?/qonly/
ID: no ID defined
Reads the number of errors in the error/event queue.

8.2.13.3.3 [:NEXT]?

SCPI: :SYSTem:ERRor[:NEXT]?/qonly/
SHORT: ERR?/qonly/
ID: no ID defined
Reads the oldest entry from the error/event queue, including error code and error description, separated by commas.

8.2.13.4 :HELP

8.2.13.4.1 :HEADers?

SCPI: :SYSTem:HELP:HEADers?/qonly/
SHORT: HEAD?/qonly/
ID: no ID defined
Returns a list of all SCPI headers. This list is a <defined length arbitrary block response data>. Because this command has a very special output format, it should only be used stand-alone.

8.2.13.4.2 :SHEaders?

SCPI: :SYSTem:HELP:SHEaders?/qonly/
SHORT: SHEAD?/qonly/
ID: no ID defined
Returns a list of all SHORT headers. This list is a <defined length arbitrary block response data>. Because this command has a very special output format, it should only be used stand-alone.

8.2.13.5 :KEY

SCPI: :SYSTem:KEY <NRi>,
SHORT: KEY <NRi>
ID: no ID defined
Queries the last pressed key or simulates the pressing of a key.

8.2.13.6 :LANGuage

SCPI: :SYSTem:LANGuage/nquery/ <NRi>,
SHORT: LANG/nquery/ <NRi>
ID: no ID defined
Changes the command set to be used. Parameters can be:
'0' or 'SCPI' to go to the SCPI command set [*RST default value]
'1' or 'SHORT' to go to the SHORT command set
The new language will be used beginning with the following command header.

8.2.13.6.1 :PHEader

SCPI: :SYSTem:PHEader <string program data>,
SHORT: PHDR <string program data>
ID: no ID defined
Sets or reads the printer header. At *RST, this value is deleted.
For example, 'PHDR „HELLO"<lf>' would cause to output „HELLO" before each printing.

8.2.13.7 :TIME

SCPI: :SYSTem:TIME <NRf>,<NRf>,<NRf>
SHORT: TIME <NRf>,<NRf>,<NRf>
ID: no ID defined
Reads and sets the system time. Format is TIME hh,mm,ss. Example: TIME 10,26,46 sets the time to 10:26:46.

8.2.13.8 :VERSion?

SCPI: :SYSTem:VERSion?/qonly/
SHORT: VER? \f if/qonly/
ID: no ID defined
Returns the version of the SCPI implementation. Returns always '1999.0'.

8.2.14 :TRIGger Commands

8.2.14.1 :ACTion

SCPI: :TRIGger:ACTion/nquery/
SHORT: ACTN/nquery/
ID: no ID defined
Defines an action that has to be performed when :INIT:CONT is set to ON and a trigger event occurs. All program headers that follow behind the ';', after TRIG:ACT, will be used until the end of the program message.

Example: ACTN;UTRMS?;ITRMS?

This command defines that, each time a trigger event occurs in the INIT:CONT ON state, the TRMS values of voltage and current are returned. See also 8.2.6.1 *':CONTinuous CONT'*. The same example in SCPI syntax would be:
:TRIG:ACT;:FETC:TRMS?;:FETC:CURR:TRMS?
There is no *RST default value.

8.2.14.2 :ICURrent

SCPI: :TRIGger:ICURrent/nquery/
SHORT: IINC/nquery/
ID: no ID defined
Triggers the measuring of the inrush current. The value for the inrush current is reset to 0.

8.2.14.3 :INTerval

8.2.14.3.1 :RESet
SCPI: :TRIGger:INTerval:RESet/nquery/
SHORT: RESET/nquery/
ID: no ID defined
Resets the energy measurement.

8.2.14.3.2 :STARt

SCPI: :TRIGger:INTerval:STARt/nquery/
SHORT: START/nquery/
ID: no ID defined
Starts the energy measurement.

8.2.14.3.3 :STOP

SCPI: :TRIGger:INTerval:STOP/nquery/
SHORT: STOP/nquery/
ID: no ID defined
Stops the energy measurement.

8.2.14.4 [:SEQuence]

8.2.14.4.1 :COUPle

SCPI: :TRIGger[:SEQuence]:COUPle <NRi>
SHORT: COUPL <NRi>
ID: no ID defined
Sets or reads the coupling mode for the trigger (synchronization) signal. Possible values are:
'0' or 'ACDC' for AC/DC coupling mode [*RST default value]
'1' or 'BP' for BP coupling mode
'2' or 'AM' for AM coupling mode

8.2.14.4.2 :SOURce

SCPI: :TRIGger[:SEQuence]:SOURce <NRi>
SHORT: SYNC <NRi>
ID: no ID defined
Sets or reads the synchronization source. Possible values are:
'0' or 'LINE' for line synchronization
'1' or 'EXTS' for external synchronization
'2' or 'U' for synchronization to the voltage signal [*RST default value]
'3' or 'I' for synchronization to the current signal

Example 1

Following, you will find an example of a periodic data exchange via RS232 interface:

```
' QBasic 1.1
' Example for reading data from a PMi
' PMi should be set to following:
' MEASURING Menu
' Normal measuring mode, 500ms cycle time
' IF/IO (OPTIONS) Menu
' Rmote Device: COM1 RS232
' Dev.: COM1: 9600 Baud, EOS <lf>, Echo off, Protocol None
' Connect COM1 of your PC to COM1 of PMi with a 1:1 cable (all pins
' connected, no NULL modem).

DECLARE FUNCTION readans$ ()
OPEN "COM1:9600,N,8,1,ASC,CD0,CS0,DS0,OP0,RS,TB2048,RB4096" FOR
RANDOM AS #1
PRINT #1, "syst:lang short" + CHR$(10); ' Change command set
PRINT #1, "actn;utrms?;itrms?" + CHR$(10); ' Request Utrms and Itrms
PRINT #1, "cont on" + CHR$(10); ' Continue output
DO
answer$ = readans$ ' Read answer from PMI
val1 = VAL(answer$) ' Calculate values
val2 = VAL(MID$(answer$, 1 + INSTR(1, answer$, ";")))
PRINT USING "Answer:& Value1: ###.###V Value2: ##.#####A"; readans$; val1;
val2
LOOP UNTIL INKEY$ = CHR$(32) ' Loop, until SPACE bar pressed
PRINT #1, "cont off" + CHR$(10); ' Stop continue output
SLEEP 1
PRINT #1, "gtl" + CHR$(10); ' Go back to local mode
CLOSE #1
FUNCTION readans$
answer$ = ""
DO
a$ = INPUT$(1, 1) ' Read character from interface
IF a$ <> CHR$(10) THEN ' If it is not the EOS character
answer$ = answer$ + a$ ' add character to answer string
END IF
LOOP WHILE a$ <> CHR$(10) ' Loop until EOS is reached
readans$ = answer$ ' return answer
END FUNCTION
```

Example 2

Following, you will find an example for a one-time data exchange via RS232 interface. In addition to the SCPI commands, you will find the same functionality in SHORT syntax.

```
' QBasic 1.1
' Example for reading data from a PMI
' PMI should be set to following:
' MEASURING Menu
' Normal measuring mode, 500ms cycle time
' IF/IO (OPTIONS) Menu
' Rmote Device: COM1 RS232
' Dev.: COM1: 9600 Baud, EOS <lf>, Echo off, Protocol None
' Connect COM1 of your PC to COM1 of PMI with a 1:1 cable (all pins
' connected, no NULL modem).

DECLARE FUNCTION readans$ ().

OPEN "COM1:9600,N,8,1,ASC,CD0,CS0,DS0,OP0,RS,TB2048,RB4096" FOR
RANDOM AS #1
PRINT #1, "READ:CURRENT:TRMS;:FETCH:VOLTAGE:TRMS" + CHR$(10);
'Request values
(SCPI)
'PRINT #1, "SYST:LANG SHORT" + CHR$(10); 'Change Language to SHORT
'PRINT #1, "INIM;ITRMS?;UTRMS?" + CHR$(10); 'Request values (SHORT)
DO
answer$ = readans$ ' Read answer from PMI
val1 = VAL(answer$) ' Calculate values
val2 = VAL(MID$(answer$, 1 + INSTR(1, answer$, ";")))
PRINT USING "Answer:& Value1: ##.####A Value2: ###.###V"; readans$; val1;
val2
LOOP UNTIL INKEY$ = CHR$(32) ' Loop, until SPACE bar pressed
"&gtl"PRINT #1, "gtl" + CHR$(10); ' Go back to local mode
CLOSE #1
FUNCTION readans$
answer$ = ""
DO
a$ = INPUT$(1, 1) ' Read character from interface
```

```
IF a$ <> CHR$(10) THEN ' If it is not the EOS character
answer$ = answer$ + a$ ' add character to answer string
END IF
LOOP WHILE a$ <> CHR$(10) ' Loop until EOS is reached
readans$ = answer$ ' return answer
END FUNCTION
```

8.2.15 Testing the Interface Using a Terminal Program

Set up the PM¿ pressing **IF/IO**, **Rmote** and **Dev.**, until 'Device' is set to 'COM1 RS232'. Use **back** and **Dev.** to change the menu. Use **Dev.** until 'COM1' appears. Set up Baud = 38400, EOS = Terminal, Echo = On, Protocol = None. Now set up you computer. Start you terminal program, and set up COM1 to 38400 Baud, 8 Data Bit, 1 Stop Bit, No Parity and No Protocol. Now connect COM1 of your computer with COM1 of the PMI with a 1:1 cable without any crossings or null modem functions. If you now type in '*RST' and press Return, the status bar of the PM¿ should change from 'Active Local' to 'Active Remote'. If not, check if the characters you typed in are echoed on your screen or not. If all this fails, check all setings and cables and try again.

9 Appendix 2

9.1 Formulae

9.1.1 Definition of Measuring Values

Given below are the definitions of all values quoted by the PMℓ. Values specific to each measuring mode are given in separate sections.

The following basic notations are used:

u(t) The instantaneous value of the voltage.
i(t) The instantaneous value of the current.
n The harmonic order.
T The total time of an integer number of periods of the synchronization signal. The integer factor depends on the measuring mode used:

Normal measuring mode, the integer factor depends on the chosen measuring cycle time and may vary from cycle to cycle.
CE-harmonic and CE-flicker modes, the integer factor is given in the standard IEC61000-4-7. Hence 16 periods are measured.
100-harmonic mode, the integer factor is given in section 9.1.4 below.

9.1.1.1 Values from Single Measuring

Voltage and Current

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

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

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

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

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

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

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

Power

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

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

Apparent power: $S = Utrms * Itrms$

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

Following the power factor value might be an 'i' or 'c', showing whether the load is inductive or capacitive. This is only given under the following conditions:

$\lambda < 0.999995$ and $1.05 < U_{ff} < 1.2$ and $1.05 < I_{ff} < 1.2$

Note: The i/c notation is intended for usual line applications. When working with high frequencies, this indication may be inaccurate.

Impedances

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

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

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

9.1.1.2 Integrated Values

The following basic definitions are used:

n The value from the measuring cycle number n.

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

Energy

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

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

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

Average Values

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

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

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

Miscellaneous

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

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

9.1.2 Definition of Values in CE-Harmonic Mode

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

9.1.3 Definition of Values in CE-Flicker Mode

The harmonic values **I(n)** and **U(n)** are calculated by a DFT algorithm.
The values **Pmom**, **Pst** and **Plt** are calculated by a flicker meter according to IEC868/IEC61000-4-15. **dc** and **dmax** are calculated according to IEC61000-3-3.

9.1.4 Definition of Values in 100-Harmonic Mode

In this mode, **T** is defined as the total time of an integer number of periods of the synchronization signal. The integer factor depends on the frequency of the basic wave:

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

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

The harmonic values **I(n)**, **U(n)** and **Phase(n)** are calculated by a DFT algorithm.
From these values, **P(n)**, **S(n)** and **Q(n)** are calculated.

Q(n) is the reactive power caused only by the phase shift between voltage and current components of the same frequency. Therefore, in this mode, it is also possible to calculate the reactive power caused by voltage and current components of different frequencies. This value is called **D**:

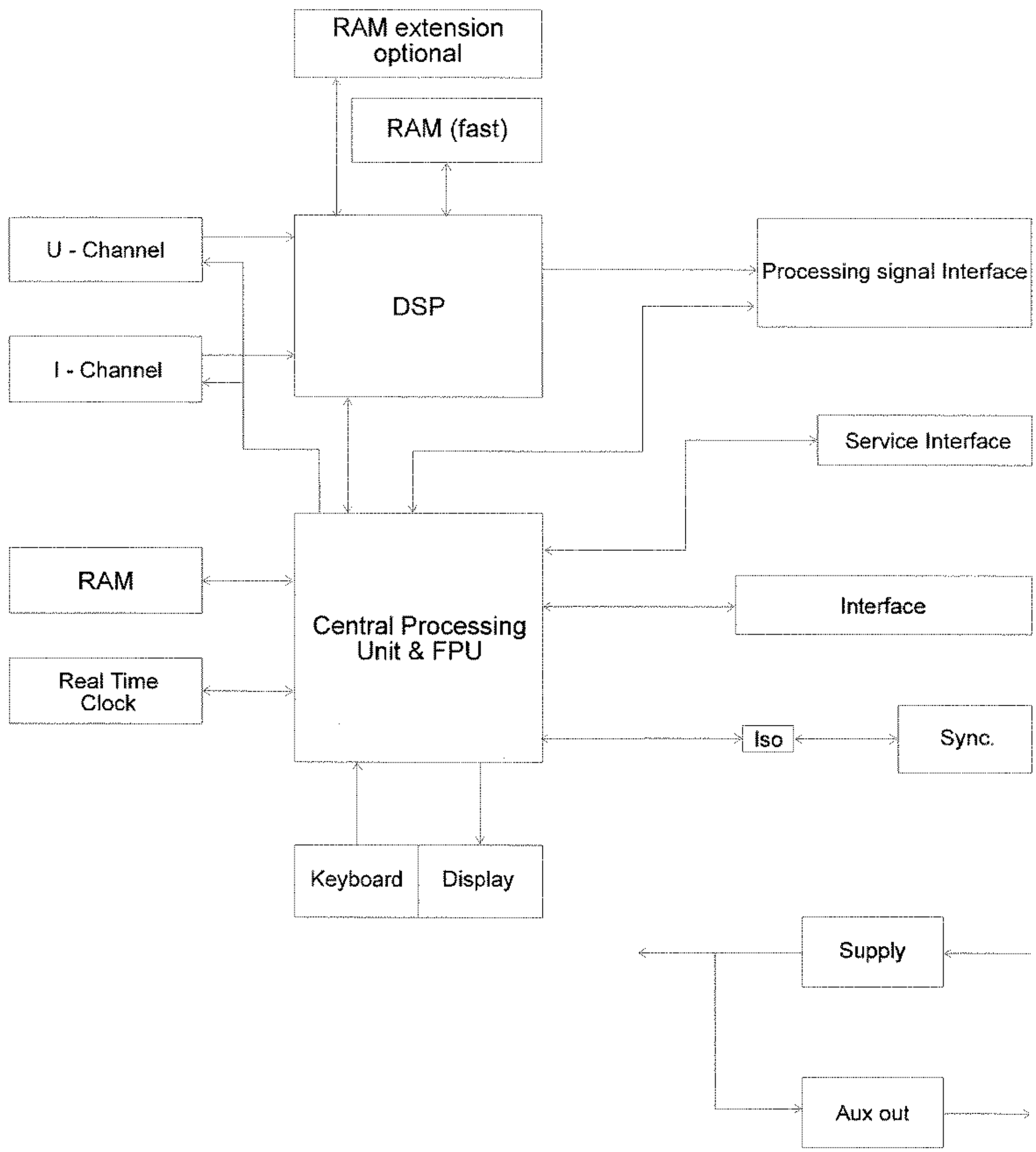
$$D = \sqrt{S^2 - P^2 - Qshift^2}$$

where $Qshift = \sum_{n=0}^{99} Q(n)$.

P and S are as defined above.

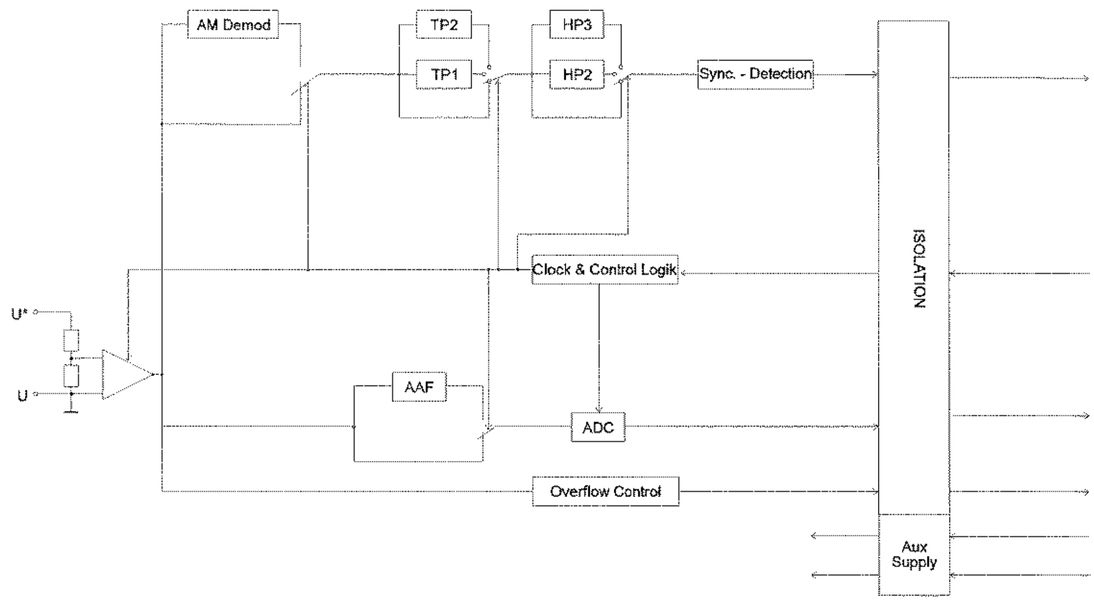
9.2 Functional Block Diagrams

9.2.1 Overall System



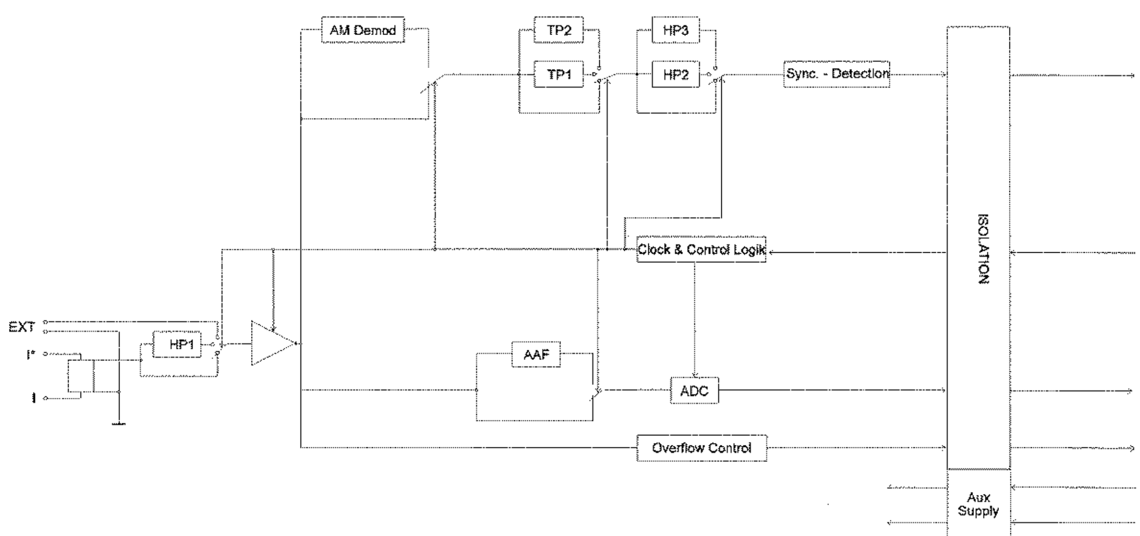
Overall system

9.2.2 Voltage Channel



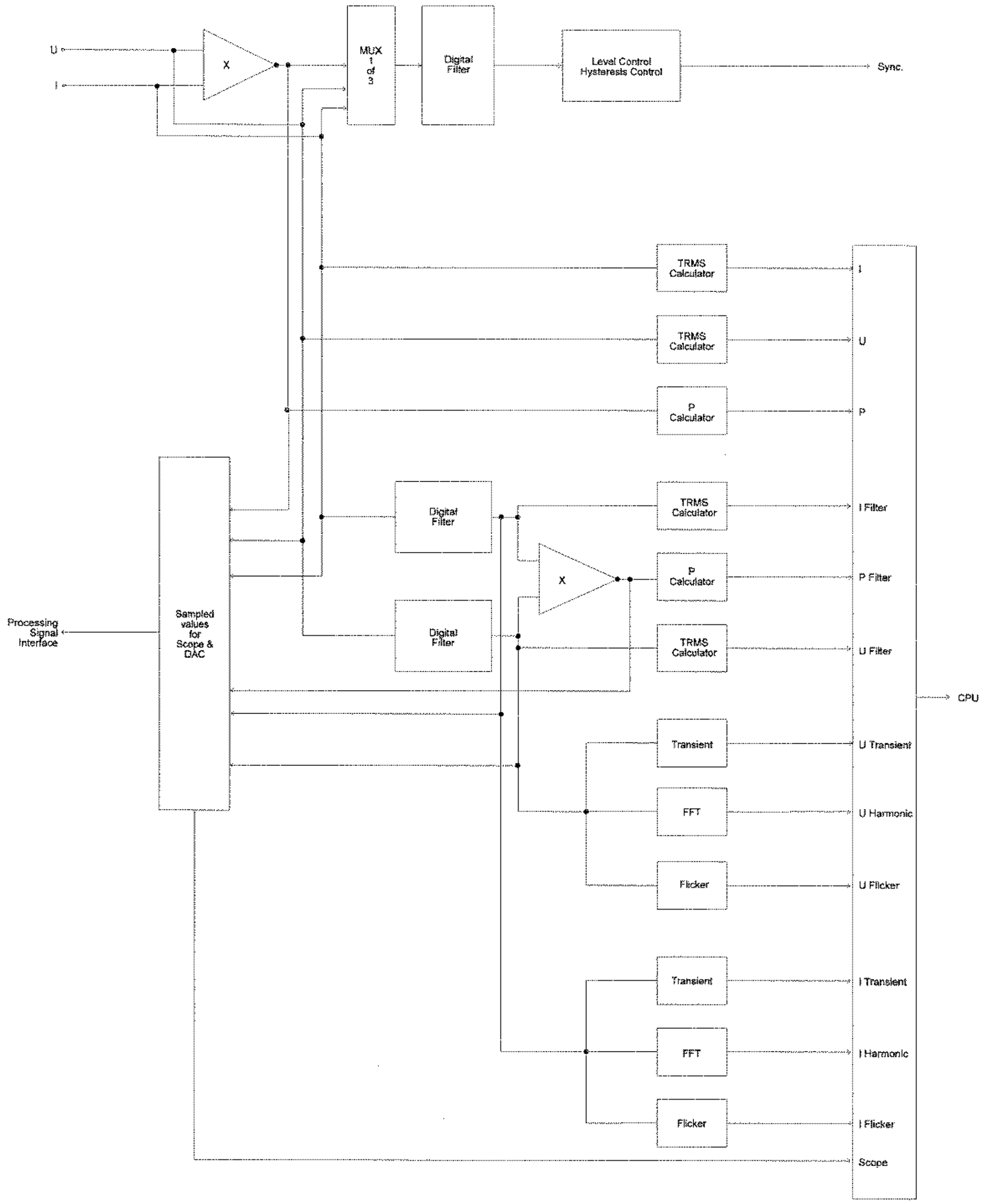
Voltage channel

9.2.3 Current Channel



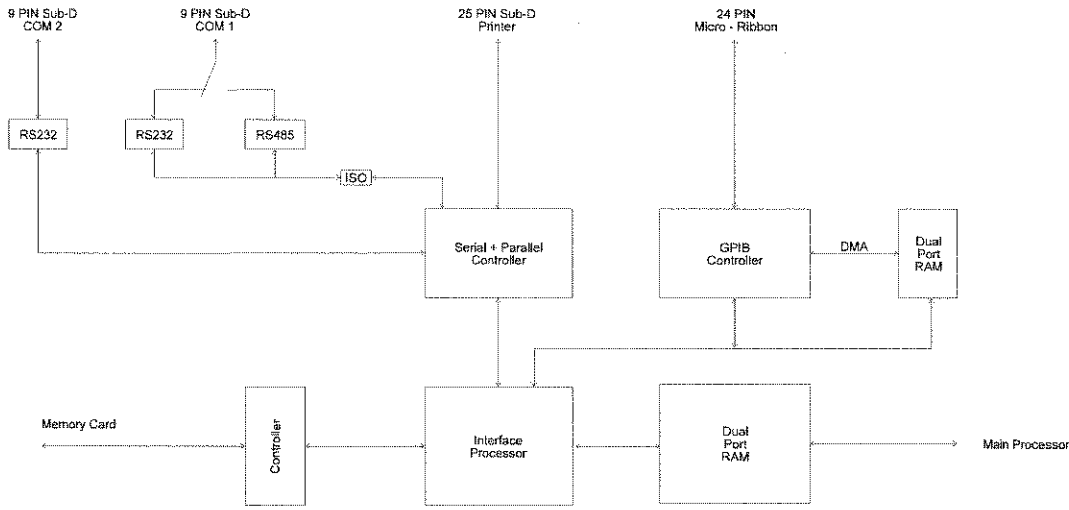
Current channel

9.2.4 Computing Unit



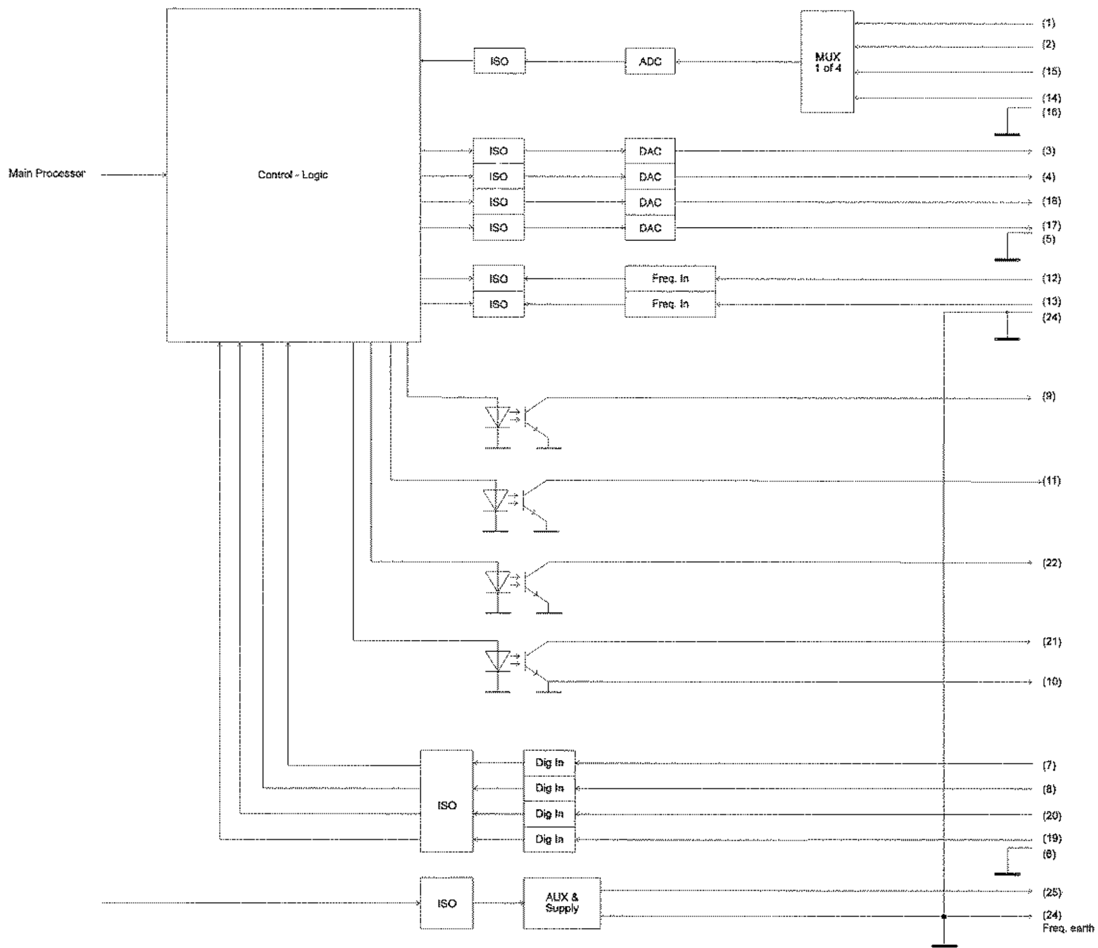
Computing unit

9.2.5 Computer Interface



Computer interface

9.2.6 Processing Signals Interface

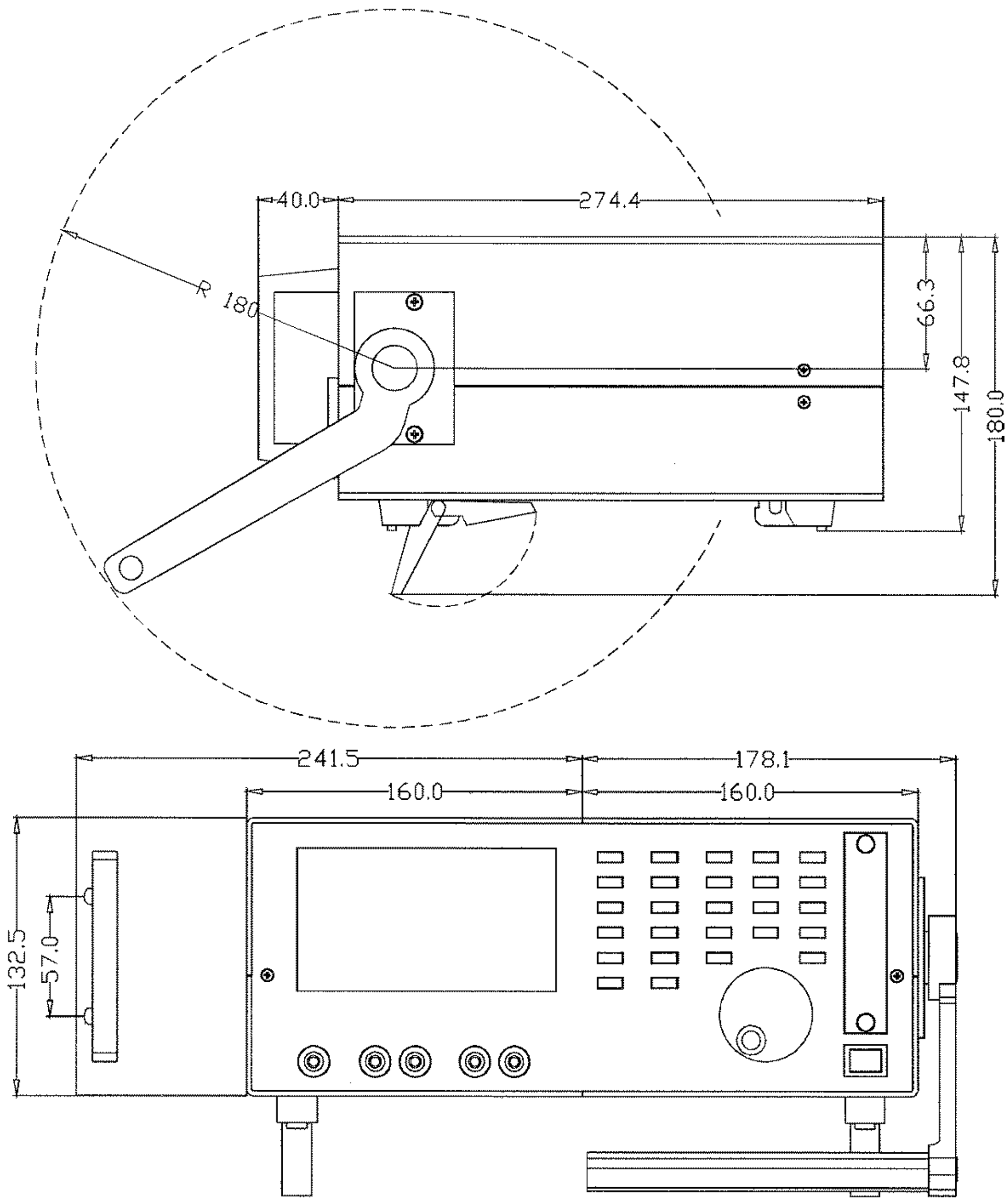


Processing signals interface

9.3 Technical Specifications

9.3.1 General

Display:	Monochrome display, resolution 256x128 pixels
Weight:	6.5kg
Mains supply:	90...260V, 45...65Hz, 25W
Storage temperature:	-20°C to +55°C
Climatic class:	KYG according to DIN 40040 0°C...40°C, humidity max. 85%, annual average 65%, no dewing
Protection method:	IP20 according DIN40050
Protection class:	I Overvoltage class III and pollution degree 2 according to IEC61010-1
EMC:	EN55011, EN50082
Safety:	EN61010
Dimensions:	Desktop: 320mm (W) x 148mm (H) x 275mm (D) 19“ rack: 63TU x 3HU x 315mm



PMℓ Dimensions (in mm)

9.3.2 Display of Values

Measured values are displayed with six digits and a decimal point. The position of the decimal point is set to the position required to display the maximum allowed TRMS value.

If the TRMS value of a measuring channel is lower than 0.75% of the measurable TRMS value of the range, all channel values are displayed as 0.0.

9.3.3 Sampling

The sampling is performed synchronously in all channels, at a rate of about 100kHz per channel.

9.3.4 Standard Ranges

Voltage ranges

Rated range value / V	6	12.5	25	60	130	250	400	600
Measurable TRMS value / V	7.2	14.4	30	60	130	270	560	720
Permissible peak value / V	12.5	25	50	100	200	400	800	1600

Overload capability	600V continuously, 1500V for 1s
Input resistance	1MΩ, 23pF
Capacitance against earth	45pF
Common mode rejection	>140dB (measured with 100V at 100kHz)

Current ranges

Rated range value / A	0.15	0.3	0.6	1.2	2.5	5	10	20	120	240	480	960
Measurable TRMS value / A	0.3	0.6	1.3	2.6	5.2	10	21	21	21	21	21	21
Permissible peak value / A	0.469	0.938	1.875	3.75	7.5	15	30	60	120	240	480	960

Overload capability	24A continuously, 160A for 1s
Input resistance	5mΩ
Capacitance against earth	51pF
Common mode rejection	>150dB (measured with 100V at 100kHz)
Capacitance between U and I channels	5pF
Channel separation	>140dB (measured with 100V at 100kHz)

Voltage inputs for current measuring with shunt / transducer

Rated range value / V	0.03	0.06	0.12	0.25	0.5	1	2	4
Measurable TRMS value / V	0.06	0.13	0.27	0.54	1	2	4	8
Permissible peak value / V	0.0977	0.1953	0.3906	0.7813	1.563	3.125	6.25	12.5

Overload capability	100V continuously, 250V for 1s
Input resistance	100kΩ, 28pF
Common mode rejection	>134dB (measured with 100V at 100kHz)

9.3.5 Measuring Accuracy

50kHz version

Frequency/Hz	DC	0.05-15	15-45, 65-1k	45-65	1k-3k	3k-15k	15k-50k
Voltage	0.02+0.06	0.02+0.04	0.015+0.03	0.01+0.02	0.03+0.06	0.1+0.2	0.5+1.0
Current	0.02+0.06	0.02+0.04	0.015+0.03	0.01+0.02	0.03+0.06	0.1+0.2	0.5+1.0
Active power	0.03+0.06	0.035+0.04	0.025+0.03	0.015+0.02	0.05+0.06	0.2+0.2	1.0+1.0

400kHz version

Frequency/Hz	DC	0.05-15	15-45, 65-1k	45-65	1k-3k	3k-15k	15k-100k	100k-200k	200k-300k	300k-400k
Voltage	0.02+0.06	0.02+0.04	0.015+0.03	0.01+0.02	0.025...0.05	0.03+0.06	0.1+0.2	0.5+1.0	1.0+2.0	3.0+3.0
Current	0.02+0.06	0.02+0.04	0.015+0.03	0.01+0.02	0.025...0.05	0.03+0.06	0.1+0.2	0.5+1.0	1.0+2.0	3.0+3.0
Active power	0.03+0.06	0.035+0.04	0.025+0.03	0.015+0.02	0.04...0.05	0.05+0.06	0.2+0.2	1.0+1.0	2.0+2.0	6.0+3.0

The values are in ±(% of measuring value + % of measuring range)

Accuracies are based on:

1. sinusoidal voltages and currents
2. ambient temperature 23°C
3. warm-up time 1h
4. power range is the product of current and voltage range, $0 \le |\lambda| \le 1$
5. voltage and current are ≥ 10% of range
6. calibration interval 1 year

Temperature effect: 0.01% of measuring value / K

9.3.6 Filters

There are eleven different filters available. The anti-aliasing filter (AAF) removes the additional harmonics associated with the sampling frequency. It has a cut-off frequency of about 10kHz, and its characteristic is given below.

The AAF is enabled in addition to any digital low-pass filter that is selected. There are several situations in which filters are useful, such as in measurements on motors where only fundamental harmonics are responsible for torque production.

The cut-off frequencies (in Hz) of the digital low-pass filters available are:
30, 60, 87.5, 175, 1.4k, 2k, 6k, 9.2k, 18k.

9.3.6.1 Anti Aliasing Filter (AAF)

The analog anti-aliasing filter has the following response:

Frequency / Hz	Rejection / dB
10	0.0019
20	0.0005
50	0
100	-0.0004
200	-0.0014
500	-0.0086
1000	-0.0319
2000	-0.1459
5000	-0.8350
10000	-3.16
20000	-14.45
50000	-49.45

9.3.6.2 CE Harmonics

Relative deviations between F1 and frequency fsync, to which the sampling rate is synchronized	< 0.0155 of F1
Attentuation of anti-aliasing filter	> 50 dB

The amplitude error of each harmonic is equal to the error the harmonic would have, if it were the only signal. This is valid, if the amplitude of the harmonic is > 0.1 % of the range peak value.

The phase error is 0.15 degrees + 0.25 degress/kHz, if the amplitude of the harmonic is >0.1% of the range peak value.

9.3.6.3 Custom Channel Options and Ranges

It it possible to purchase a PM*ϵ* with other than the standard 600 V, 20 A channel configuration. Please refer to the options below. Optional channels must be specified at the time of the original order. They are not field-upgradeable options.

PM*ϵ* Channel Selection

OP-11 200 mV Channel

Rated range value/mV	1.5	3	6	12	25	50	100	200
Measurable TRMS value/mV	1.8	3.6	7.2	14.4	30	60	120	240
Permissible peak value/mV	3	6	12	24	49	98	195	391

Overload capability 30V continuously, 80V for 1s

Input resistance 10kΩ, 200pF

OP-12 3V Channel

Rated range value/V	0.025	0.05	0.1	0.2	0.4	0.8	1.5	3
Measurable TRMS value/V	0.03	0.06	0.12	0.24	0.48	0.96	1.8	3.6
Permissible peak value/V	0.049	0.098	0.195	0.391	0.781	1.563	3.125	6.25

Overload capability 100V continuously, 250V for 1s

Input resistance 100kΩ, 70pF

OP-13 12V Channel

Rated range value/V	0.1	0.2	0.4	0.8	1.5	3	6	12
Measurable TRMS value/V	0.16	0.33	0.67	1.33	2.5	5	10	20
Permissible peak value/V	0.24	0.47	0.94	1.88	3.75	7.5	15	30

Overload capability 100V continuously, 250V for 1s
Input resistance 100kΩ, 70pF

OP-14 60V Channel

Rated range value/V	0.4	0.8	1.5	3	6	12	25	60
Measurable TRMS value/V	0.48	0.96	1.8	3.6	7.2	14.4	30	60
Permissible peak value/V	0.781	1.563	3.125	6.25	12.5	25	50	100

Overload capability 250V continuously, 600V for 1s
Input resistance 330kΩ, 40pF

OP-15 80 mA Channel

Rated range value/mA	0.6	1.2	2.5	5	10	20	40	80	500	1000	2000	4000
Measurable TRMS value/mA	1.2	2.4	5	10	20	40	80	160	320	640	800	800
Permissible peak value/mA	2	4	8	16	32	65	130	250	500	1000	2000	4000

Overload capability 0.8A continuously, 2A for 1s
Input resistance 0.5Ω

OP-16 1.2A Channel

Rated range value/A	0.01	0.02	0.04	0.08	0.15	0.3	0.6	1.2	7.5	15	30	60
Measurable TRMS value	0.02	0.04	0.08	0.16	0.3	0.6	1.3	2.0	2.0	2.0	2.0	2.0
Permissible peak value/A	0.0293	0.0585	0.1171	0.2343	0.469	0.938	1.875	3.75	7.5	15	30	60

Overload capability 2A continuously, 5A for 1s
Input resistance 0.1Ω

OP-17 5A Channel

Rated range value/A	0.04	0.08	0.15	0.3	0.6	1.2	2.5	5	30	60	120	240
Measurable TRMS value/A	0.08	0.16	0.3	0.6	1.3	2.6	5	6	6	6	6	6
Permissible peak value/A	0.1171	0.2343	0.469	0.938	1.875	3.75	7.5	15	30	60	120	240

Overload capability 6A continuously, 15A for 1s
Input resistance 20mΩ

9.3.7 Processing Signals Interface (Optional)

9.3.7.1 Analog Inputs

Sampling rate: 1kHz
Resolution: 16-bit
Accuracy: ±(0.05% of measuring value + 0.05% of full scale)
Input signal: ±12V
Overload capability: -15...+25V
Input resistance: 100kΩ
Sample memory: 512k words

9.3.7.2 Analog Outputs

Update rate: 100kHz
Resolution: 16-bit
Accuracy: ±(0.05% of measuring value + 0.05% of full scale)
Output signal: ±11V
Output load: load resistance > 2kΩ

9.3.7.3 Digital Inputs

Sampling rate: 1kHz
Input signal: U_{low}max=1V, U_{high}min=4V@2mA,
U_{high}max=60V@3mA
Sample memory: 512k values

9.3.7.4 Frequency Inputs

Input signal: U_{low}max=1V, U_{high}min=4V, U_{high}max=10V
Input resistance: 1MΩ
Maximum frequency: 5MHz

9.3.7.5 Digital Outputs

Open collector outputs.
Output high impedance: max 30V@100µA
Output low impedance: max. 1.5V@100mA

9.3.7.6 Auxiliary Supply

Output voltage: ±5V, 10% @ 50mA

9.3.8 External Synchronization

External sync input: 5V, drives LED and 1.5kΩ series resistor
Control in: 5V, drives LED and 1.5kΩ series resistor
Control out: Open collector output

9.3.9 Auxiliary Transducer Supply

This output delivers two voltages:

+15V ±10%, I_{max}=0.4A

-15V ±10%, I_{max}=0.2A

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