

USERS MANUAL 101A

General Purpose Power Analyzer Single- and Three Phase



Infratek

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1. SAFETY

Before using the Power Analyzer, read the following safety information carefully. In this manual „**WARNING**“ is reserved for conditions that pose hazards to the user; „**CAUTION**“ is reserved for conditions that may damage your instrument.

- Avoid working alone.
- Follow all safety procedures for equipment being tested.
- Inspect the test leads for damaged insulation.
- Be sure the Power Analyzer is in good operating condition.
- To avoid electrical shock, use caution when working above 30V dc or rms.
- Disconnect the live test leads before disconnecting the common test leads.
- When making a current- or power measurement, turn the circuit power off before connecting the Power Analyzer in the circuit.
- Switching on inductive loads means large inrush currents. Take precautions to avoid overloading the current channels by shorting the start-up currents across the current inputs.
- Switching off inductive loads or switching on rotating loads means large voltages or extremely fast changing voltages on the Power Analyzer input terminals. Such conditions may damage the instrument and are potentially hazardous.
- To comply with EN50081-1 the current- and voltage test leads must form 6 windings through ferrite torroid Siemens B64290-L40-X830 or equivalent. (This measure will also enhance immunity with respect to fast common mode transients), the RS-232 interface cable must be shielded and must form 1 winding through Fair-rite VO 0444176451.

- 1kV burst test: use shielded input- and output cables.
- The Power Analyzer complies with the safety standards IEC 1010-1, EN 61010-1.

1.1 WARNINGS

- Before reading the manual or before using this instrument read carefully the warnings below and make sure you understand them.
- **WARNING: Line Power**
To avoid shock hazard, connect the instrument power cord to a power receptacle with earth ground.
- **WARNING**
The maximum floating voltage above earth ground on the current input terminals and the voltage Lo-input terminals is 600V. Exceeding these limits poses a hazard to the meter and operator.
- **WARNING**
Qualified personnel must operate this instrument.
- **WARNING**
Refer all servicing of this instrument to qualified personnel. Before opening case disconnect all leads connected to the instrument and finally disconnect the power line cord.
- **WARNING**
The specifications given in this manual solely describe the technical properties of the instrument. They do not imply any other properties unless it is explicitly said so.
- **WARNING**
Use of this instrument in life support systems and in systems for people transportation must be expressly authorized.
The manufacturer of this Power Analyzer must sign the authorization.
- **WARNING**
Do not operate the front panel keys with pointed objects. A damaged key may pose shock hazard.
If you observe a damaged front panel key, please report this to your nearest Infratek representative and return the instrument for repair.

2. INTRODUCING THE POWER ANALYZER

WARNING

Read the „Power Analyzer Safety“ in section 1 of this manual before using the instrument.

This 1- and 3-phase Power Analyzer is designed for bench-top, field service, and system application.

Some features provided by the Power Analyzer are:

- Blue LCD monitor, 108 x 56mm (240x128 pixels).
- Fully menu controlled operation with only 11 soft keys.
- Meter mode and graphics mode.
- Measures and computes all electrical quantities of current, voltage, power, energy and harmonics of current, and voltage simultaneously.
- AC-, and AC+DC-coupling for individual quantities.
- Built-in integrator for energy measurement.
- Harmonic Analysis of current and voltage.
- Bar graph and wave form display.
- Wide voltage- and current range (600mA - 50A).

2.1 INSTRUMENT VERSIONS, OPTIONS, ACCESSORIES

101A-1

Low Cost Single Phase Power / Energy Analyzer, 0.15 % accuracy, peak hold function, tilt stand

101A-3

Low Cost Three Phase Power / Energy Analyzer, 0.15 % accuracy, peak hold function, tilt stand

Option 01

RS-232 Interface. Windows Operating Software (95, 98, NT, 2000, ME, XP)

Option 02

Rechargeable battery for 6 hours autonomous operation including built in charger

ACS1

Single phase load connection box,
(User installs country specific power receptacle)

ACS2

Three phase load connection box
(User installs country specific 3-phase plug and 3-phase connector)

ACS3

Soft carrying case for 101A

ACS10

RS-232 / USB Adapter cable

ACS11

RS-232 / Ethernet Adapter

2.2 SPECIFICATIONS

Voltage	4 ranges: 30 V, 100 V, 300 V, 1000 V; max. 600 V Frequency range: DC-50 kHz Accuracy: 10 Hz – 2 kHz, $\pm(0.1 \% \text{ rdg} + 0.1 \% \text{ range})$ 2 kHz – 10 kHz, $\pm(0.8 \% \text{ rdg} + 0.3 \% \text{ range})$
Current	5 ranges: 600 mA, 2 A, 6 A, 20 A, 60 A; max. 30 A continuous, max. 100A, 1 second Frequency range: DC – 50 kHz Accuracy: 10 Hz – 400 Hz, $\pm(0.15 \% \text{ rdg} + 0.15 \% \text{ range})^*$ 400 Hz – 2 kHz, $\pm(1.5 \% \text{ rdg} + 1.0 \% \text{ range})$ *Lowest range and current >10A multiply percentage figures by 2.
Power	Accuracy: Add accuracy percentage figures of current and voltage, PF = 0 to ± 1 .
Measured Quantities	Vrms, Vmax, Vpeakhold, Arms, Amax, Apeakhold, power, apparent power, power factor, energy, apparent energy, elapsed time, voltage- and current harmonics n=1 to 20.
Display	Blue liquid crystal graphic display with EL backlight. Displays values of each phase, total values, or values of all three phases. Displays wave forms and bar graphs.
Dielectric	Inputs to case, Line input to case: 2 kV/2 kV
Dimension	H x W x D = 132 x 185 x 267 mm. Weight 2.5 kg, Tilt stand.
Options	RS-232 Interface and Windows Operating Software (95, 98, NT, 2000, ME, XP). Battery back up for 6 hours operation with built in charger.
Accessories	Single- and three phase load connection box Carrying case 32A Test leads

3. MATHEMATICAL DEFINITIONS USED BY THE POWER ANALYZER

**RMS-, and maximum values apply to current and voltage.
Energies apply to real- and apparent power.**

RMS-value $(1/T \int_0^T i^2 dt)^{1/2}$; RMS of total and RMS of harmonic (1-63)

Maximum max. (i) in averaging interval

Average Power $P = 1/T \int_0^T u i dt$

Apparent Power $S = \text{RMS current} \times \text{RMS voltage}$

Power Factor P/S

Power Factor 3-phase system $(P1 + P2 + P3) / S1 + S2 + S3)$

Energies $\int_0^t x dt$ $x = P, S$

4. GETTING STARTED

This section explains how to prepare the Power Analyzer for operation, discusses general operating features, and explains some common measurements.

4.1 FRONT PANEL AND REAR PANEL

The front panel in figure 4.1 shows the graphic display in its configuration when the Power Analyzer starts up. The main menus at the bottom of the display are selected by pressing menu keys M1 through M6. Below the menu keys are 4 cursor control keys and one “**SET**” key. The cursor control keys are used to move the cursor up and down or to the right or to the left.

The basic operations are:

- Move the cursor in the side menu and press “**SET**”. A pull down menu is presented to select a new setting.
- Move the cursor right to any display number field and press “**SET**”. A measurement quantity selection table is presented to select a new quantity.



Figure 4.1. Power / Energy Analyzer Front Panel

The rear panel of a single phase 101A is shown in Figure 4.2. The input terminals are on the right hand side. Load current is measured between red and blue terminals and voltage is measured between blue and black terminals. The three phase Power Analyzer has the inputs for phase 1 (L1) at the bottom, phase 2 (L2) inputs are in the middle, and phase 3 (L3) inputs at the top. On the left hand side of the rear panel is the RS-232 interface connector (not shown in Figure 4.2).



Figure 4.2. Power / Energy Analyzer Rear Panel

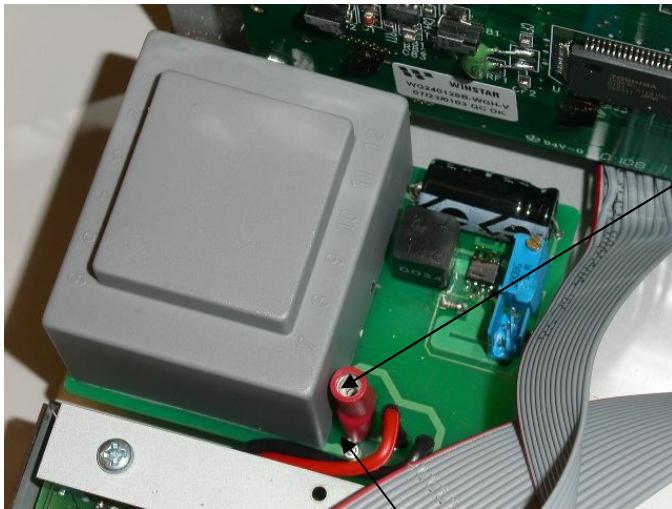
4.2. LINE VOLTAGE SELECTION

The line operating voltage is factory set. Before operating your Power Analyzer on line power please check the voltage setting written on the tag above the line receptacle. In case the voltage does not match the operating voltage of your country the voltage setting can be changed as shown below:

WARNING

Before changing the internal voltage setting disconnect all electrical connections to the Power Analyzer.

- Remove all connections to your Power Analyzer.
- Remove the instrument hood by removing 4 screws on each side of the case.
- Change the jumper setting as shown in Figure 4.3.



Red Voltage Selector shown is set for 230V/50Hz operation (use pin in the middle and to the right)

Position of Voltage Selector for 110V/60Hz operation (use pin in the middle and to the left)

Figure 4.3. Position of Voltage Selector for 110V/60Hz and 230V/50Hz operation.

4.3 TURNING THE POWER ANALYZER ON

Insert the line cord into the receptacle on the charger. It will operate on the line voltage marked above the line cord receptacle.

Turn on the instrument by activating the on/off-switch located on the front panel.

Alternatively, you can operate the Power Analyzer on the internal optional batteries without external supply.

When the instrument is turned on the display is set to its start-up configuration with most values set to zero for about 2 seconds. The Power Analyzer assumes its initial setting as follows: the first line of the display number field shows the RMS current and the RMS voltage. The second line shows power and power factor, and the third line shows active energy and time.

The fourth and fifth lines are graphic area. At start-up the voltage wave form is displayed.

Three phase instruments will display values from phase L1.

The side menu shows the following settings:

IN 50A	current input 0-50A
600mA A	600mA range in auto ranging
30V A	30V range in auto ranging
Syn = I	synchronization to current phase L1
>500 ms	500ms measurement time
VIEW L1	displays phase L1 values

The main menus along the bottom side of the display are:

| **HOLD** | | | | **VIEW** | |

4.4 USING THE FUNCTION KEYS

Below the display are 2 rows of control keys. The top row contains 6 menu control keys **M1**, **M2**, **M3**, **M4**, **M5**, and **M6**. The bottom row contains 4 cursor control keys and 1 “SET” control key.

The basic use of the two key control fields is as follows:

The **cursor control keys** are used to move the cursor to the desired position on the display. Pressing the **SET-key** means that you want to modify this position; this can be a position to the very left of the display (side menu) such as current range- or voltage range selection, or synchronization to I or U (current or voltage of phase L1), or selection of averaging time, or selection of phase L1, L2, L3, SUM, or ALL display.

When you move the cursor to the display number field the display can be reconfigured, that is, you can place at the selected position a different quantity. The **menu control keys M1** through **M6** go with the 6 menus shown along the bottom of the display. These menus are dynamically changing, depending on the cursor position and other action you may take.

4.5 TAKING BASIC MEASUREMENTS

The following procedures describe the basics of taking common power measurements operating the Power Analyzer from the front panel. This information is provided for the user who needs to get started quickly.

WARNINGS

- Read the Power Analyzer safety before operating this instrument.
- To avoid electrical shock or damage to the Power Analyzer, do not apply more than 850V peak between any terminal and earth ground.
The user should be well aware of the fact, that switching off inductive loads may generate extremely fast and high voltage transients exceeding above limits.
To measure voltage, current, power and related quantities in a 3-phase circuit connect the test leads as shown in figure 4.4 and follow the procedure described below.

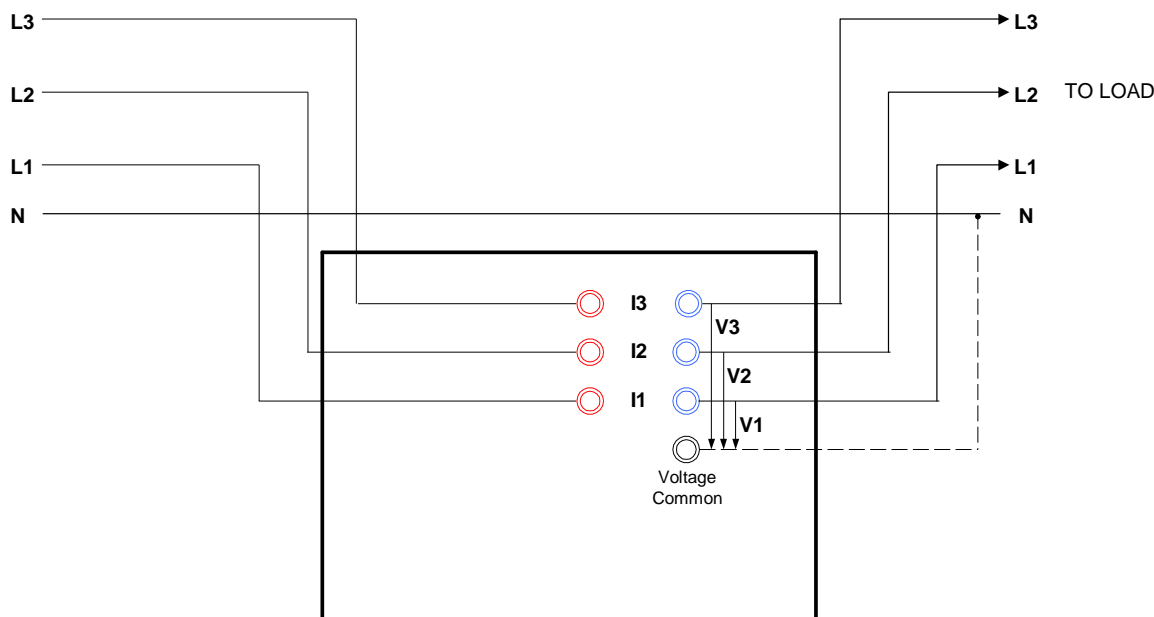


Figure 4.4: Wiring of the Power Analyzer in a 3-phase 4-wire circuit. The 3-Wattmeter connection is used. Total Power = $P1+P2+P3$. If no neutral is available leave voltage Lo unconnected. (Frequency inverters, star point network 500k Ω is built in)

- Turn off power in the circuit to be measured.
- Break the circuit in each phase and connect phase L1 to the current input 1, phase L2 to current input 2, and phase L3 to current input 3. The current flows from source to load; as a consequence you must connect the Hi current inputs (red) to the source side and the Lo current inputs (blue) to the load side.
- In three phase 4-wire systems connect the Lo input terminal (black) to Neutral. In three phase 3-wire systems leave Lo input unconnected.
- Switch on the Power Analyzer (it will be in automatic ranging).
- Turn on power to the load under test.
- The Power Analyzer will automatically select the voltage range and displays the following six electrical quantities (display top to bottom) RMS-current, RMS-voltage, power, power factor active energy, and elapsed time of phase L1.
- Use the side menu to display values from phase L2, L3, SUM, and ALL.

5. OPERATING THE POWER ANALYZER FROM THE FRONT PANEL

Section 5 explains how to operate the Power Analyzer from the front panel. You may want to configure the instrument to your personal needs going through the steps described in this section. Six menu keys M1 through M6 below the display, four cursor control keys, and one SET key perform all operations.

All front panel operations can just as well be achieved by using the computer interface.

5.1 OPERATING PHILOSOPHY

The display monitor is subdivided into the side menu field, the number- and graphics field, and the bottom line menu field (Figure 5.1). The cursor can be moved to the side menu field and the number field.

If you move the cursor to one of the side menu annunciators and press the SET key a pull-down menu is presented from which you can make a new choice. Moving the cursor in the pull-down menu to the desired value does this. Press the SET key again. The new setting becomes active and appears now as annunciator in the side menu.

If you move the cursor to the display number field and press the SET key a selection table of the available measurement values is presented from which you can make a new choice. Moving the cursor in the selection table to the desired value does this. Press the SET key again. The new measurement quantity now becomes active and appears now in the selected display number field.

Finally, the keys M1 through M6 operate the bottom-line menu field. The main menus HOLD, AC+DC, VIEW appear when the cursor is located in the side menu. When the cursor is located in the display number field a secondary menu appears matching the measurement quantity the cursor is pointing at. If the cursor is pointing at an FFT-value, for example, the bottom-line menu lets you alter the harmonic number shown in the annunciator in the middle section of the side menu field.

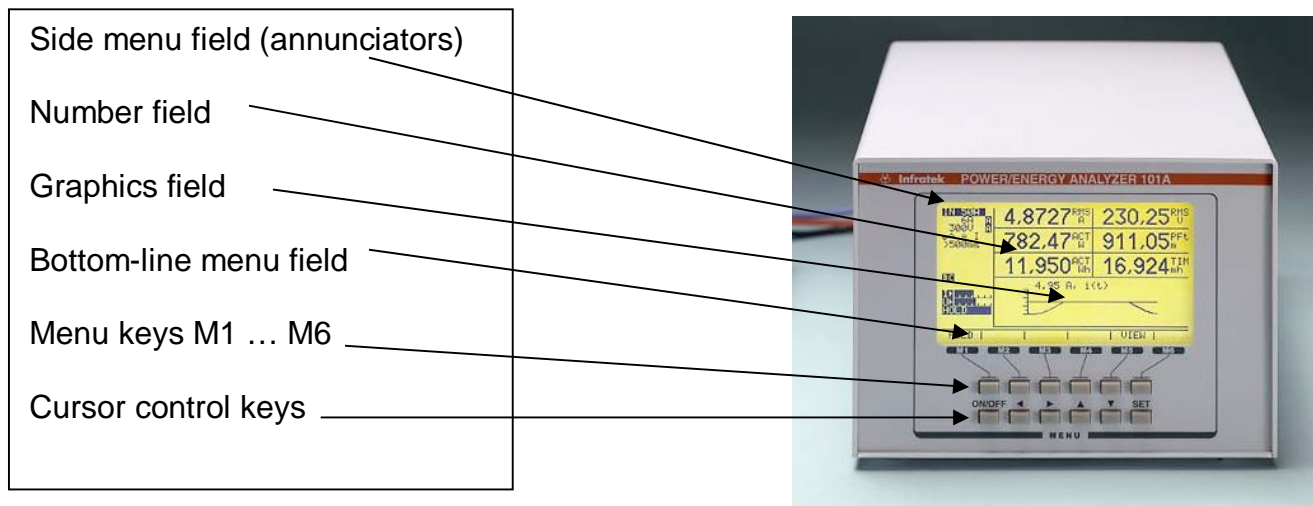


Figure 5.1 Power Analyzer Front Panel Controls

5.2 OPERATIONS CONTROLLED BY THE SIDE MENUS

The side menus control such functions as current input selection, range selection, measurement time and special functions selection, and display mode selection.

5.2.1 RANGE SELECTION, AUTO RANGE SELECTION

Current Ranging

To select a current range you move the cursor in the side menu to the current range annunciator and press the **SET** key.

Move the cursor to the desired range and press **SET** to return to the side menu.

Auto Ranging

When you have set a range manually an inverse M to the right of the range annunciator is displayed indicating that current is in manual ranging. With menu key **M2** you can toggle the current input from manual ranging to auto ranging (indicated by an inverse A), and back to manual ranging. For all but a few measurements auto ranging will work fine. Manual ranging must be used for the data logging and dynamic torque measurement and for those measurements where occasional large current peaks cause an undesired up- and down ranging.

Voltage Ranging

To select a voltage range you move the cursor in the side menu to the voltage range annunciator and press the **SET** key. From the pull-down menu 30V/100V/300V/1000V select the desired range with the cursor. Press **SET** to activate the range and return to the side menu. The inverse M to the right of the voltage range annunciator indicates manual ranging for the voltage inputs. For auto range selection proceed as described in “**Auto Ranging**” above.

NOTE: When you are using a three phase Power Analyzer all three channels are in the same voltage – and current range. If the signal level of one channel is much below the others you will still achieve good accuracy. The Power Analyzer exhibits excellent linearity for signal levels from 5 to 130 % of full scale.

5.2.2 SELECTING SYNCHRONIZATION / 2W, 3W-CONFIG.

The fourth annunciator from the top of the side menu indicates the selected measurement signal synchronization. Move the cursor to this position and press **SET**. The pull-down menu **Sync I / Sync U** is displayed. Move the cursor to the desired setting and press **SET** to return to the side menu.

Sync I: When you select **Sync I** the fundamental waveform of current L1 is used. The calculation of rms-, power-, and harmonic values is synchronized to the fundamental waveform.

Sync U: When you select **Sync U** the fundamental waveform of voltage L1 is used. The calculation of rms-, power-, and harmonic values is synchronized to the fundamental waveform.

For measurements on **frequency inverters** we recommend to utilize **Sync I**.

3W: 3-Wattmeter configuration, averages and sums are computed from phase L1, L2, and L3.

2W: 2-Wattmeter configuration averages and sums are computed from phase L1 and L2.

5.2.3 SELECTING MEASUREMENT TIME AND SPECIAL FUNCTIONS

The fifth annunciator from the top of the side menu displays the selected minimum signal acquisition time or the special function **peakhold**. Move the cursor to this annunciator and press **SET**. The following pull down menu appears:

>250ms / >500ms / >1s / >2s / peak-hd

Now move the cursor to the desired time or function and press **SET** to return to the side menu.

The basic measurement process for measurement times >250ms, ..., 2s and for the special function is described below:

>250ms, ..., 2s: The selected time sets the duration of signal data acquisition for one measurement interval. The measurement is synchronized to the zero crossing of either current (Sync I), or voltage (Sync U). Measurements are thus taken over full periods and result in stable readings for signal frequencies down to 2Hz. In case the selected time interval has expired but the signal period has not reached its end the measurement time is extended to the end of the signal period.

In the selected measurement time all raw data in a three phase system are collected, and are made available for display or for data transfer to a PC via interface. This process runs continuously.

Peak-hd: This function selects >500ms measurement time and stores the maximum of current and voltage since measurement start.

A manual Reset function is provided. Move the cursor to the display of Amax or Vmax. Key **M5** becomes the Reset key for Amax and Vmax.

5.2.4 SELECTING VARIOUS DISPLAY MODES

Move the cursor to the sixth annunciator in the side menu and press **SET**. The pull-down menu **VIEW L1 / VIEW L2 / VIEW L3 / VIEWSUM / VIEWALL** presents five choices of possible display modes (available on 3-phase Power Analyzers only).

The **VIEW L1/L2/L3**-display-modes display numeric values in large size numbers combined with graphics of the selected phase.

The **VIEWSUM**-display-mode displays numeric values in large size numbers with graphics selectable from phase L1, L2, or L3. For power and associated values the total and for voltage- and current values the average of the 3-phase system is displayed (see section 3 for definitions).

The **VIEWALL**-display-mode displays up to 40 numeric values of the 3-phase system. The screen is split in four columns for L1-, L2-, L3-, and sum values. In this display mode no graphics area is available.

5.2.5 SELECTING THE GRAPHICS IN THE VIEWSUM-DISPLAY-MODE

If you have selected the **VIEWSUM**-display-mode (section 5.3.6) you can select in the graphics area data from phase L1, L2, or L3. An annunciator indicates the display mode in the side menu (seventh from top). Move the cursor to this position and press **SET**; the pull-down menu **GRAPHL1 / GRAPHL2 / GRAPHL3** appears from which you can select graphics from L1, L2, or L3.

5.3 OPERATIONS CONTROLLED BY THE BOTTOM LINE MENUS

This section describes the use of the main menu. The main menu is displayed when the cursor is placed in the side menu or in one of the numeric fields. The keys M1, M2, M3, M4, M5, M6 are used to select a function. Pressing a key pointing to an empty menu field has no effect.

5.3.1 MAIN MENUS

Keys M1 through M6 select the main menus | HOLD | AC+DC | | | VIEW | |. The menu |AC+DC| is only present when the cursor is in the numeric display field pointing at a quantity that can have a DC component.

5.3.2 MAIN MENU <HOLD>

Press key M1 to enter the display hold state. The HOLD annunciator at left bottom indicates it. Numeric values and graphics are held while the measurement process goes on. This is particularly useful for the energy measurement.

Press key M1 again to return to the RUN state.

5.3.3 MAIN MENU <AC+DC>

The menu |AC+DC| is selected by M2 and is used to include or exclude DC components in a measured quantity. RMS- and power values offer the choice of AC- or AC+DC-coupling. Therefore, move the cursor to an RMS- or power value in the numeric field to activate the AC+DC menu. Simultaneously, a status indicator AC or DC above the current deflection bar graph indicates whether the value includes DC components or not. Key M2 toggles the status indicator AC/DC. This way DC components can individually be included or not.

NOTE: Selecting a value to include DC it will be included in phase L1, L2, and L3.

5.3.4 MAIN MENU <VIEW>

The menu **VIEW** lets you change the graphics in the graphics area of the display. Press key **M5** to display the sub-menu | **ESC** | **FFT_i** | **FFT_u** | | **i (t)** | **u (t)** |. The bar graphs FFT_i, and FFT_u of current and voltage, and the waveforms i (t), and u (t) of current and voltage are available. Press one of the keys **M2**, **M3**, **M5**, or **M6** to select the desired graphics; with key **M1** you return to the main menu.

The number of harmonics displayed in the bar graph depends on the fundamental frequency range of the signal as shown in the table below.

Fundamental frequency	Harmonics	Waveform
4Hz-400Hz	20	1 period
400Hz-3kHz	8	8 periods
3kHz-13kHz	1	

5.4 OPERATIONS CONTROLLED BY THE NUMERIC DISPLAY FIELD

This section describes how you can place measurement functions in the numeric fields and how you select associated parameters.

5.4.1 THE MEASUREMENT FUNCTION SELECTION TABLE

This is how you can visualize the measurement function table. Move the cursor away from the side menu to one of the numeric display fields, say field 0 and press SET. The measurement function selection table is presented from which you can choose a new function to be displayed in field 0 (remember field 0 is at top left) and field 9 at bottom right).

Current	RMS	Max	FFT		
Voltage	RMS	Max	FFT		
Power	Activ	VAapp	PFact		
Energy	Active	VAapp	Time		

Measurement Function Selection Table

Please refer to section 3 for definitions of the measurement functions. With the cursor you can reach any position in the function selection table.

This implies that in the display fields 0 to 5 any measurement function can be displayed.

Simply move the cursor to the desired position in the function selection table, press **SET** to return to the main display. The cursor sits now on the revised display field displaying the selected measurement function. In a last step you can now modify the attributes associated with the selected measurement function. The attributes such as AC, AC+DC, h01, are displayed in the side menu and can be modified by means of a bottom line menu. These procedures are described in sections 5.4.2 through 5.4.7.

5.4.2 SELECTING RMS-VALUES

RMS values apply to phase currents and phase voltages. An rms value contains DC-components if you set the attribute to DC, or it contains AC components only if you set the attribute to AC. RMS values always contain all harmonics within the frequency range of the instrument. It is acceptable to display the rms value in one display field with DC-component and in another without DC-component. To achieve this move the cursor to the desired display field and press **SET**. The function selection table is presented. Move the cursor to **RMS** and press **SET** again to return to the main display. The cursor points to the revised display field. The annunciator DC or AC in the side menu can be toggled with menu key **M2** (menu AC+DC) to the required coupling (including or excluding DC component).

NOTE: In the VIEWALL-display mode, display field 0 corresponds to display line 0 and display field 5 corresponds to display line 5.

5.4.3 SELECTING MIN AND MAX

Min, Max apply to phase currents and phase voltages. All values are DC-coupled and therefore have the DC attribute only.

To select one of these quantities move the cursor to the display field, press **SET** and now move the cursor in the measurement function selection table to the required function. To finish press **SET** and return to the main display mode. The DC attribute is shown in the side menu.

5.4.4 SELECTING POWER VALUES

Power values are: active power (or just power) and apparent power. The values include harmonics of the whole spectrum up to 50kHz and more.

DC components can be accounted for when selecting the DC attribute (AC+DC-coupled).

Selecting the AC attribute DC components of the power values is disregarded. The procedure for displaying power values is the same as described for rms values.

5.4.5 SELECTING AND RESETTING ENERGY VALUES AND TIME

The two energy values, active energy and apparent energy, are the summation of power and apparent power over time. Values for every phase and their total are determined from start (after reset) to the end of measurement. The summation goes on even when the display is in HOLD. In addition to energy values you can also display elapsed time in hours since Reset.

To start an energy measurement you probably want to reset the energy values and time. For this purpose move the cursor to an energy value or time and press menu key M5 (RESET) to start energy computation.

5.4.6 SELECTING POWER FACTOR (PF)

The power factor is displayed by selecting PFact in the measurement function selection table. The power factor is the ratio of power divided by apparent power. In many situations using modern power electronics the power factor appears to be too small. Why?

Power electronics most often generates a more or less sinusoidal current using a train of voltage pulses. The broadband rms voltage is larger than an equivalent sinusoidal voltage that would cause the same current to flow. As a consequence apparent power increases in case of the pulsed voltage and power factor decreases.

5.4.7 SELECTING FFT VALUES, HARMONICS 1-20

FFT-values (Fast Fourier Transform) are available for 3 phase currents and 3 phase voltages. All values are computed simultaneously. You can display up to 30 FFT values if you select the **VIEWALL** display mode.

Let us display harmonics 1, 3, and 5 of current in display fields 0, 1, and 2. Move the cursor to display field 0 and press **SET**. From the measurement function selection table select FFT of current and press SET once more to return to the main display. Because the cursor points to display field 0 the attribute h01 of the FFT-value is shown in the side menu. The bottom line menu | **HOLD** | **N-10** | **N-1** | **N+1** | **N+10** | lets you increment or decrement the harmonic number by 1 or by 10. Let us place harmonic h01 in display field 0. Similarly, we place harmonic 3 in display field 1, this time we increment the harmonic number to h03 using the bottom line menu. Finally, we place harmonic number 5 in display field 2 and increment the harmonic attribute to h05. The fundamental of current and voltage are important quantities when working with inverters.

Range of fundamental frequency	4Hz-380Hz:	available Harmonics 0-20
Range of fundamental frequency	380 Hz- 3kHz:	available Harmonics 0-7
Range of fundamental frequency	3kHz- 10kHz:	available Harmonics 0-1

6. OPERATING THE POWER ANALYZER USING THE COMPUTER INTERFACE

6.1 INTRODUCTION

The Power Analyzer can be operated from a host by sending commands to it through a computer interface on the rear panel.

Section 6 describes how to set up, configure, and operate the Power Analyzer via the RS-232.

6.2 LOCAL AND REMOTE OPERATIONS

When the Power Analyzer is operated from a host then it is operated „remotely“, when operated from its front panel the Power Analyzer is operated „locally“.

The Power Analyzer is no longer controllable from the front panel when via interface the Local Lockout state has been enabled.

6.3 RS-232 COMPUTER INTERFACE

Your Power Analyzer can be equipped with RS-232 interface.

You can operate several instruments in parallel if you install the required number of RS-232 ports on your computer.

6.4 INTERFACE PARAMETERS

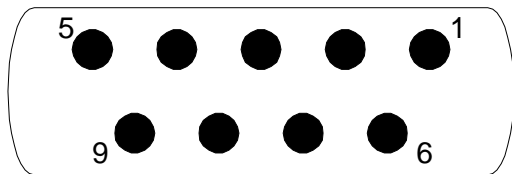
The Power Analyzer sets the parameters at startup to the following values:

Baud:	9600
Parity:	None
Terminator:	CR
Handshake:	None
IEEE-address:	n/a

In order for the Power Analyzer and the host to communicate through the interface the communication parameters of the Power Analyzer must match those of the host.

6.5 CABLING THE POWER ANALYZER TO A HOST

Turn Power Analyzer off. When cabling is complete turn power on again. The RS-232 interface on the Power Analyzer rear panel uses a DB-9 connector. Its pin out is given below.



1	DCD	Data Carrier Detect
2	RxD	Received Data
3	TxD	Transmitted Data
4	DTR	Data Terminal Ready
5	Grd	Signal Ground
6	DSR	Data Set Ready
7	RTS	Request To Send
8	CTS	Clear To Send
9	RNG	Ring

The RS-232 cable length should be less than 15m to make sure not to exceed the allowable (2000pF) cable capacitance.

NOTE: Use a standard one-to-one connected RS-232 interface cable to connect PC and Power Analyzer (RxD and .TxD are not crossed).

6.6 HOW THE POWER ANALYZER PROCESSES INPUT

The Power Analyzer processes and executes valid input strings sent by the host. A **CR/LF** (carriage return/line feed) terminates an input string.

When the Power Analyzer receives input, it stores it in a 32 byte input buffer. As soon as the input terminators have been recognized the data in the buffer are processed.

The Power Analyzer accepts upper and lower case characters. If a command cannot be understood, or it was longer than 32 characters, which cannot be the case for correct commands, the command will be ignored and an error will be generated.

6.6.1 INPUT TERMINATOR

An input terminator is a character or command sent by the host identifying the end of a string. Any of these terminators will be recognized as „end of message“.

Valid terminators for the RS-232 interface are:

CR (Carriage Return), LF (Line Feed)
CRLF (Carriage Return / Line Feed), and
LFCR (Line Feed / Carriage Return)

6.6.2 SENDING COMMANDS TO THE POWER ANALYZER

Command	Action
VOLT:RMS:AC 1	AC-coupled rms voltage is displayed in display field 1 (fields are: 0 = top left, 1 = top right ... 9). The minimum required characters (upper case) are used.
voltage:rms:ac?	Query form. To this command the Power Analyzer outputs (in scientific format) an alphanumeric string of the ac-coupled rms voltage. The maximum allowable characters in lower case are used.
CURR:FFT?	Query form. The Power Analyzer returns the harmonics of current in the range specified by the FORMAT:START/END command.

Commands can be sent in upper or lower case characters. The upper case letters in the command set table are the minimal string to be sent, the lower case letters are optional.

No space is allowed except for the selector at the end of a command where a space is mandatory.

RULE 1: A terminator must close every command. The maximum length must not exceed 32 characters.

Rule 1 implies that sending a batch file to the Power Analyzer consisting of several commands requires a delay of up to 200ms between the commands. This delay is particularly needed at start-up. When configuring the instrument, e.g., current range, voltage range, measurement time, and configuring the display. If you send these commands without delays most likely only part of the commands are executed.

In the normal measurement process you send a query and wait for the response. You send the next query only if you have received data. Therefore, a delay is not required.

RULE 2: Read Power Analyzer's output only once for each query command. The output buffer is cleared after it has been read. This prevents previously read data from being read a second time by mistake. A device dependent error is generated. (Query commands are identified by the „?“ at its end).

RULE 3: Read query responses before sending another command string.

If you send a query without removing the old message from the query before the old message gets lost. A device dependent error is generated.

6.6.3 HOW THE POWER ANALYZER PROCESSES OUTPUT

When the host sends a query command the Power Analyzer places an alphanumeric string into the output buffer. In case of the RS-232 interface, data are transmitted right away and are terminated with the set terminators (see RS232: Terminator command).

The output from the Power Analyzer can be measurement data in scientific format. This can be a single string or, for a range of harmonics, 2 to 63 strings.

Query	Examples	Explanation
VOLT:RMS?	+ 1.0238e+01	Measured voltage 10.238V
POW:ACT?	- 1.8351e+00	Measured power -1.8351W
CURR:RMS?	+ 5.8975e-03	Measured current 5.8975mA
FORM:START 1		Harmonic currents n = 1 to 5.
FORM:END 5		
CURR:FFT?	+ 9.0000e+00	
	+ 0.0000e+00	
	3.0000e+00	
	+ 0.0000e+00	
	+ 1.8000e+00	

6.6.4 OPTIMIZING SPEED FOR DATA TRANSFER

The Power Analyzer is optimized for continuous data acquisition. Servicing the RS-232 interface has second priority.

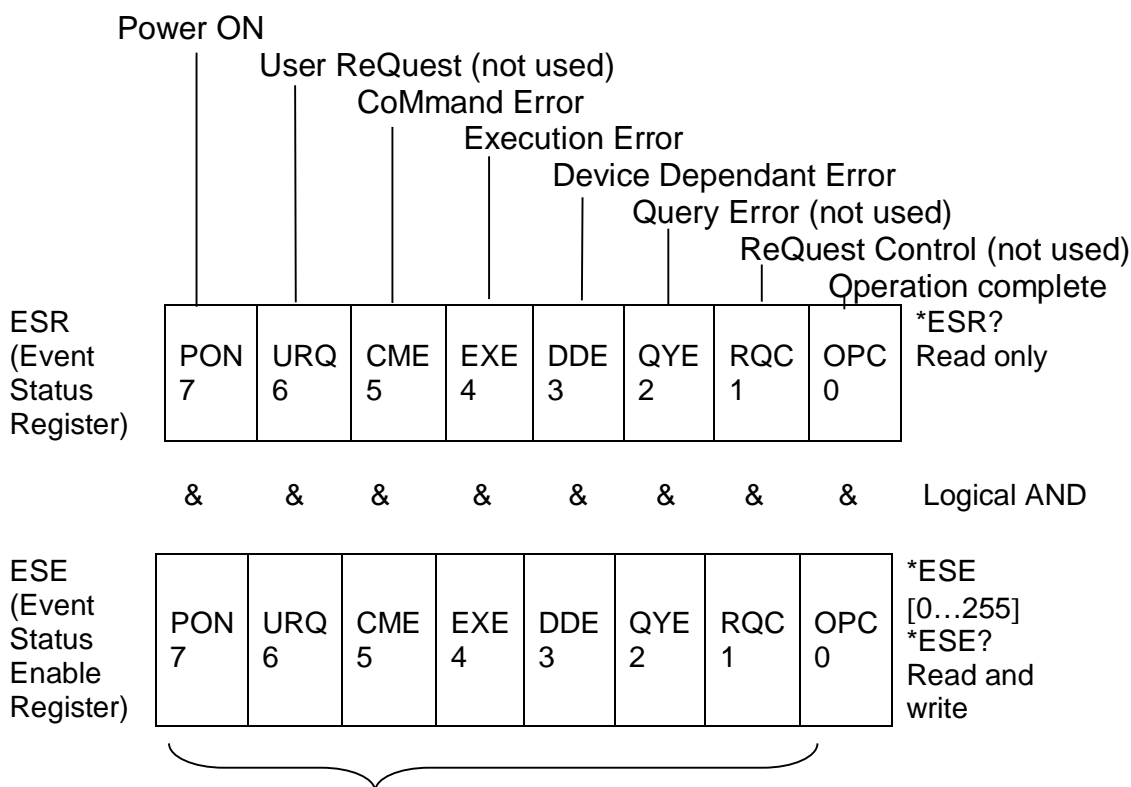
For all Power Analyzer operating modes the standard Baud rate of 9600 Baud is used. For 3-phase Power Analyzers a special command is available to read all 3 phases values using one query. **Once you have sent FORM:PH ALL the 3-phase Power Analyzer will always return 3 values to every query, phase L1 value first, L2 value second, and L3 value third.**

6.7 OPERATING SEVERAL INSTRUMENTS ON RS-232 FROM ONE COMPUTER

Sometimes it is desirable to control more than one instrument from the same computer. To do this you must have additional RS-232 ports available or you must install additional RS-232 ports.

You have now several options: either you write your own operating software using one of the available design software implementing as many RS-232 as needed, or, if you use more than one Power Analyzer, open windows for all Power Analyzers and operate them in parallel.

STATUS AND EVENT REGISTER DEFINITION



6.8 COMPUTER INTERFACE COMMAND SET

The following table lists the RS-232 commands. A parameter that must be supplied by the user is enclosed in angle brackets <parameter>. Commands can be sent in upper case or lower case.

The following conventions are used:

<F> = Field selector; it is an integer 0 to 5 used to select the display field on which a value must be displayed. Field 0 is top left, 1 is top right, ... field 5 is 3rd line right.

<N> = Signed integer number, e.g. +1024.

Query commands are terminated with „?“ and do not contain a <parameter>. That part of the command that is written in capital letters is mandatory. The lower case letters are optional. We suggest to use the minimum number of characters required.

*** Command only available on three phase instrument.

COMMAND	DESCRIPTION										
VOLTage:RMS <F>	Query or set field for DC coupled RMS voltage										
:AC <F>	Query or set field for AC coupled RMS voltage										
:MAX <F>	Query or set field for positive peak voltage										
:FFT <F>	Set the field (0,1,...,5) for voltage harmonic previously selected by the FORMat:START command.										
:FFT?	Query all voltage harmonics in the range specified by the FORMat:STart and FORMat:END commands.										
CURRent:RMS <F>	Query or set field for DC coupled RMS current										
:AC <F>	Query or set field for AC coupled RMS current										
:FFT <F>	Set the field (0,1,...,5) for current harmonic previously selected by the FORMat:START command.										
:FFT?	Query all current harmonics in the range specified by the FORMat:START and FORMat:END commands.										
POWer:ACTive <F>	Query or set field DC coupled power in Watt.										
:AC <F>	Query or set field AC coupled power in Watt.										
:APParent <F>	Query or set field DC coupled apparent power.										
:AC <F>	Query or set field AC coupled apparent power.										
:FACTOR <F>	Query or set the field for the DC coupled power factor										
:AC <F>	Query or set the field for the AC coupled power factor										
ENergy:ACTive <F>	Query or set field of energy (long time integration)										
:APParent <F>	Query or set field of apparent energy (long time integration)										
:RESET	No query form, resets all energy values										
TIME <F>	Query or set field of elapsed time since last Reset.										
ACQuire:RANge:VOLTage	<table> <tr> <td>Auto</td><td></td></tr> <tr> <td>30</td><td>Query or set voltage range.</td></tr> <tr> <td>100</td><td>Examples:</td></tr> <tr> <td>300</td><td>ACQ:RAN:VOLT AUTO Voltage in autoranging</td></tr> <tr> <td>1000</td><td>ACQ:RAN:VOLT 300 Selects 300V range.</td></tr> </table>	Auto		30	Query or set voltage range.	100	Examples:	300	ACQ:RAN:VOLT AUTO Voltage in autoranging	1000	ACQ:RAN:VOLT 300 Selects 300V range.
Auto											
30	Query or set voltage range.										
100	Examples:										
300	ACQ:RAN:VOLT AUTO Voltage in autoranging										
1000	ACQ:RAN:VOLT 300 Selects 300V range.										

ACQuire:RANge:CURRent	Auto 600M 2 6 20 60	Query or set current input range
------------------------------	------------------------------------	----------------------------------

:SYNChro VOLTage Query or set instrument synchronization mode,
CURRent Synchronizes to phase 1.

:APERture 250M Query or set minimal averaging time, or special
500M measurement function peak-hold.
1
2
peak-hd Example: ACQ:APER peak-hd

:Hold	Run	Query or set acquisition subsystem.
	Stop	Display data are held.

:Quality? Query overload and underload of current and voltage inputs. An integer is returned. The integer indicates the state during the previous query (VOLT:,CURR:,POW:,EN:). For more details refer to overload and underload register definition.

DISplay:Mode?	L1 L2 L3 SUM ALL	*** Query or select display mode. View L1, View L2 View L3, View Sum, and View ALL.
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FORMat:START <N> Query or set the range for data array transfer
:END <N> Range of N for harmonic values is 1 to 20.

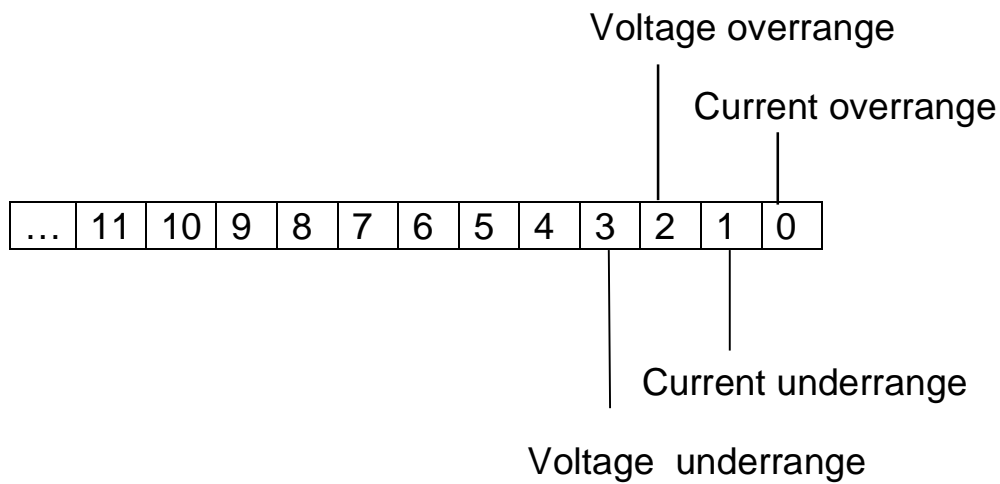
FORMat:Phase?	L1 L2 L3 ALL	*** Query or select phase for data transfers such as: VOLT:RMS? If ALL is selected 3 values (phase L1 first) are re-Returned to a query such as VOLT:RMS? ALL has To be sent once only.
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VERsion?		Query form only. Returns software version
LOCK		Locks the instrument's front panel controls. The query form returns YES or NO whether the controls are locked or not.
UNLock		Unlock the instrument front panel controls.
RS232?		Query form only, returns all settings. Output format is BAUD; PARITY; TERM; HAND
RS232:BAUD	9600	Query or set baud rate
:PARITY	None Even Odd	Query or set parity mode.
:TERMinator	CR LF CRLF	Query or set command terminating characters.
:HANDshakes	None Xon	Query or set handshake mode.
*ESE [0..255]		Query or set the Event Status Enable register
*RST		Resets instrument
*OPC?		Returns 1 if no measurement is pending.
*TST?		Performs self test, returns zero if successful
*WAI		Suspends command execution until previous commands are complete.
*IDN?		Returns identification string in form:<Vendor, Model, Serial-Number, Firmware version>.
ERRor?		Query the last error code

ERROR CODES DEFINITIONS:

- 102 Syntax Error**
The command was not recognized. ESR bit 5 is set (CoMmand Error)
- 110 Command header error**
A command followed by '?' was sent where no query form is available. And conversely: no '?' followed a query form only command. ESR bit 5 is set (CoMmand Error).
- 111 Header separator error**
Attempted to descend the command hierarchy at a place where there wasn't any subcommand. ESR bit 5 is set (CoMmand Error).
- 140 Character data error**
A too long and/or senseless command has been sent to the instrument. ESR bit 5 is set (CoMmand Error).
- 222 Data Out Of Range**
The command argument is not allowed. ESR bit 4 is set (EXecution Error).
- 2204 Measurement error, Measurement underflow. ESR bit 4 is set (EXec. Err.).**
- 2207 Measurement error, Measurement overflows. ESR bit 4 is set (EXec. Err.)**
- 350 Queue overflow**
This occurs if a query command attempts to place a new message onto the instruments output queue but there was still an old message waiting on the queue. This results in information loss. '350' replace the query answer and ESR bit 3 is set (Device Dependant Error).
- 2200 Input signal over- and under. One or more current- or voltage inputs were in over- or under load during the last query (VOLT:,CURR:,POW:,EN:,FREQ:). ESR bit 4 is set.**

Overload and underload Register Definition



Current overrange: Current L1, or L2, or L3 is overrange.
Current under range: All 3 currents are under range

Voltage overrange: Voltage L1, or L2, or L3 is overrange.
Voltage under range: All 3 voltages are under range.

7. THE POWER ANALYZER OPTIONS

This section describes the capabilities and the use of the available options.

7.1 OPTION 01: RS-232 INTERFACE, AND OPERATING SOFTWARE

The RS-232 interface on the Power Analyzer rear panel uses a DB-9 connector. The pin out of the connector is shown below.

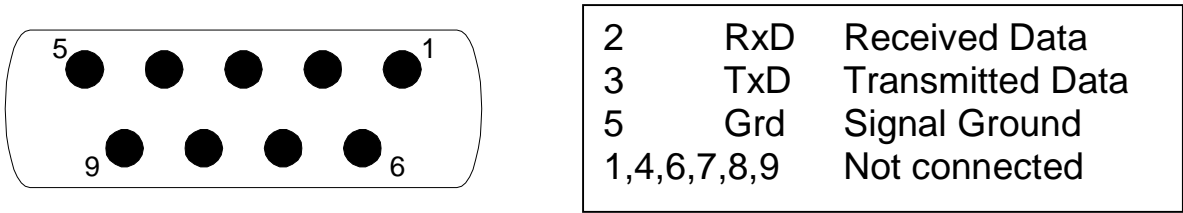


Figure 7.1 RS-232 connections for Option 01

7.1.1 RS-232 INTERFACE AND OPERATING SOFTWARE

The standard setting of the RS-232 Interface at Power Analyzer start-up is 9600 Baud and string terminators CR (carriage return) LF (line feed). Other Baudrates are not available.

The Windows Operating Software for option 01 contains modules to control the Power Analyzer, read data, and store data in EXCEL-compatible format. You can choose from the complete set of measurement quantities and you can select the number of quantities you want to display.

The software masks for the single phase and the 3-phase Power Analyzer look essentially the same and also have similar features. The 3-phase masks display three phase values and their sum or their average whereas the single phase masks read only one value (value of phase L1) per measurement quantity you selected.

The software installation procedure and the software manual are supplied in a readme.txt file with your software package. Please consult it for more information.

8. POWER ANALYZER CALIBRATION

8.1 CALIBRATION CYCLE

We recommend to verify the Power Analyzer calibration once every year or once every two years.

8.1.1 EQUIPMENT NEEDED

A calibrator that will supply voltages 30V-600V and currents 600mA to 2A at 60Hz with 0.02 % accuracy will suffice.

8.1.2 PREPARING FOR CALIBRATION

- STEP 1: Disconnect the power line-cord from Power Analyzer.
- STEP 2: Remove the Power Analyzer hood by removing 4 screws on each side panel.
- STEP 3: Lift up the hood of the case.
- STEP 4: Remove the red calibration jumper using a pair of pincers or a pair of pliers (Figure 8.1).
- CAUTION: Do not forget to reinstall the calibration jumper when calibration is done.
- STEP 5: Put the hood back in place. Connect the line-cord and turn Power Analyzer on.

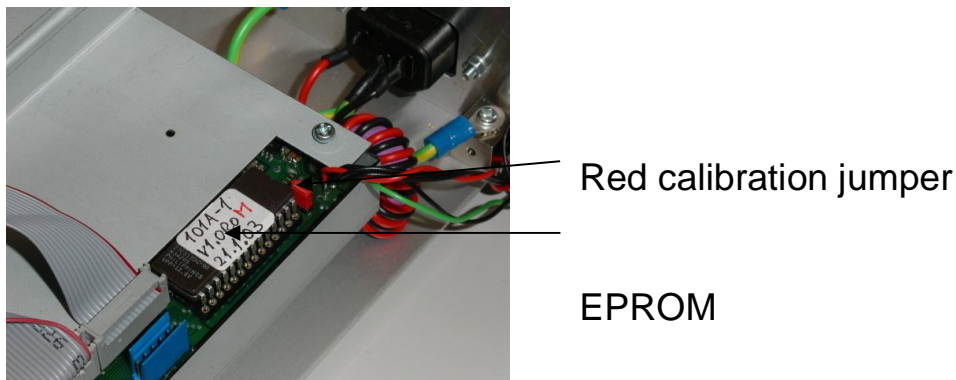


Figure 8.1 Position of Calibration Jumper

8.1.3 VOLTAGE CALIBRATION, CURRENT CALIBRATION, CLAMP CALIBRATION

Select voltage synchronization. Select 30V range. Apply 60Hz voltage to the Power Analyzer voltage inputs.

- a) **Voltage Calibration**, use manual ranging, use 2 seconds measuring time

Select 30V range	Apply 30V/60Hz	Press M1
Select 100V range	Apply 100V/60Hz	Press M1
Select 300V range	Apply 300V/60Hz	Press M1
Select 1000V range	Apply 600V/60Hz	Press M1

- b) **Current Calibration**, use manual ranging, use 2 seconds measuring time

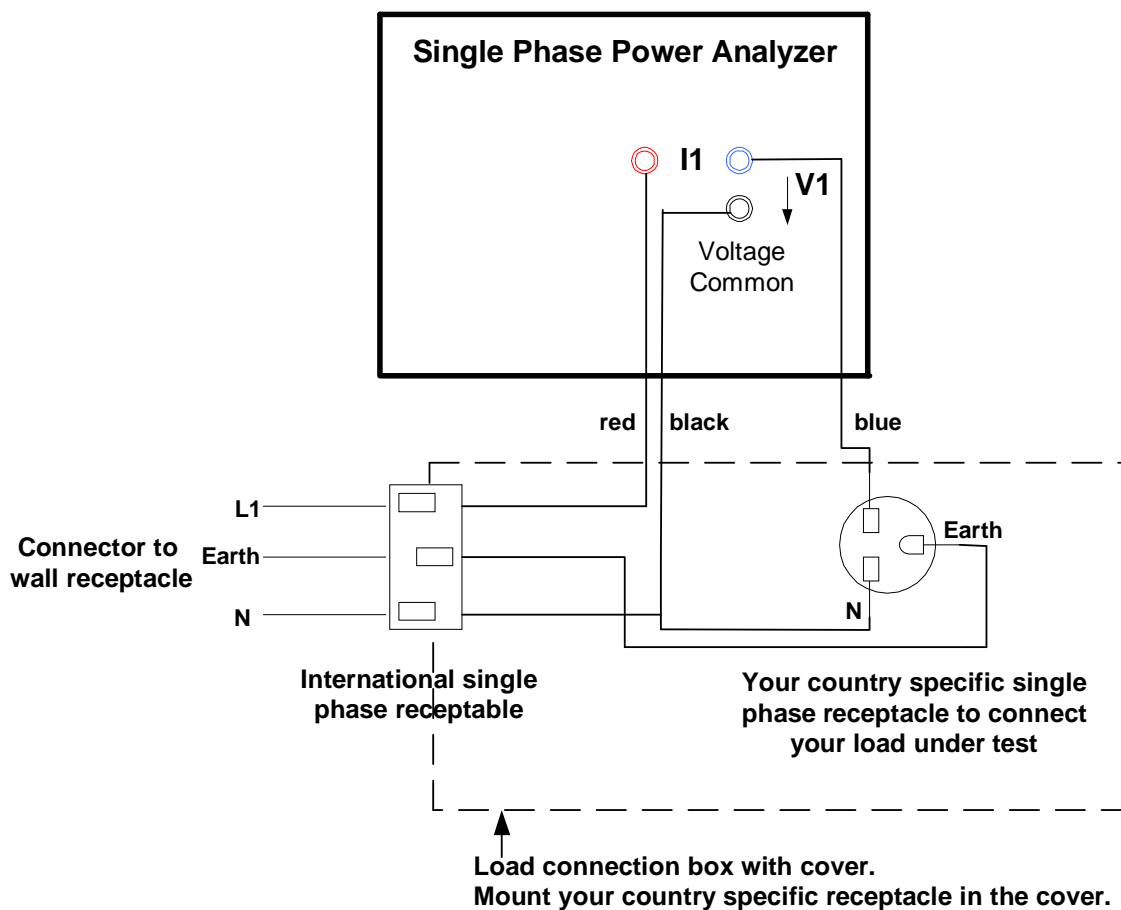
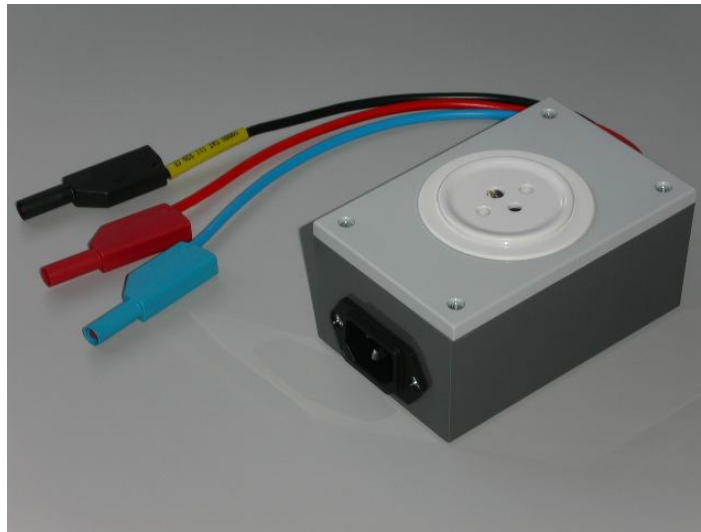
Select 600mA range, select current synchronization

Select 600mA range	Apply 600mA/60Hz	Press M2
Select 2A range	Apply 2A/60Hz	Press M2
Select 6A range	Apply 6A/60Hz	Press M2
Select 20A range	Apply 20A/60Hz	Press M2
Select 60A range	Apply 20A/60Hz	Press M2

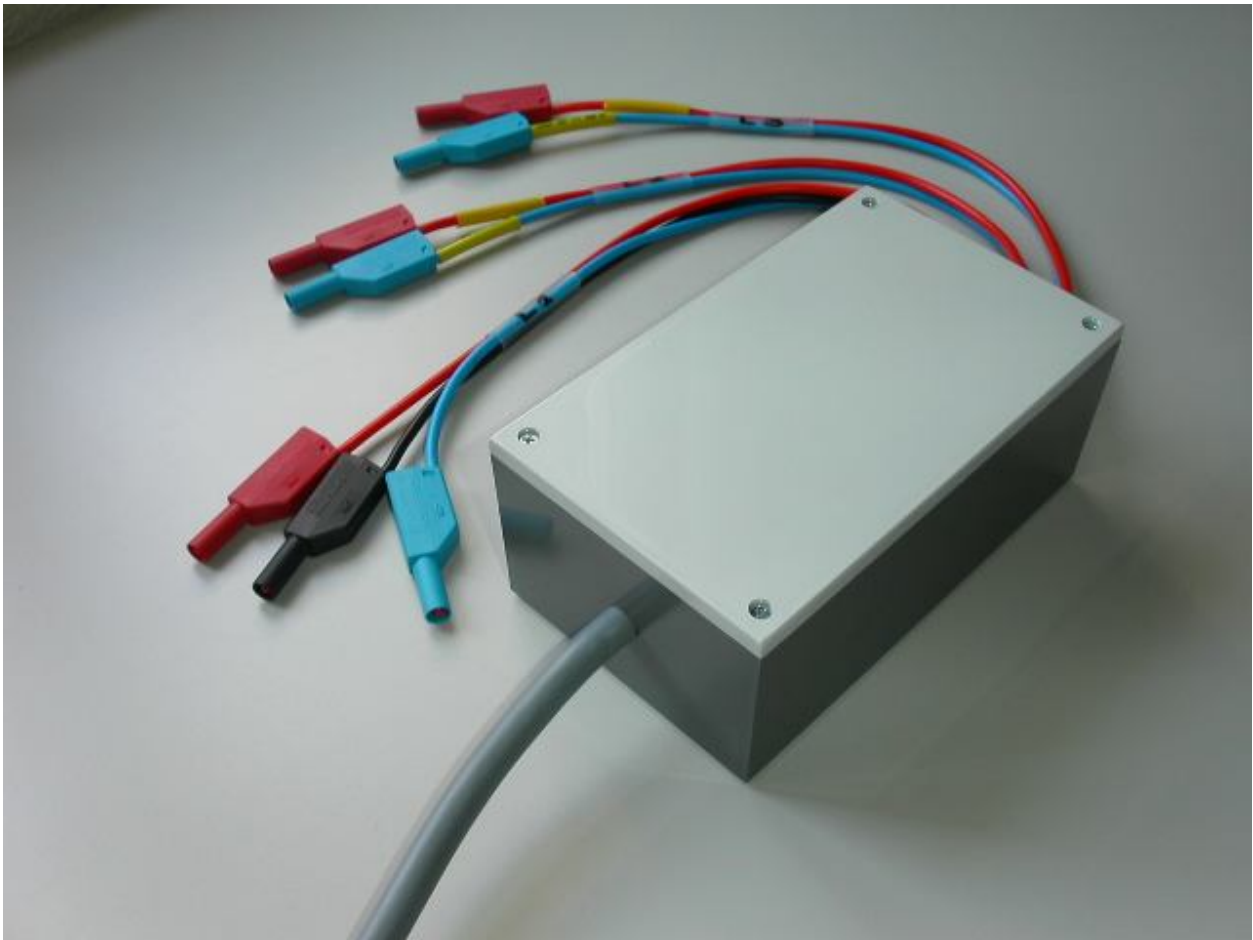
- c) **Terminate Calibration**

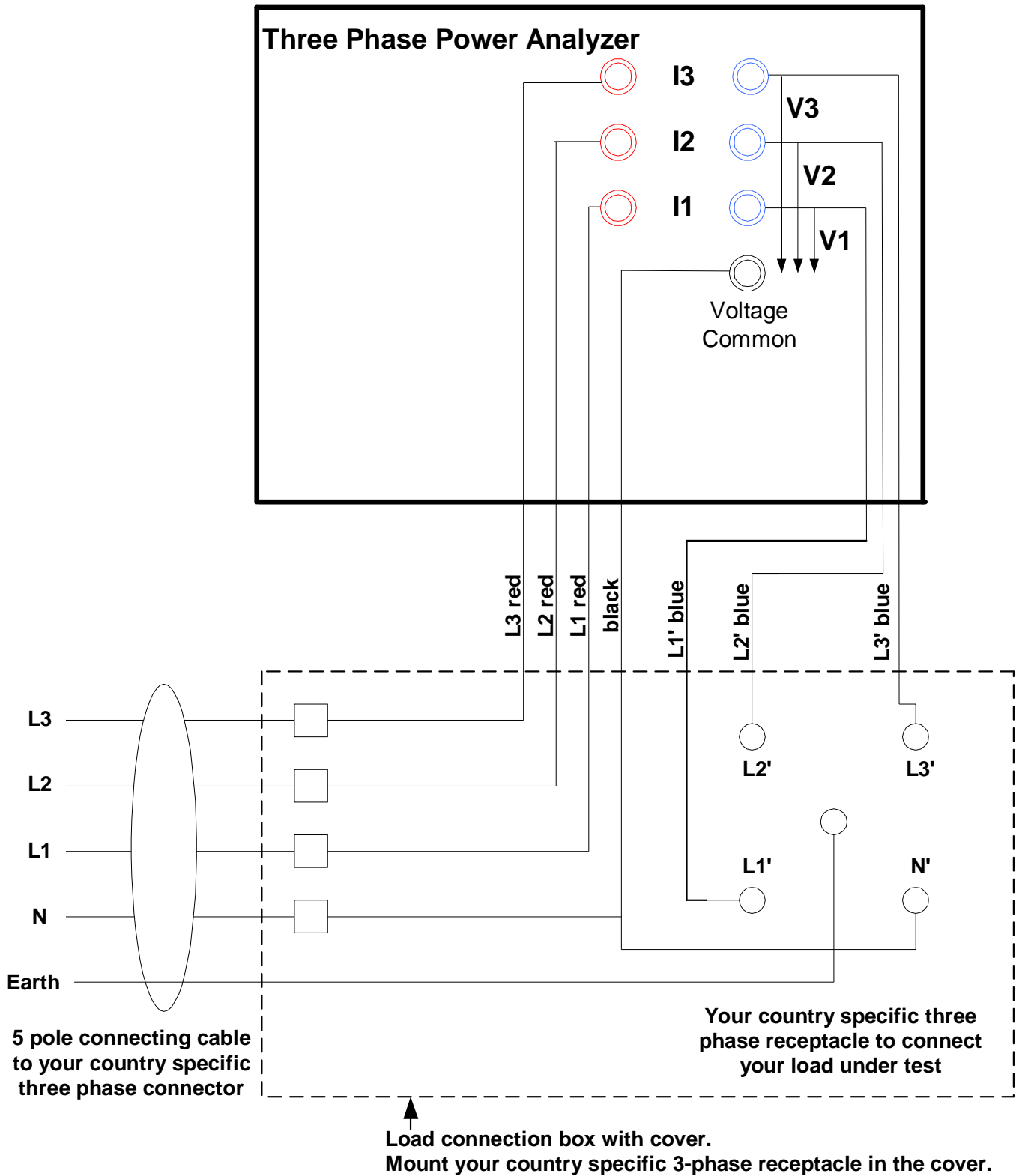
The calibration steps described in a) and b) determine the required internal constants. You must store these constants by pressing key **M3**. Having done this, turn the Power Analyzer off and disconnect all cables connected to it. Remove the hood and **reinstall the calibration jumper**. Install hood and 4 screws on each side of the hood.

9. LOAD CONNECTION BOX, SINGLE PHASE, THREE PHASE



red: Supplied 32A red cable with safety plug
black: Supplied 32A black cable with safety plug
blue: Supplied 32A blue cable with safety plug





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101A POWER ANALYZER

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89/336/EWG

Uetikon am See, Juni 2002

Dr. Hans R. Oppliger *Hans R. Oppliger*

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