HAMEG Instruments
A Rohde & Schwarz Company

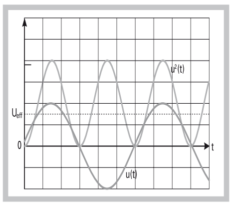
8kW Power-Meter HM8115-2

Manual
English

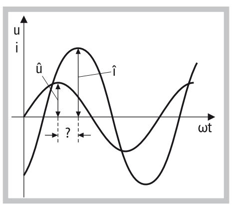
8kW Power Meter
HM8115-2

HZ815 Power adapter

RMS value



Active power



- ☑ Wide measurement range 1 mW...8 kW
- ☑ Voltage range 100 mV...500 V, current range 1 mA...16 A
- ☑ Frequency range DC...1 kHz
- ☑ Simultaneous voltage, current and power display
- ☑ Display of apparent, effective and reactive power
- ☑ Power factor display
- ☑ Autoranging, simple operation
- ☑ Monitor output (BNC) representing the instantaneous active power
- ☑ Suitable for measurements on frequency converters
- ☑ Software for remote control and data acquisition included
- ☑ Galvanically isolated USB/RS-232 Interface, optional IEEE-488

 Subject to change without notice

8 kW Power Meter HM8115-2

All data valid at 23 °C after 30 minute warm-up

Voltage	True RMS voltage measurement (AC+DC)		
Ranges:	50 V	150 V	500 V
Resolution:	0.1 V	1 V	1 V
Accuracy:	20 Hz...1 kHz:	± (0.4 % + 5 digit)	
	DC:	± (0.6 % + 5 digit)	
Input impedance:	1 MΩ II 100 pF		
Crest factor:	max. 3.5 at full scale		
Input protection:	max. 500 V_p		

Current	True RMS current measurement (AC+DC)		
Ranges:	160 mA	1.6 A	16 A
Resolution:	1 mA	1 mA	10 mA
Accuracy:	20 Hz...1 kHz:	± (0.4 % + 5 digit)	
	DC:	± (0.6 % + 5 digit)	
Crest factor:	max. 4 at full scale		
Input protection:	fuse, FF 16 A 6.3 x 32 mm (superfast)		

Active power measurement							
Ranges:	8 W	24 W	80 W	240 W	800 W	2400 W	8000 W
Resolution:	1 mW	10 mW	10 mW	100 mW	100 mW	1 W	1 W
Accuracy:	20 Hz...1 kHz: ± (0.5 % + 10 digit)						
	DC: ± (0.5 % + 10 digit)						
Display:	4-digit, 7-segment LED						

Reactive power measurement					
Ranges:	8 var	24 var	80 var	240/800 var	2400/8000 var
Resolution:	1 mvar	10 mvar	10 mvar	100 mvar	1 var
Accuracy:	20 Hz...400 Hz: ± (2.5 % + 10 digit + 0.02 x P)				
	P = active power				
Display:	4-digit, 7-segment LED				

Apparent power measurement					
Ranges:	8 VA	24 VA	80 VA	240/800 VA	2400/8000 VA
Resolution:	1 mVA	10 mVA	10 mVA	100 mVA	1 VA
Accuracy:	20 Hz...1 kHz: ± (0.8 % + 5 digit)				
Display:	4-digit, 7-segment LED				

Power factor measurement	
Display:	0.00...+1.00
Accuracy:	50 Hz...60 Hz: ± (2% + 3 digit) (sine wave) voltage and current › 1/10 of full scale

Monitor output (analog)	
Connection:	BNC connector (galvanic isolation to test circuit and RS-232 interface)
Reference potential:	protective earth
Level:	1 V_{AC} at full scale (2400/8000 digit)
Accuracy:	typ. 5 %
Output impedance:	approx. 10 kΩ
Bandwidth:	DC...1 kHz
Protected up to:	± 30 V

Functions and displays	
Measurement functions:	voltage, current, power, power factor
Range selection:	automatic/manual
Overrange alarm:	visual and acoustic
Display resolution	
Voltage:	3-digit, 7-segment LED
Current:	4-digit, 7-segment LED
Power:	4-digit, 7-segment LED
Power factor:	3-digit, 7-segment LED

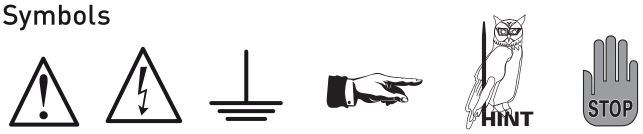
Interface	
Interface:	USB/RS-232 (standard), IEEE-488 (opt.)
Connection RS-232:	D-sub connector (galvanic isolation to test circuit and monitor output)
Protocol:	Xon / Xoff
Data rate:	9600 Baud
Functions:	control/data fetch

Miscellaneous	
Safety Class:	Safety Class I (EN 61010)
Power supply:	115/230 V ± 10 %, 50/60 Hz, CAT II
Power consumption:	approx. 15 W at 50 Hz
Operating temperature:	+5°C...+40°C
Storage temperature:	-20°C...+70°C
Max. rel. humidity:	5%...80% (non condensing)
Dimensions (W x H x D):	285 x 75 x 365 mm
Weight:	approx. 4 kg

Accessories supplied: Operator's Manual, power cable, software
Optional accessories:
HZ10S/R Silicone test lead
HZ815 Socket adapter
HO880 IEEE-488 (GPIB) Interface

Important hints

Symbols



(1) (2) (3) (4) (5) (6)

Symbol 1: Attention, please consult manual
Symbol 2: Danger! High voltage!
Symbol 3: Ground connection
Symbol 4: Important note
Symbol 5: Hints for application
Symbol 6: Stop! Possible instrument damage!

Unpacking

Please check for completeness of parts while unpacking. Also check for any mechanical damage or loose parts. In case of transport damage inform the supplier immediately and do not operate the instrument.

Check setting of line voltage selector whether it corresponds to the actual line voltage.

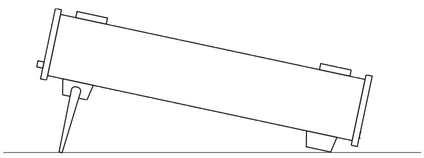
Positioning

Two positions are possible: According to picture 1 the front feet are used to lift the instrument so its front points slightly upward. (Appr. 10 degrees)

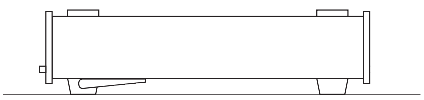
If the feet are not used the instrument can be combined with many other Hameg instruments.

In case several instruments are stacked the feet rest in the recesses of the instrument below so the instruments can not be inadvertently moved. Please do not stack more than 3 instruments. A higher stack will become unstable, also heat dissipation may be impaired.

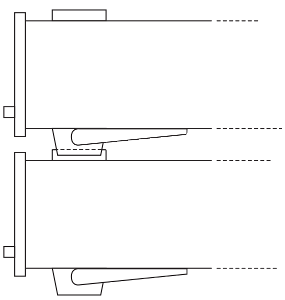
picture 1



picture 2



picture 3



Transport

Please keep the carton in case the instrument may require later shipment for repair. Improper packaging may void the warranty!

Storage

Dry indoors storage is required. After exposure to extreme temperatures 2 h should be allowed before the instrument is turned on.

Safety instructions

The instrument conforms to VDE 0411/1 safety standards applicable to measuring instruments and left the factory in proper condition according to this standard. Hence it conforms also to the European standard EN 61010-1 resp. to the international standard IEC 61010-1. Please observe all warnings in this manual in order to preserve safety and guarantee operation without any danger to the operator. According to safety class 1 requirements all parts of the housing and the chassis are connected to the safety ground terminal of the power connector. For safety reasons the instrument must only be operated from 3 terminal power connectors or via isolation transformers. In case of doubt the power connector should be checked according to DIN VDE 0100/610.

Disconnecting the protective earth internally or externally is absolutely prohibited!

As soon as the voltages applied to the INPUT terminals ⑫ exceed levels accepted as safe to the touch all applicable safety rules are to be observed!
DC voltages must be disconnected from earth.
AC voltages shall be derived from a safety isolation transformer and must also be disconnected from earth.

Before the safety connectors on the INPUT terminals ⑫ are pulled off it must be assured that the voltage has been switched off, otherwise there may be danger of accident, even danger of life!

If instruments of protective class I are connected to the OUPUT terminals ⑭ the protective earth PE must be connected separately to the test object. If this is not observed there is danger of life!

This instrument may only be opened by qualified personnel. Before opening all voltages have to be removed!

The safety connectors may become quite hot at high current levels!

- The line voltage selector must be properly set for the line voltage used.

- Opening of the instrument is allowed only to qualified personnel

- Prior to opening the instrument must be disconnected from the line and all other inputs/outputs.

In any of the following cases the instrument must be taken out of service and locked away from unauthorized use:

– Visible damages
– Damage to the power cord
– Damage to the fuse holder
– Loose parts
– No operation
– After longterm storage in an inappropriate environment , e.g. open air or high humidity.
– Excessive transport stress

Operating conditions

The instruments are destined for use in dry clean rooms. Operation in an environment with high dust content, high humidity, danger of explosion or chemical vapors is prohibited.

Operating temperature is +5 °C ... +40 °C. Storage or transport limits are –20 °C ... +70 °C. In case of condensation two hours are to be allowed for drying prior to operation.

For safety reasons operation is only allowed from 3 terminal connectors with a safety ground connection or via isolation transformers of class 2. The instrument may be used in any position, however, sufficient ventilation must be assured as convection cooling is used. For continuous operation prefer a horizontal or slightly upward position using the feet.

Do not cover either the holes of the case nor the cooling fins.

Nominal specs are valid after a warm-up period of min. 30 min. in the interval of +23 °C. Values without a tolerance are typical of an average production instrument.

Warranty and Repair

HAMEG instruments are subjected to a strict quality control. Prior to leaving the factory, each instrument is burnt-in for 10 hours. By intermittent operation during this period almost all defects are detected. Following the burn-in, each instrument is tested for function and quality, the specifications are checked in all operating modes; the test gear is calibrated to national standards.

The warranty standards applicable are those of the country in which the instrument was sold. Reclamations should be directed to the dealer.

Only valid in EU countries
In order to speed reclamations customers in EU countries may also contact HAMEG directly. Also, after the warranty expired, the HAMEG service will be at your disposal for any repairs.

Return material authorization (RMA):
Prior to returning an instrument to HAMEG ask for a RMA number either by internet (http://www.hameg.com) or fax. If you do not have an original shipping carton, you may obtain one by calling the HAMEG service dept (+49 (0) 6182 800 500) or by sending an email to service@hameg.com.

Maintenance

The instrument does not require any maintenance. Dirt may be removed by a soft moist cloth, if necessary adding a mild detergent. (Water and 1 %.) Grease may be removed with benzine (petrol ether). Displays and windows may only be cleaned with a moist cloth.

STOP **Do not use alcohol, solvents or paste. Under no circumstances any fluid should be allowed to get into the instrument. If other cleaning fluids are used damage to the lacquered or plastic surfaces is possible.**

Line voltage selector

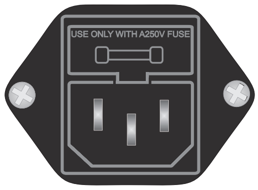
The instrument is destined for opera-tion on 115 or 230 V mains, 50/60 Hz. The proper line voltage is selected with the ⑯ line voltage selector. It is necessary to change the fuse observing the proper values printed on the back panel.

Change of fuse

The mains fuse ⑰ is accessible on the back panel. A change of the fuse is only allowed after the instrument was disconnected from the line and the power cord removed. Fuse holder and power cord must not show any sign of damage. Use a screw driver to loosen the fuse holder screw counterclockwise while pressing the top of the fuse holder down. The top holding the fuse will then come off. Exchange the defective fuse against a correct new one. Any „repair" of a defective fuse or brid-ging is dangerous and hence prohibited. Any damages to the instrument incurred by such manipulations are not covered by the warranty.

Type of fuse:

5 x 20 mm; 250V~, C;
IEC 127/III; DIN 41662
(DIN 41571/3).



Value
115 V: 200 mA slow blow
230 V: 100 mA slow blow

Designation of operating controls

Front panel

① POWER – Mains switch

② VOLT Display – Voltage display

③ AMPERE Display – Current display

④ FUNCTION – Display

⑤ MONITOR – Monitoring output

⑥ VOLT pushbuttons – Selection of voltage ranges

⑦ VOLT LED – Show range selected

⑧ AMPERE pushbuttons – Selection of current ranges

⑨ AMPERE LED – Show range selected

⑩ FUNCTION pushbuttons – Select function desired

⑪ FUNCTION LED – Show function selected

⑫ INPUT – Input for test object

⑬ FUSE – Fuse for measurement circuit

⑭ OUTPUT – Output to test object

Rear panel

⑮ Connector (D-Sub, 9-pin) for serial interface

⑯ Mains voltage selector

⑰ Mains input connector combined with fuse holder

Basics of Power Measurement

Abbreviations and symbols used:

W	active, true power	P
VA	apparent power	S
var	reactiv power	Q

$u(t)$ voltage as a variable of time
$u^2(t)$ voltage squared as a variable of time
$|\hat{U}|$ rectified voltage
V_{rms} rms value of voltage
$\hat{u}$ peak value of voltage

I_{rms} rms value of current
$\hat{\imath}$ peak value of current

φ phase angle between voltage and current
$\cos\varphi$ power factor, valid only for sine waveform
PF power factor in general for arbitrary waveforms

Arithmetic mean value (average)

$$\overline{x}(t) = \frac{1}{T}\int_0^T x(t) \cdot dt$$

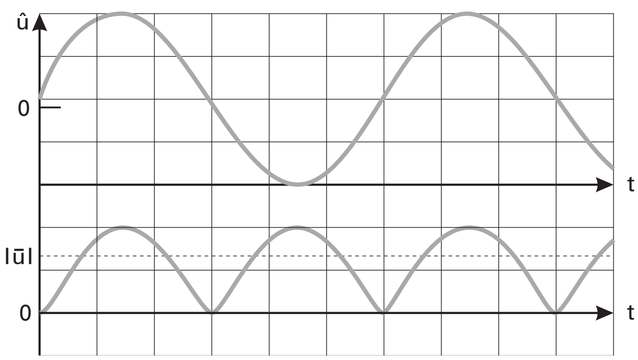
The arithmetic mean value of a periodic signal is the average calculated for a full period T, it is identical to its DC content.

- If the average = 0 it is a pure AC signal
- If all instantaneous values are equal to the average it is pure DC
- Otherwise the average will constitute the DC content of the signal

Rectified mean value

$$|\overline{x}|(t) = \frac{1}{T}\int_0^T |x(t)| \cdot dt$$

The rectified mean is the average of the absolute values. The absolute values are derived by rectifying the signal. In general the rectified mean is calculated by integrating the absolute values for a period T.



In case of a sine wave $u(t) = \hat{u} \sin \omega t$ the rectified mean will amount to $2/\pi = 0.637$ of the peak value according to:

$$|\overline{u}| = \frac{1}{T}\int_0^T |\hat{u} \sin\omega t| \; dt = \frac{2}{\pi}\hat{u} = 0{,}637\hat{u}$$

Root-Mean-Square Value (RMS)

The quadratic mean value of a signal is equal to the mean of the signal squared integrated for a full period

$$\overline{x(t)^2} = \frac{1}{T}\int_0^T x(t)^2 \cdot dt$$

The rms value is derived by calculating the square root

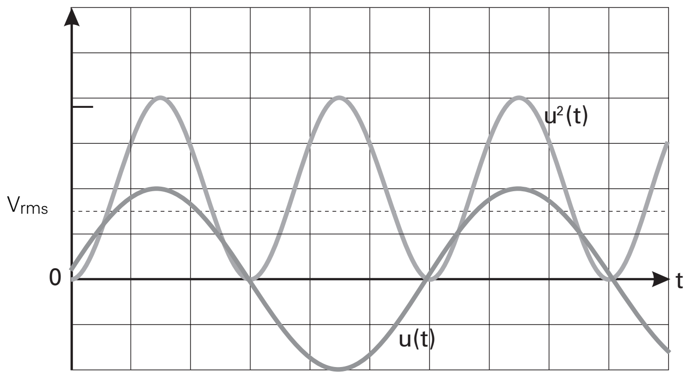
$$x_{eff} = \sqrt{\frac{1}{T}\int_0^T x(t)^2 \cdot dt}$$

The purpose of the rms value was to create a value which allows the use of the same formulas as with DC for resistance, power etc. The rms value of an AC signal generates the same effect as a DC signal of the same numerical value.

Example:
If an AC rms signal of 230 V is applied to an incandescent lamp (purely resistive at 50/60 Hz) the lamp will be as bright as powered by 230 V DC.

For a sine wave $u(t) = \hat{u} \sin \omega t$ the rms value will be $1/\sqrt{2} = 0.707$ of the peak value:

$$U = \sqrt{\frac{1}{T}\int_0^T (\hat{u} \sin\omega t)^2 \, dt} = \frac{\hat{u}}{2} = 0{,}707\hat{u}$$



Form factor

The form factor multiplied by the rectified value equals the rms value. The form factor is derived by:

$$F = \frac{V_{rms}}{|\hat{u}|} = \frac{\text{rms value}}{\text{rectified value}}$$

HINT

For a sine wave the form factor is

$$\frac{\pi}{2\sqrt{2}} = 1{,}11$$

Crest factor

The crest factor is derived by dividing the peak value by the rms value of a signal. It is very important for the correct measurement of pulse signals and a vital specification of a measuring instrument.

$$C = \frac{\hat{u}}{V_{rms}} = \frac{\text{peak value}}{\text{rms value}}$$

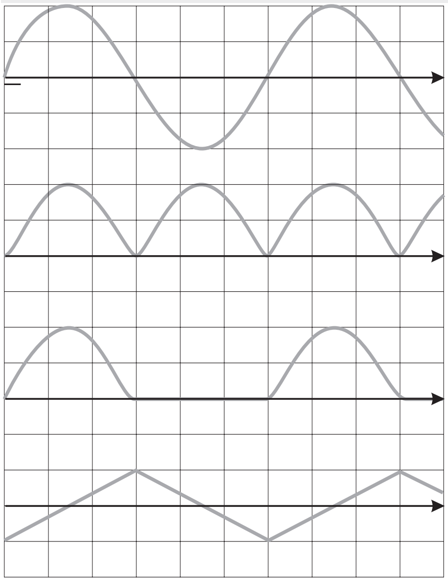
HINT

For sinusoidal signals the crest factor is $\sqrt{2} = 1{,}414$

Please note that erroneous results will show if the crest factor of a signal is higher than that of the measuring instrument because it will be overdriven.

Hence the accuracy of the rms value measurement will depend on the crest factor of the signal, the higher the crest factor the less the accuracy. Please note also that the crest factor specification relates to the full scale value, if the signal is below full scale its crest factor may be proportionally higher.

Form factors



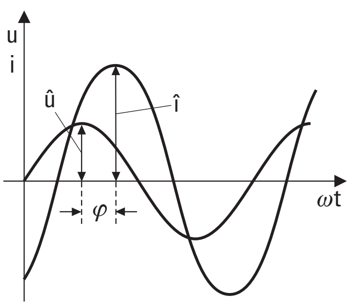
Crest-factor C	Form-factor F
$\sqrt{2}$	$\frac{\pi}{2\sqrt{2}} = 1{,}11$
$\sqrt{2}$	$\frac{\pi}{2\sqrt{2}} = 1{,}11$
2	$\frac{\pi}{2} = 1{,}57$
$\sqrt{3}$	$\frac{2}{\sqrt{3}} = 1{,}15$

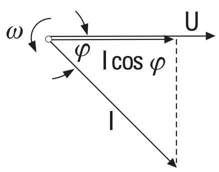
Power

With DC power is simply derived by multiplying voltage and current.
With AC the waveform and the phase angle resp. time relationship between voltage and current have also to be taken into account. For sine waves the calculation is fairly simple, as the sine is the only waveform without harmonics. For all other waveforms the calculation will be more complex.
As long as the instrument specifications for frequency and crest factor are observed the power meter will accurately measure the average of the instantaneous power.

Active, true Power (unit W, designation P)

As soon as either the source or the load or both contain inductive or capacitive components there will be a phase angle or time difference between voltage and current. The active power





is calculated from the rms voltage and the real component of the current as shown in the vector diagram above.

Defining: P = active power
V_{rms} = rms value of voltage
I_{rms} = rms value of current
φ = phase angle

the active power is derived as follows:

$$P = V_{rms} \cdot I_{rms} \cdot \cos\varphi$$

$\cos\varphi$ is the socalled power factor (valid for sine waves only).

HINT **The instantaneous power is the power at time t equal to the product of voltage and current both at time t.**

$p_{(t)} = i_{(t)} \cdot u_{(t)}$

For sine waves the instantaneous power is given by:

$$p_{(t)} = \hat{u} \sin(\omega t + \varphi) \cdot \hat{\imath} \sin \omega t$$

The active power or true power is equal to the arithmetic mean of the instantaneous power. The active power is derived by integrating for a period T and dividing by the period T as folllows:

$$P = \frac{1}{T}\int_0^T \hat{\imath} \sin\omega t \cdot \hat{u} \sin(\omega t + \varphi)\, dt$$

$$= \frac{\hat{\imath} \cdot \hat{u} \cdot \cos\varphi}{2}$$

$$= U_{eff} \cdot I_{eff} \cdot \cos\varphi$$

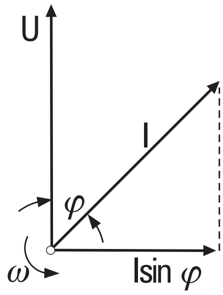
HINT **The power factor will be maximum $\cos\varphi = 1$ at zero phase shift. This is only the case with a purely resistive circuit.**
In an ac circuit which contains only reactances the phase shift will be $\varphi = 90°$ and the power factor hence $\cos\varphi = 0$. The active power will be also zero.

Reactive Power (unit VAr, designation Q)

Reactive power equals rms voltage times reactive current.

With the designations:
Q = reactive Power
V_{rms} = rms voltage
I_{rms} = rms current
φ = phase angle between voltage and current

a vector diagramm can be drawn as follows:



The reactive power is derived by:

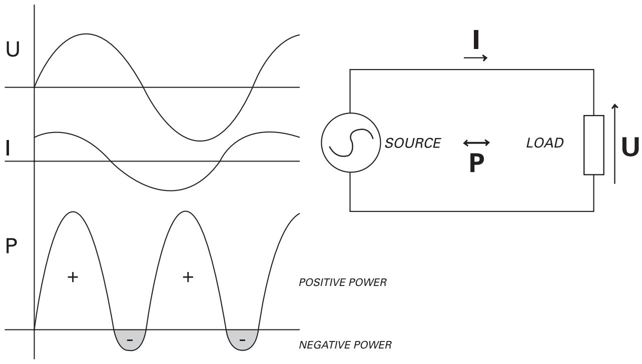
$$Q = V_{rms} \cdot I_{rms} \cdot \sin\varphi$$

HINT **Reactive currents constitute a load on the public mains. In order to reduce the reactive power the phase angle φ must be made smaller. For most of the reactive power transformers, motors etc. are responsible, therefore capacitors in parallel to these loads must be added to compensate for their inductive currents.**

Example of power including reactive power
With DC the instantanesous values of voltage and current are constant with respect to time, hence the power is constant.

In contrast to this the instantaneous value of power of AC or AC + DC signals will fluctuate, its amplitude and polarity will periodically change. If the phase angle is zero this is the special case of pure active power which remains positive (exclusively directed from source to load) at all times.

If there is a reactive component in the circuit there will be a phase difference between voltage and current. The inductive or capacitive element will store and release energy periodically which creates an additional current component, the reactive part. The product of voltage and current will therefore become negative for portions of a period which means that energy will flow back to the source.

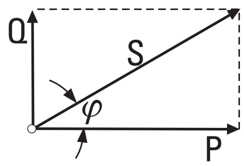


Apparent power (unit VA)

The apparent power is equal to the product of voltage and current. The apparent power is further equal to the geometric sum of active and reactive power as shown in this diagram:

With the designations:

- S = apparent power
- P = active power
- Q = reactive power
- V_{rms} = rms voltage
- I_{rms} = rms current



the apparent power is derived:

$$S = \sqrt{P^2 + Q^2} = V_{rms} \times J_{rms}$$

Power factor

In general the power factor PF is derived:

$$PF = \frac{P}{S}$$

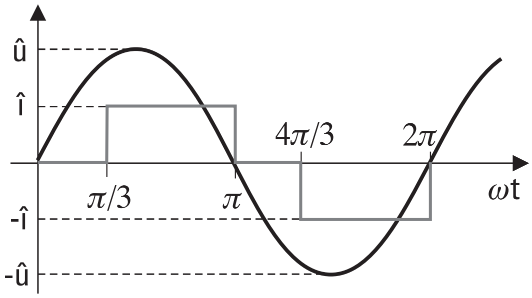
- PF = power factor
- S = apparent power
- P = active power

HINT

In the very special case of sinusoidal voltage and current the power factor equals

$PF = \cos\varphi$

If e.g. the current is rectangular while the voltage is sinusoidal the power factor will be P/S. Also in such case the reactive power can be determined as demonstrated in the following example:



$\hat{u}$ = 325,00 V
$\hat{\imath}$ = 12,25 A

How to calculate the power factor (example):

rms voltage is:

$$U_{eff} = \frac{\hat{u}}{\sqrt{2}} = 229{,}8\,V \approx 230\,V$$

The rms current is given by:

$$I_{eff} = \sqrt{\frac{1}{2\pi} \int_0^{2\pi} \hat{\imath}^2 \cdot d\varphi}$$

$$= \sqrt{\frac{\hat{\imath}^2}{2\pi} \cdot \left[\left(\pi - \frac{\pi}{3}\right) + \left(2\pi - \frac{4\pi}{3}\right)\right]}$$

$$= \sqrt{\hat{\imath}^2 \cdot \frac{2}{3}} = \hat{\imath} \cdot \sqrt{\frac{2}{3}}$$

$$I_{eff} = 12{,}25\,A \cdot \frac{2}{3} = 10{,}00\,A$$

The apparent power S:

$$S = V_{rms} \cdot I_{rms} = 230\,V \cdot 10{,}0\,A = 2300\,VA$$

The active power is derived from:

$$P = \frac{1}{\pi} \int_{\frac{\pi}{3}}^{\pi} \hat{u} \cdot \hat{\imath} \sin\varphi \cdot d\varphi = \frac{\hat{u} \cdot \hat{\imath}}{\pi} \left[-\cos\varphi\right]_{\frac{\pi}{3}}^{\pi}$$

$$= \frac{\hat{u} \cdot \hat{\imath}}{\pi} \left[\left(-(-1)\right) - (-0{,}5)\right] = \frac{1{,}5}{\pi} \cdot \hat{u} \cdot \hat{\imath}$$

$$= \frac{1{,}5}{\pi} \cdot 325\,V \cdot 12{,}25\,A = 1900\,W$$

The power factor thus becomes:

$$PF = \frac{P}{S} = \frac{1900\,W}{2300\,VA} = 0{,}826$$

Obviously there is a reactive power component as the apparent power exceeds the active power:

$$Q = \sqrt{S^2 - P^2} = \sqrt{(2300\,VA)^2 - (1900\,W)^2} = 1296\text{ var}$$

Concept of the HM8115-2

The HM8115-2 uses true rms converters for measuring voltage and current. The instantaneous power is measured using an analog multiplier. The active power is derived by integrating the instantaneous power for a period T. All other values are calculated.

The apparent power:

$$S = V_{rms} \times I_{rms}.$$

The reactive power

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

The power factor PF = P/S. This will always yield the correct power factor because the cosj is only defined for purely sinusoidal signals. However, in SMPS, motor controls etc. nonsinusoidal signals are prevalent.

The instantaneous power can be taken off the rear panel terminal and shown on a scope. The HM8115-2 can be remotely controlled via the serial interface, also all values can be read via the interface. Measuring circuit, monitor output and serial interface are isolated from each other.

Introduction to the Operation of the HM8115-2

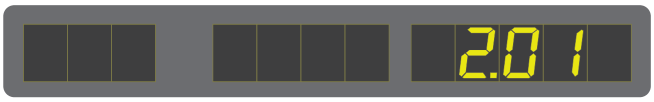
Please read the instruction manual carefully.

At first time operation please observe the following recommendations:

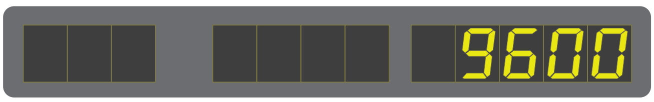
- The mains voltage selector ⑯ has been set to the correct voltage, and the correct fuse has been installed inside the mains connector ⑰
- Proper connection to an outlet with safety ground contact or an isolation transfomer has been made.
- There are no visible damages to the instrument
- There are no loose parts floating around inside the instrument.

Self Test

After turn-on with power switch ① the 3rd display ④ for the FUNCTION will show the nuber of the firmware implemented, e.g. „2.01“.



The LED display ④ FUNCTION shows the baud rate of the serial interface, e.g. „9600“.



The instrument will automatically go into the active power measurement mode, the LED located near “FUNCTION ⑪” and labelled “WATT” will light up. The AUTO range function will select the optimum ranges for voltage and current.

Operating controls and Displays

① Power
This is the mains switch labelled “I” = On and “0” = Off.
After turn-on the LED display for “FUNCTION ④” will show for a moment the number of the version of firmware installed , e.g. “2.01”, then the baud rate of the serial interface, e.g. “9600”, then it will go into the active power measurement mode. The LED near “FUNCTION ⑪” labelled “WATT” will light up. Autoranging will be active and select the optimum ranges for voltage and current.

② VOLT display
This display will indicate the voltage on the output . Due to the drop across the shunt this voltage will be slightly reduced with respect to the input voltage. In case of overrange the display will show blinking horizontal bars. In order to go to the appropriate range the righthand VOLT pushbutton Å must be used or the autorange function selected.

③ AMPERE display
This displays shows the current. In case of overrange the display will show blinking horizontal bars. In order to go to the appropriate range the righthand AMPERE ⑧ pushbutton must be activated or the autorange function selected.

④ FUNCTION display
The FUNCTION display will indicate the measurement result of the selected function.

These function can be chosen:

- Active power in watts
- Reactive power in voltamperes reactive
- Apparent power in voltamperes
- Power factor PF

The function desired can be selected using the FUNCTION ⑩ pushbuttons, the selected function will be indicated by the proper LED.

If either the voltage or the current range or both too low or high in order to achieve a meaningful result the FUNCTION display will show 3 to 4 horizontal bars irrespective of the function selected.

In PF mode such bars indicate that no meaningful power factor can be calculated. There are several possible reasons:

1. No current or pure DC current.
2. No voltage or pure DC voltage.
3. Either the voltage or the current or both are too low.
4. Manually selected voltage or/and current ranges are too low or too high.

Warning signal in case of overrange
Overrange will be indicated by blinking horizontal bars in the respective display(s) and an acoustical signal.

Warning signal setting
Switch off HM 8115-2 with switch ①.
Switch HM8115-2 back on and push the righthand pushbutton of the FUNCTION ⑩ pushbutton set.
Keep this button depressed until the LED "WATT" will light up. This function will remain stored unless changed.

⑥ VOLT

Pushbuttons and a LED are provided for the manual or automatic selection of the voltage ranges. After turn-on the AUTO LED will light up, the instrument will automatically select the appropriate range. The selected range will be indicated by the associated LED. If the voltage changes the range will automatically follow.

If any of the manual select pushbuttons is depressed the autorange mode will be left, the AUTO LED will extinguish. Then any of the ranges can be manually selected. Pressing the AUTO button will return the instrument to the autoranging function, the AUTO LED will light.

The VOLT display ② will show the voltage at the terminals. If an inappropriate range was selected manually this will be shown by blinking horizontal bars in the display(s) and an acoustical warning.

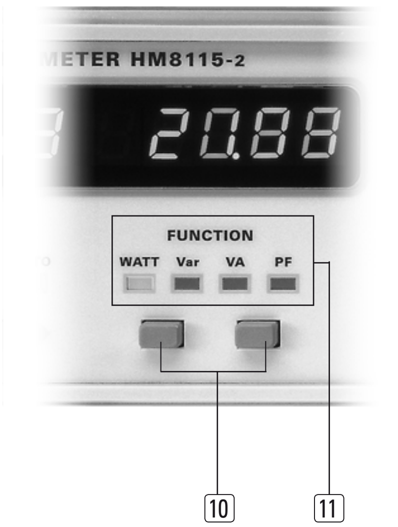
⑧ AMPERE

Pushbuttons and LEDs are provided for the manual or automatic range selection.
After turn-on of the HM8115-2 the AUTO LED will light up, the instrument will automatically select the optimum range. The range selected will be indicated by the associated LED.
If the current changes the range will automatically follow. If any of the manual select pushbuttons is depressed the AUTO function will be left, the AUTO LED will extinguish. Then the desired range can be selected manually. Pressing the AUTO button will return the instrument to the autoranging function.

The AMPERE display ③ will show the current through the terminals. If an inappropriate range was selected manually blinking horizontal bars will be displayed, and an acoustical warning signal will sound off.

⑩ FUNCTION

The following functions can be selected by the FUNCTION pushbuttons and shown on the associated display:



Active power (Watt)
Reactive power (CAr)
Apparent power (VA)
Power factor PF

WATT (Active power)
After turn-on the instrument will automatically select the active power mode, the LED will light up, the display ④ will show the active power. By using the FUNCTION pushbuttons other functions may be chosen.

Var (Reactive power)
In this mode the reactive power will be measured, the LED will light up, the display ④ will show the reactive power.

The reactive power will be displayed as a positive value irrespective of any capacitive or inductive loads.

HINT **The reactive power display will also show correct values if voltage or current are non-sinusoidal. The apparent power (U_{rms} x I_{rms}) and the active power (arithmetic mean of u(t) x i(t)) are independent of the waveform, the reactive power is calculated from both.**

Power factor (PF)

In this mode the power factor will be measured, the LED will light up, the display ④ will show the power factor = active/ by apparent power. The HM8115-2 allows the measurement of the average of the instantaneous power irrespective of the waveform as long as the specifications for crest factor and frequency are observed.

Please note that a power factor can only be shown for AC or AC + DC signals of sufficient minimum amplitu-des. If the signal amplitude of either vol-tage or current or both is insufficient horizontal bars will be displayed, this will also be the case if DC is being measured.

HINT **$\cos\varphi$ is only defined for truly sinusoidal signals. As soon as at least one of the signals is distorted a $\cos\varphi$ derived from the phase shift between voltage and current will not be identical to the true power factor.**

Connectors

⑤ MONITOR (BNC)

This is an analog output representing the instantaneous active power e.g. for display on a scope.

HINT **The instantaneous power is the product of voltage and current at time (t)**

$$p(t) = i(t) \cdot u(t)$$

in case of sine wave:

$$p(t) = \hat{u} \sin(\omega t + \varphi) \cdot \hat{\imath} \sin \omega t$$

The active power is the average of the instantaneous power in-tegrated over the interval T = period divided by the period T:

$$P = \frac{1}{T} \int_0^T \hat{\imath} \sin\omega t \cdot \hat{u} \sin(\omega t + \varphi)\, dt$$

$$= \frac{\hat{\imath} \cdot \hat{u} \cdot \cos\varphi}{2}$$

$$= U_{eff} \cdot I_{eff} \cdot \cos\varphi$$

The monitor output will always deliver the instantaneous power no matter which function was selected. For positive instanta-neous power the output will be positive, for negative instan-taneous power it will be negative. If DC is being measured the monitor output will hence deliver a DC signal.

The BNC terminal outer conductor is connected to the instrument housing, however, the signal is isolated by a transformer.

The temperature dependent drift is automatically corrected for by disconnecting the input/output terminals, during this interval (100 ms) there will thus be no monitor signal. After instrument turn-on the autozero will be activated every 3 se-conds for the first minute, after warm-up the breaks will occur every 2 minutes.

The average of the monitor output voltage will be 1 V if the input signals are such that the WATT dis-play shows full scale. There is no indication of the power range, the range has to be calculated and is the product of the VOLT and AMPERE ranges.

Examples:

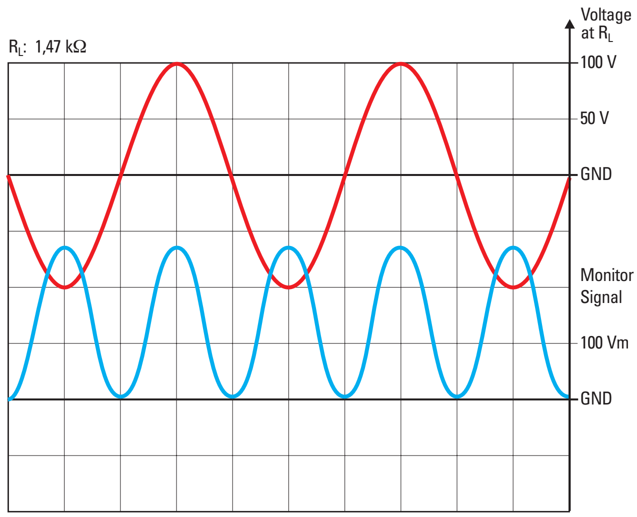
50V	x 0,16A	= 8W	→	1 V (average)
150V	x 16,0A	= 2400W	→	1 V (average)
500V	x 1,6A	= 800W	→	1 V (average)

HINT **If both voltage and current are equal to their full scale values in the ranges selected and if both are sinusoidal the monitor output signal will be 2 V_{pp}. If the power is purely active the signal will oscillate between 0 and 2 V_p, the average of this is 1 V.**

For DC full scale values the monitor output will be 1 V_{DC}.

Example 1:

A wirewound resistor of 1.47 K is connected to 70 V_{rms}. The picture shows the voltage across the resistor and the monitor output. The ranges selected are 150 V and 0.16 A which yields a 24 W full scale 1 V average signal at this output. There is no phase shift.



The scope shows an undistorted instantaneous power signal. The negative peak is equal to 0 V, the positive peak equals 0.27 V, thus the average equals 0.135 V.

This average value multiplied by the full scale value 24 W equals 3.24 W which is the average power.

The HM8115-2 displays the following results:

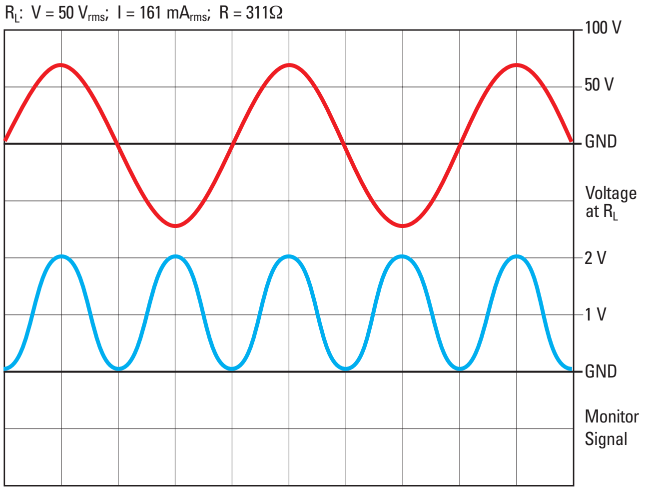
V_{rms}	= 70 V	Q	= 0,2 var
I_{rms}	=0,048 A	S	=3,32 VA
P	=3,34 W	PF	=1,00

Example 2:

A wirewound resistor of 311 ohms is connected to 50 Vrms/50 Hz. The picture shows the voltage across the resistor and the monitor output.

The ranges are 50 V and 0.16 A, the full scale power is hence 8 W corresponding to 1 V average at the monitor output.

There is no phase shift with this purely resistive load. The sco-pe shows an undistorted signal. The negative peak equals 0 V, the positive peak 2 V, the average is thus 1 V.



As the monitor output is 1 V and the full scale value is 8 W The power equals 8 W. The HM8115-2 displays:

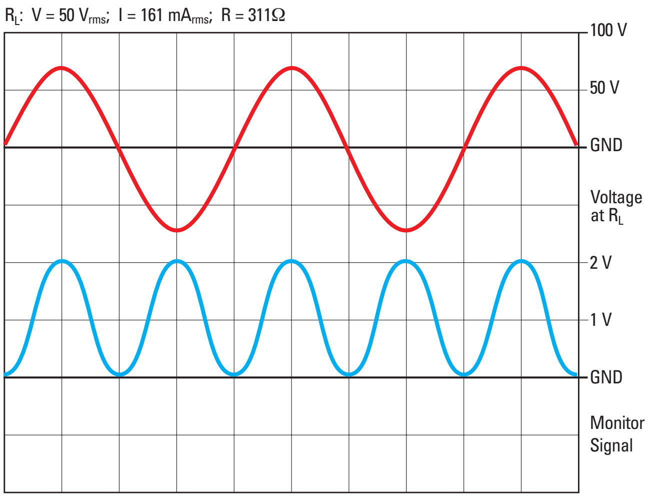
V_{rms}	= 50 V	Q	=0,73 var
I_{rms}	=0,161 A	S	=8,038 VA
P	=8,010 W	PF	=1,00

Example 3:
A resistor of 92 ohms and a capacitor of 10.6 uF are connected in series to 50 V_{rms}/50 Hz.

$$Z = \sqrt{R^2 - X_C^2} \quad \text{mit } X_C = \frac{1}{2\pi f \cdot c} = \frac{1}{\omega \cdot c}$$

The impedance of the series circuit Z = 314 ohms so that the levels are similar to those of the foregoing examples. The picture shows the voltage across the load and the monitor output.

The ranges selected are 50 V and 0.16 A, the full scale power range is again 8 W which is equivalent to 1 V average at the monitor output.



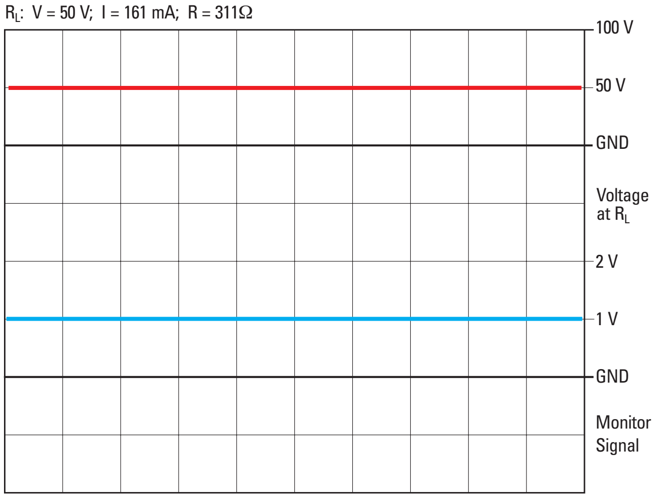
TheHM8115-2 displays:

V_{rms}	= 50 V	Q	=7,67 var
I_{rms}	=0,161 A	S	=8,042 VA
P	=2,416 W	PF	=0,30

HINT

The frequency of the instantaneous power output is twice the mains frequency of 50 Hz hence 100 Hz. During one period of 50 Hz the maximum power reaches twice its maximum, twice it will be zero.

Example 4:
A 311 ohm resistor is connected to a DC voltage of 50 V.



⑫ INPUT / ⑭ OUTPUT

(4 mm safety connectors)
The measuring circuit of the HM8115-2 is separated from safety earth PE! The two lefthand connectors are labelled INPUT and are connected to the power supply. The object under test will be connected to the right-hand connectors OUTPUT.

Please observe all relevant safety instructions if voltages higher than the ones listed below are applied to the INPUT terminals.
Keep DC voltages disconnected from ground. Isolate AC voltages by inserting an isolation transformer.

Please note:
Voltages which exceed any of the following values are considered dangerous:
1st 30 V_{rms};
2nd 42.4 V_p;
3rd 60 V_{DC}.
Voltages higher than those values may only be applied by qualified personnel who know the applicable safety rules.

Disconnect the input voltage before unplugging the safety connectors at the input terminals. Disregarding this can lead to accidents, in the worst case there may be danger of life!

If objects specified for safety class I are connected to the OUTPUT terminals without an isolation transformer the safety earth must be separately connected to the object under test, otherwise there ist danger of life.

The safety plugs may become quite hot at high currents.

The upper two terminals (red) are internally connected. Do not apply any voltage, this would be short-circuited
The shunt is connected internally between the two lower (black) terminals. Do not apply any voltage either because this would practically short-circuit it.

The shunt is protected by a fuse which is accessible from the front. Do not attempt to "repair" a blown fuse or bridge it. Disconnect the input voltage before changing a fuse.

The current path is designed for a maximum of 16 Arms, hence a FF 16 A is specified.

The maximum input voltage is 500 V. The maximum peak voltage between any of the 4 terminals and the instrument housing = protectve earth is 500 V.

Please note: Any voltage higher than those listed is considered dangerous:

1st 30 V_{rms};
2nd 42.4 V_p;
3rd 60 V_{DC}.

Only qualified personnel well aware of the potential dangers is authorized to apply voltages higher than those listed. The relevant safety rules must be observed.

⑬ Fuses in the measuring circuit

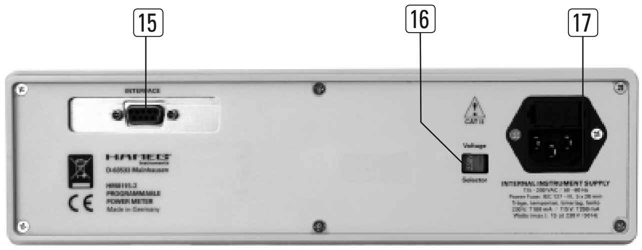
The front panel fuse (FF 16 A) protects the shunt. The circuit is designed for 16 Arms.

Type of fuse: FF 16 A 250 V, size 6.3 x 32 mm, US standard: UL198G, CSA22-2 No. 590

Before exchanging a blown fuse the input voltage must be disconnected. Do not attempt to „repair" a blown fuse or to bridge it.

Changing the measuring circuit fuse

The measuring circuit fuse ⑬ is accessible on the front panel. Before exchanging the fuse remove all connections to the INPUT ⑫ and OUTPUT ⑭ terminals. Disconnect the HM8115-2 from the mains. Use a suitable screwdriver to turn the top of the fuseholder counterclockwise while depressing it. The top and the fuse can then be easily removed. Use only the specified type of fuse and do not attempt to „repair" a blown fuse or to bridge it. Any damage caused by using false fuses or by bridging it will void the warranty.



⑮ Serial interface
The RS-232 interface connector is located on the rear panel (9-pin submin D). This bidirectional interface allows fetching of data from the instrument and to remotely control it.

⑯ Mains voltage selector
The instrument can be powered by 115 or 230 V, 50 or 60 Hz. The voltage selector switch is used to set the correct voltage. Any change requires that the mains fuse be changed to the appropriate value as indicated on the rear panel.

⑰ Mains voltage connector with integrated fuse holder
The mains connector is a standard type accepting cables with plugs according to DIN 49457.

Listing of software commands

These commands have to be transmitted as ASCII characters, they may be lower or upper key. Each command must use oDh (Enter) at its end.

Command	Response	Text
PC > HM8115-2	HM8115-2 > PC	
Instrument status		
*IDN?	HAMEG HM8115-2	Instrument identification request
VERSION?	version x.xx	Request for the software version installed Response e.g.: version 1.01
STATUS?	function, range	Request for outputting all present instrument settings functions: WATT, VAR, VA, PF voltage ranges: U1 = 50 V, U2 = 150 V, U3 = 500 V Current ranges: I1 = 0,16 A, I2 = 1,6 A, I3 = 16 A
General commands		
VAL?	ranges and results	Request for outputting instrument settings and measurement results. Example of VAr: U3=225.6E+0 (225.6V in the 500 V range) I2=0.243E+0 (0.243 A in the 1.6 A range) VAR=23.3E+0 (Reactive power of 23.3 VAr) “OF“ indicates range overflow. In case the command was sent during a measurement cycle the response will come after its completion.
VAS?	ranges	Selective request for the parameters and the result of FUNCTION.
	function and result	Example if PF was selected: U3, I2, PF= 0.87E+0.
Bus commands		
FAV0	none	Disabling of all front panel controls VOLT, AMPERE, FUNCTION
FAV1	none	Enabling of all front panel controls VOLT, AMPERE, FUNCTION
Instrument settings		
BEEP	none	Generates a single acoustic signal
BEEP0	none	Acoustic signal disabled
BEEP1	none	Acoustic signal enabled
Operating modes		
WATT	none	Active power
VAR	none	Reactive power
VAMP	none	Apparent power
PFAC	none	Power factor PF
AUTO:U	none	AUTORANGE- function voltage enabled
AUTO: I	none	AUTORANGE- function current enabled
MA1	value / function	Continuous transmission of parameters and results to the PC Example of PF selected: U3,I2,cos=0.87E+0 “OF“ designates overflow. Transmission will be continued until ended by MA0.
MA0	none	Ends transmission started with MA1.
SET:Ux	none	Disables autoranging resp. changes the voltage range to „x(Volt)“
SET:U1		Sets 50 V range
SET:U2		Sets 150 V range
SET:U3		Sets 500 V range
SET:Ix	none	Disables autoranging resp. changes the current range to „x(Ampere)“
SET:I1		Sets 0.16 A range
SET:I2		Sets 1.6 A range
SET:I3		Sets 16 A range

Serial Interface

The HM8115-2 is well equipped for use in automated test systems. An optcoupler-isolated RS-232 interface is standard.

Interface parameters
N, 8, 1, Xon-Xoff:
(No parity bit, 8 data bits, 1 stop bit, Xon-Xoff.

A terminal program like HyperTerminal may be used for data transmission. After performing all settings in the terminal program press the ENTER key once prior to sending the first command to the HM8115-2

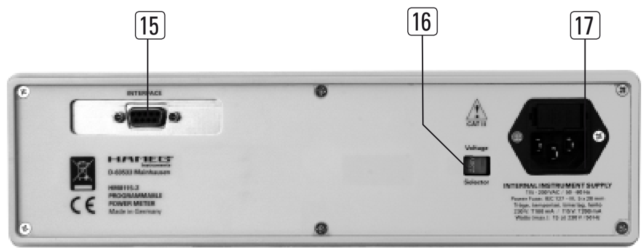
Baud rate
1200 or 9600 baud.

Changing interface parameters
Only the baud rate can be selected as either 1200 or 9600 baud. In order to do this proceed as follows:

– Turn off the HM8115-2.
– Turn the instrument back on.
– Press the lefthand FUNCTION pushbutton ⑩
– Press the lefthand pushbutton ⑩ and keep it depressed until the LED "WATT" lights up.

This new baud rate will be stored permanently unless changed.

⑮ **Serial interface**



The RS-232 interface connector is located on the rear panel (9pin submin D). The interface allows the transmission of data from the instrument and its remote control.

For the connection between the HM8115-2 and a PC (COM port) any standard cable with 9pin submin D on both sides may be used, provided it is shielded and < 3 m.

HINT **If a PC has a 25pin connector an adapter 25 to 9pin has to be inserted, only 3 wires are used.**

Connections:

	POWER METER		PC COM Port (9poles)
Pin	name / function	Pin	name / function
2	Tx Data / output	2	Rx Data / input
3	Rx Data / input	3	Tx Data / output
5	Ground	5	Ground

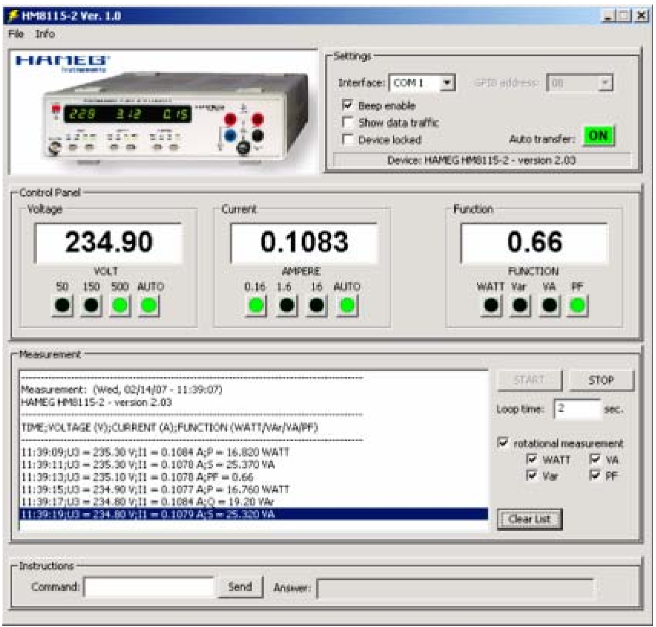
Software

1. Installation

For the installation of the software HM8115-2 please start the file setup.exe and follow the instructions of the installation assistant.

2. The program

The software HM8115-2 was developed for the programmable Hameg Instruments Power Meter HM8115-2. The power meter can be connected with the PC by 3 different interfaces: Serial interface (standard), USB interface (HO870) and GPIB interface (HO880). If the USB interface is used, a virtual COM port has to be installed. The COM port driver can be downloaded from our website www.hameg.com



Picture 2.1: User interface

IMPORTANT WITH GPIB!
This software only supports National Instruments GPIB cards and cards, that are fully compatible with the National Instruments cards.

The program is devided into 4 parts (Settings, Control panel, Measurement, Instruction), which are described in the following:

2.1 Settings
Six different parameters can be set:

Interface: In this field the interface can be selected, which is used for the connection to the PC. Available settings: Com1-4, GPIB
GPIB address: Setting of the GPIB address the HM8115-2(only with GPIB)
Beep enable: Activation/Deactivation of acoustic signals
Show data traffic: This option offers the possibility of letting the data traffic in the editing fields 'Command' and 'Answer' indicate.
Device locked: With this option activated the instrument only can be operated by software. The control elements are locked!

Autotransfer: With this button the automatic data transfer between PC and HM8115-2 can be turned on or off. If the autotransfer is off, the values in the fields of the 'Control Panel' are not being refreshed. This option should be only used, if individual, manual instructions are sent with the 'Command' field.

If the instrument is identified by the software, the ID of the is-ntrument is shown in the status field below. If the instrument could not be identified the status field displays "NO DEVICE DETECTET". After program exit the software settings are stored (except the setting of "autotransfer").
Please note that the identification can take 4-5 seconds!

2.2 Control Panel

In the field 'Control Panel' the current mesurement values are displayed and are being refreshed every second. With the buttons below the data read-outs the measurement ranges can be selected. The actual range is indicated by a green button. With selection of the "Auto" function the HM8115-2 automatically switches to the suitable voltage/current range.

2.3 Measurement

In the 'Measurement' field you can do automated measurements and store the values in a csv file (csv = Comma Separated Values).
With the 'Start' button the test series is started. The measurement value can be set in the field 'Loop time'. After expiration of the measurement intervall the software queries the values from the power meter and displays the answer in the text field on the left hand side. These values can be stored by opening the menu 'File – Save measurement'.
With the option 'rotational measurement' activated the measurement function are automatically alternated. For example you can activate all options WATT, VAR, VA, PF. The functions will be successively polled from the power meter and displayed in the text field. With the 'Stop' button the current test series is stopped. With the button 'Clear List'" the content of the text window is deleted and a new test series can be started.

2.4 Instructions

With these two fields and the 'Send' button you can send individual commands to the equipment. See the Operating Manual of HM8115-2 for the command reference.
Please note, that the commands are sent to the instrument without being checked by the software. If the HM8115-2 sends an answer, it will be displayed in the 'Answer' field.
If you send the commands manually to the instrument, we recommend to turn off the 'autotransfer' option. If the 'Show data traffic' option is selected, all commands and answers are shown in the fields 'Command' and 'Answer'.

3. Deinstallation

For correct deinstallation of the software HM8115-2, please open the option 'Sofware' of your 'Windows Control Panel'. In the 'Software' window select the entry HM8115-2 and press 'remove'. The deinstallation assistant will automatically deinstall the software HM8115-2.

Glossary HM8115-2