WAGO-I/O-SYSTEM 750

Manual

750-494(/xxx-xxx)

3-Phase Power Measurement Module

Version 1.5.0

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Every conceivable measure has been taken to ensure the accuracy and completeness of this documentation. However, as errors can never be fully excluded, we always appreciate any information or suggestions for improving the documentation.

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We wish to point out that the software and hardware terms as well as the trademarks of companies used and/or mentioned in the present manual are generally protected by trademark or patent.

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1 Notes about this Documentation

Note

Always retain this documentation!
This documentation is part of the product. Therefore, retain the documentation during the entire service life of the product. Pass on the documentation to any subsequent user. In addition, ensure that any supplement to this documentation is included, if necessary.

1.1 Validity of this Documentation

This documentation is only applicable to the I/O module 750-494 (3-Phase Power Measurement Module) and the variants listed in the table below.

Table 1: Variants

Item Number	Description
750-494	3-Phase Power Measurement Module 1 A
750-494/000-001	3-Phase Power Measurement Module 5 A
750-494/025-000	3-Phase Power Measurement Module 1 A, Operating temperature -20 °C … +60 °C
750-494/025-001	3-Phase Power Measurement Module 5A, Operating temperature -20 °C … +60 °C

Note

Documentation Validity for Variants
Unless otherwise indicated, the information given in this documentation applies to listed variants.

The I/O module 750-494 shall only be installed and operated according to the instructions in this manual and in the manual for the used fieldbus coupler/controller.

NOTICE

Consider power layout of the WAGO-I/O-SYSTEM 750!
In addition to these operating instructions, you will also need the manual for the used fieldbus coupler/controller, which can be downloaded at www.wago.com. There, you can obtain important information including information on electrical isolation, system power and supply specifications.

1.2 Revision History

Table 2: Revision History

Document Version	Device Version		Description of Change
	Hardware	Software	
1.0.0	01	02	First issue
1.0.1	01	02	In section „Commissioning“ > „Displaying the Measured Values via WAGO-I/O-*CHECK*“ the figure „Measured values, harmonics chart“ was changed.
1.1.0	01	02	Change of approvals
1.2.0	01	02	Change of approvals

1.3 Copyright

1.4 Symbols

DANGER

Personal Injury!
Indicates a high-risk, imminently hazardous situation which, if not avoided, will result in death or serious injury.

DANGER

Personal Injury Caused by Electric Current!
Indicates a high-risk, imminently hazardous situation which, if not avoided, will result in death or serious injury.

WARNING

Personal Injury!
Indicates a moderate-risk, potentially hazardous situation which, if not avoided, could result in death or serious injury.

CAUTION

Personal Injury!
Indicates a low-risk, potentially hazardous situation which, if not avoided, may result in minor or moderate injury.

NOTICE

Damage to Property!
Indicates a potentially hazardous situation which, if not avoided, may result in damage to property.

NOTICE

Damage to Property Caused by Electrostatic Discharge (ESD)!
Indicates a potentially hazardous situation which, if not avoided, may result in damage to property.

Note

Important Note!
Indicates a potential malfunction which, if not avoided, however, will not result in damage to property.

Information

Additional Information:
Refers to additional information which is not an integral part of this documentation (e.g., the Internet).

1.5 Number Notation

Table 3: Number Notation

Number Code	Example	Note
Decimal	100	Normal notation
Hexadecimal	0x64	C notation
Binary	'100' '0110.0100'	In quotation marks, nibble separated with dots (.)

1.6 Font Conventions

Table 4: Font Conventions

Font Type	Indicates
italic	Names of paths and data files are marked in italic-type. e.g.: *C:\Program Files\WAGO Software*
Menu	Menu items are marked in bold letters. e.g.: **Save**
>	A greater-than sign between two names means the selection of a menu item from a menu. e.g.: **File** > **New**
Input	Designation of input or optional fields are marked in bold letters, e.g.: **Start of measurement range**
“Value”	Input or selective values are marked in inverted commas. e.g.: Enter the value “4 mA” under **Start of measurement range**.
[Button]	Pushbuttons in dialog boxes are marked with bold letters in square brackets. e.g.: **[Input]**
[Key]	Keys are marked with bold letters in square brackets. e.g.: **[F5]**

2 Important Notes

This section includes an overall summary of the most important safety requirements and notes that are mentioned in each individual section. To protect your health and prevent damage to devices as well, it is imperative to read and carefully follow the safety guidelines.

2.1 Legal Bases

2.1.1 Subject to Changes

WAGO Kontakttechnik GmbH & Co. KG reserves the right to provide for any alterations or modifications. WAGO Kontakttechnik GmbH & Co. KG owns all rights arising from the granting of patents or from the legal protection of utility patents. Third-party products are always mentioned without any reference to patent rights. Thus, the existence of such rights cannot be excluded.

2.1.2 Personnel Qualifications

All sequences implemented on WAGO-I/O-SYSTEM 750 devices may only be carried out by electrical specialists with sufficient knowledge in automation. The specialists must be familiar with the current norms and guidelines for the devices and automated environments.

All changes to the coupler or controller should always be carried out by qualified personnel with sufficient skills in PLC programming.

2.1.3 Use of the WAGO-I/O-SYSTEM 750 in Compliance with Underlying Provisions

Fieldbus couplers, fieldbus controllers and I/O modules found in the modular WAGO-I/O-SYSTEM 750 receive digital and analog signals from sensors and transmit them to actuators or higher-level control systems. Using programmable controllers, the signals can also be (pre-) processed.

The devices have been developed for use in an environment that meets the IP20 protection class criteria. Protection against finger injury and solid impurities up to 12.5 mm diameter is assured; protection against water damage is not ensured. Unless otherwise specified, operation of the devices in wet and dusty environments is prohibited.

Operating the WAGO-I/O-SYSTEM 750 devices in home applications without further measures is only permitted if they meet the emission limits (emissions of interference) according to EN 61000-6-3. You will find the relevant information in the section “Device Description” > “Standards and Guidelines” in the manual for the used fieldbus coupler/controller.

Appropriate housing (per 2014/34/EU) is required when operating the WAGO-I/O-SYSTEM 750 in hazardous environments. Please note that a prototype test certificate must be obtained that confirms the correct installation of the system in a housing or switch cabinet.

2.1.4 Technical Condition of Specified Devices

The devices to be supplied ex works are equipped with hardware and software configurations, which meet the individual application requirements. WAGO Kontakttechnik GmbH & Co. KG will be exempted from any liability in case of changes in hardware or software as well as to non-compliant usage of devices.

Please send your request for modified and new hardware or software configurations directly to WAGO Kontakttechnik GmbH & Co. KG.

2.2 Safety Advice (Precautions)

For installing and operating purposes of the relevant device to your system the following safety precautions shall be observed:

DANGER

Install protection against electric shock!
All wiring for the measurement system shall be provided with protection against shock hazard voltages along with the corresponding safety signs!

DANGER

Do not work on devices while energized!
All power sources to the device shall be switched off prior to performing any installation, repair or maintenance work.

DANGER

Install the device only in appropriate housings, cabinets or in electrical operation rooms!
The WAGO-I/O-SYSTEM 750 and its components are an open system. As such, install the system and its components exclusively in appropriate housings, cabinets or in electrical operation rooms. Allow access to such equipment and fixtures to authorized, qualified staff only by means of specific keys or tools.

DANGER

For current messurement, alsways use current transformers!
Generally use current transformers for current measurement!

DANGER

DC current measurement is not permitted!
The measurement of DC currents is not permitted!

NOTICE

Note the max. continuous measuring current of 1 A resp. 5 A!
The max. continuous measuring current of the module is 1 A resp. 5 A. If the used current transformers allow greater secondary currents than 1 A resp. 5 A install additional transformers with an appropriate transforming ratio!

NOTICE

Replace defective or damaged devices!
Replace defective or damaged device/module (e.g., in the event of deformed contacts), since the long-term functionality of device/module involved can no longer be ensured.

NOTICE

Protect the components against materials having seeping and insulating properties!
The components are not resistant to materials having seeping and insulating properties such as: aerosols, silicones and triglycerides (found in some hand creams). If you cannot exclude that such materials will appear in the component environment, then install the components in an enclosure being resistant to the above-mentioned materials. Clean tools and materials are imperative for handling devices/modules.

NOTICE

Clean only with permitted materials!
Clean soiled contacts using oil-free compressed air or with ethyl alcohol and leather cloths.

NOTICE

Do not use any contact spray!
Do not use any contact spray. The spray may impair contact area functionality in connection with contamination.

NOTICE

Do not reverse the polarity of connection lines!
Avoid reverse polarity of data and power supply lines, as this may damage the devices involved.

NOTICE

Avoid electrostatic discharge!
The devices are equipped with electronic components that may be destroyed by electrostatic discharge when touched. Please observe the safety precautions against electrostatic discharge per DIN EN 61340-5-1/-3. When handling the devices, please ensure that environmental factors (personnel, work space and packaging) are properly grounded.

3 Device Description

The 3-phase power measurement module (also called I/O Module) measures the electrical data in a 3-phase supply network.

The 3 phase voltages are measured via connection to L1, L2, L3 and N. The currents are fed to IL1, IL2, IL3 and IN via current transformers. Based on these input signals the I/O module calculates numerous values like voltages, currents, powers (active, reactive and apparent), energies, power factors, phase shift angles and frequencies. Furthermore, an analysis of harmonic waves is carried out up to the 41st harmonic. The measured values are available in the process image. Therefore, no high computing power is required from the higher-level controller.

The calculated values indicate whether the load is inductive or capacitive and whether it consumes or generates energy. For this purpose a 4-quadrant display is incorporated in WAGO-I/O-*CHECK*.

The I/O module provides a great number of measured values for a comprehensive supply network analysis via the fieldbus. By means of the measured values the operator can regulate the supply to a drive or machine in the best possible way and protect the installation from damage/failure.

The I/O modules 750-494, 750-494/025-000 measure currents up to 1 A and 750-494/000-001, 750-494/025-001 measure currents up to 5 A.

3.1 View

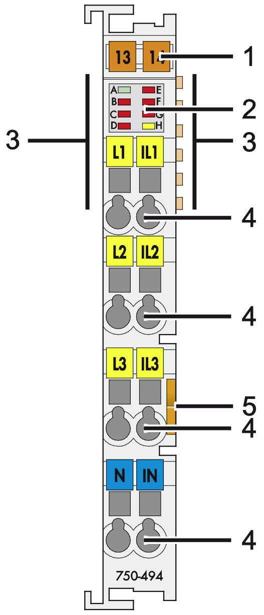


Figure 1: View

Table 5: Legend for Figure “View”

Pos.	Description	Details See Section
1	Marking possibility with Mini-WSB	---
2	Status LEDs	“Device Description” > “Display Elements”
3	Data contacts	“Device Description” > “Connectors”
4	CAGE CLAMP® connectors	“Device Description” > “Connectors”
5	Release tab	“Mounting” > ”Inserting and Removing Devices”

3.2 Connectors

3.2.1 Data Contacts/Internal Bus

Communication between the fieldbus coupler/controller and the I/O modules as well as the system supply of the I/O modules is carried out via the internal bus. It is comprised of 6 data contacts, which are available as self-cleaning gold spring contacts.

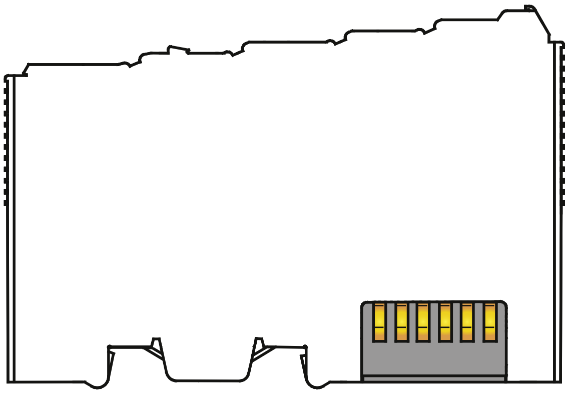


Figure 2: Data Contacts

NOTICE

Do not place the I/O modules on the gold spring contacts!
Do not place the I/O modules on the gold spring contacts in order to avoid soiling or scratching!

NOTICE

Ensure that the environment is well grounded!
The devices are equipped with electronic components that may be destroyed by electrostatic discharge. When handling the devices, ensure that the environment (persons, workplace and packing) is well grounded. Avoid touching conductive components, e.g. data contacts.

3.2.2 Power Jumper Contacts/Field Supply

The I/O module 750-494 has no power jumper contacts.

3.2.3 CAGE CLAMP® Connectors

8 CAGE CLAMP® connectors make up the measuring inputs. The 3-phase supply network and the loads are clamped here. See also section “Connect Devices“.

Two connectors each form the three measuring channels:

- L1 and IL1: voltage and current of phase L1
- L2 and IL2: voltage and current of phase L2
- L3 and IL3: voltage and current of phase L3

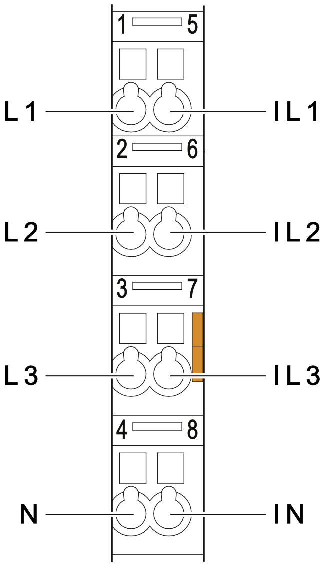


Figure 3: CAGE CLAMP® Connectors

Table 6: Legend for Figure “CAGE CLAMP® Connectors”

Channel	Designation	Connector	Function
1	L1	1	Voltage L1
	IL1	5	Current L1
2	L2	2	Voltage L2
	IL2	6	Current L2
3	L3	3	Voltage L3
	IL3	7	Current L3
–	N	4	Neutral wire for voltage measurement
	IN	8	Neutral wire for current measurement

3.3 Display Elements

LED A indicates the operating status, LEDs B … H indicate possible errors.

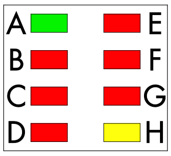


Figure 4: Display Elements

The meaning of these indications is as follows:

Table 7: Legend for Figure “Display Elements”

LED	State	Message
A	Off	No operational readiness or the internal data bus communication is interrupted. Note: If the watchdog was disabled, the LED is always green. See section “Commissioning” > “Configuration with WAGO-I/O-*CHECK*“.
	Green	Operational readiness and correct internal data bus communication
B	Off	No error
	Red	General error message for L1: Under-/overvoltage or overcurrent
C	Off	No error
	Red	General error message: Clipping of a current measuring path IL1, IL2 or IL3
D	Off	No error
	Red	High measuring error, caused by undershooting the min. voltage at L1, L2 or L3
E	Off	No error
	Red	General error message for L2: Under-/overvoltage or overcurrent
F	Off	No error
	Red	General error message for L3: Under-/overvoltage or overcurrent
G	Off	No error
	Red	General error message: Clipping of a voltage measuring path L1, L2 or L3
H	Off	No error
	Yellow	Error of the phase sequence L1-L2-L3

3.4 Operating Elements

The I/O module 750-494 has no operating elements.

3.5 Schematic Diagram

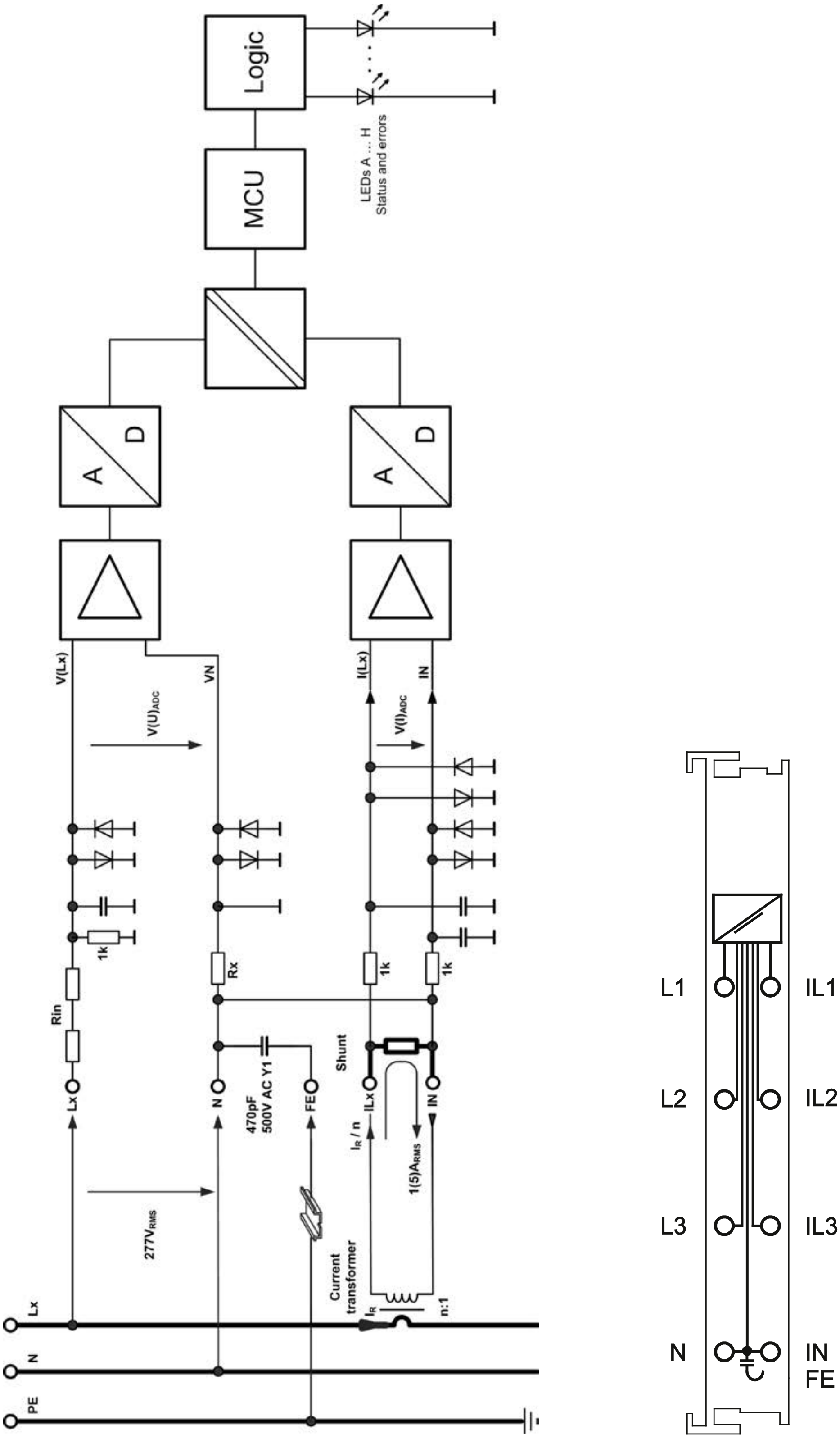


Figure 5: Schematic Diagram

Note

Function Earth FE!
In order to get a function earth, the connectors N and IN are connected to the mounting rail via a 470 pF capacitor and a spring contact. If the rail is correctly connected to PE, the immunity to interference is increased.

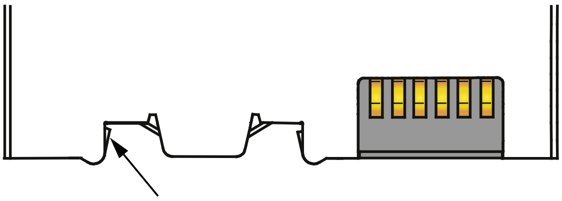


Figure 6: FE Spring Contact

Note

N and IN are shorted!
The connections N and IN are firmly shorted and form the internal reference for all electrical measurements.

3.6 Technical Data

3.6.1 Dimensions and Weight

Table 8: Technical Data – Dimensions and Weight

Width	12 mm
Height (from upper edge of carrier rail)	64 mm
Length	100 mm
Weight	48 g

3.6.2 Voltage Supply

Table 9: Technical Data – Voltage Supply

Voltage	5 V DC (system voltage via internal bus)
Current consumption max. (internal)	100 mA

3.6.3 Measuring Inputs

Table 10: Technical Data – Measuring Inputs

Number of inputs	6 (3 voltage measuring inputs, 3 current measuring inputs)
Input voltage max. Input resistance typ.	Phase-to-phase voltage Lx-Ly: 480 VAC, phase voltage Lx-N: 277 VAC 1072 kΩ
Input current max. Input resistance typ.	1 A for 750-494 and /025-000, 5 A for 750-494/xxx-001 22 mΩ for 750-494 and /025-000, 5 mΩ for 750-494/xxx-001
Frequency range	
• Frequency of supply network	45 … 65 Hz
• Analysis of harmonics	0 … 3300 Hz
Max. frequency	15.9 kHz
Signal form	Any periodic signal (considering the max. operating frequency)
Category of overvoltage	III
Nominal voltage spike	4 kV
Degree of contamination	2

3.6.4 Measured Values

Table 11: Technical Data – Measured Values

Measuring procedure	Calculation of true RMS for voltages and currents, sample rate 8 kHz synchronous on all 6 measuring inputs, 24 bits resolution
Calculated values	Phase-to-phase voltages, powers, energies, power factors, network frequencies, harmonics analysis up to the 41st harmonic
Update cycle of process data	
RMS voltage Lx-N	40 ms
Min./max. RMS voltage Lx-N	50 ms
RMS voltage Lx-Ly	340 ms
Arithmetic mean value voltage Lx-N	To be set, 5 ... 900 s
Peak value voltage Lx-N	200 ms
RMS current Lx	40 ms
Min./max. RMS current Lx	50 ms
Arithmetic mean value current Lx	To be set, 5 ... 900 s
Peak value current Lx	200 ms
Active power Lx	40 ms
Min./max. active power Lx	50 ms
Reactive power Lx	340 ms
Apparent power Lx	40 ms
All energy values	400 ms
Supply network frequency Lx	280 ms
Min./max. frequency of supply network Lx	280 ms
Phase angle phi Lx	340 ms
Power factor cos phi Lx	340 ms
Power factor PF Lx	280 ms
Power factor LF Lx	280 ms
Harmonics analysis	
• Current	260 ms
• Voltage	260 ms
• HD/THD current	260 ms
• HD/THD voltage	260 ms
Measuring errors	
Voltage	<= 0.3 % of full-scale value (<= 0.5 % for 750-494/025-xxx)
Current	<= 0.5 % of full-scale value

Active power	<= 0.5 %
Phase angle	+/- 0.3°
Frequency	+/- 0.01 Hz
Harmonics measured values	<= 1%

3.6.5 Internal Bus Communication

Table 12: Technical Data – Internal Bus Communication

Bit width (internal bus)	Input and output data with 128 bits process data and 64 bits control/status each

3.6.6 Connection Type

Table 13: Technical Data – Data Contacts

Data contacts	Slide contact, hard gold plated, self-cleaning

Table 14: Technical Data – Field Wiring

Wire connection	CAGE CLAMP®
Cross section	0.08 mm² … 2.5 mm², AWG 28 … 14
Stripped lengths	8 mm … 9 mm / 0.33 in

3.6.7 Climatic Environmental Conditions

Table 15: Technical Data – Climatic Environmental Conditions

Operating temperature range	0 °C … 55 °C
Operating temperature range for components with extended temperature range (750-xxx/025-xxx)	−20 °C … +60 °C
Storage temperature range	−25 °C … +85 °C
Storage temperature range for components with extended temperature range (750-xxx/025-xxx)	−40 °C … +85 °C
Relative humidity	Max. 5 % … 95 % without condensation
Resistance to harmful substances	Acc. to IEC 60068-2-42 and IEC 60068-2-43
Maximum pollutant concentration at relative humidity < 75 %	$SO_2 \leq 25$ ppm $H_2S \leq 10$ ppm
Special conditions	Ensure that additional measures for components are taken, which are used in an environment involving: – dust, caustic vapors or gases – ionizing radiation

3.7 Approvals

The following approvals have been granted to the basic version and all variants of 750-494 I/O modules:

Conformity Marking

UL508

The following Ex approvals have been granted to the basic version of 750-494 I/O modules:

TÜV 07 ATEX 554086 X

I M2 Ex d I Mb
II 3 G Ex nA IIC T4 Gc
II 3 D Ex tc IIIC T135°C Dc

IECEx TUN 09.0001 X

Ex d I Mb
Ex nA IIC T4 Gc
Ex tc IIIC T135°C Dc

$_{C}UL_{US}$ ANSI/ISA 12.12.01
Class I, Div2 ABCD T4

The following Ex approvals have been granted to the variation 750-494/025-000:

$_{C}UL_{US}$ ANSI/ISA 12.12.01
Class I, Div2 ABCD T4

The following ship approvals have been granted to the variations 750-494 listed below:

				DNV GL				
750-494				x				
750-494 /000-001				X				
750-494 /025-000				x				
750-494 /025-001				x				

DNV GL
[Temperature: B, Humidity: A, Vibration: B, EMC: B, Enclosure: A]

Note

Applicable from SW 01 / HW 02!
This ship approval is only applicable from SW 01 / HW 02!

3.8 Standards and Guidelines

The basic version and all variants of 750-494 I/O modules meet the following standards and guidelines:

Explosive atmosphere Devices – General requirements	EN 60079-0
Explosive atmosphere Equipment protection by type of protection “n”	EN 60079-15
Explosive atmosphere Equipment dust ignition protection by enclosure “t”	EN 60079-31
EMC CE-Immunity to interference	EN 61000-6-2
EMC CE-Emission of interference	EN 61000-6-3

4 Function Description

4.1 Measuring Principle

The 3-phase power measurement module operates using 6 analog/digital converters for acquiring the current and voltage levels in all three phases.
The 3 phases are connected to the current measuring channels of the I/O module in "single-ended" measurement topology, i.e. all secondary windings of the current transformers are connected to the common clamp IN. Low pass filters on the 6 measuring inputs have a limit frequency of 15.9 kHz. Each input signal is scanned at a frequency of 8 kHz, quantized with 24 bits and further processed digitally.
Acquisition and processing of the measured values of all three phases is performed simultaneously in the very same way.

4.2 Measured Values

The 3-phase power measurement module makes the following measured values available per phase (Lx, Ly = L1, L2 or L3):

Voltage:
- RMS value voltage Lx-N
- Max. RMS value voltage Lx-N
- Min. RMS value voltage Lx-N
- Arithmetic mean value voltage Lx-N
- Peak value voltage Lx-N
- RMS value phase-to-phase voltage Lx-Ly

Current:
- RMS value current Lx
- Max. RMS value current Lx
- Min. RMS value current Lx
- Arithmetic mean value current Lx
- Peak value current Lx

Power:
- Active power Lx
- Max. active power Lx
- Min. active power Lx
- Reactive power Lx
- Apparent power Lx

Energy:
- Active energy Lx
- Active energy acquisition Lx
- Active energy delivery Lx
- Active energy total

- Active energy acquisition total
- Active energy delivery total
- Reactive energy Lx
- Reactive energy inductive Lx
- Reactive energy capacitive Lx
- Reactive energy total
- Reactive energy inductive total
- Reactive energy capacitive total
- Apparent energy Lx

Frequency:

- Supply network frequency Lx
- Max. supply network frequency Lx
- Min. supply network frequency Lx

Harmonics:

Harmonics analysis for a selected phase L_{sel} (L1 or L2 or L3)

- RMS value current fundamental wave L_{sel}
- RMS value voltage fundamental wave L_{sel}
- THD (Total Harmonic Distortion) current L_{sel}
- THD (Total Harmonic Distortion) voltage L_{sel}

For the selected phase L_{sel}, three selectable harmonics (no. 2 to 41) can be analyzed: harmonics A, B and C.

- RMS value current harmonic A
- RMS value voltage harmonic A
- HD (Harmonic Distortion) current harmonic A
- HD voltage harmonic A
- RMS value current harmonic B
- RMS value voltage harmonic B
- HD current harmonic B
- HD voltage harmonic B
- RMS value current harmonic C
- RMS value voltage harmonic C
- HD current harmonic C
- HD voltage harmonic C

Power factors:

- cos phi Lx (fundamental wave)
- Power factor PF Lx (all harmonics)
- Power factor LF Lx (all harmonics)

Phase angle:

- phi Lx

Rotary field:	• Direction of rotation
Limit values:	• Undervoltage Lx • Overvoltage Lx • Overcurrent Lx

Note

Harmonics!
In general, the first harmonic means the fundamental wave and the second harmonic means the wave with double frequency etc.!

4.3 Description of Measured Values

Calculating the RMS Values for Current and Voltage

The I/O module measures the true RMS of the voltages and currents applied to the measurement inputs per period. See figure below.

$$I_{eff} = \sqrt{\frac{1}{N}\sum_{k=0}^{N-1} i_k^{\,2}} \qquad U_{eff} = \sqrt{\frac{1}{N}\sum_{k=0}^{N-1} u_k^{\,2}}$$

i_k:	Sampling value of current	I_{eff}:	RMS value of the current
u_k:	Sampling value of voltage	U_{eff}:	RMS value of the voltage
N:	No. of sampling values		

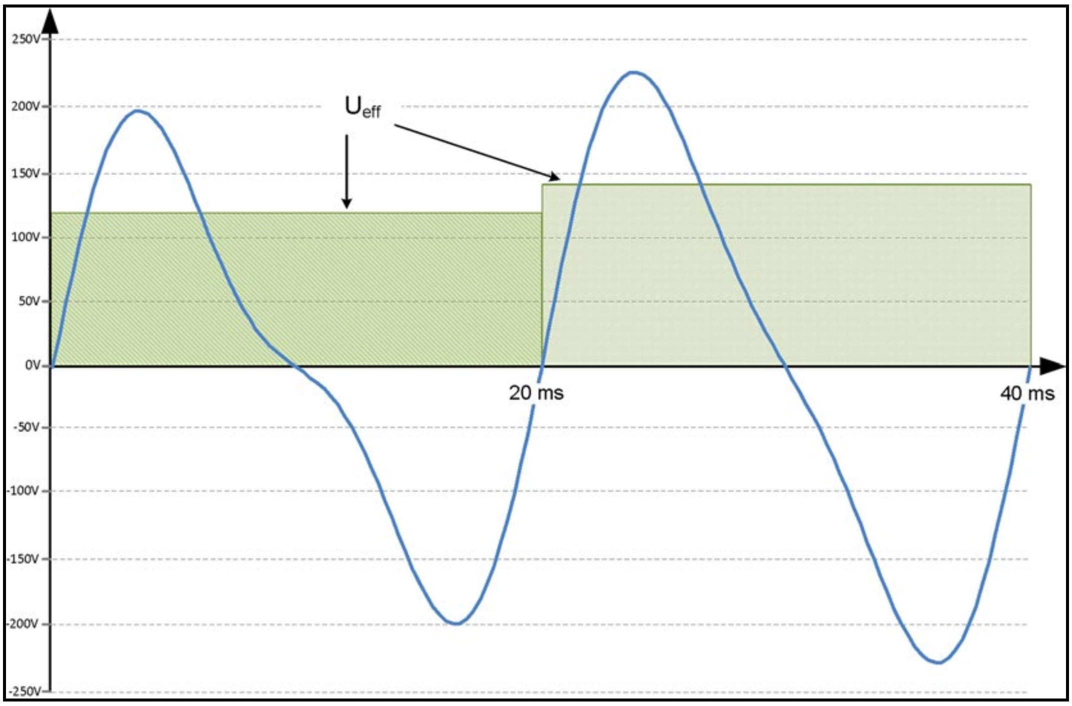


Figure 7: RMS Value Calculation (Example, Not to Scale)

The current and voltage RMS values are calculated for each period in the I/O module. The RMS values can be exported with every second period (2 T) with the specified measuring accuracy via the process image. In a 50Hz-network this corresponds to an update rate of 40 ms.

The **arithmetic mean value** for phase current and voltage is generated on the basis of the RMS values. You can set the time period during which the mean value is to be generated using WAGO-I/O-*CHECK*, or parameters 34, 35, 36. The RMS minimum and maximum values for current and voltage are also determined over a configurable time period (WAGO-I/O-*CHECK* or parameters 37, 38, 39).

Peak current and voltage values can also be recorded, but for only one selectable phase. The specified observation interval for this can be set using the number of half-waves (WAGO-I/O-*CHECK* or registers 43, 44, 45).

Calculation of phase-to-phase voltages is performed on the basis of the phase voltages and the corresponding phase angles.

Calculating Power

Individual, synchronous sampling values for current and voltage are used for calculating active power (P). Phase shifts between the currents and voltages are taken into account for power calculation. Positive values occur when the power is "consumed" by a load, i.e., current has a phase shift of -90° … +90° compared to voltage (operation under load, Quadrant I and IV). Negative values are yielded when the power is "fed in" by a generator, i.e., the current has phase shifting of 90° … 270° relative to voltage (generator operation, Quadrant II and III).

Note

Negative active power!
Negative active power occurs when the connections of up-circuit current transformers are reversed!

Active power minimum and maximum values are determined over a configurable time period (WAGO-I/O-*CHECK* or parameters 37, 38, 39).

In real supply networks, not all electrical loads are purely ohmic. Phase shifting occurs between current and voltage. However, this does not affect the method for determining the RMS values for current voltage previously described. The I/O module calculates both the reactive power (Q) and the apparent power (S) for each phase.

Calculating Energy

Time-based integration of power yields the level of energy for each phase. The I/O module provides the values for active, reactive and apparent energy. Values for the individual phases and an overall value are provided both for active and reactive energy. A distinction can also be drawn between acquisition/delivery of active energy and inductive/capacitive reactive energy (see figure below).

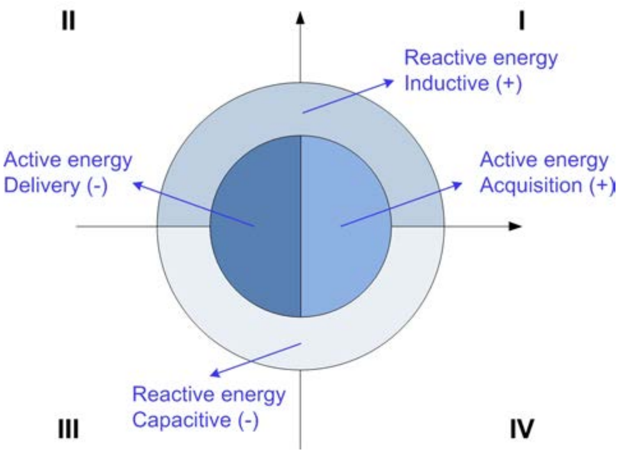


Figure 8: Allocation of Active and Reactive Energy in the 4 Quadrants

All of the energy meter values are saved in the I/O module. These operate internally with the resolutions mWh / mVARh / mVAh and are reset when 1 billion kWh (kVARh, kVAh) is reached.

The representation of the energy values can be scaled using a defined factor in the process image (PI). This factor can be set by the user with WAGO-I/O-*CHECK* or register 35 and can be changed at any time. The two examples below illustrate the information required for this:

Example 1:
- 750-494, meter: Active energy acquisition L1 (UInt32 in the PI)
- Scaling (WAGO-I/O-*CHECK*, Register 35): 0 (1 mWh)
- Maximum meter value in the PI: 4 294 967 295 mWh = ~4 295 kWh

A counter overflow can occur for the counter shown in the PI even though the internal meter has not yet reached the overflow threshold. This is signaled in the PI by the flag "Overflow process value x". The user must select scaling of the measured value in accordance with the application being used.

Example 2:
- 750-494/000-001, meter: Reactive energy, total (Int32 in the PI)
- Scaling (WAGO-I/O-*CHECK*, Register 35): 6 (5 kVARh)
- Maximum meter value in the PI: +10 737 418 235 kVARh (2s complement)

An overflow of the internal meter can occur here, as it can only count to a maximum of 1 billion kVARh. The meter shown in the PI can, however, continue to count substantially higher on account of the scaling that has been set.

The values for the energy meters can be set via WAGO-I/O-*CHECK*. More information on this is given in the section "Commissioning".

The I/O module also allows you to set thresholds for energy measurement, i.e., energy is not metered until these set starting values are reached. This threshold can be defined for each type of energy using WAGO-I/O-*CHECK* or parameters 40, 41, 42.

You can also define the storing cycle using WAGO-I/O-*CHECK* or Register 46 in which the energy meter values are saved internally. The valid range for this is 60 … 255 s. With a storing cycle time of 60 s the lifetime of the internal meters is around 19 years. Each second added to this time increases the lifetime by about 0.3 years.

Determining the Frequency

The phase frequencies are calculated using zero crossing detection of the sampled signals for each phase. The minimum and maximum frequencies are determined over a configurable time period (WAGO-I/O-*CHECK* or parameters 37, 38, 39).

Harmonics Analysis

The I/O module calculates the frequency spectrum for the periodic input signals and analyzes the fundamental component and the next 40 harmonics for each phase. This analysis can be conducted on one of the three phases (L1 or L2 or L3).

The I/O module always yields the RMS values for current and voltage of the fundamental component for the selected phase. The I/O module also provides the total harmonic distortion (THD) for current and voltage.

From the 40 harmonics, three can be selected and analyzed at the same time. The RMS value for current and voltage is calculated for each selected harmonic, along with the harmonic distortion (HD). The harmonics can be freely selected, e.g., 4 – 12 – 19 or 2 – 35 – 40.

Calculating the Power Factors

The power factor **cos phi** is the cosine of the phase angle between voltage and current for the specific phase. Calculation of the power factor only takes into account the phase shifting of the fundamental components of voltage and current. The sign used in front of "cos phi" indicates the following:

- positive (plus) sign: Acquisition of active power from the supply network
- negative (minus) sign: Delivery of active power into the supply network

The **power factor PF** is the quotient of the active power (P) and apparent power (S) and takes the entire spectrum into account, i.e., the fundamental component and the harmonics.

$$PF = P / S$$

- positive (plus) sign: Acquisition of active power from the supply network
- negative (minus) sign: Delivery of active power into the supply network

The **power factor LF** is the quotient from the amount for active power (P) and apparent power (S), multiplied by the sign for reactive power (Q) and takes the entire spectrum into account, i.e., the fundamental component and the harmonics:

$$LF = \text{sign } Q \cdot |P| / S$$

- positive (plus) sign: positive reactive power
- negative (minus) sign: negative reactive power

Note

Jump of power factor LF from +1 to -1
The LF value can jump between +1 and -1 when reactive power is very low. This behavior occurs because of digitization noise!

The 4-quadrant display appears as follows:

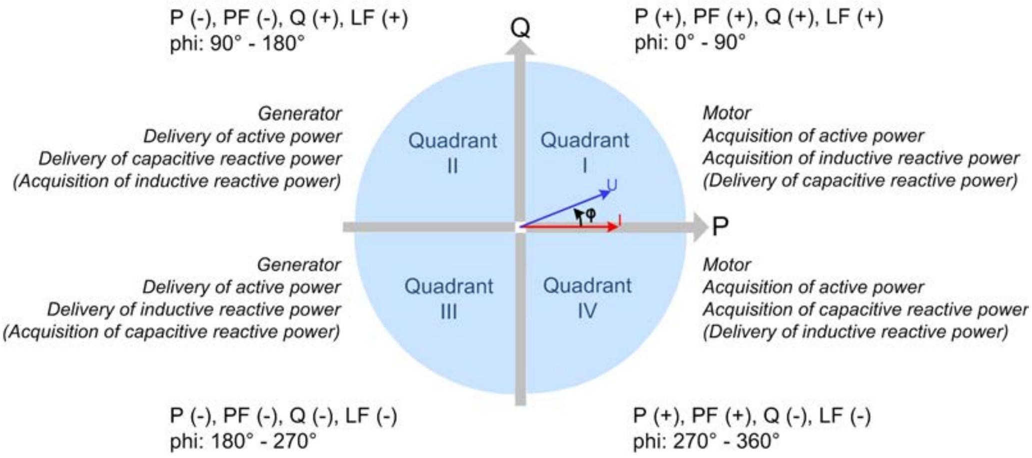


Figure 9: 4-Quadrant Display for Active and Reactive Power

The 4-quadrant display is also shown in WAGO- I/O-*CHECK* for the measured value views "Overview", "Phase Lx" and "Power" in the dialog "3-phase power measurement".

Phase Angle

The phase angle between voltage and current is calculated for each phase using time-synchronous sampling. The phase angle is indicated in degrees.

Rotary Field Detection

The zero crossings of the voltage characteristics for the 3 phases are monitored by rotary field detection. The direction of rotation of a motor or machine can only be determined when the phase sequence L1-L2-L3 at the I/O module has been connected the same as at the motor and when this corresponds to the provisions of VDE 0530-8 or DIN EN 60034-8 with regard to "Terminal designations and direction of rotation" (L1 at U-Motor, L2 at V-Motor, L3 at W-Motor).
Phase sequence L1-L2-L3 signals clockwise rotation, whereas a reversed phase sequence will signal counter-clockwise rotation. Caution: It is not possible to detect double reversing.

Limits

The I/O module also offers limit monitoring. Limits for undervoltage, overvoltage and overcurrent can be set for each phase (WAGO-I/O-*CHECK* or Register 36-38, parameters 23-31). Signaling is carried out in the process image (PI).

4.4 Measuring Errors and Accuracy

The measuring errors of the I/O module are specified in the table below. The values already take into account the errors caused by the connection method (single-ended 0.1%) and the calibration tolerance (0.1%). They apply to the entire temperature range of 0 to 55 °C and to frequencies of 45 to 65 Hz. Outside this frequency range, the error is max. 2%.

Table 16: Measuring Errors

Measuring Errors	750-494 and 750-494/000-001	750-494/025-000 and 750-494/025-001
Voltage	<= 0.3 % of full-scale value	<= 0.5 % of full-scale value
Current	<= 0.5 % of full-scale value	<= 0.5 % of full-scale value
Active power	<= 0.5 %	<= 0.5 %
Phase angle	+/- 0.3°	+/- 0.3°
Frequency	0.01 Hz	0.01 Hz

The harmonics components are determined on the basis of a number of individual values measured within the current curve shapes for voltage and current. Calculation is performed to yield the components included in the actual base frequency (45 to 65 Hz) and their integer harmonics. The accuracy of the calculation results is typically within a range of around 1%.

Note

"Leakage effect" with the harmonics analysis!
Harmonics components in the actual curve shapes for measured voltages and currents with non-integer multiples of the base frequency can affect the accuracy of the calculation results for "neighboring harmonics" (so-called "leakage effect“).

The measuring accuracy of the I/O module falls when an RMS voltage falls below 45 V. This state is called ZC limit and is displayed via the "D" LED (SAG LED). The following conditions can also degrade the measuring accuracy of the I/O module:

1. If only one or two phases of the three-phase supply network are connected, higher measuring errors can occur in the voltage measurement (+0.1%).

2. If all phases fall below the ZC limit, accurate measurement of phase angle,

frequency and current are no longer possible. The measuring accuracy of all current-depending variables (current, power, energy) falls off by 0.4%.

3. Near the ZC limit, the accuracy of the phase angle measurement decreases to a value of ± 1.5 °.

4. If a current measuring input operates near no-load, higher measuring errors can occur for this measuring path.

5. Measuring errors due to input overdrive:
When the input current or input voltage exceeds the nominal values for the I/O module, input overdrive is produced (see figure below). The I/O module cannot digitize these values and limits the measured values to the maximum measurable range (clipping of the current or voltage measured values). As a result, the RMS value that is output is erroneous. The more the input is overdriven (and, thus, the reference points for RMS calculation), the greater the measuring error.
Clipping of the voltage or current values is displayed via the expanded status word 1 in the process image and by LED C (current) or LED G (voltage) in diagnostics.

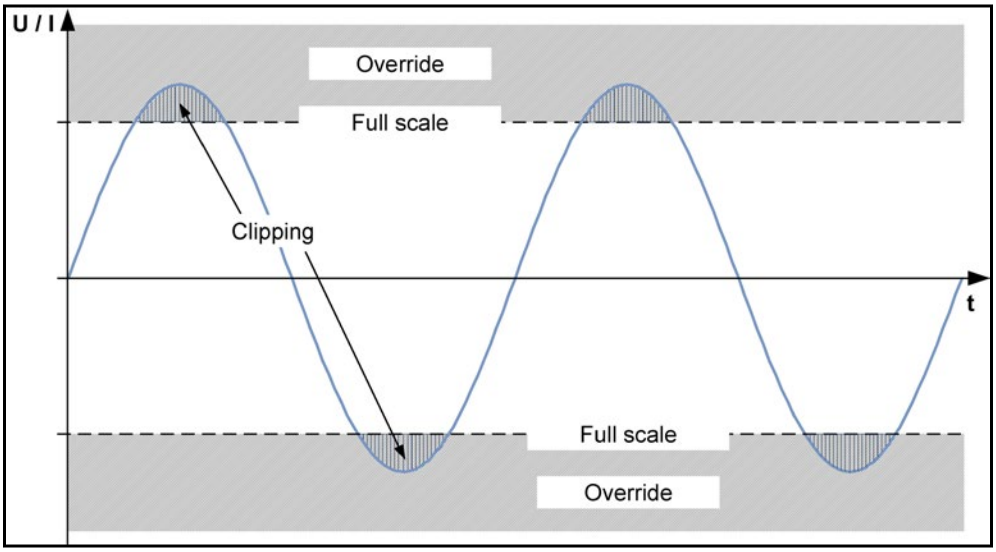


Figure 10: Input Overdrive (Clipping)

5 Process Image

The I/O module provides, on 1 logical channel, 24 bytes input and 24 bytes output process data to a fieldbus coupler/controller. These consist of 8 control/status bytes and 16 data bytes.

NOTICE

Notice that the process data image depends on the used fieldbus coupler/ controller!
Mapping the process data into the process image is specific for the fieldbus coupler/controller used. You will find both this information and the specific configuration of the relevant control/status bytes in the manual of the coupler/controller, section "Fieldbus Specific Configuration of Process Data" which describes the process image.

5.1 Overview of Process Data

Byte	Output data	Input data
0	Control word	Status word
1		
2	Expanded control word 1	Expanded status word 1
3		
4	Expanded control word 2	Expanded status word 2
5		
6	Expanded control word 3	Expanded status word 3
7		
8	---	Process value 1
9		
10		
11		
12	---	Process value 2
13		
14		
15		
16	---	Process value 3
17		
18		
19		
20	---	Process value 4
21		
22		
23		

5.2 Output Data

The output data is transmitted to the I/O module by the fieldbus coupler/controller. This data consists of 4 control words and 8 data words.

5.2.1 Definition of Control Words

Control word

Byte 0							
(Bit 7)	(Bit 6)	(Bit 5)	(Bit 4)	(Bit 3)	(Bit 2)	(Bit 1)	(Bit 0)
COM	RES	-	-	-	-	-	-
COM		Communication mode: 0: Process data communication 1: Register communication					
RES		reserved					
Byte 1							
(Bit 7)	(Bit 6)	(Bit 5)	(Bit 4)	(Bit 3)	(Bit 2)	(Bit 1)	(Bit 0)
-	-	-	-	-	-	STAT	
STAT		Request for status query: 0 = Status Phase L1 1 = Status Phase L2 2 = Status Phase L3 3 = Status I/O module					

Expanded control word 1

Byte 2							
(Bit 7)	(Bit 6)	(Bit 5)	(Bit 4)	(Bit 3)	(Bit 2)	(Bit 1)	(Bit 0)
-	-	-	-	-	-	-	-
Byte 3							
(Bit 7)	(Bit 6)	(Bit 5)	(Bit 4)	(Bit 3)	(Bit 2)	(Bit 1)	(Bit 0)
COL_ID							
COL_ID		Selection of measured value collection: 000 … 006= reserved 007 = reserved 008 = reserved 009 = Measured values 010 … 019= reserved 020 = Harmonics analysis L1 021 = Harmonics analysis L2 022 = Harmonics analysis L3 023 … 255= reserved					

Expanded control word 2

Byte 4							
(Bit 7)	(Bit 6)	(Bit 5)	(Bit 4)	(Bit 3)	(Bit 2)	(Bit 1)	(Bit 0)
MET_ID_1							
MET_ID_1	ID for selection of the measured value from the collection COL_ID, which is delivered with process value 1 of the input data.						
Byte 5							
(Bit 7)	(Bit 6)	(Bit 5)	(Bit 4)	(Bit 3)	(Bit 2)	(Bit 1)	(Bit 0)
MET_ID_2							
MET_ID_2	ID for selection of the measured value from the collection COL_ID, which is delivered with process value 2 of the input data.						

Expanded control word 3

Byte 6							
(Bit 7)	(Bit 6)	(Bit 5)	(Bit 4)	(Bit 3)	(Bit 2)	(Bit 1)	(Bit 0)
MET_ID_3							
MET_ID_3	ID for selection of the measured value from the collection COL_ID, which is delivered with process value 3 of the input data.						
Byte 7							
(Bit 7)	(Bit 6)	(Bit 5)	(Bit 4)	(Bit 3)	(Bit 2)	(Bit 1)	(Bit 0)
MET_ID_4							
MET_ID_4	ID for selection of the measured value from the collection COL_ID, which is delivered with process value 4 of the input data.						

5.2.2 Definition of Output Data Words

The data words in the output data can be ignored.

5.3 Input Data

The input data are transmitted to the fieldbus coupler/controller by the I/O module. This data consists of 4 status words and 8 data words (process values 1 … 4).

5.3.1 Definition of Status Words

Status word

<table>
<tr><th colspan="8">Byte 0</th></tr>
<tr><td>(Bit 7)</td><td>(Bit 6)</td><td>(Bit 5)</td><td>(Bit 4)</td><td>(Bit 3)</td><td>(Bit 2)</td><td>(Bit 1)</td><td>(Bit 0)</td></tr>
<tr><td>COM</td><td>ERROR</td><td>-</td><td>-</td><td>ERR_BK</td><td>ERR_L3</td><td>ERR_L2</td><td>ERR_L1</td></tr>
<tr><td colspan="2">COM</td><td colspan="6">Communication mode:
0: Process data communication
1: Register communication</td></tr>
<tr><td colspan="2">ERROR</td><td colspan="6">General error:
0 = Ok
1 = General error (one or more ERR_* Bits are set)</td></tr>
<tr><td colspan="2">ERR_BK</td><td colspan="6">Group error for I/O module
0 = Ok
1 = Error occurred</td></tr>
<tr><td colspan="2">ERR_L3</td><td colspan="6">Group error Phase L3
0 = Ok
1 = Error occurred</td></tr>
<tr><td colspan="2">ERR_L2</td><td colspan="6">Group error Phase L2
0 = Ok
1 = Error occurred</td></tr>
<tr><td colspan="2">ERR_L1</td><td colspan="6">Group error Phase L1
0 = Ok
1 = Error occurred</td></tr>
<tr><th colspan="8">Byte 1</th></tr>
<tr><td>(Bit 7)</td><td>(Bit 6)</td><td>(Bit 5)</td><td>(Bit 4)</td><td>(Bit 3)</td><td>(Bit 2)</td><td>(Bit 1)</td><td>(Bit 0)</td></tr>
<tr><td>WARN</td><td>CAL</td><td>OVER_1</td><td>OVER_2</td><td>OVER_3</td><td>OVER_4</td><td colspan="2">STAT_SEL</td></tr>
<tr><td colspan="2">WARN</td><td colspan="6">Warning: Transient reaction measured value collection active
0 = Ok
1 = The selected collection measured values are not yet stable; wait until the end of build-up time.</td></tr>
<tr><td colspan="2">CAL</td><td colspan="6">Display Calibration mode:
0 = No Calibration mode
1 = The I/O module is in the Calibration mode.</td></tr>
<tr><td colspan="2">OVER_1</td><td colspan="6">Range limiting for process value 1:
0 = Ok
1 = The measured value shown in process value 1 is situated outside the defined value range.</td></tr>
</table>

OVER_2	Range limiting for process value 2: 0 = Ok 1 = The measured value shown in process value 2 is situated outside the defined value range.
OVER_3	Range limiting for process value 3: 0 = Ok 1 = The measured value shown in process value 3 is situated outside the defined value range.
OVER_4	Range limiting for process value 4: 0 = Ok 1 = The measured value shown in process value 4 is situated outside the defined value range.
STAT_SEL	Confirmation for the status query requested in the output data – Status active for: 0 = Status Phase L1 1 = Status Phase L2 2 = Status Phase L3 3 = Status I/O module

Expanded status word 1

Byte 2							
(Bit 7)	(Bit 6)	(Bit 5)	(Bit 4)	(Bit 3)	(Bit 2)	(Bit 1)	(Bit 0)
STAT7	STAT6	STAT5	STAT4	STAT3	STAT2	STAT1	-

STAT7	STAT_SEL = Status Lx = L1 / L2 / L3: - Threshold value Undervoltage Lx: 0 = Threshold not reached 1 = Threshold reached or exceeded STAT_SEL = Status I/O module: No significance
STAT6	STAT_SEL = Status Lx = L1 / L2 / L3: - Threshold value Overvoltage Lx: 0 = Threshold not reached 1 = Threshold reached or exceeded STAT_SEL = Status I/O module: Rotating Field Indicator 0 = Rotary field correct L1-L2-L3, clockwise 1 = Rotary field not correct, counter-clockwise
STAT5	STAT_SEL = Status Lx = L1 / L2 / L3: - Threshold value Overcurrent Lx: 0 = Threshold not reached 1 = Threshold reached or exceeded STAT_SEL = Status I/O module: No significance

STAT4	STAT_SEL = Status Lx = L1 / L2 / L3: - Status Zero crossings: 0 = Signal zero crossings at the phase Lx 1 = No signal zero crossings at the phase Lx STAT_SEL = Status I/O module: No significance
STAT3	STAT_SEL = Status Lx = L1 / L2 / L3: - Clipping of voltage signal at Lx: 0 = OK 1 = The voltage signal is outside the measurable range of the I/O module and has been limited (clipped). STAT_SEL = Status I/O module: No significance
STAT2	STAT_SEL = Status Lx = L1 / L2 / L3: - Clipping of current signal at Lx: 0 = OK 1 = The current signal is outside the measurable range of the I/O module and has been limited (clipped). STAT_SEL = Status I/O module: No significance
STAT1	STAT_SEL = Status Lx = L1 / L2 / L3: - SagLevel Voltage Lx: 0 = OK 1 = Elevated measuring error due to inadequate input voltage at Lx STAT_SEL = Status I/O module: No significance

Byte 3							
(Bit 7)	(Bit 6)	(Bit 5)	(Bit 4)	(Bit 3)	(Bit 2)	(Bit 1)	(Bit 0)
COL_ID_SEL							

COL_ID_SEL	Index for the selected measured value collection (see also COL_ID in output data): 000 … 006= reserved 007 = reserved 008 = reserved 009 = Measured values 010 … 019= reserved 020 = Harmonics analysis L1 021 = Harmonics analysis L2 022 = Harmonics analysis L3 023 … 255= reserved

Expanded status word 2

Byte 4							
(Bit 7)	(Bit 6)	(Bit 5)	(Bit 4)	(Bit 3)	(Bit 2)	(Bit 1)	(Bit 0)
MET_ID_1_SEL							
MET_ID_1_SEL	ID for the measured value from the collection COL_ID_SEL which is in process value 1 of the input data.						
Byte 5							
(Bit 7)	(Bit 6)	(Bit 5)	(Bit 4)	(Bit 3)	(Bit 2)	(Bit 1)	(Bit 0)
MET_ID_2_SEL							
MET_ID_2_SEL	ID of the measured value from the collection COL_ID_SEL which is in process value 2 of the input data.						

Expanded status word 3

Byte 6							
(Bit 7)	(Bit 6)	(Bit 5)	(Bit 4)	(Bit 3)	(Bit 2)	(Bit 1)	(Bit 0)
MET_ID_3_SEL							
MET_ID_3_SEL	ID for the measured value from the collection COL_ID_SEL which is in process value 3 of the input data.						
Byte 7							
(Bit 7)	(Bit 6)	(Bit 5)	(Bit 4)	(Bit 3)	(Bit 2)	(Bit 1)	(Bit 0)
MET_ID_4_SEL							
MET_ID_4_SEL	ID for the measured value from the collection COL_ID_SEL which is in process value 4 of the input data.						

5.3.2 Definition of Input Data Words

Process value 1

Byte 8							
(Bit 7)	(Bit 6)	(Bit 5)	(Bit 4)	(Bit 3)	(Bit 2)	(Bit 1)	(Bit 0)
PROC1[7:0]							
PROC1[7:0]	Byte of the measured value with the MET_ID "MET_ID_1_SEL" from the collection COL_ID_SEL which is in process value 1 of the input data (the format of the 32-bit measured values is defined in the Section "Collections of Measured Values")						
Byte 9							
(Bit 7)	(Bit 6)	(Bit 5)	(Bit 4)	(Bit 3)	(Bit 2)	(Bit 1)	(Bit 0)
PROC1[15:8]							
PROC1[15:8]	=> See Process value 1 – Byte 8						

Byte 10							
(Bit 7)	(Bit 6)	(Bit 5)	(Bit 4)	(Bit 3)	(Bit 2)	(Bit 1)	(Bit 0)
PROC1[23:16]							
PROC1[23:16]	=> See Process value 1 – Byte 8						
Byte 11							
(Bit 7)	(Bit 6)	(Bit 5)	(Bit 4)	(Bit 3)	(Bit 2)	(Bit 1)	(Bit 0)
PROC1[31:24]							
PROC1[31:24]	=> See Process value 1 – Byte 8						

Process value 2

Byte 12							
(Bit 7)	(Bit 6)	(Bit 5)	(Bit 4)	(Bit 3)	(Bit 2)	(Bit 1)	(Bit 0)
PROC2[7:0]							
PROC2[7:0]	Byte of the measured value with the MET_ID "MET_ID_2_SEL" from the collection COL_ID_SEL which is in process value 2 of the input data (the format of the 32-bit measured values is defined in the Section "Collections of Measured Values")						
Byte 13							
(Bit 7)	(Bit 6)	(Bit 5)	(Bit 4)	(Bit 3)	(Bit 2)	(Bit 1)	(Bit 0)
PROC2[15:8]							
PROC2[15:8]	=> See Process value 2 – Byte 12						
Byte 14							
(Bit 7)	(Bit 6)	(Bit 5)	(Bit 4)	(Bit 3)	(Bit 2)	(Bit 1)	(Bit 0)
PROC2[23:16]							
PROC2[23:16]	=> See Process value 2 – Byte 12						
Byte 15							
(Bit 7)	(Bit 6)	(Bit 5)	(Bit 4)	(Bit 3)	(Bit 2)	(Bit 1)	(Bit 0)
PROC2[31:24]							
PROC2[31:24]	=> See Process value 2 – Byte 12						

Process value 3

Byte 16							
(Bit 7)	(Bit 6)	(Bit 5)	(Bit 4)	(Bit 3)	(Bit 2)	(Bit 1)	(Bit 0)
PROC3[7:0]							
PROC3[7:0]	Byte of the measured value with the MET_ID "MET_ID_3_SEL" from the collection COL_ID_SEL which is in process value 3 of the input data (the format of the 32-bit measured values is defined in the Section "Collections of Measured Values")						

Byte 17							
(Bit 7)	(Bit 6)	(Bit 5)	(Bit 4)	(Bit 3)	(Bit 2)	(Bit 1)	(Bit 0)
PROC3[15:8]							
PROC3[15:8]	=> See Process value 3 – Byte 16						
Byte 18							
(Bit 7)	(Bit 6)	(Bit 5)	(Bit 4)	(Bit 3)	(Bit 2)	(Bit 1)	(Bit 0)
PROC3[23:16]							
PROC3[23:16]	=> See Process value 3 – Byte 16						
Byte 19							
(Bit 7)	(Bit 6)	(Bit 5)	(Bit 4)	(Bit 3)	(Bit 2)	(Bit 1)	(Bit 0)
PROC3[31:24]							
PROC3[31:24]	=> See Process value 3 – Byte 16						

Process value 4

Byte 20							
(Bit 7)	(Bit 6)	(Bit 5)	(Bit 4)	(Bit 3)	(Bit 2)	(Bit 1)	(Bit 0)
PROC4[7:0]							
PROC4[7:0]	Byte of the measured value with the MET_ID "MET_ID_4_SEL" from the collection COL_ID_SEL which is in process value 4 of the input data (the format of the 32-bit measured values is defined in the Section "Collections of Measured values")						
Byte 21							
(Bit 7)	(Bit 6)	(Bit 5)	(Bit 4)	(Bit 3)	(Bit 2)	(Bit 1)	(Bit 0)
PROC4[15:8]							
PROC4[15:8]	=> See Process value 4 – Byte 20						
Byte 22							
(Bit 7)	(Bit 6)	(Bit 5)	(Bit 4)	(Bit 3)	(Bit 2)	(Bit 1)	(Bit 0)
PROC4[23:16]							
PROC4[23:16]	=> See Process value 4 – Byte 20						
Byte 23							
(Bit 7)	(Bit 6)	(Bit 5)	(Bit 4)	(Bit 3)	(Bit 2)	(Bit 1)	(Bit 0)
PROC4[31:24]							
PROC4[31:24]	=> See Process value 4 – Byte 20						

5.4 Process Image Descriptions

The I/O module provides a large number of measured values for a three-phase supply network. These measured values are organized into **collections** which can be selected by specifying the COL_ID. The following collections are available:

COL_ID = 009 – Measured values
All measured values provided by the I/O module involved with measurement.

COL_ID = 020 – Harmonics analysis L1
All measured values provided by the I/O module involved with the harmonics analysis for Phase L1.

COL_ID = 021 – Harmonics analysis L2
All measured values provided by the I/O module involved with the harmonics analysis for Phase L2.

COL_ID = 022 – Harmonics analysis L3
All measured values provided by the I/O module involved with the harmonics analysis for Phase L3.

The individual measured values are identified within a collection by specifying a MET_ID. The following section "Collections of Measured Value " contains a definition of all the measured value collections with the corresponding MET_IDs, measured value data types and scaling factors in the process image.

Example: COL_ID = 009, MET_ID = 003

Measured value:	RMS value, current
Data type in the PI:	L3 UInt32
Scaling factor PI 750-494:	0.0001A / LSB
Scaling factor PI 750-494/000-001:	0.0005A / LSB

The I/O module measured values are made available in the process image as a function of the selected collection (COL_ID) and of the measured values selected in the collection.

Collection Measured values (009)

The collection is selected in the I/O module output data and the various measured values selected from the collection using the corresponding MET_IDs. These measured values are then made available in the input data. After this, four other MET_IDs can be selected, and so on.

Example:

Byte	Output data	Input data
0	0x00	0x44
1	0x02 (Status query)	0x02
2	0x00	0x40
3	0x09 (COL_ID)	0x09 (COL_ID_SEL)
4	0x06 (MET_ID_1)	0x06 (MET_ID_1_SEL)
5	0x03 (MET_ID_2)	0x03 (MET_ID_2_SEL)
6	0x4E (MET_ID_3)	0x4E (MET_ID_3_SEL)
7	0x17 (MET_ID_4)	0x17 (MET_ID_4_SEL)
8	---	Voltage, RMS L3-N [7:0]
9	---	Voltage, RMS L3-N [15:8]
10	---	Voltage, RMS L3-N [23:16]
11	---	Voltage, RMS L3-N [31:24]
12	---	Current, RMS L3 [7:0]
13	---	Current, RMS L3 [15:8]
14	---	Current, RMS L3 [23:16]
15	---	Current, RMS L3 [31:24]
16	---	Reactive energy L3 [7:0]
17	---	Reactive energy L3 [15:8]
18	---	Reactive energy L3 [23:16]
19	---	Reactive energy L3 [31:24]
20	---	cos phi L2 [7:0]
21	---	cos phi L2 [15:8]
22	---	cos phi L2 [23:16]
23	---	cos phi L2 [31:24]

The status query was also set in the examples given here. In the example, the status query is made for phase L3. The status word (Byte 0) is at 0x44, an error has occurred at phase L3 (ERROR, ERR_L3). Byte 2 is at 0x40, i.e., overvoltage at Phase L3, the set threshold has been exceeded.

Collections for harmonics analysis (020, 021, 022)

The corresponding harmonics analysis collection is selected in the I/O module output data and the MET_IDs set. These measured values are then made available in the input data.

The type of measured value is selected in the harmonics analysis collections using the corresponding MET_ID_1. The following types of measured data are available:

MET_ID_1 = 001 :	RMS value current for fundamental component or harmonic
MET_ID_1 = 002 :	RMS value voltage for fundamental component or harmonic
MET_ID_1 = 003 :	THD (Total Harmonic Distortion) for fundamental component or HD (Harmonic Distortion) for current harmonic
MET_ID_1 = 004 :	THD for fundamental component or HD for voltage harmonic

MET_ID_2, MET_ID_3 and MET_ID_4 are then used to select the harmonic (MET_ID_x = 1 ... 40) or fundamental component (MET_ID_x = 100) for the measured values defined by MET_ID_1 are to be made available in the process image input data. This means that 3 measured values are provided with the input data.

Example 1:

Byte	Output data	Input data
0	0x00	0x48
1	0x03 (Status query)	0x00
2	0x00	0x40
3	0x14 (COL_ID)	0x14 (COL_ID_SEL)
4	0x02 (MET_ID_1)	0x02 (MET_ID_1_SEL)
5	0x64 (MET_ID_2)	0x64 (MET_ID_2_SEL)
6	0x01 (MET_ID_3)	0x01 (MET_ID_3_SEL)
7	0x02 (MET_ID_4)	0x02 (MET_ID_4_SEL)
8	---	Measured value type Ueff - [7:0] = 0x02
9	---	Measured value type Ueff - [15:8] = 0x00
10	---	Measured value type Ueff - [23:16] = 0x00
11	---	Measured value type Ueff - [31:24] = 0x00
12	---	Ueff – Fundamental component L1 [7:0]
13	---	Ueff – Fundamental component L1 [15:8]
14	---	Ueff – Fundamental component L1 [23:16]
15	---	Ueff – Fundamental component L1 [31:24]
16	---	Ueff – 1st harmonic L1 [7:0]

17	---	Ueff – 1st harmonic L1 [15:8]
18	---	Ueff – 1st harmonic L1 [23:16]
19	---	Ueff – 1st harmonic L1 [31:24]
20	---	Ueff – 2nd harmonic L1 [7:0]
21	---	Ueff – 2nd harmonic L1 [15:8]
22	---	Ueff – 2nd harmonic L1 [23:16]
23	---	Ueff – 2nd harmonic L1 [31:24]

Example 2:

Byte	Output data	Input data
0	0x00	0x41
1	0x00 (Status query)	0x80
2	0x00	0x08
3	0x16 (COL_ID)	0x16 (COL_ID_SEL)
4	0x03 (MET_ID_1)	0x03 (MET_ID_1_SEL)
5	0x08 (MET_ID_2)	0x08 (MET_ID_2_SEL)
6	0x64 (MET_ID_3)	0x64 (MET_ID_3_SEL)
7	0x25 (MET_ID_4)	0x25 (MET_ID_4_SEL)
8	---	Measured value type, distortion, current - [7:0] = 0x03
9	---	Measured value type, distortion, current - [15:8] = 0x00
10	---	Measured value type, distortion, current - [23:16] = 0x00
11	---	Measured value type, distortion, current - [31:24] = 0x00
12	---	HD current – 8th harmonic L3 [7:0]
13	---	HD current – 8th harmonic L3 [15:8]
14	---	HD current – 8th harmonic L3 [23:16]
15	---	HD current – 8th harmonic L3 [31:24]
16	---	THD current – fundamental component L3 [7:0]
17	---	THD current – fundamental component L3 [15:8]
18	---	THD current – fundamental component L3 [23:16]
19	---	THD current – Fundamental component L3 [31:24]
20	---	HD current – 37th harmonic L3 [7:0]
21	---	HD current – 37th harmonic L3 [15:8]
22	---	HD current – 37th harmonic L3 [23:16]
23	---	HD current – 37th harmonic L3 [31:24]

The status query was also set in the examples given here. In example 1, the status query is made for the I/O module. The status word (Byte 0) is at 0x48, an error occurred at the I/O module (ERROR, ERR_BK). Byte 2 is at 0x40, i.e., the rotary field is not correct, counter-clockwise.

In example 2, the status query is made for phase L1. The status word (Byte 0) is at 0x41, an error has occurred at phase L1 (ERROR, ERR_L1). Byte 2 is at 0x08, i.e., the voltage signal at phase L1 is outside the valid range for the I/O module and has been clipped. In addition, byte 1 is at 0x80. This means that the measured values of the collection are not yet stable. The transient reaction period (build-up) must end, then the measured values are stable.

5.4.1 Building-up the Measured Values

Build-up times must be taken into account when switching measured value collections in order to obtain stable measured values in the process image. You can check whether the measured values are stable by the "WARN" flag in the status word (Byte 1). The build-up times are given in the next section "Process Image" > "Collections of Measured Values".

5.5 Collections of Measured Values

5.5.1 Collection 009 – Measured Values

Note

Wait to the end of build-up time!
The selected measured values of the collection are stable after approx. 1400 ms!

Table 18: Measured Values of Collection 009 in the Process Image (PI)

MET_ID	Measured Value	Data Type PI	Scaling Factor PI		Update Rate PI [ms]
			1A-Variants	5A-Variants	
Voltage					
004	RMS voltage L1-N	UInt32	0.01V	0.01V	40
005	RMS voltage L2-N	UInt32	0.01V	0.01V	40
006	RMS voltage L3-N	UInt32	0.01V	0.01V	40
043	Max. RMS voltage L1-N	UInt32	0.01V	0.01V	50
044	Max. RMS voltage L2-N	UInt32	0.01V	0.01V	50
045	Max. RMS voltage L3-N	UInt32	0.01V	0.01V	50
046	Min. RMS voltage L1-N	UInt32	0.01V	0.01V	50
047	Min. RMS voltage L2-N	UInt32	0.01V	0.01V	50
048	Min. RMS voltage L3-N	UInt32	0.01V	0.01V	50
031	RMS voltage L1-L2	UInt32	0.01V	0.01V	340
032	RMS voltage L1-L3	UInt32	0.01V	0.01V	340
033	RMS voltage L2-L3	UInt32	0.01V	0.01V	340
049	Arithmetic mean value voltage L1-N	UInt32	0.01V	0.01V	adjustable 5 ... 900s
050	Arithmetic mean value voltage L2-N	UInt32	0.01V	0.01V	adjustable 5 ... 900s
051	Arithmetic mean value voltage L3-N	UInt32	0.01V	0.01V	adjustable 5 ... 900s
091	Peak value voltage L1-N	UInt32	0.01V	0.01V	200
092	Peak value voltage L2-N	UInt32	0.01V	0.01V	200
093	Peak value voltage L3-N	UInt32	0.01V	0.01V	200
Current					
001	RMS current L1	UInt32	0.0001A	0.0005A	40
002	RMS current L2	UInt32	0.0001A	0.0005A	40
003	RMS current L3	UInt32	0.0001A	0.0005A	40
034	Max. RMS current L1	UInt32	0.0001A	0.0005A	50
035	Max. RMS current L2	UInt32	0.0001A	0.0005A	50
036	Max. RMS current L3	UInt32	0.0001A	0.0005A	50
037	Min. RMS current L1	UInt32	0.0001A	0.0005A	50
038	Min. RMS current L2	UInt32	0.0001A	0.0005A	50
039	Min. RMS current L3	UInt32	0.0001A	0.0005A	50
040	Arithmetic mean value current L1	UInt32	0.0001A	0.0005A	adjustable 5 ... 900s
041	Arithmetic mean value current L2	UInt32	0.0001A	0.0005A	adjustable 5 ... 900s
042	Arithmetic mean value current L3	UInt32	0.0001A	0.0005A	adjustable 5 ... 900s
094	Peak value current L1	UInt32	0.0001A	0.0005A	200
095	Peak value current L2	UInt32	0.0001A	0.0005A	200
096	Peak value current L3	UInt32	0.0001A	0.0005A	200

Power					
007	Active power L1	Int32	0.01W	0.05W	40
008	Active power L2	Int32	0.01W	0.05W	40
009	Active power L3	Int32	0.01W	0.05W	40
052	Max. active power L1	Int32	0.01W	0.05W	50
053	Max. active power L2	Int32	0.01W	0.05W	50
054	Max. active power L3	Int32	0.01W	0.05W	50
055	Min. active power L1	Int32	0.01W	0.05W	50
056	Min. active power L2	Int32	0.01W	0.05W	50
057	Min. active power L3	Int32	0.01W	0.05W	50
010	Reactive power L1	Int32	0.01VAR	0.05VAR	340
011	Reactive power L2	Int32	0.01VAR	0.05VAR	340
012	Reactive power L3	Int32	0.01VAR	0.05VAR	340
013	Apparent power L1	UInt32	0.01VA	0.05VA	40
014	Apparent power L2	UInt32	0.01VA	0.05VA	40
015	Apparent power L3	UInt32	0.01VA	0.05VA	40
Energy					
064	Active energy L1	Int32	Setup with WAGO-I/O-*CHECK* or in Register 35		400
065	Active energy L2	Int32	Setup with WAGO-I/O-*CHECK* or in Register 35		400
066	Active energy L3	Int32	Setup with WAGO-I/O-*CHECK* or in Register 35		400
067	Active energy acquisition L1	UInt32	Setup with WAGO-I/O-*CHECK* or in Register 35		400
068	Active energy acquisition L2	UInt32	Setup with WAGO-I/O-*CHECK* or in Register 35		400
069	Active energy acquisition L3	UInt32	Setup with WAGO-I/O-*CHECK* or in Register 35		400
070	Active energy delivery L1	UInt32	Setup with WAGO-I/O-*CHECK* or in Register 35		400
071	Active energy delivery L2	UInt32	Setup with WAGO-I/O-*CHECK* or in Register 35		400
072	Active energy delivery L3	UInt32	Setup with WAGO-I/O-*CHECK* or in Register 35		400
073	Active energy total	Int32	Setup with WAGO-I/O-*CHECK* or in Register 35		400
074	Active energy acquisition total	UInt32	Setup with WAGO-I/O-*CHECK* or in Register 35		400
075	Active energy delivery total	UInt32	Setup with WAGO-I/O-		400

			CHECK or in Register 35	
076	Reactive energy L1	Int32	Setup with WAGO-I/O-*CHECK* or in Register 35	400
077	Reactive energy L2	Int32	Setup with WAGO-I/O-*CHECK* or in Register 35	400
078	Reactive energy L3	Int32	Setup with WAGO-I/O-*CHECK* or in Register 35	400
079	Reactive energy inductive L1	UInt32	Setup with WAGO-I/O-*CHECK* or in Register 35	400
080	Reactive energy inductive L2	UInt32	Setup with WAGO-I/O-*CHECK* or in Register 35	400
081	Reactive energy inductive L3	UInt32	Setup with WAGO-I/O-*CHECK* or in Register 35	400
082	Reactive energy capacitive L1	UInt32	Setup with WAGO-I/O-*CHECK* or in Register 35	400
083	Reactive energy capacitive L2	UInt32	Setup with WAGO-I/O-*CHECK* or in Register 35	400
084	Reactive energy capacitive L3	UInt32	Setup with WAGO-I/O-*CHECK* or in Register 35	400
085	Reactive energy total	Int32	Setup with WAGO-I/O-*CHECK* or in Register 35	400
086	Reactive energy inductive total	UInt32	Setup with WAGO-I/O-*CHECK* or in Register 35	400
087	Reactive energy capacitive total	UInt32	Setup with WAGO-I/O-*CHECK* or in Register 35	400
088	Apparent energy L1	UInt32	Setup with WAGO-I/O-*CHECK* or in Register 35	400
089	Apparent energy L2	UInt32	Setup with WAGO-I/O-*CHECK* or in Register 35	400
090	Apparent energy L3	UInt32	Setup with WAGO-I/O-*CHECK* or in Register 35	400

Frequency					
016	Supply network frequency L1	UInt32	0.001Hz	0.001Hz	280
017	Supply network frequency L2	UInt32	0.001Hz	0.001Hz	280
018	Supply network frequency L3	UInt32	0.001Hz	0.001Hz	280
058	Max. supply network frequency L1	UInt32	0.001Hz	0.001Hz	280
059	Max. supply network frequency L2	UInt32	0.001Hz	0.001Hz	280
060	Max. supply network frequency L3	UInt32	0.001Hz	0.001Hz	280
061	Min. supply network frequency L1	UInt32	0.001Hz	0.001Hz	280
062	Min. supply network frequency L2	UInt32	0.001Hz	0.001Hz	280
063	Min. supply network frequency L3	UInt32	0.001Hz	0.001Hz	280
Phase angle					
019	Phase angle phi L1	UInt32	0.01 °		340
020	Phase angle phi L2	UInt32	0.01 °		340
021	Phase angle phi L3	UInt32	0.01 °		340
Power factor					
022	cos phi L1	Int32	0.01	0.01	340
023	cos phi L2	Int32	0.01	0.01	340
024	cos phi L3	Int32	0.01	0.01	340
025	Power factor PF L1	Int32	0.01	0.01	280
026	Power factor PF L2	Int32	0.01	0.01	280
027	Power factor PF L3	Int32	0.01	0.01	280
028	Power factor LF L1	Int32	0.01	0.01	280
029	Power factor LF L2	Int32	0.01	0.01	280
030	Power factor LF L3	Int32	0.01	0.01	280

5.5.2 Collection 020 – Harmonics Analysis L1

Note

Wait to the end of build-up time!
The selected measured values of the collection are stable after approx. 1100 ms! When switching to another harmonic (1 … 40) a build-up time of 1100 ms must be considered for the new values!

Table 19: Measured Values of Collection 020 in the Process Image (PI)

Selection of measured value type:					
MET_ID_1	**Measured Value**	**Data Type PI**	**Scaling Factor PI**		**Update Rate PI [ms]**
			1A-Variants	**5A-Variants**	
RMS current					
001	Current L1	UInt32	0.0001A	0.0005A	260
RMS voltage					
002	Voltage L1	UInt32	0.01V	0.01V	260
Distortion current					
003	Current L1	UInt32	0.01%	0.01%	260
Distortion voltage					
004	Voltage L1	UInt32	0.01%	0.01%	260
Selection of 3 harmonics:					
MET_ID_2, _3 and _4	**Measured Value**	**Data type PI**	**Scaling factor PI**		**Update Rate PI [ms]**
			1A-Variants	**5A-Variants**	
1st harmonic					
100	1st harmonic (fundamental component) L1	-depends on selected measured value			260
2nd to 41st harmonic					
1 … 40	2nd … 41st harmonic L1	-depends on selected measured value			260

5.5.3 Collection 021 – Harmonics Analysis L2

Note

Wait to the end of build-up time!
The selected measured values of the collection are stable after approx. 1100 ms! When switching to another harmonic (1 … 40) a build-up time of 1100 ms must be considered for the new values!

Table 20: Measured Values of Collection 021 in the Process Image (PI)

Selection of measured value type:					
MET_ID_1	**Measured Value**	**Data Type PI**	**Scaling Factor PI**		**Update Rate PI [ms]**
			1A-Variants	**5A-Variants**	
RMS current					
001	Current L2	UInt32	0.0001A	0.0005A	260
RMS voltage					
002	Voltage L2	UInt32	0.01V	0.01V	260
Distortion current					
003	Current L2	UInt32	0.01%	0.01%	260
Distortion voltage					
004	Voltage L2	UInt32	0.01%	0.01%	260
Selection of 3 harmonics:					
MET_ID_2, _3 and _4	**Measured Value**	**Data type PI**	**Scaling factor PI**		**Update Rate PI [ms]**
			1A-Variants	**5A-Variants**	
1st harmonic					
100	1st harmonic (fundamental component) L2	-depends on selected measured value			260
2nd to 41st harmonic					
1 … 40	2nd … 41st harmonic L2	-depends on selected measured value			260

5.5.4 Collection 022 – Harmonics Analysis L3

Note

Wait to the end of build-up time!
The selected measured values of the collection are stable after approx. 1100 ms! When switching to another harmonic (1 … 40) a build-up time of 1100 ms must be considered for the new values!

Table 21: Measured Values of Collection 022 in the Process Image (PI)

Selection of measured value type:					
MET_ID_1	**Measured Value**	**Data Type PI**	**Scaling Factor PI**		**Update Rate PI [ms]**
			1A-Variants	**5A-Variants**	
RMS current					
001	Current L3	UInt32	0.0001A	0.0005A	260
RMS voltage					
002	Voltage L3	UInt32	0.01V	0.01V	260
Distortion current					
003	Current L3	UInt32	0.01%	0.01%	260
Distortion voltage					
004	Voltage L3	UInt32	0.01%	0.01%	260
Selection of 3 harmonics:					
MET_ID_2, _3 and _4	**Measured Value**	**Data type PI**	**Scaling factor PI**		**Update Rate PI [ms]**
			1A-Variants	**5A-Variants**	
1st harmonic					
100	1st harmonic (fundamental component) L3	-depends on selected measured value			260
2nd to 41st harmonic					
1 … 40	2nd … 41st harmonic L3	-depends on selected measured value			260

5.6 Examples of Calculating the Measured Values from the process values

The format of the measured values with sign (Int16) is the two's complement. Generally, use the following equation to calculate the measured values from the process values:

Measured value = Process value x Scaling factor PI

The scaling factors are defined in section „Collections of Measured values".

Following examples of calculating:

Voltage	1A-varints	5A-variants
Process value	0x000007D0 (2000)	0x00003D76 (15734)
Scaling factor PI	0.01V	0.01V
Equation	Measured value = Process value x Scaling factor PI	
Measured value	20.00 V	157.34 V

Frequency	1A-varints	5A-variants
Process value	0x0000C3B8 (50104)	0x0000EB9C (60316)
Scaling factor PI	0.001Hz	0.001Hz
Equation	Measured value = Process value x Scaling factor PI	
Measured value	50.10 Hz	60.32 Hz

phi	1A-varints	5A-variants
Process value	0x 00004E3 (1251)	0x0000226E (8814)
Scaling factor PI	0.01 °	0.01 °
Equation	Measured value = Process value x Scaling factor PI	
Measured value	12.51 °	88.14 °

cos phi	1A-varints	5A-variants
Process value	0x FFFFFFB2 (-78)	0x00000059 (89)
Scaling factor PI	0.01	0.01
Equation	Measured value = Process value x Scaling factor PI	
Measured value	-0.78	0.89

Current
When calculating current-dependent values, the **current transformer ratio (CTR)** must be taken into account when using a current transformer.

Information

Current transformers
Current transformers are available on the market in different designs. On the primary side, currents of 20 A, 25 A, 30 A, 35 A, 40 A, 45 A, 50 A, 75 A, 100 A … 5000 A are supported, on the secondary side 1 A or 5 A.

For example, transformation ratios of 45:1 A or 200:5 A are possible. Thus, the corresponding current transformer ratios (CTR) are 1:45 and 1:40.

The I/O module allows you to set **user scaling** using WAGO-I/O-*CHECK* or via Register 32, bits 12, 13 and 14. If the bit is set to 0, user scaling is disabled and the transformation ratio of the current is 1:1. If a bit is set to 1, user scaling is enabled and the transformation ratio is already taken into account in the I/O module.

Operating current transformers the user scaling should always be on and the CTR set in the I/O module. Thus a calculation by the higher control system is not necessary. As the process values are 32 bits long in the PI even big measured values can be processed.

Information

Difference to 3-Phase Power Measurement Module 750-493/xxx-xxx
With 750-493/xxx-xxx the process values are only 16 bits long. Therefore calculations with big CTR values have to be performed by the higher control system.

The transformation ratio is set using WAGO-I/O-*CHECK* or in Registers 39, 40, 41. The **divisor of the CTR (D-CTR)** is set in the registers, i.e. according to the examples above:

- 1A-variants: CTR = 1:45, D-CTR = 45 => Registers 39, 40, 41
- 5A-variants: CTR = 1:40, D-CTR = 40 => Registers 39, 40, 41

Therefore, the following setting options and calculations for the measured values result in the process image for the current-dependent variables:

A. User Scaling OFF, Measurement with Current Transformer 1:1

Current	1A-varints	5A-variants
Register 32, bits 12 … 14	0	0
Register 39 … 41 (D-CTR)	0x0001 (1)	0x0001 (1)
Process value	0x000010A9 (4250)	0x00002062 (8290)
Scaling factor PI	0.0001A	0.0005A
Equation	Measured value = Process value x Scaling factor PI	
Measured value	0.425 A	4.145 A

Active Power	1A-varints	5A-variants
Register 32, bits 12 … 14	0	0
Register 39 … 41 (D-CTR)	0x0001 (1)	0x0001 (1)
Process value	0x00002639 (9785)	0xFFFFC618 (-14824)
Scaling factor PI	0.01W	0.05W
Equation	Measured value = Process value x Scaling factor PI	
Measured value	97.85 W	-741.20 W

Active Energy	1A-varints	5A-variants
Register 32, bits 12 … 14	0	0
Register 39 … 41 (D-CTR)	0x0001 (1)	0x0001 (1)
Register 35*	1	3
Process value	0x000022ED (8941)	0x00001126 (4390)
Scaling factor PI	0.01Wh	5Wh
Equation	Measured value = Process value x Scaling factor PI	
Measured value	89.41 Wh	21950 Wh

* Register 35: The set value defines the scaling factor PI for energy values.

B. User Scaling ON, Measurement with Current Transformer 45:1 (1A Variants) and 40:1 (5A Variants)

Current	1A-varints	5A-variants
Register 32, bits 12 … 14	1	1
Register 39 … 41 (D-CTR)	0x002D (45)	0x0028 (40)
Process value	0x0005E250 (385616)	0x0003C9D1 (248273)
Scaling factor PI	0.0001A	0.0005A
Equation	Measured value = Process value x Scaling factor PI	
Measured value	38.562 A	124.137 A

Active Power	1A-varints	5A-variants
Register 32, bits 12 … 14	1	1
Register 39 … 41 (D-CTR)	0x002D (45)	0x0028 (40)
Process value	0x000049B5 (18869)	0x0001C3F8 (115704)
Scaling factor PI	0.01W	0.05W
Equation	Measured value = Process value x Scaling factor PI	
Measured value	188.69 W	5785.20 W

Active Energy	1A-varints	5A-variants
Register 32, bits 12 … 14	1	1
Register 39 … 41 (D-CTR)	0x002D (45)	0x0028 (40)
Register 35*	2	4
Process value	0x00000D86 (3462)	0x00002CA3 (11427)
Scaling factor PI	0.1Wh	50Wh
Equation	Measured value = Process value x Scaling factor PI	
Measured value	346.2 Wh	571350 Wh

* Register 35: The set value defines the scaling factor PI for energy values.

6 Mounting

6.1 Mounting Sequence

Fieldbus couplers/controllers and I/O modules of the WAGO-I/O-SYSTEM 750 are snapped directly on a carrier rail in accordance with the European standard EN 50022 (DIN 35).

The reliable positioning and connection is made using a tongue and groove system. Due to the automatic locking, the individual devices are securely seated on the rail after installation.

Starting with the fieldbus coupler/controller, the I/O modules are mounted adjacent to each other according to the project design. Errors in the design of the node in terms of the potential groups (connection via the power contacts) are recognized, as the I/O modules with power contacts (blade contacts) cannot be linked to I/O modules with fewer power contacts.

⚠ CAUTION

Risk of injury due to sharp-edged blade contacts!
The blade contacts are sharp-edged. Handle the I/O module carefully to prevent injury.

NOTICE

Insert I/O modules only from the proper direction!
All I/O modules feature grooves for power jumper contacts on the right side. For some I/O modules, the grooves are closed on the top. Therefore, I/O modules featuring a power jumper contact on the left side cannot be snapped from the top. This mechanical coding helps to avoid configuration errors, which may destroy the I/O modules. Therefore, insert I/O modules only from the right and from the top.

Note

Don't forget the bus end module!
Always plug a bus end module (750-600) onto the end of the fieldbus node! You must always use a bus end module at all fieldbus nodes with WAGO-I/O-SYSTEM 750 fieldbus couplers/controllers to guarantee proper data transfer.

6.2 Inserting and Removing Devices

NOTICE

Perform work on devices only if they are de-energized!
Working on energized devices can damage them. Therefore, turn off the power supply before working on the devices.

6.2.1 Inserting the I/O Module

1. Position the I/O module so that the tongue and groove joints to the fieldbus coupler/controller or to the previous or possibly subsequent I/O module are engaged.

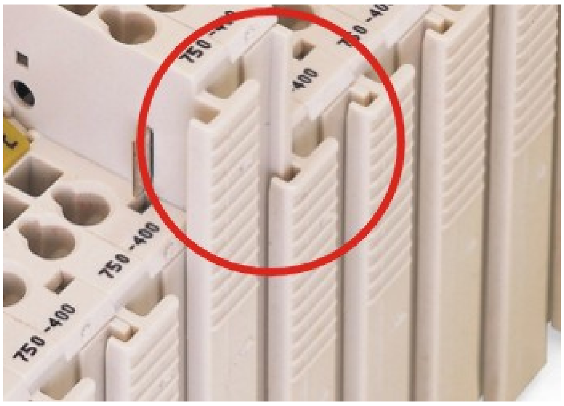


Figure 11: Insert I/O Module (Example)

2. Press the I/O module into the assembly until the I/O module snaps into the carrier rail.

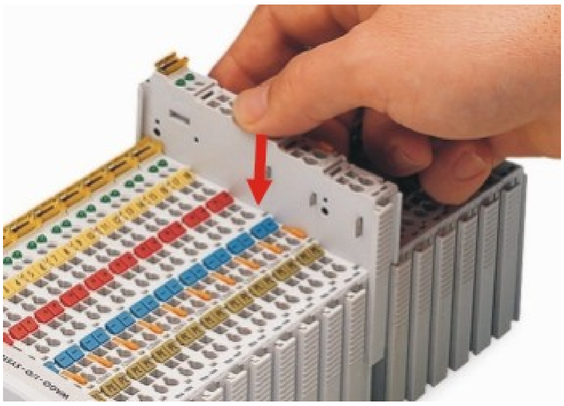


Figure 12: Snap the I/O Module into Place (Example)

With the I/O module snapped in place, the electrical connections for the data contacts and power jumper contacts (if any) to the fieldbus coupler/controller or to the previous or possibly subsequent I/O module are established.

6.2.2 Removing the I/O Module

1. Remove the I/O module from the assembly by pulling the release tab.

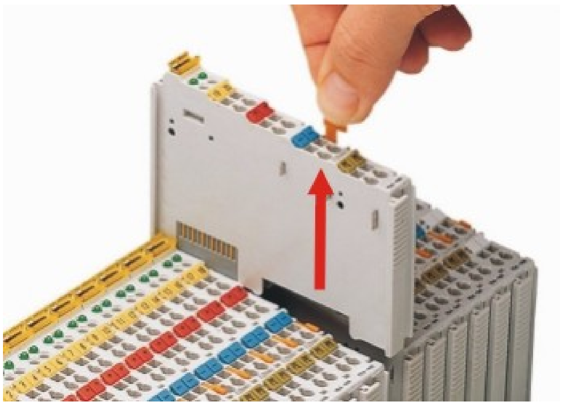


Figure 13: Removing the I/O Module (Example)

Electrical connections for data or power jumper contacts are disconnected when removing the I/O module.

7 Connect Devices

7.1 Connecting a Conductor to the CAGE CLAMP®

The WAGO CAGE CLAMP® connection is appropriate for solid, stranded and finely stranded conductors.

Note

Only connect one conductor to each CAGE CLAMP®!
Only one conductor may be connected to each CAGE CLAMP®.
Do not connect more than one conductor at one single connection!

If more than one conductor must be routed to one connection, these must be connected in an up-circuit wiring assembly, for example using WAGO feed-through terminals.

1. For opening the CAGE CLAMP® insert the actuating tool into the opening above the connection.

2. Insert the conductor into the corresponding connection opening.

3. For closing the CAGE CLAMP® simply remove the tool. The conductor is now clamped firmly in place.

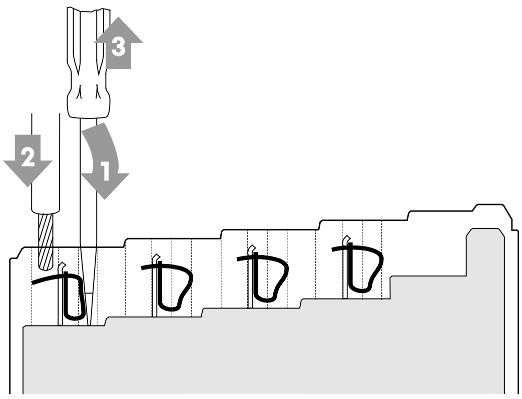


Figure 14: Connecting a Conductor to a CAGE CLAMP®

7.2 Voltage Measurement

In order to measure just the 3 phase voltages of a supply network, connect its 4 wires with the CAGE CLAMPS® L1, L2, L3 and N.

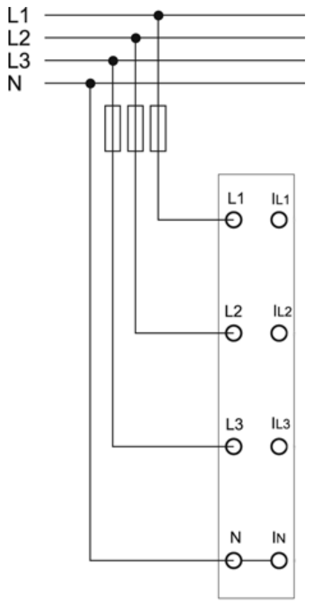


Figure 15: Voltage Measurement

⚠ CAUTION

Use safety fuses in voltage paths.
To protect the voltage path against short circuit and overload, apply a safety fuse (0.5 A, slow).

For applications in areas covered by UL, only safety fuses having a UL approval are permitted for use.

NOTICE

Do not confuse the current and voltage connections
When connecting, be sure not to confuse the current and voltage paths, since direct connection of the line voltages to the low-impedance current inputs will destroy the I/O module.

NOTICE

Strictly observe the connection diagram!
In order to avoid damage to the I/O module and to achieve the specified measuring accuracy, strictly observe the connection diagram!

If you want to measure the currents simultaneously, consider the section “Power Measurement” below.

7.3 Current Measurement

7.3.1 Current Measurement on a Motor

For measuring the currents of a 3 phase electrical motor connect it with the CAGE CLAMPS® IL1, IL2, IL3 and IN via current transformers.

DANGER

Connect CAGE CLAMP® N to earth, if not connected to the neutral wire!
If you do not connect the CAGE CLAMP® N with the neutral wire of the supply network (e.g. using the module for pure current measurement) you must connect N to earth PE to avoid hazardous voltages in the event of faults!

DANGER

For current messurement, alsways use current transformers!
Generally use current transformers for current measurement!

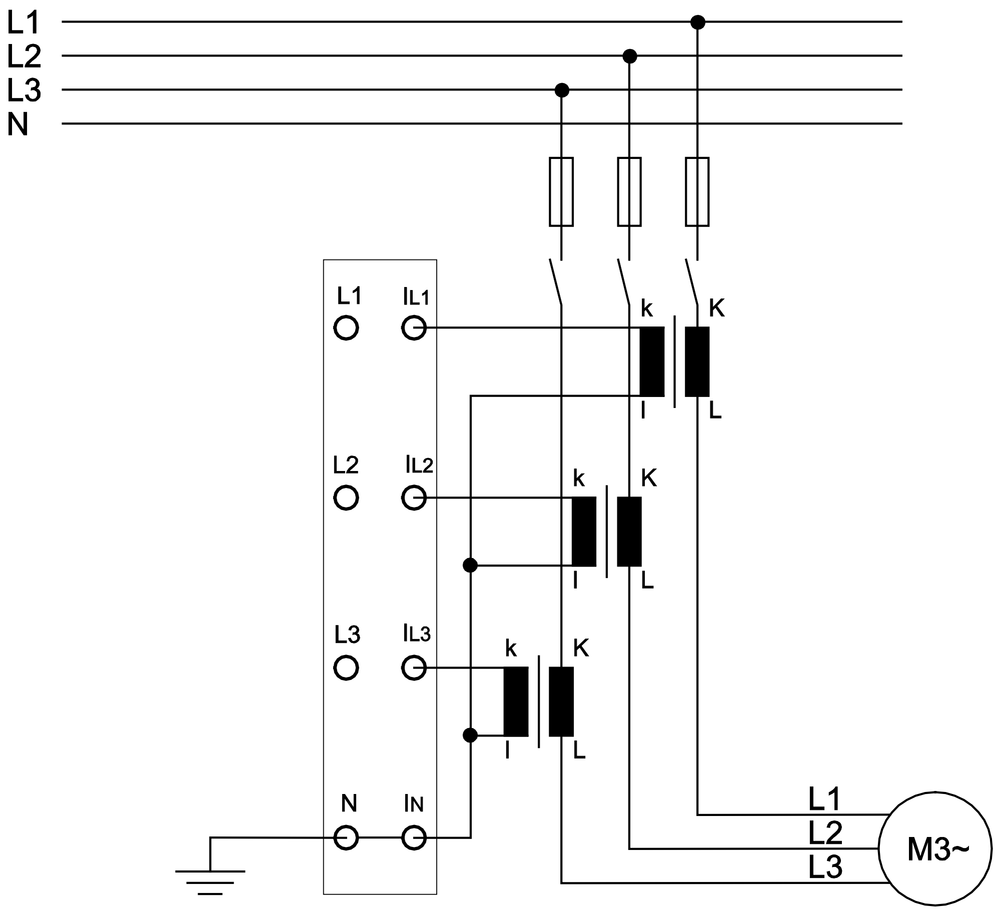


Figure 16: Current Measurement on a Motor

7.3.2 Current Transformers

Normally, the selection of the current transformers is not a critical factor. The internal resistance in the current path of the 3-phase power measurement module is so low that it can be neglected when considering the overall resistance of the current loop.
The transformers must provide a rated secondary current of 1 A resp. 5 A. The rated primary current I_{pn} shall be equal or higher than the currents to be measured. The normal, permissible overload level of 1.2 x I_{pn} presents no problem for the 3-phase power measurement module, but can, however, lead to minor measurement inaccuracies.

NOTICE

Do not operate with open load!
Please note that current transformers from some manufacturers shall not be operated with an open output circuit! Connect the I/O modules to the current transformers' secondary windings before commissioning the current transformers!

7.3.2.1 Accuracy

Please note that the overall accuracy of the measuring setup consisting of the 3-phase power measurement module and the current transformers essentially depends on the transformers' accuracy category.

Note

Do not use transformers of class 0.5 for accounting purposes!
A measuring system with a class 0.5 current transformer cannot be approved or certified for accounting purposes as the 3-phase power measurement module is not an approved utility billing meter as defined in the standard for electricity meters (DIN 43 586).

7.3.2.2 Types of Current

The 3-phase power measurement module can measure periodic signals with a fundamental frequency (line frequency + tolerance) of 45 Hz to 65 Hz with upper harmonic components up to a frequency of 3.3 kHz (with 65 Hz fundamental frequency).

7.3.2.3 Overcurrent Limiting Factor FS

The overcurrent limiting factor (FS) for current transformers indicates at which multiple of its rated primary current saturation occurs which protects the connected measuring instruments. FS shall be max. 10 for the 1 A module resp. max. 5 for the 5 A module.

NOTICE

Note the max. continuous measuring current of 1 A resp. 5 A!
The max. continuous measuring current of the module is 1 A resp. 5 A. If the used transformers allow greater secondary currents than 1 A resp. 5 A install additional transformers with an appropriate transforming ratio!

7.3.2.4 Protection against Shock Hazard Voltages

No hazardous voltage is produced when the 3-phase power measurement module is used as specified, with appropriate current transformers. Secondary voltage is only a few Volts. Nevertheless, the following faults can result in high voltage levels:

- Open current path for one or more transformers
- Disconnected/cut N conductor at the voltage measuring end of the 3-phase power measurement module
- General insulation faults

DANGER

Install protection against electric shock!
All wiring for the measurement system shall be equipped with protection against shock hazard voltages along with the corresponding safety signs!

The 3-phase power measurement module permits a maximum voltage of 480 V for normal operating conditions. The voltages at the voltage inputs shall not exceed 480 V. For higher voltages use a transformer stage. This one however, shall not produce a phase angle shift (Yy0)!

The 3-phase power measurement module is equipped with a protective impedance of 1072 kΩ at the voltage measurement end. If the N conductor is not connected, and only one of the three voltage measuring terminals is under power, a voltage of 230 VAC to ground is yielded in a 3-phase system with a phase-to-phase voltage of 400 VAC. This voltage is also present at the current measuring end and can be measured using a multimeter with 10 MΩ input resistance. This does not represent an insulation fault.

7.3.3 Additional Measuring Instruments in the Current Path

Please note that adding measuring instruments (such as ammeters) in the current path can substantially increase the total apparent power.
In addition, the CAGE CLAMP® IN of the I/O module must form a star point (neutral) for the three secondary windings. See figure above. Therefore, additional measuring instruments must be potential-free and wired accordingly.

7.4 Power Measurement

7.4.1 Power Measurement on a Machine

For measuring power, all of the eight CAGE CLAMPS® have to be connected according to the figure below.

NOTICE

Do not confuse current and voltage clamps!
When making the connections do not confuse the current and voltage paths, as connecting the phase voltages directly to the low impedance current clamps IL1 … IL3 shall destroy the I/O module and lead to critical states!

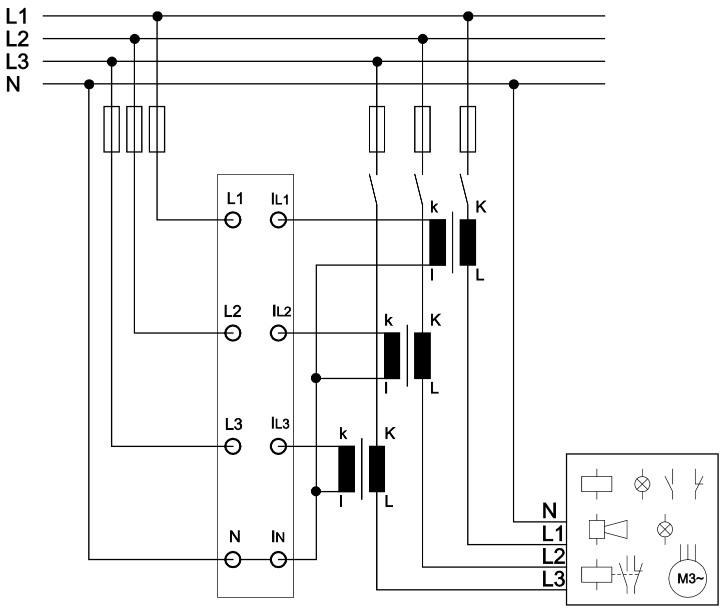


Figure 17: Power Measurement on a Machine

Note

Negative power values!
If you measure negative power values, check the connection of the associated current transformer circuit in the proper direction.

7.4.2 Power Measurement on Two Motors Regulated by Frequency Converters

The example here illustrates power measurement on two 3-phase motors regulated by a frequency converter (ac power converter) used e. g. in a conveyor system. Each of these motors is monitored by a 3-phase power measurement module.

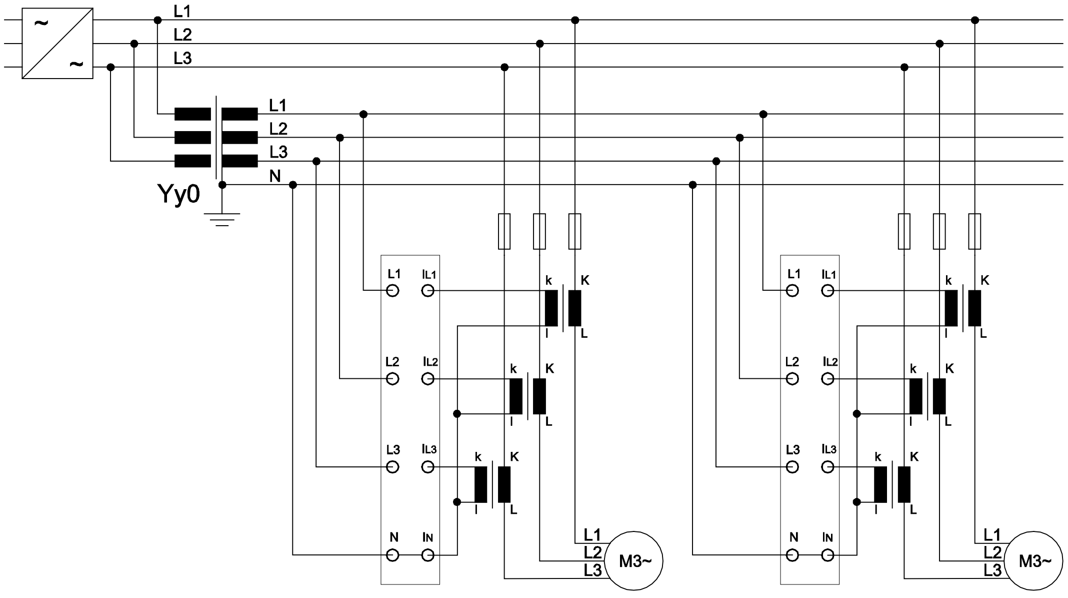


Figure 18: Power Measurement on Two Motors Regulated by Frequency Converters

The galvanic separation achieved by the 3-phase transformer (Yy0) allows measurement after the frequency converter.

DANGER

CAGE CLAMP® N must be connected to earth!
Based on the galvanic separation by the 3-phase transformer, you must ground CAGE CLAMP® N of the I/O modules to prevent any excessive, hazardous voltage in the event of a current transformer fault.

Note

Transformation ratio 1:1 !
The three-phase transformer must have a transformation ratio of 1:1 and may not produce any phase shifting in the supply network (Yy0)!

As the high-frequency portions only have a minor effect on the motors, distortion caused by the 3-phase transformer during transmission of the harmonic waves generated by the frequency converter will have virtually no effect on practical measurement.

Distribution of the power is mapped very well, thanks to the use of one I/O module for each motor. This also allows to detect elevated current consumptions by every single motor at an early stage.

8 Commissioning

The I/O module latched in the bus node and wired for the measurement can be put into operation using the WAGO-I/O-*CHECK* software for Windows. For that, the fieldbus coupler/controller of the node is connected, for example, to the USB port of a PC using the WAGO USB communication cable.

WAGO-I/O-*CHECK* provides the following functions:

- Graphic display of the bus node
- Display, recording and export of the process data (measured values)
- Application settings
- Settings for the measurements for each of the three phases
- I/O module settings
- Settings for saving the energy values
- Saving all settings

Information

WAGO-I/O-*CHECK*
You can obtain the WAGO-I/O-*CHECK* software on a CD under Item No. 759-302. This CD contains all the application program files and a description.
The description is also available in the Internet at http://www.wago.com under Documentation > WAGO Software > WAGO-I/O-*CHECK*.

To display the bus node on the PC, use the USB communication cable to connect coupler/controller and PC and launch WAGO-I/O-*CHECK*.

8.1 Configuration with WAGO-I/O-*CHECK*

Right-click on the image of the I/O module and select the **[Settings]** menu item.

See the figure below:

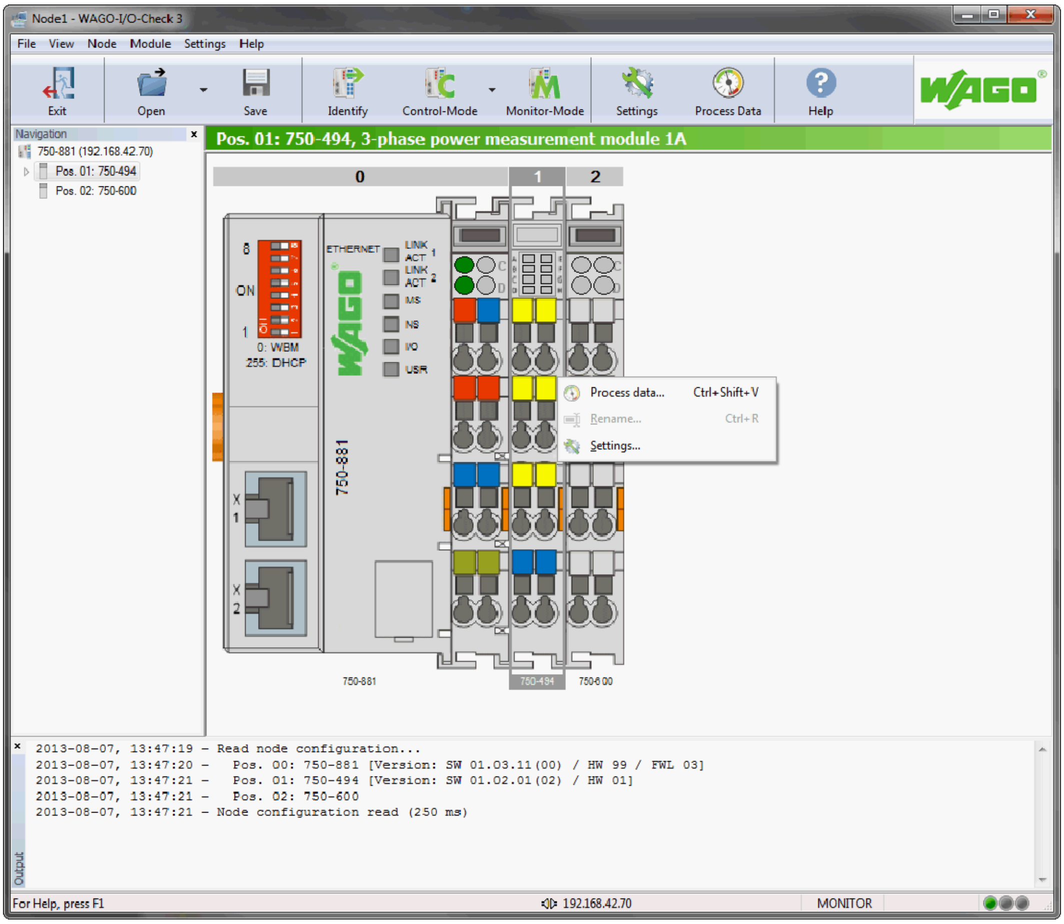


Figure 19: WAGO-I/O-*CHECK* User Interface, Bus Node With I/O Module 750-494

The "3-Phase Power Measurement" dialog opens. See figure below.

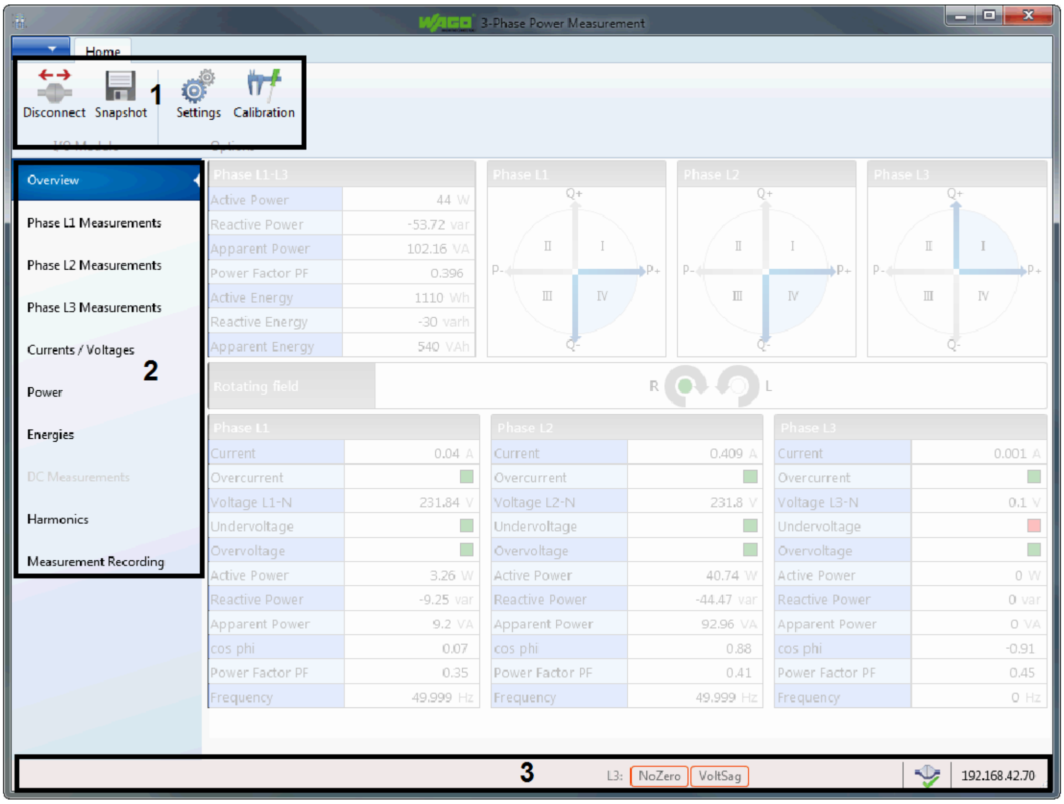


Figure 20: „3-Phase Power Measurement“ Dialog

The following buttons appear in the **Home (1)** ribbon:

[**Disconnect**]	Separates the fieldbus coupler/controller from the PC
[**Snapshot**]	Opens a "Save as" standard dialog to save all actual measured values, I/O module settings and error messages from the status bar (3) as a CSV file. In this dialog, enter a file name and select a location to save the file, e.g. see section "Appendix".
[**Settings**]	Opens the settings dialog.
[**Calibration**]	Opens the calibration dialog. More information is available from the WAGO Support.

The buttons for the individual **measured value views** appear in the **menu (2)**.

The **status bar (3)** displays the connection icon and IP address of the fieldbus coupler/controller or the name of the COM port. Per phase possible error messages are shown. These are:

- No Zero (no zero crossing)
- VoltClip (voltage override - clipping)
- CurClip (current override - clipping)
- VoltSag (high measuring error - undervoltage)

Click **[Settings]** to open the "Settings" dialog in which you can configure the application and I/O module.

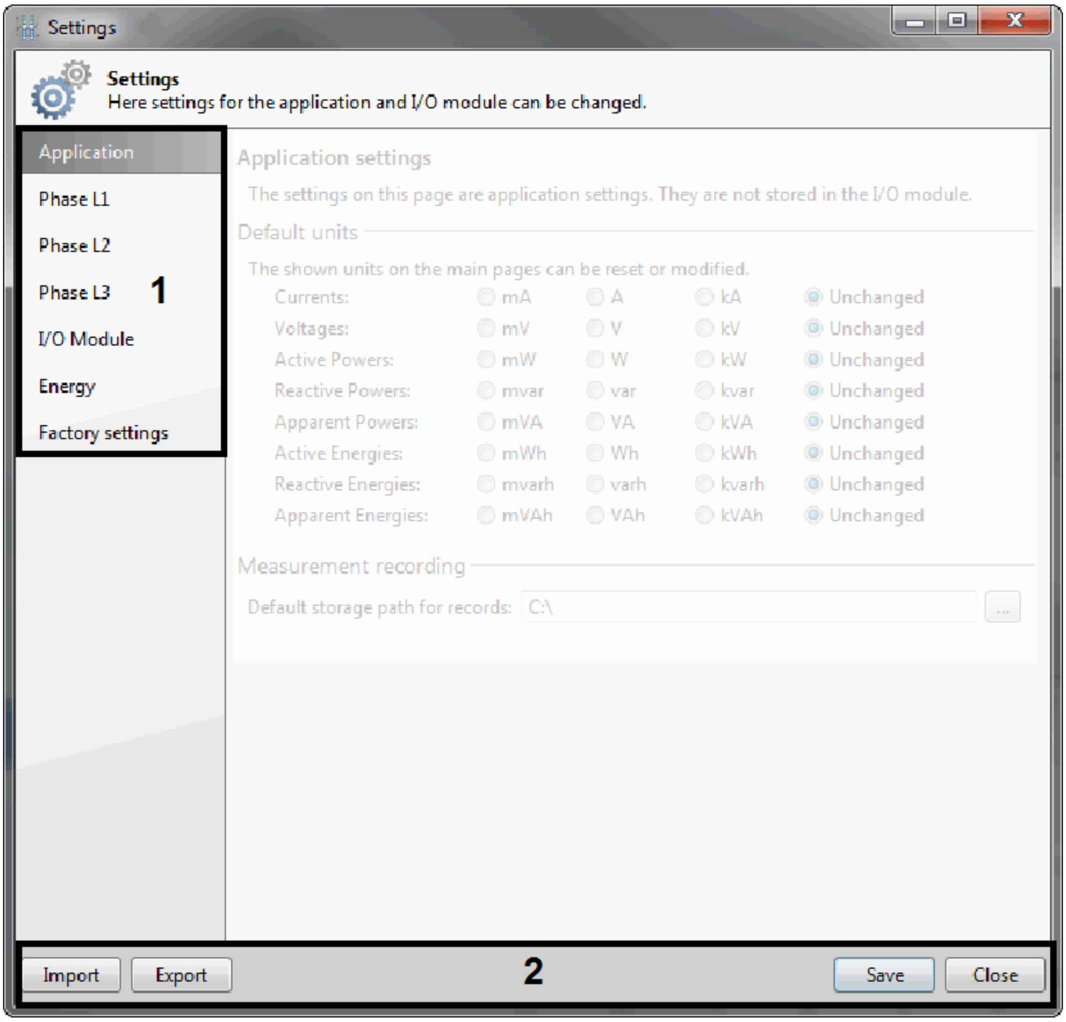


Figure 21: „Settings“ Dialog

The **main menu (1)** with the Application, Phase L1, Phase L2, Phase L3, I/O Module, Energy and Factory Settings tabs are on the left side. These are explained in more detail in the following sections.

At the window's bottom you can find the **command bar (2)** with 4 buttons.
Use **[Import]** to load the settings from your hard drive that you may have already saved when setting up another I/O module. You can change these settings if necessary and then **[Save]** them to the I/O module.
Use **[Export]** to save the current settings to your computer to simplify future configurations.

Note

Pay attention to energy values!
The energy values are not taken into account when importing and exporting!

[Save] writes any changed settings to registers, i.e. the configuration of the I/O module and the application settings are changed. The "Settings" dialog closes.
To not save and discard the changed settings, click **[Close]**. The "Settings" dialog closes.

8.1.1 “Application“ Tab

Make application settings in the "Application" tab. These settings are not stored in the I/O module, but on the connected PC.

You specify again the decimal multiples for displaying the measuring units for the various measured variables or keep them:
10^{-3}=milli or 10^{0}=1 or 10^{3}=kilo.

In addition, you specify the storage path for the measured value records. See "Measurement Recording" in the following section "Displaying the Measured Values via WAGO-I/O-*CHECK*".

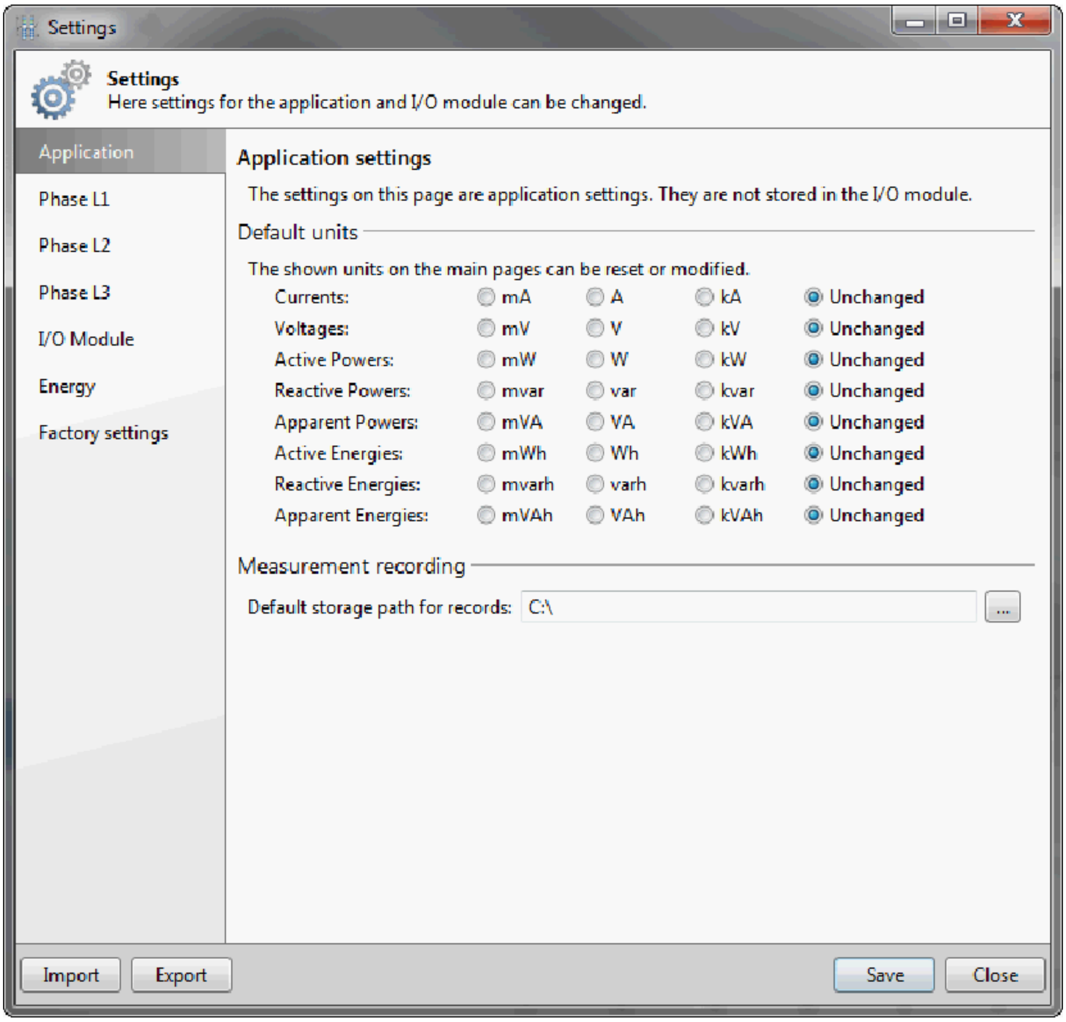


Figure 22: „Application“ Tab

8.1.2 "Phase L1", "Phase L2", "Phase L3" Tabs

Use the "Phase L1", "Phase L2", "Phase L3" tabs to configure user scaling, min.-/max. values and general parameters. These settings are saved to the I/O module.

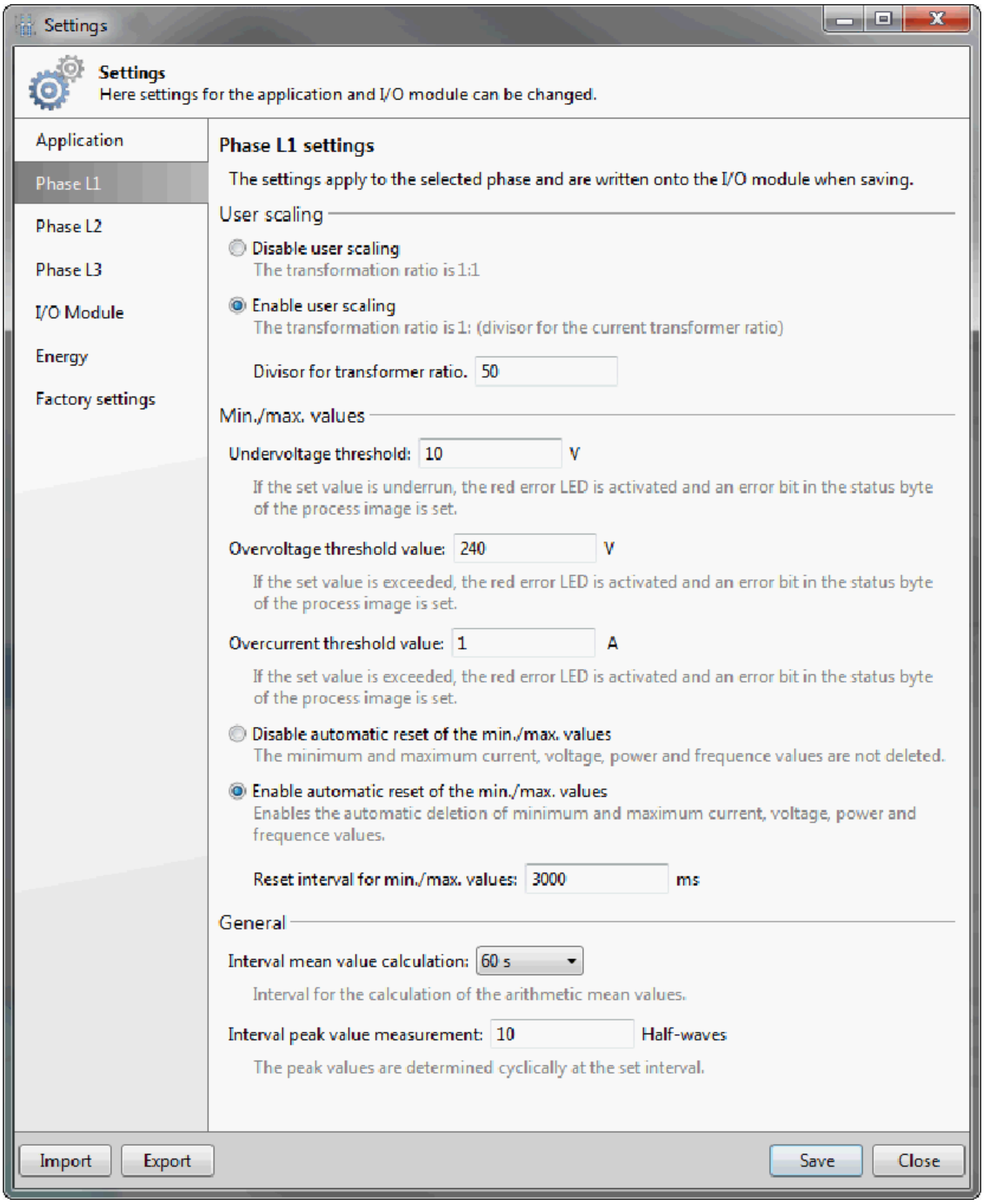


Figure 23: „Phase L1“ Tab

Specify in user scaling whether you want to take into account the current transformer ratio CTR when calculating the measured values in the respective phase or not. If yes, specify the divisor of the current transformer ratio D-CTR, e.g. "50 ". Register 32 and 39 … 41 are written. For details, see section „Process Image“.

For „Min.-/Max. values“ specify the thresholds for undervoltage, overvoltage and overcurrent. Under- resp. overshooting one of these values results in setting an error bit in the status byte of the process image and activating a red error LED. Also, define whether the min.-/max. values of current, voltage, power and frequency are automatically reset after a specific time or not. If yes, set the reset interval.

Further, two general settings can be done: the time intervals for the calculation of the arithmetic mean values (in s) and detecting the peak values (in half-waves).

8.1.3 “I/O Module“ Tab

On the "I/O Module" tab you can do settings for the entire I/O module. Make general settings, delete min.-/max. values and configure the energy measurement.

For „General“ choose the frequency of the supply grid and the phase for the peak value measurement (only one phase). You can enable DC measurement and watchdog. The watchdog deactivates the green status LED A if no process data is received within 200 ms. DC measurement is not permitted and thus not supported.

For "Min.-/Max. values" you can reset specific min.-/max. values by selecting them and clicking **[Delete]**. This action is executed immediately.

For „Energy“ select the scaling factor from the list. The energy values are then shown accordingly.
Set the interval for cyclically saving the energy values.
At last, you can enter threshold values for measuring active, reactive and apparent energy. This way creepage currents are ignored. The energy measurement is interrupted as soon as these thresholds are undershot. The parameters 40, 41 and 42 „NOLOAD“ are written.

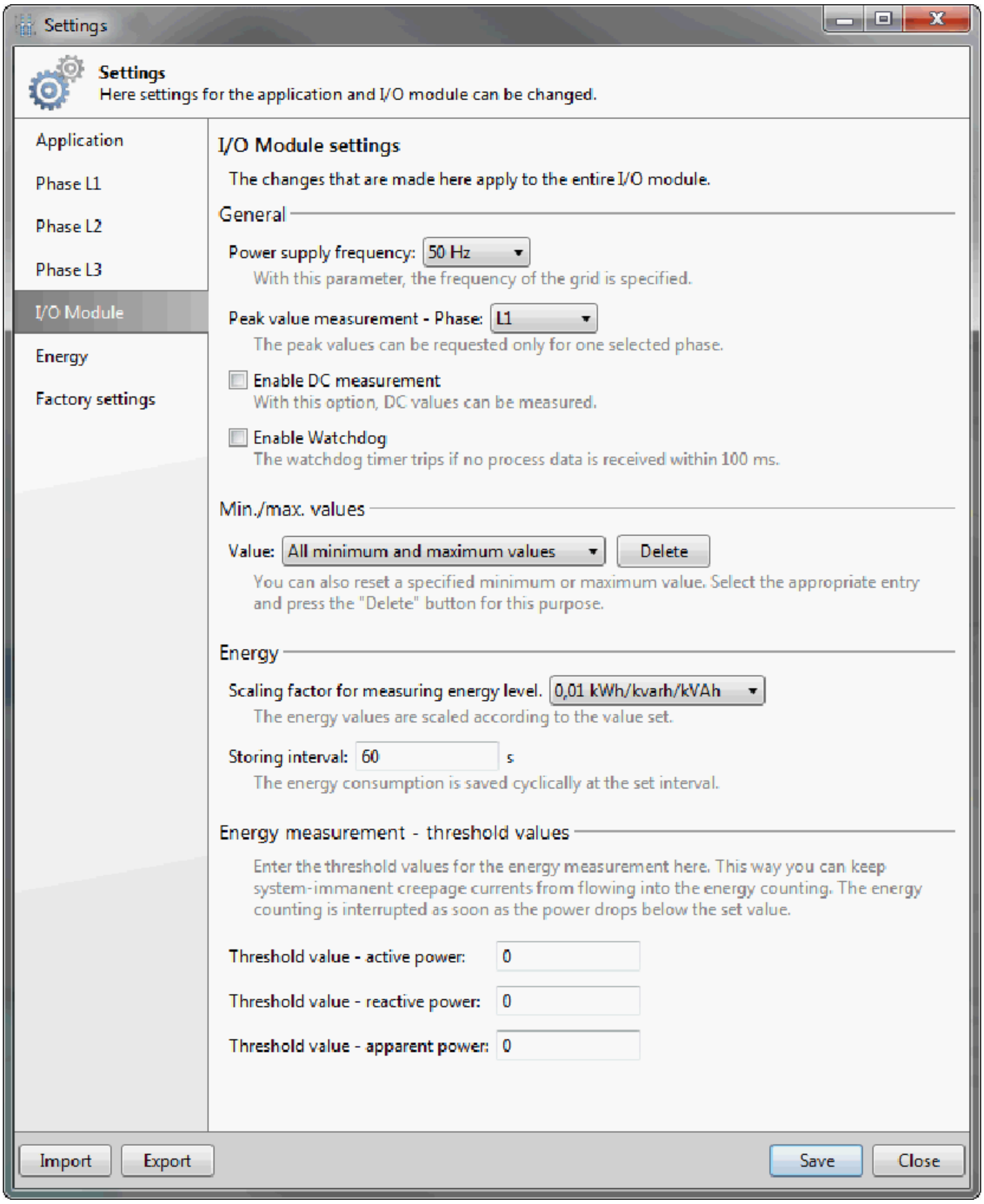


Figure 24: „I/O Module“ Tab

8.1.4 “Energy“ Tab

After entering a password, you can set or reset the energy values per phase on the "Energy" tab. The initial password is: wago. Please change this password on first use by clicking **[Change password]**. Should you have forgotten the password deinstall and install again the application “3-Pase Power Measurement”. This way the initial password is valid again.

The I/O module registers the energy consumption and saves the values cyclically. With [**Save**] and [**Delete**] you can save the values at any time regardless the cycle or reset them to 0.

You can further set a specific value by choosing the energy from the list, entering a value in milliwatt hours and [**Save**] it. The energy measurement starts at this set value.

These actions are carried out immediately and cannot be undone. Therefore, the **[Save]** button is disabled at the bottom of the window.

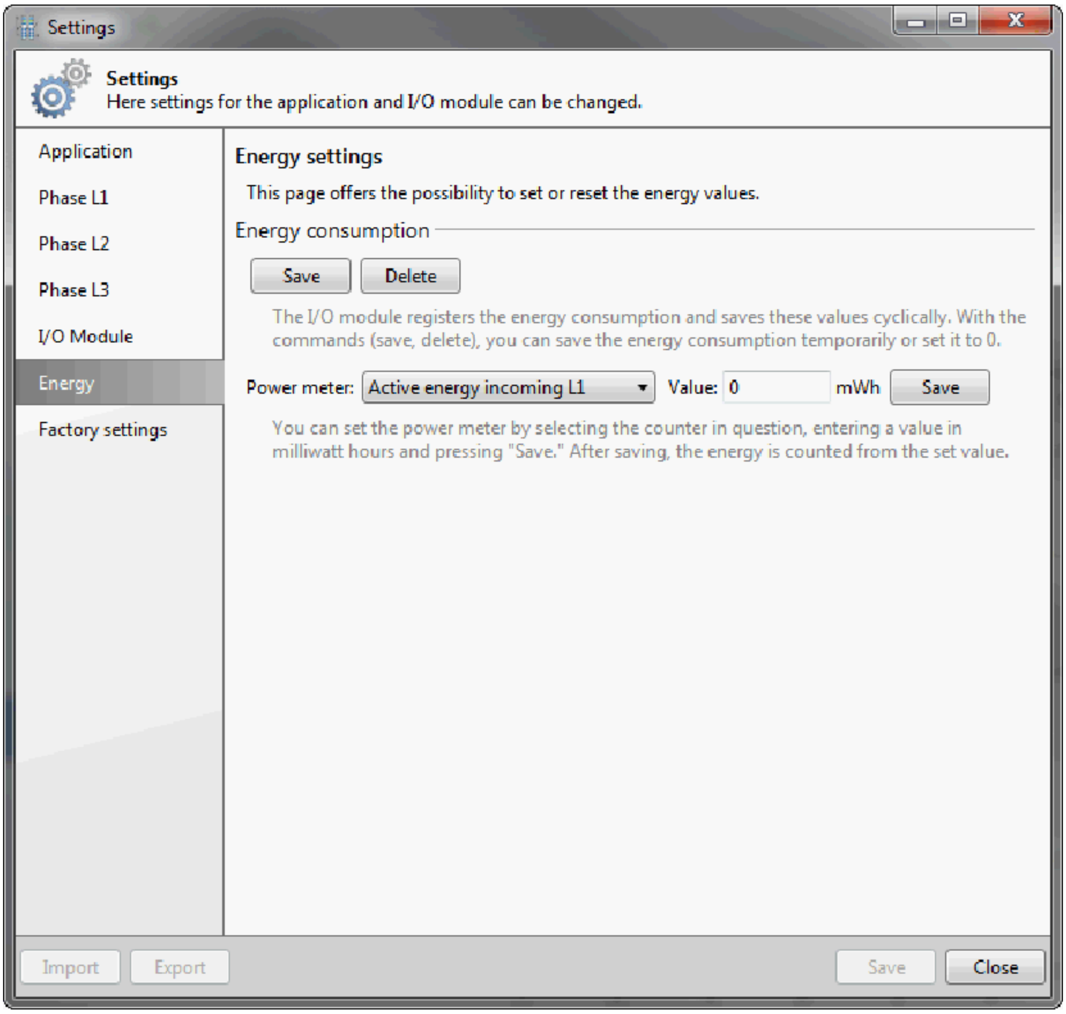


Figure 25: “Energy” Tab

8.1.5 "Factory Settings" Tab

After entering a password (see "Energy" tab above), you can reset all parameters of the I/O module to their factory settings on the "Factory Settings" tab.

Information

List of factory settings
A list of factory settings may be found in section “Appendix”.

Use I/O Module Settings [**Restore**] to reset the I/O module settings only. Calibration data remains unchanged.
Use Calibration Data **[Restore]** to reset the calibration data only. The I/O module settings remain unchanged.
Use Total **[Restore]** to reset all I/O module settings and calibration data.
These actions are carried out immediately and cannot be undone. Therefore, the **[Save]** button is disabled at the bottom of the window.

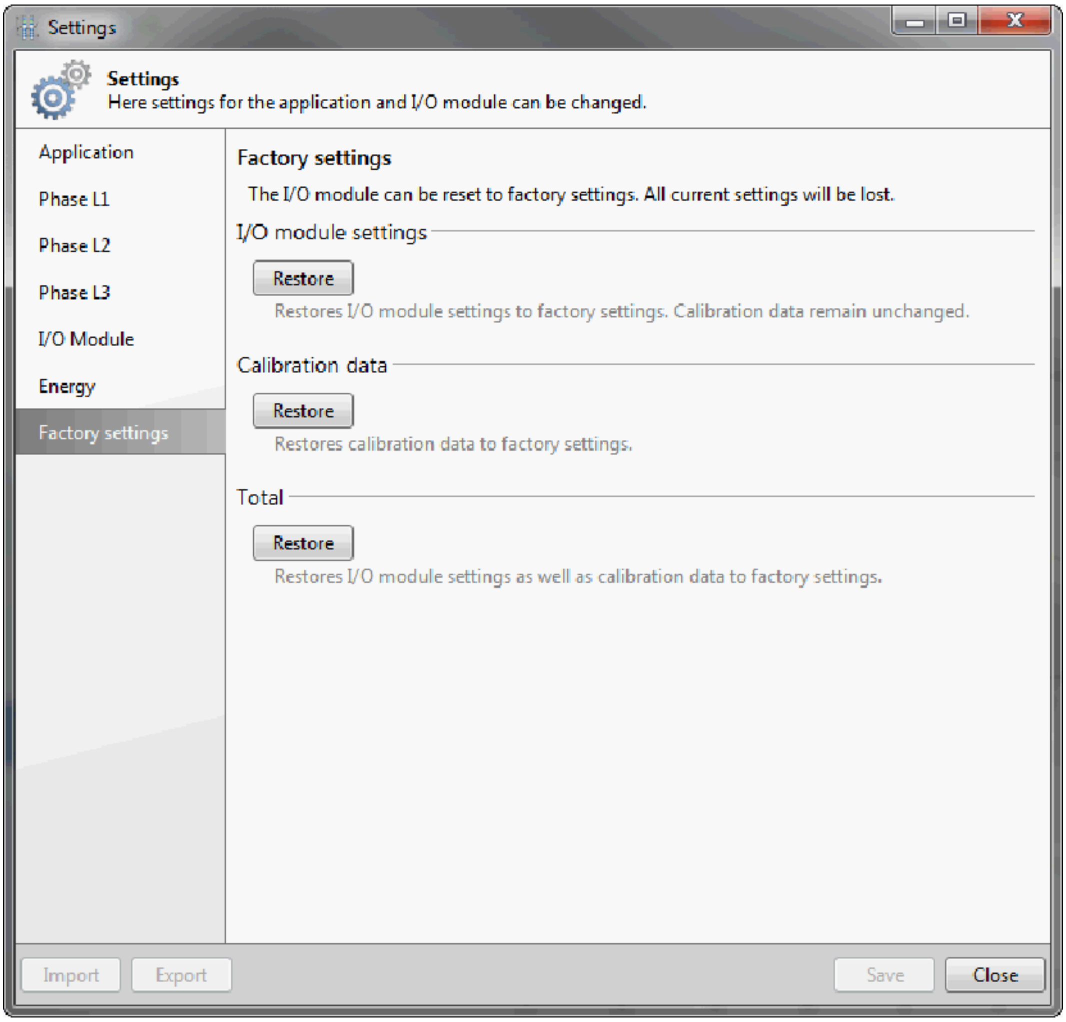


Figure 26: “Factory Settings” Tab

8.2 Displaying the Measured Values via WAGO-I/O-*CHECK*

The measured values are displayed in the "3-phase power measurement" dialog in several views, to be found in menu (2) on the left side:

- Overview
- Phase Lx Measurements
- Currents/Voltages
- Power
- Energies
- DC Measurements
- Harmonics
- Measurement Recording

These views are described in detail on the following pages.

The **Overview** view displays the measured values of all three phases continuously. These are:

- A sum view (Phase L1-L3) with active, reactive and apparent power, power factor PF, active, reactive and apparent energy.
- 4-quadrant display per phase
- Rotating field of the 3-phase supply network
- Current, voltage Lx-N, active, reactive and apparent power, cos phi, Power factor PF and frequency per phase. Overcurrent, under and overvoltage are identified as a red square, if not present as a green one.

Information

Change of the Measuring Units!
Specify the prefixes of the measuring units by selecting Home > Settings > Application. See section "Configuration with WAGO-I/O-*CHECK*" > "Application" Tab.
The units can only be changed in the lists with the same physical variables. For lists with different variables, base units are always used!

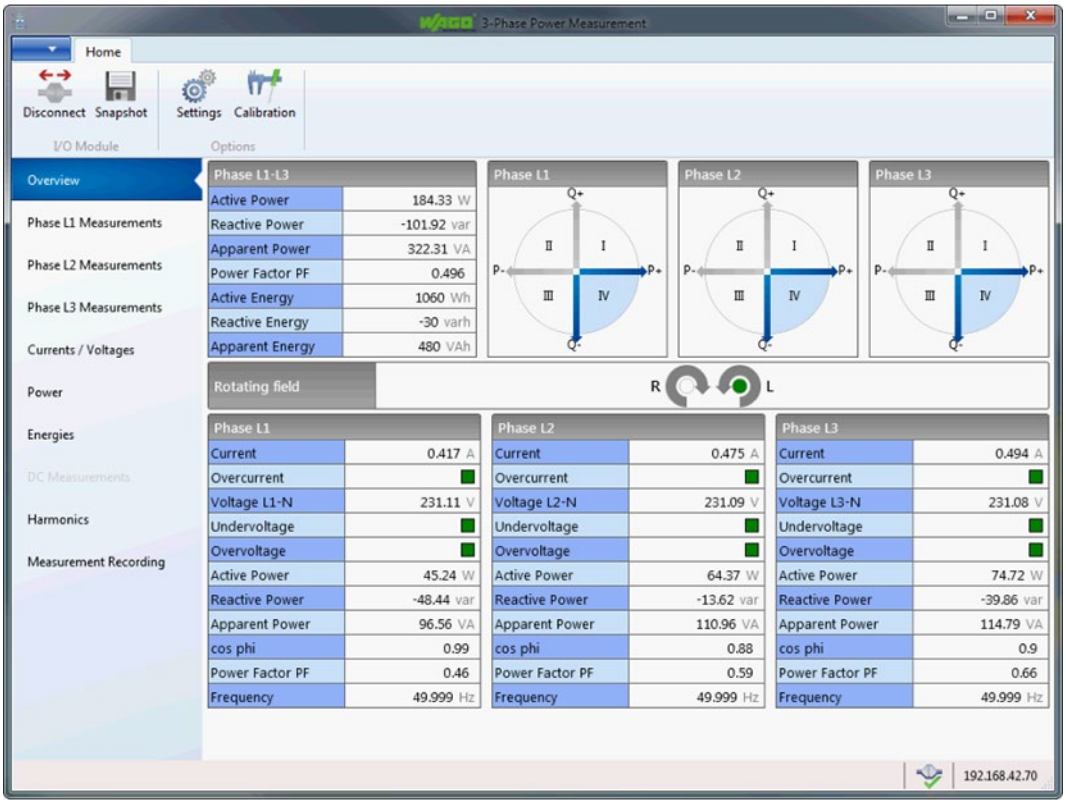


Figure 27: Measured Values – Overview

Selecting **Phase L1 (resp. L2 or L3) Measurements**, the measured values of the respective phase are displayed in detailed including min., max., average and peak values. Note: Peak values are only displayed if this phase was selected for peak value measurement. See section "Configuration with WAGO-I/O-*CHECK*" > "I/O module" Tab. Overcurrent, under and overvoltage are identified as a red square, if not present as a green one.

- Current
- Voltage Lx-N
- Phase-to-phase voltage
- Active power
- Reactive power
- Apparent power
- 4-quadrant display
- cos phi, power factor PF, power factor LF
- Active energy
- Reactive energy
- Apparent energy

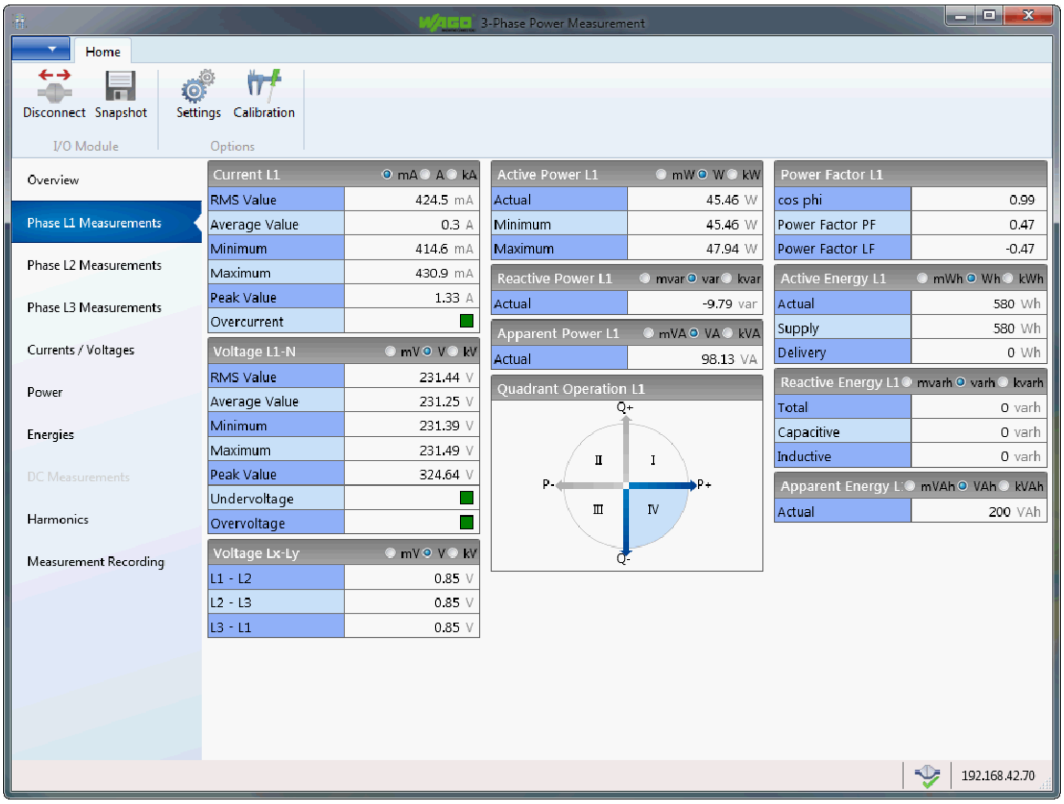


Figure 28: Measured Values – Phases

Currents/Voltages displays all currents, voltages, phase angles and frequencies, including min., max., average and peak values.
Note: Peak values are only displayed for the phase which was selected for peak value measurement. See section "Configuration with WAGO-I/O-*CHECK*" > "I/O module" Tab.

Overcurrent, under and overvoltage are identified as a red square, if not present as a green one.

- Current
- Voltage Lx-N
- Phase-to-phase voltage
- Phase angle
- Frequency

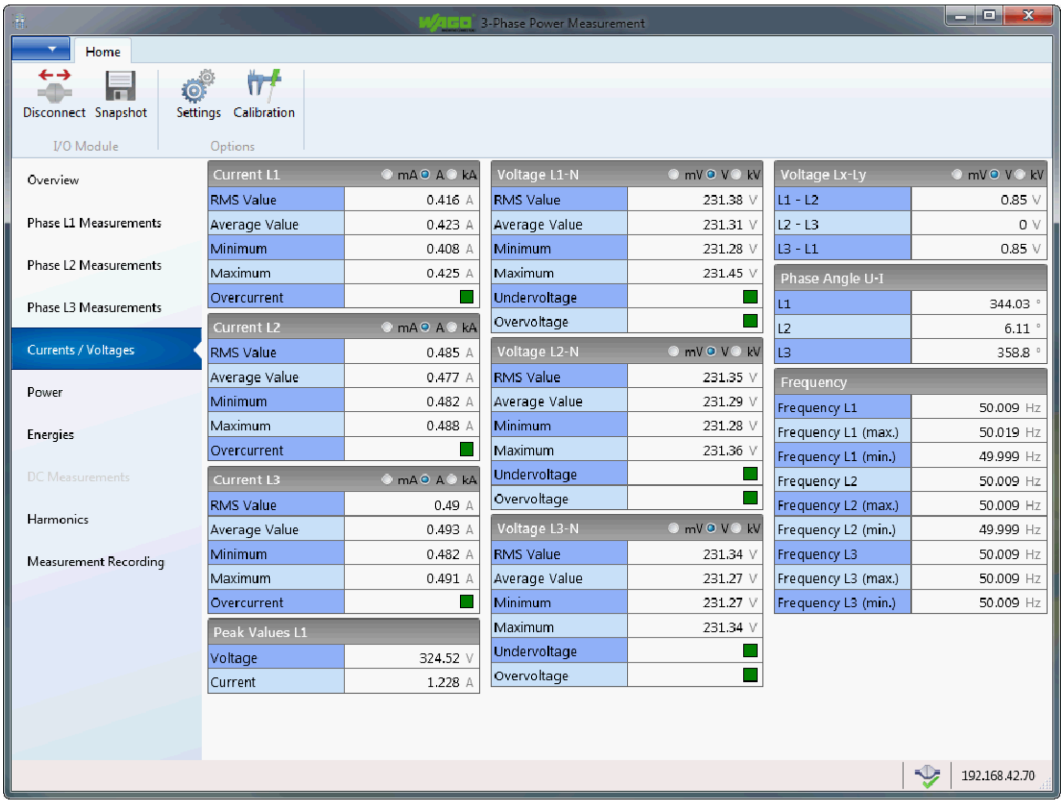


Figure 29: Measured Values – Currents and Voltages

If you select **Power**, you see active, reactive and apparent power of all 3 phases with min. and max. values, the power factors and the 4-quadrant displays.

- Active power
- Reactive power
- Apparent power
- cos phi, power factor PF, Power factor LF
- 4-quadrant displays

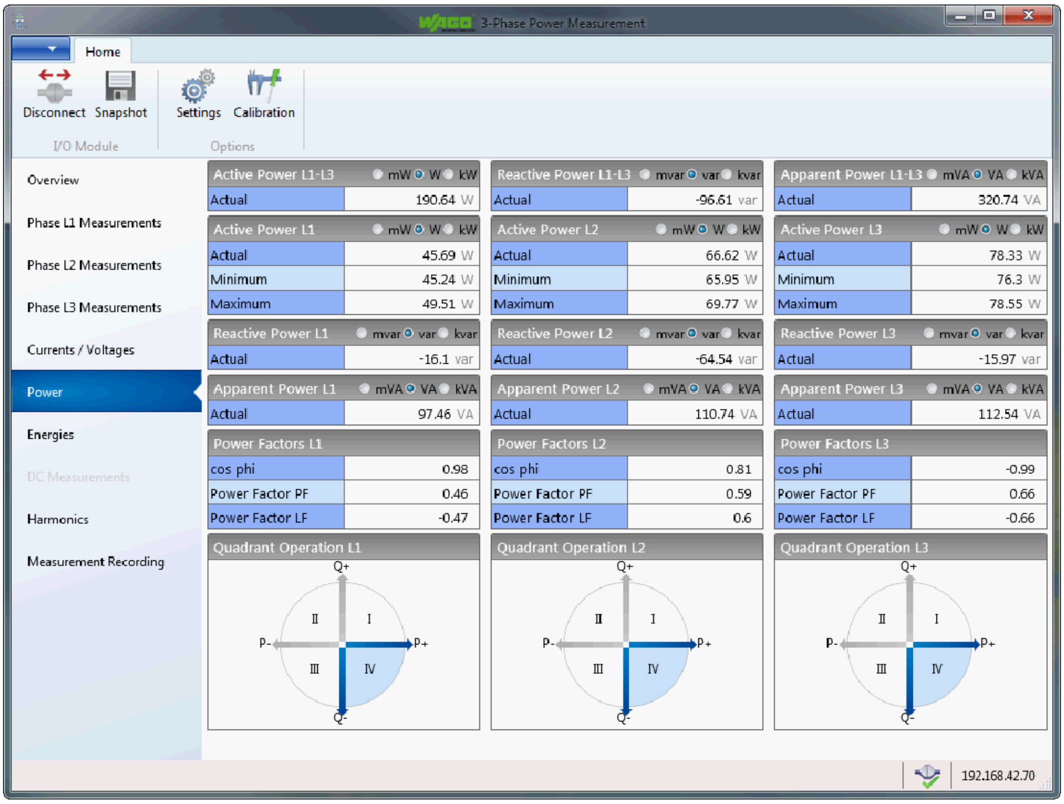


Figure 30: Measured Values – Power

If you select **Energies**, you see the active energies with supply and delivery, reactive energies with capacitive and inductive component and the apparent energies that have been consumed/generated since the beginning of the measurement.

- Active energy
- Reactive energy
- Apparent energy

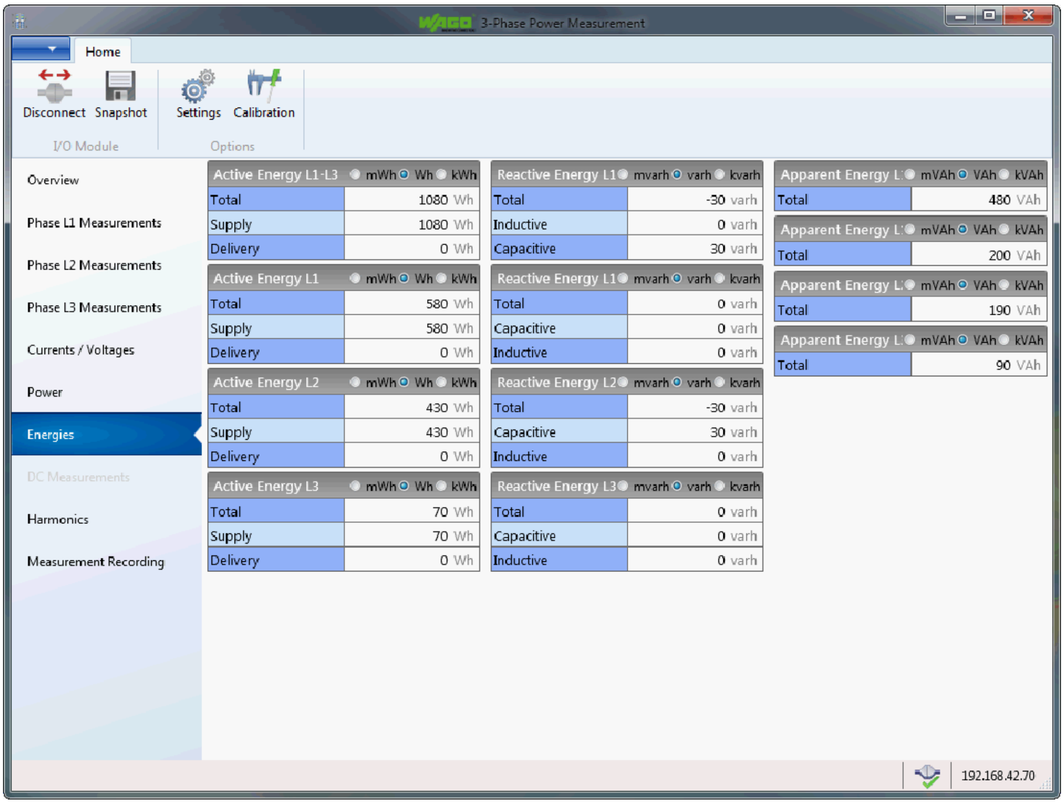


Figure 31: Measured Values – Energies

Selecting **DC Measurements** is not supported. DC measurement is not permitted.

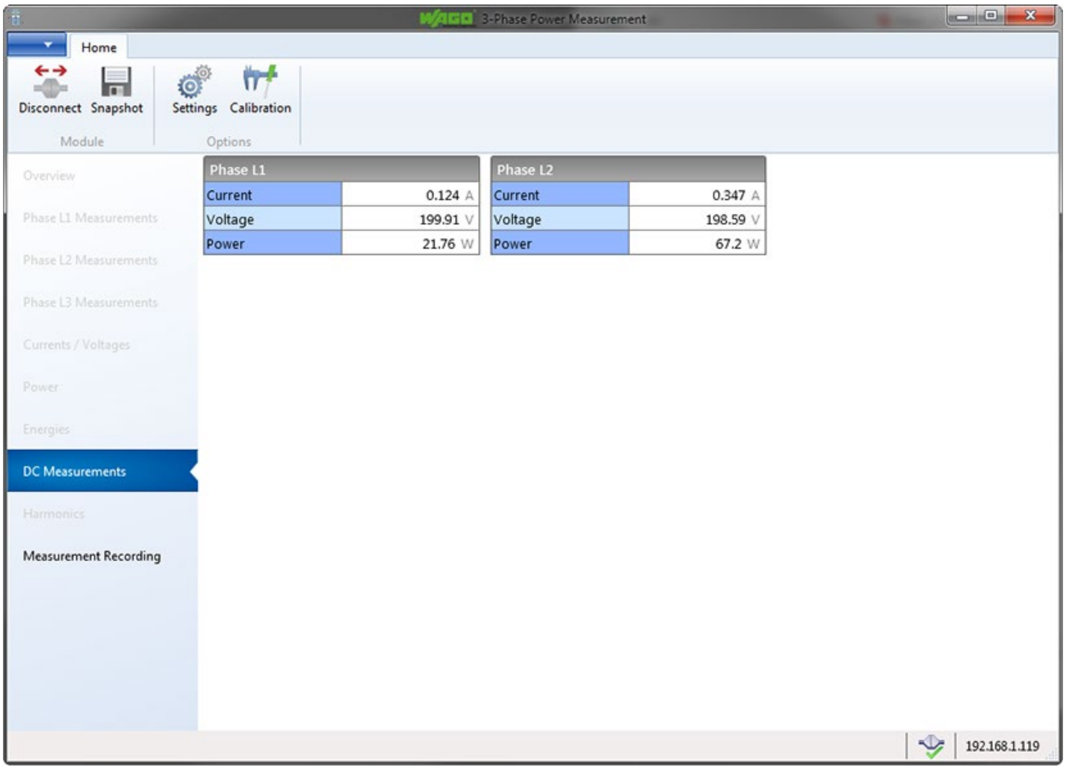


Figure 32: Measured Values – DC

If you select **Harmonics** you get a chart or a table regarding the 40 harmonics of the phases. The tab „Harmonics analysis“ opens.

Here you select chart or table view, the phase to be analyzed and the measured value (voltage or current).

The **Chart View** shows:

- Voltage resp. current of 40 harmonics (no. 2 to 41)
- Supply network frequency (actual, max. and min. value)
- Total harmonic distortion THD

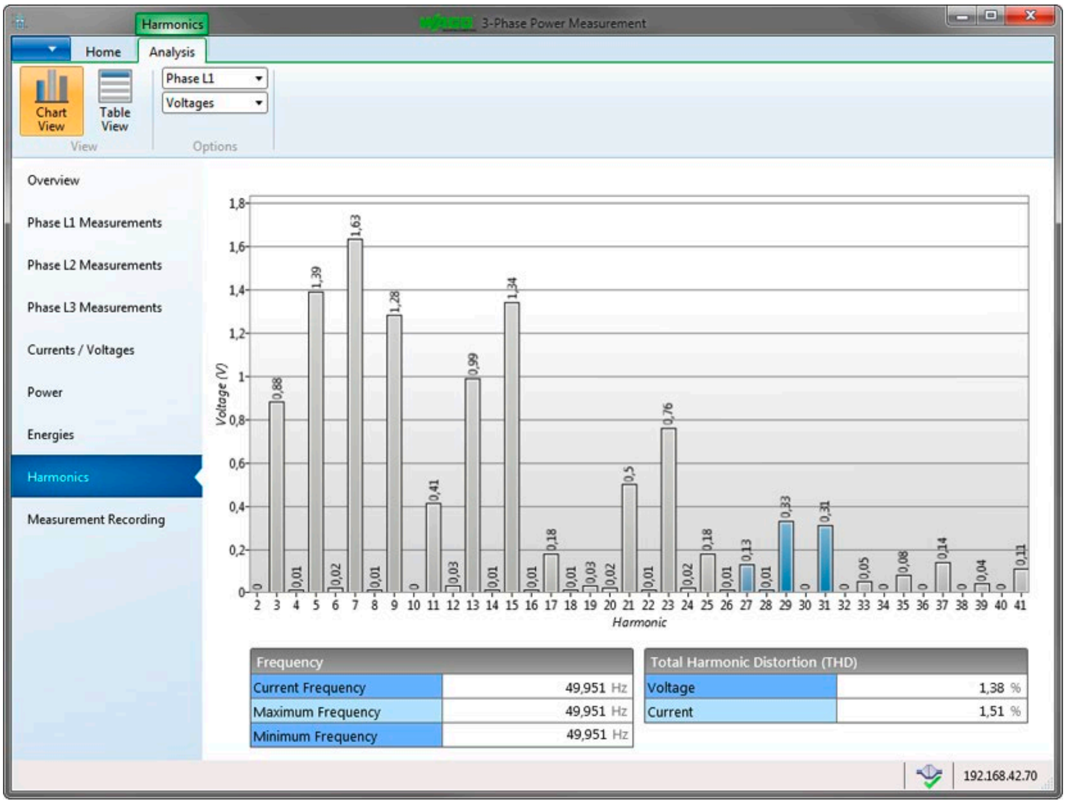


Figure 33: Measured Values – Harmonics Chart

The **Table View** shows the following values of 1st harmonic (fundamental wave) and another 3 selectable harmonics of the selected phase:

- Current
- Harmonic distortion THD and HD current
- Voltage
- Harmonic distortion THD and HD voltage

As long as the selection of harmonics is not changed the measured values are updated every 260 ms.

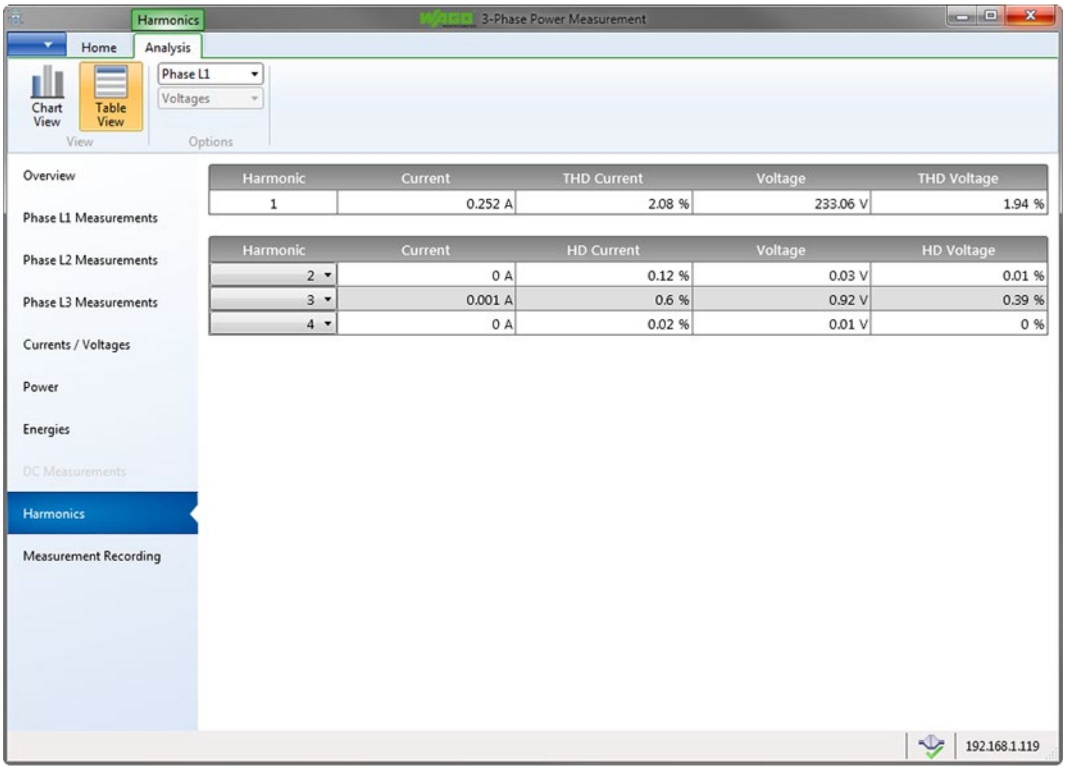


Figure 34: Measured Values – Harmonics Table

On the **Measurement Recording** view, 3 measured variables are represented in chronological sequence. You can select the measured variables you want to see in the 3 drop-down lists.

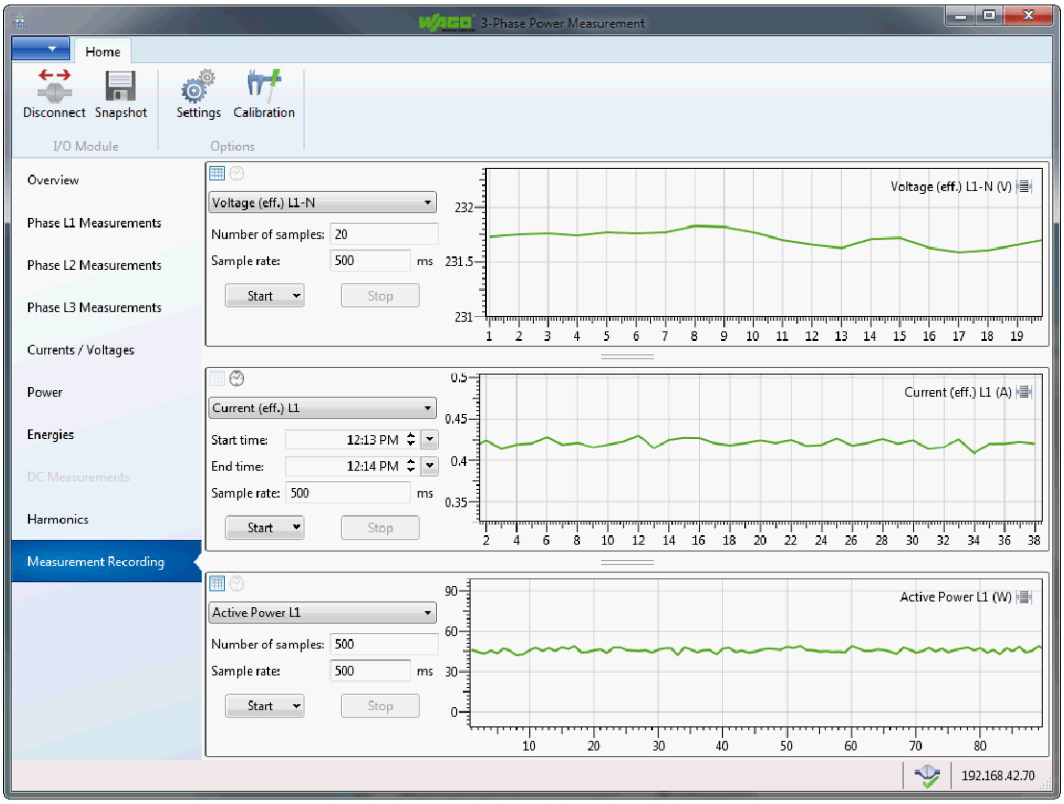


Figure 35: Measured Values – Recording

In general, you can select in the 3 waveforms whether:

- The samples are displayed over a certain period of time (with). or
- A certain number of samples is displayed (with).

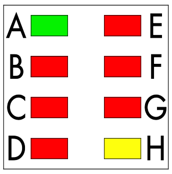
You can then enter the duration by start and end time or the number of samples. In both cases, the measurement interval, i.e. sample rate, can also be selected from 250 to 300,000 ms.

Clicking the arrow, the [**Start**] button generates a drop-down list in which you can select "No Export". By doing this, no export CSV file is generated.
If you click [**Start**] as usual, a "Save" window opens in which you can specify the storage location for the CSV file. After you have specified the storage location the measurement starts. Use [**Stop**] to stop the measurement prematurely. For examples of CSV files, see section "Appendix".

Use the mouse wheel to zoom in and out within the three graphic waveforms. Hold down the left mouse button to move the displayed range.
Click again to follow the current waveform.

9 Diagnostics

LED A indicates the operating status, LEDs B … H indicate possible errors.



The meaning of these indications is as follows:

Table 22: Diagnostics

LED	State	Message
A	Off	No operational readiness or the internal data bus communication is interrupted. Note: If the watchdog was disabled, the LED is always green. See section "Commissioning" > "Configuration with WAGO-I/O-*CHECK*".
	Green	Operational readiness and correct internal data bus communication
B	Off	No error
	Red	General error message for L1: Under-/overvoltage or overcurrent
C	Off	No error
	Red	General error message: Clipping of a current measuring path IL1, IL2 or IL3
D	Off	No error
	Red	High measuring error, caused by undershooting the min. voltage at L1, L2 or L3
E	Off	No error
	Red	General error message for L2: Under-/overvoltage or overcurrent
F	Off	No error
	Red	General error message for L3: Under-/overvoltage or overcurrent
G	Off	No error
	Red	General error message: Clipping of a voltage measuring path L1, L2 or L3
H	Off	No error
	Yellow	Error of the phase sequence L1-L2-L3

10 Appendix

10.1 Examples of CSV Data Files

10.1.1 Snapshot

The following table shows an example CSV data file generated in WAGO-I/O-*CHECK* with the function **Snapshot**. All actual measured values and all parameters are listed.

7/30/2013 12:14:01 PM	WAGO Kontakttechnik GmbH & Co. KG	I/O-Check-3 Phase Power Measurement (1.3.3.366)	0750-0494 /0000-0000
Measurements			
Total Active Power	195.36 W		
Total Reactive Energy	-44.55 var		
Total Apparent Power	320.06 VA		
Power Factor PF Total	0.520999026		
Total Active Energy	1090 Wh		
Reactive Energy Total	-30 varh		
Apparent Energy Total	510 VAh		
Current (eff.) L1	0.4287 A		
Current (eff.) L2	0.497 A		
Current (eff.) L3	0.5002 A		
Voltage (eff.) L1-N	231.84 V		
Voltage (eff.) L2-N	231.81 V		
Voltage (eff.) L3-N	231.79 V		
Active Power L1	44.56 W		
Active Power L2	72.02 W		
Active Power L3	78.78 W		
Reactive Power L1	-14.86 var		
Reactive Power L2	-2.93 var		
Reactive Power L3	-26.76 var		
Apparent Power L1	94.31 VA		
Apparent Power L2	113.44 VA		
Apparent Power L3	112.31 VA		
Frequency L1	50.019 Hz		
Frequency L2	50.019 Hz		
Frequency L3	50.009 Hz		
cos phi L1	0.98		
cos phi L2	0.99		
cos phi L3	0.97		
Power Factor PF L1	0.47		

Power Factor PF L2	0.6		
Power Factor PF L3	0.67		
Quadrant L1	4		
Quadrant L2	4		
Quadrant L3	4		
Average Value Current (eff.) L1	0.4213 A		
Average Value Current (eff.) L2	0.4912 A		
Average Value Current (eff.) L3	0.4937 A		
Minimum Current (eff.) L1	0.4111 A		
Minimum Current (eff.) L2	0.4775 A		
Minimum Current (eff.) L3	0.4839 A		
Maximum Current (eff.) L1	0.4287 A		
Maximum Current (eff.) L2	0.5138 A		
Maximum Current (eff.) L3	0.5071 A		
Peak Value Current L1	1.3594 A		
Average Value Voltage (eff.) L1-N	231.74 V		
Average Value Voltage (eff.) L2-N	231.71 V		
Average Value Voltage (eff.) L3-N	231.69 V		
Minimum Voltage (eff.) L1-N	231.81 V		
Minimum Voltage (eff.) L2-N	231.78 V		
Minimum Voltage (eff.) L3-N	231.77 V		
Maximum Voltage (eff.) L1-N	231.93 V		
Maximum Voltage (eff.) L2-N	231.92 V		
Maximum Voltage (eff.) L3-N	231.91 V		
Peak Value Voltage L1-N	325.46 V		
External Conductor Voltage L1-L2	0.29 V		
External Conductor Voltage L3-L1	0.27 V		
External Conductor Voltage L2-L3	0.29 V		
Minimum Active Power L1	43.89 W		
Minimum Active Power L2	67.75 W		
Minimum Active Power L3	73.6 W		
Maximum Active Power L1	47.94 W		
Maximum Active Power L2	74.27 W		
Maximum Active Power L3	80.58 W		
Power Factor LF L1	-0.47		
Power Factor LF L2	0.6		
Power Factor LF L3	-0.67		
Active Energy L1	590 Wh		
Active Energy L2	430 Wh		
Active Energy L3	70 Wh		
Active Energy Supply L1	590 Wh		
Active Energy Supply L2	430 Wh		
Active Energy Supply L3	70 Wh		
Active Energy Delivery L1	0 Wh		
Active Energy Delivery L2	0 Wh		

Active Energy Delivery L3	0 Wh		
Reactive Energy L1	0 varh		
Reactive Energy L2	-30 varh		
Reactive Energy L3	0 varh		
Reactive Energy Capacitive L1	0 varh		
Reactive Energy Capacitive L2	30 varh		
Reactive Energy Capacitive L3	0 varh		
Reactive Energy Inductive L1	0 varh		
Reactive Energy Inductive L2	0 varh		
Reactive Energy Inductive L3	0 varh		
Apparent Energy L1	210 VAh		
Apparent Energy L2	200 VAh		
Apparent Energy L3	100 VAh		
Phase Angle U-I L1	350.99 °		
Phase Angle U-I L2	358.52 °		
Phase Angle U-I L3	346.21 °		
Maximum Frequency L1	50.019 Hz		
Maximum Frequency L2	50.019 Hz		
Maximum Frequency L3	50.009 Hz		
Minimum Frequency L1	50.009 Hz		
Minimum Frequency L2	50.009 Hz		
Minimum Frequency L3	50.009 Hz		
Total Active Energy Supply	1090 Wh		
Total Active Energy Delivery	0 Wh		
Reactive Energy Inductive Total	0 varh		
Reactive Energy Capacitive Total	30 varh		
Errors / Warnings			
Parameter Phase L1			
Overvoltage threshold value	240 V		
Overcurrent threshold value	1000 A		
Interval observation : arithm. mean calculation	60 s		
Interval observation : peak value measurement	10 Half-Wave(s)		
Heed transformer ratio	True		
Automatic reset of the min./max. values	True		
Transformer ratio	500		
Undervoltage threshold	10 V		
Interval - reset: min./max. values	3000 ms		
Parameter Phase L2			
Overvoltage threshold value	240 V		

Overcurrent threshold value	1000 A		
Interval observation : arithm. mean calculation	60 s		
Interval observation : peak value measurement	10 Half-Wave(s)		
Heed transformer ratio	True		
Automatic reset of the min./max. values	True		
Transformer ratio	500		
Undervoltage threshold	10 V		
Interval - reset: min./max. values	5000 ms		
Parameter Phase L3			
Overvoltage threshold value	240 V		
Overcurrent threshold value	1000 A		
Interval observation : arithm. mean calculation	60 s		
Interval observation : peak value measurement	10 Half-Wave(s)		
Heed transformer ratio	True		
Automatic reset of the min./max. values	True		
Transformer ratio	500		
Undervoltage threshold	10 V		
Interval - reset: min./max. values	5000 ms		
I/O Module Parameters			
Watchdog process data communication active	False		
Rated frequency	50 Hz		
Scaling factor energy values	0.01 kWh/kvarh/kVAh		
Storing interval energy consumption	60 s		
Energy measurement NOLOAD active power	0		
Energy measurement NOLOAD reactive power	0		
Energy measurement NOLOAD apparent power	0		
Phase peak value measurement	L1		

10.1.2 CSV Data File „Measurement Recording“

The following table shows an example CSV data file generated in the view „Measurement Recording“ with [**Start**]. In this example the variable „Voltage (eff.) L1-N“ was selected shown as measuring series with 20 values.

04.07.2013 06:48:13	WAGO Kontakttechnik GmbH & Co. KG	I/O-Check-3 Phase Power Measurement (1.3.3.366)	0750-0494 /0000-0000	Voltage (eff.) L1-N	V
04.07.2013 06:48:14	233.11				
04.07.2013 06:48:15	233.12				
04.07.2013 06:48:15	233.08				
04.07.2013 06:48:16	233.14				
04.07.2013 06:48:16	233.11				
04.07.2013 06:48:17	233.14				
04.07.2013 06:48:17	233.06				
04.07.2013 06:48:18	233.1				
04.07.2013 06:48:18	233.14				
04.07.2013 06:48:19	233.1				
04.07.2013 06:48:19	233.2				
04.07.2013 06:48:20	233.19				
04.07.2013 06:48:20	233.22				
04.07.2013 06:48:21	233.19				
04.07.2013 06:48:21	233.15				
04.07.2013 06:48:22	233.06				
04.07.2013 06:48:22	233.06				
04.07.2013 06:48:23	233.04				
04.07.2013 06:48:23	233.11				
04.07.2013 06:48:24	233.12				

10.2 Factory Settings

The following values are stored in registers and parameters at delivery:

Table 23: Factory Settings

Register	Factory setting (Default)
R32 ≙ P10	0x0000 ≙ 0
R35 ≙ P11	0x0004 ≙ 0.01 resp. 0.05 kWh
R36 ≙ P12	0x0000 ≙ 0 V
R37 ≙ P13	0x0000 ≙ 0 V
R38 ≙ P14	0x0000 ≙ 0 V
R39 ≙ P15	0x0001 ≙ 1
R40 ≙ P16	0x0001 ≙ 1
R41 ≙ P17	0x0001 ≙ 1
R43 ≙ P19	0x000A ≙ 10 half waves
R44 ≙ P20	0x000A ≙ 10 half waves
R45 ≙ P21	0x000A ≙ 10 half waves
R46 ≙ P22	0x003C ≙ 60 s
R47	0x0000 ≙ 0
R48	0x0000 ≙ 0
R49	0x0000 ≙ 0
R50	0x0000 ≙ 0
R51	0x0000 ≙ 0
R52	0x0000 ≙ 0
R53	0x0000 ≙ 0
R54	0x0000 ≙ 0
R55	0x0000 ≙ 0
Parameter	**Factory setting (Default)**
P10	0x0000 ≙ 0
P11	0x0004 ≙ 0.01 resp. 0.05 kWh
P12	0x0000 ≙ 0 V
P13	0x0000 ≙ 0 V
P14	0x0000 ≙ 0 V
P15	0x0001 ≙ 1
P16	0x0001 ≙ 1
P17	0x0001 ≙ 1
P19	0x000A ≙ 10 half waves
P20	0x000A ≙ 10 half waves
P21	0x000A ≙ 10 half waves
P22	0x003C ≙ 60 s
P23	0x09C4 ≙ 250 V
P24	0x09C4 ≙ 250 V
P25	0x09C4 ≙ 250 V
P26, P27	0x02FAF080 ≙ 5 000 A

P28, P29	0x02FAF080 ≙ 5 000 A
P30, P31	0x02FAF080 ≙ 5 000 A
P34	0x0004 ≙ 60 s
P35	0x0004 ≙ 60 s
P36	0x0004 ≙ 60 s
P37	0x000A ≙ 2 s
P38	0x000A ≙ 2 s
P39	0x000A ≙ 2 s
P40	0x0000 ≙ 0
P41	0x0000 ≙ 0
P42	0x0000 ≙ 0

10.3 Register Assignment

The tables below show the assignments and factory settings for the registers written during configuration and during operation. All registers have a size of two bytes.

Table 24: Register 4

Register 4 – Command interface request				
Function		**Data type**	**Access**	**Factory setting**
Command Interface Request		UINT	R/W	0x0000
High byte				
Sequence number (Session ID)				
Low byte				
Request				
0x04	Reset register and calibration data to factory default settings			
0x37	Preset apparent energy delivery phase L1			
0x38	Preset apparent energy delivery phase L2			
0x39	Preset apparent energy delivery phase L3			
0x3A	Preset active energy acquisition phase L1			
0x3B	Preset active energy delivery phase 1			
0x3C	Preset active energy acquisition phase L2			
0x3D	Preset active energy delivery phase L2			
0x3E	Preset active energy acquisition phase L3			
0x3F	Preset active energy delivery phase L3			
0x40	Preset reactive energy inductive phase L1			
0x41	Preset reactive energy capacitive phase L1			
0x42	Preset reactive energy inductive phase L2			
0x43	Preset reactive energy capacitive phase L2			
0x44	Preset reactive energy inductive phase L3			
0x45	Preset reactive energy capacitive phase L3			
0x91	Save energy consumption early			
0x92	Delete all minimum and maximum values			
0x93	Delete minimum RMS current			
0x94	Delete maximum RMS current			
0x95	Delete minimum RMS voltage			
0x96	Delete maximum RMS voltage			
0x97	Delete minimum power			
0x98	Delete maximum power			
0x99	Initialize all energy meters to 0			
0x9A	Delete minimum frequency			
0x9B	Delete maximum frequency			
0x9C	Reset registers and parameters to factory settings			
0x9D	Reset calibration data to factory settings			
0xA0	Start mode for manufacturer calibration			
0xA2	Start mode for user calibration			
0xA4	Start mode for measuring operation (halts calibration mode)			

Table 25: Register 5

Register 5 – Command interface response			
Function	**Data type**	**Access**	**Factory setting**
Command Interface Response	UINT	[R]	0x0000
High byte			
Sequence number (Session ID)			
Low byte			
Response			
Request	A mirror image of the request command is created when the command is successfully applied.		
0xF0	Command is valid, but cannot be executed.		
0xFD	The session ID received by the master does not correspond to the last confirmed session ID + 1.		
0xFE	The command received by the master is not implemented in the slave.		
0xFF	General internal error		

Table 26: Register 32

Register 32 – Feature register			
Function	**Data type**	**Access**	**Factory setting**
Feature Register	Flags	R/W	0x0000
Bit 0: -Reserved-			
Bit 1: -Reserved-			
Bit 2: Activation of the RUN LED/Watchdog Timer			
0:	The green RUN LED "A" lights up when data are transferred over the internal bus. This LED is deactivated after a period of inactivity of 200 ms (factory setting).		
1:	The green RUN LED "A" remains lit.		
Bit 3: Selection of nominal frequency			
0:	The nominal frequency is 50 Hz (factory setting).		
1:	The nominal frequency is 60 Hz.		
Bit 4 + 5: -Reserved-			
Bit 6 + 7: Phase selection for peak measurement			
0:	Peak measurement for phase L1 is active (factory setting).		
1:	Peak measurement for phase L2 is active.		
2:	Peak measurement for phase L3 is active.		
3:	-reserved-		
Bit 8: Activation of automatic reset of min/max values for phase L1			
0:	Automatic deleting of minimum and maximum current, voltage and power values is not activated (factory settings).		
1:	Automatic deleting of minimum and maximum current, voltage and power values is activated.		
Bit 9: Activation of automatic reset of min/max values for phase L2			
0:	Automatic deleting of minimum and maximum current, voltage and power values is not activated (factory settings).		
1:	Automatic deleting of minimum and maximum current, voltage and power values is activated.		
Bit 10: Activation of automatic reset of min/max values for phase L3			
0:	Automatic deleting of minimum and maximum current, voltage and power values is not activated (factory settings).		

1:	Automatic deleting of minimum and maximum current, voltage and power values is activated.
Bit 11: -Reserved-	
Bit 12: User-defined scaling (current transformer ratio) phase L1	
0:	User-defined scaling is deactivated, the transformation ratio is 1:1 (factory setting).
1:	User-defined scaling is active, the transformation ratio is 1: (divisor for the current transformer ratio).
Bit 13: User-defined scaling (current transformer ratio) phase L2	
0:	User-defined scaling is deactivated, the transformation ratio is 1:1 (factory setting).
1:	User-defined scaling is active, the transformation ratio is 1: (divisor for the current transformer ratio).
Bit 14: User-defined scaling (current transformer ratio) phase L3	
0:	User-defined scaling is deactivated, the transformation ratio is 1:1 (factory setting).
1:	User-defined scaling is active, the transformation ratio is 1: (divisor for the current transformer ratio).
Bit 15: -Reserved-	

Table 27: Register 35

Register 35 – Scaling factor for energy values			
Function	**Data type**	**Access**	**Factory setting**
Scaling factor for energy values	UINT	R/W	0x0004

	1A-variants	5A-variants
0:	1 mWh/VARh/VAh	5 mWh/VARh/VAh
1:	0.01 Wh/VARh/VAh	0.05 Wh/VARh/VAh
2:	0.1 Wh/VARh/VAh	0.5 Wh/VARh/VAh
3:	1 Wh/VARh/VAh	5 Wh/VARh/VAh
4:	0.01 kWh/VARh/VAh	0.05 kWh/VARh/VAh
5:	0.1 kWh/VARh/VAh	0.5 kWh/VARh/VAh
6:	1 kWh/VARh/VAh	5 kWh/VARh/VAh
≥7:	-not permitted-	

Table 28: Register 36

Register 36 – Undervoltage threshold phase L1			
Function	**Data type**	**Access**	**Factory setting**
Undervoltage threshold phase L1, Resolution: 0.1 V	UINT	R/W	0 x 0000, 0 V

0:	Checking of undervoltage threshold is deactivated.
≥1:	Value for undervoltage threshold.

Table 29: Register 37

Register 37 – Undervoltage threshold phase L2			
Function	**Data type**	**Access**	**Factory setting**
Undervoltage threshold phase L2, Resolution: 0.1 V	UINT	R/W	0 x 0000, 0 V

0:	Checking of undervoltage threshold is deactivated.
≥1:	Value for undervoltage threshold.

Table 30: Register 38

Register 38 – Undervoltage threshold phase L3				
Function		**Data type**	**Access**	**Factory setting**
Undervoltage threshold phase L3, Resolution: 0.1 V		UINT	R/W	0 x 0000, 0 V
0:	Checking of undervoltage threshold is deactivated.			
≥1:	Value for undervoltage threshold.			

Table 31: Register 39

Register 39 – Current transformer ratio phase L1				
Function		**Data type**	**Access**	**Factory setting**
Divisor for the current transformer ratio, phase L1, Activation via Register 32, Bit 12 required		UINT	R/W	0x0001
0:	-not permitted-			
≥1:	Value for the current transformer ratio divisor D-CTR.			

Table 32: Register 40

Register 40 – Current transformer ratio phase L2				
Function		**Data type**	**Access**	**Factory setting**
Divisor for the current transformer ratio, phase L2, Activation via Register 32, Bit 13 required		UINT	R/W	0x0001
0:	-not permitted-			
≥1:	Value for the current transformer ratio divisor D-CTR.			

Table 33: Register 41

Register 41 – Current transformer ratio phase L3				
Function		**Data type**	**Access**	**Factory setting**
Divisor for the current transformer ratio, phase L3, Activation via Register 32, Bit 14 required		UINT	R/W	0x0001
0:	-not permitted-			
≥1:	Value for the current transformer ratio divisor D-CTR.			

Table 34: Register 43

Register 43 – Observation interval, peak value measurement phase L1				
Function		**Data type**	**Access**	**Factory setting**
Observation interval, peak value measurement, phase L1		UINT	R/W	0 x 000 A
0 … 5:	-not permitted-			
6 … 254:	Number of half waves for measuring peak values.			
≥255:	-not permitted-			

Table 35: Register 44

Register 44 – Observation interval, peak value measurement phase L2				
Function		**Data type**	**Access**	**Factory setting**
Observation interval, peak value measurement, Phase 2		UINT	R/W	0 x 000 A
0 … 5:	-not permitted-			
6 … 254:	Number of half waves for measuring peak values.			
≥255:	-not permitted-			

Table 36: Register 45

Register 45 – Observation interval, peak value measurement phase L3				
Function		**Data type**	**Access**	**Factory setting**
Observation interval, peak value measurement, phase L3		UINT	R/W	0 x 000 A
0 … 5:	-not permitted-			
6 … 254:	Number of half waves for measuring peak values.			
≥255:	-not permitted-			

Table 37: Register 46

Register 46 – Storing interval for energy values				
Function		**Data type**	**Access**	**Factory setting**
Storing interval for energy values, Resolution: 1 second		UINT	R/W	0x003C (60s)
0 … 59:	-not permitted-			
60 … 255:	Time in seconds up to automatic storing of energy values.			
≥256:	-not permitted-			

Table 38: Register 47

Register 47 – Error register for the parameter channel			
Function	**Data type**	**Access**	**Factory setting**
Error register for the parameter channel	UINT	[R]	0x0000

0:	Calibration procedure, no error
1:	Calibration procedure, division by zero
2:	Calibration procedure "Gain" > 2
3:	Calibration procedure, commande sequence not followed
4:	Calibration procedure, calibration step not implemented
5:	Calibration procedure, the "period" register in the microcontroller has never been read.
≥6:	-not permitted-

Table 39: Register 48

Register 48 – Container 1			
Function	**Data type**	**Access**	**Factory setting**
Container 1, for energy preset and calibration	UINT	R/W	0x0000

Table 40: Register 49

Register 49 – Container 2			
Function	**Data type**	**Access**	**Factory setting**
Container 2, for energy preset and calibration	UINT	R/W	0x0000

Table 41: Register 50

Register 50 – Container 3			
Function	**Data type**	**Access**	**Factory setting**
Container 3, for energy preset and calibration	UINT	R/W	0x0000

Table 42: Register 51

Register 51 – Container 4			
Function	**Data type**	**Access**	**Factory setting**
Container 4, for energy preset and calibration	UINT	R/W	0x0000

Table 43: Register 52

Register 52 – Container 5			
Function	**Data type**	**Access**	**Factory setting**
Container 5, for energy preset and calibration	UINT	R/W	0x0000

Table 44: Register 53

Register 53 – Container 6			
Function	**Data type**	**Access**	**Factory setting**
Container 6, for energy preset and calibration	UINT	R/W	0x0000

Table 45: Register 54

Register 54 – Container 7			
Function	**Data type**	**Access**	**Factory setting**
Container 7, for energy preset and calibration	UINT	R/W	0x0000

Table 46: Register 55

Register 55 – Container 8			
Function	**Data type**	**Access**	**Factory setting**
Container 8, for energy preset and calibration	UINT	R/W	0x0000

10.4 Parameter Assignment

Table 47: Parameter 10

Parameter 10 – Feature register			
Function	**Data type**	**Access**	**Factory setting**
-Corresponds to register 32. (See section above.)			

Table 48: Parameter 11

Parameter 11 – Scaling factor for energy values			
Function	**Data type**	**Access**	**Factory setting**
-Corresponds to register 35. (See section above.)			

Table 49: Parameter 12

Parameter 12 – Undervoltage threshold phase L1			
Function	**Data type**	**Access**	**Factory setting**
-Corresponds to register 36. (See section above.)			

Table 50: Parameter 13

Parameter 13 – Undervoltage threshold phase L2			
Function	**Data type**	**Access**	**Factory setting**
-Corresponds to register 37. (See section above.)			

Table 51: Parameter 14

Parameter 14 – Undervoltage threshold phase L3			
Function	**Data type**	**Access**	**Factory setting**
-Corresponds to register 38. (See section above.)			

Table 52: Parameter 15

Parameter 15 – Current transformer ratio phase L1			
Function	**Data type**	**Access**	**Factory setting**
-Corresponds to register 39. (See section above.)			

Table 53: Parameter 16

Parameter 16 – Current transformer ratio phase L2			
Function	**Data type**	**Access**	**Factory setting**
-Corresponds to register 40. (See section above.)			

Table 54: Parameter 17

Parameter 17 – Current transformer ratio phase L3			
Function	**Data type**	**Access**	**Factory setting**
-Corresponds to register 41. (See section above.)			

Table 55: Parameter 19

Parameter 19 – Observation interval, peak value measurement phase L1			
Function	**Data type**	**Access**	**Factory setting**
-Corresponds to register 43. (See section above.)			

Table 56: Parameter 20

Parameter 20 – Observation interval, peak value measurement phase L2			
Function	**Data type**	**Access**	**Factory setting**
-Corresponds to register 44. (See section above.)			

Table 57: Parameter 21

Parameter 21 – Observation interval, peak value measurement phase L3			
Function	**Data type**	**Access**	**Factory setting**
-Corresponds to register 45. (See section above.)			

Table 58: Parameter 22

Parameter 22 – Storing interval for energy values			
Function	**Data type**	**Access**	**Factory setting**
-Corresponds to register 46. (See section above.)			

Table 59: Parameter 23

Parameter 23 – Overvoltage threshold phase L1			
Function	**Data type**	**Access**	**Factory setting**
Overvoltage threshold phase L1, Resolution: 0.1 V	UINT	R/W	0x09C4 (250 V)

Table 60: Parameter 24

Parameter 24 – Overvoltage threshold phase L2			
Function	**Data type**	**Access**	**Factory setting**
Overvoltage threshold phase L2, Resolution: 0.1 V	UINT	R/W	0x09C4 (250 V)

Table 61: Parameter 25

Parameter 25 – Overvoltage threshold phase L3			
Function	**Data type**	**Access**	**Factory setting**
Overvoltage threshold phase L3, Resolution: 0.1 V	UINT	R/W	0x09C4 (250 V)

Table 62: Parameter 26 and 27

Parameter 26 und 27 – Overcurrent threshold phase L1			
Function	**Data type**	**Access**	**Factory setting**
Overcurrent threshold phase L1, Resolution: 0.1 mA	UINT	R/W	0x02FAF080 (5 000 A)
0:	Overcurrent is not checked.		
≥1:	Overcurrent threshold (value)		

Table 63: Parameter 28 and 29

Parameter 28 und 29 – Overcurrent threshold phase L2			
Function	**Data type**	**Access**	**Factory setting**
Overcurrent threshold phase L2, Resolution: 0.1 mA	UINT	R/W	0x02FAF080 (5 000 A)
0:	Overcurrent is not checked.		
≥1:	Overcurrent threshold (value)		

Table 64: Parameter 30 and 31

Parameter 30 und 31 – Overcurrent threshold phase L3				
Function		**Data type**	**Access**	**Factory setting**
Overcurrent threshold phase L3, Resolution: 0.1 mA		UINT	R/W	0x02FAF080 (5 000 A)
0:	Overcurrent is not checked.			
≥1:	Overcurrent threshold (value)			

Table 65: Parameter 34

Parameter 34 – Calculation interval arithmetic mean values phase L1				
Function		**Data type**	**Access**	**Factory setting**
Calculation interval arithmetic mean values phase L1		UINT	R/W	0x0004
0:	5 s			
1:	10 s			
2:	15 s			
3:	30 s			
4:	60 s			
5:	300 s			
6:	480 s			
7:	600 s			
8:	900 s			
≥9:	-reserved-			

Table 66: Parameter 35

Parameter 35 – Calculation interval arithmetic mean values phase L2				
Function		**Data type**	**Access**	**Factory setting**
Calculation interval arithmetic mean values phase L2		UINT	R/W	0x0004
0:	5 s			
1:	10 s			
2:	15 s			
3:	30 s			
4:	60 s			
5:	300 s			
6:	480 s			
7:	600 s			
8:	900 s			
≥9:	-reserved-			

Table 67: Parameter 36

Parameter 36 – Calculation interval arithmetic mean values phase L3				
Function		Data type	Access	Factory setting
Calculation interval arithmetic mean values phase L3		UINT	R/W	0x0004
0:	5 s			
1:	10 s			
2:	15 s			
3:	30 s			
4:	60 s			
5:	300 s			
6:	480 s			
7:	600 s			
8:	900 s			
≥9:	-reserved-			

Table 68: Parameter 37

Parameter 37 – Interval of automatically resetting the min/max values phase L1			
Function	Data type	Access	Factory setting
Interval of automatically resetting the min/max values phase L1, resolution 200 ms, activation via register 32, bit 8 required.	UINT	R/W	0x000A (2 s)

Table 69: Parameter 38

Parameter 38 – Interval of automatically resetting the min/max values phase L2			
Function	Data type	Access	Factory setting
Interval of automatically resetting the min/max values phase L2, resolution 200 ms, activation via register 32, bit 9 required.	UINT	R/W	0x000A (2 s)

Table 70: Parameter 39

Parameter 39 – Interval of automatically resetting the min/max values phase L3			
Function	Data type	Access	Factory setting
Interval of automatically resetting the min/max values phase L3, resolution 200 ms, activation via register 32, bit 10 required.	UINT	R/W	0x000A (2 s)

Table 71: Parameter 40

Parameter 40 – Factor NOLOAD-threshold active energy				
Function		**Data type**	**Access**	**Factory setting**
Factor NOLOAD-threshold active energy		UINT	R/W	0x0000 (disabled)
0:	The NOLOAD-threshold is disabled.			
1 … 19:	-reserved-			
20 … 24000:	Factor of the NOLOAD-threshold for calculating $P_{THRESHOLD}$ = (1 / factor) x $P_{NOMINAL}$ $P_{NOMINAL}$ = 277V x 1A = 277W for the 1A-variants resp. 277V x 5A = 1385W for the 5A-variants			
≥24001:	-reserved-			

Table 72: Parameter 41

Parameter 41 – Factor NOLOAD-threshold reactive energy				
Function		**Data type**	**Access**	**Factory setting**
Factor NOLOAD-threshold reactive energy		UINT	R/W	0x0000 (disabled)
0:	The NOLOAD-threshold is disabled.			
1 … 19:	-reserved-			
20 … 24000:	Factor of the NOLOAD-threshold for calculating $Q_{THRESHOLD}$ = (1 / factor) x $Q_{NOMINAL}$ $Q_{NOMINAL}$ = 277V x 1A = 277VAR for the 1A-variants resp. 277V x 5A = 1385VAR for the 5A-variants			
≥24001:	-reserved-			

Table 73: Parameter 42

Parameter 42 – Factor NOLOAD-threshold apparent energy				
Function		**Data type**	**Access**	**Factory setting**
Factor NOLOAD-threshold apparent energy		UINT	R/W	0x0000 (disabled)
0:	The NOLOAD-threshold is disabled.			
1 … 19:	-reserved-			
20 … 24000:	Factor of the NOLOAD-threshold for calculating $S_{THRESHOLD}$ = (1 / factor) x $S_{NOMINAL}$ $S_{NOMINAL}$ = 277V x 1A = 277VA for the 1A-variants resp. 277V x 5A = 1385VA for the 5A-variants			
≥24001:	-reserved-			

11 Use in Hazardous Environments

The **WAGO-I/O-SYSTEM 750** (electrical equipment) is designed for use in Zone 2 hazardous areas.

The following sections include both the general identification of components (devices) and the installation regulations to be observed. The individual subsections of the “Installation Regulations” section must be taken into account if the I/O module has the required approval or is subject to the range of application of the ATEX directive.

11.1 Marking Configuration Examples

11.1.1 Marking for Europe According to ATEX and IEC-Ex

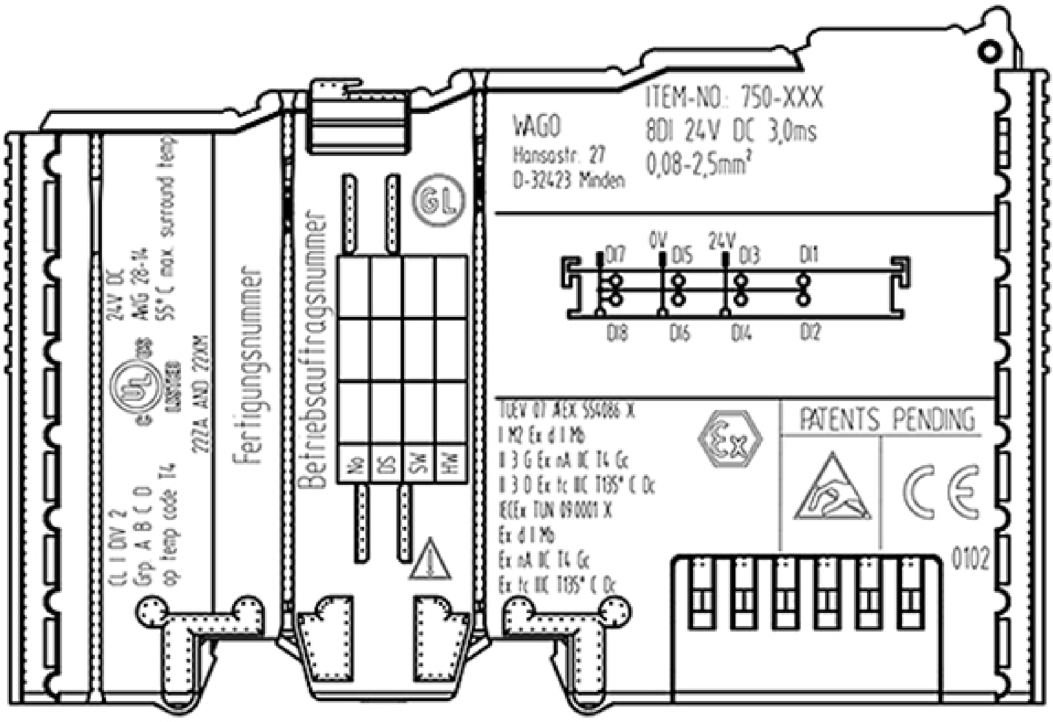


Figure 36: Side Marking Example for Approved I/O Modules According to ATEX and IECEx

Figure 37: Text Detail – Marking Example for Approved I/O Modules According to ATEX and IECEx.

Table 74: Description of Marking Example for Approved I/O Modules According to ATEX and IECEx

Marking	Description
TÜV 07 ATEX 554086 X IECEx TUN 09.0001 X	Approving authority and certificate numbers
Dust	
II	Equipment group: All except mining
3D	Category 3 (Zone 22)
Ex	Explosion protection mark
tc Dc	Type of protection and equipment protection level (EPL):protection by enclosure
IIIC	Explosion group of dust
T 135°C	Max. surface temperature of the enclosure (without a dust layer)
Mining	
I	Equipment group: Mining
M2	Category: High level of protection
Ex	Explosion protection mark
d Mb	Type of protection and equipment protection level (EPL): Flameproof enclosure
I	Explosion group for electrical equipment for mines susceptible to firedamp
Gases	
II	Equipment group: All except mining
3G	Category 3 (Zone 2)
Ex	Explosion protection mark
nA Gc	Type of protection and equipment protection level (EPL): Non-sparking equipment
nC Gc	Type of protection and equipment protection level (EPL): Sparking apparatus with protected contacts. A device which is so constructed that the external atmosphere cannot gain access to the interior
IIC	Explosion group of gas and vapours
T4	Temperature class: Max. surface temperature 135°C

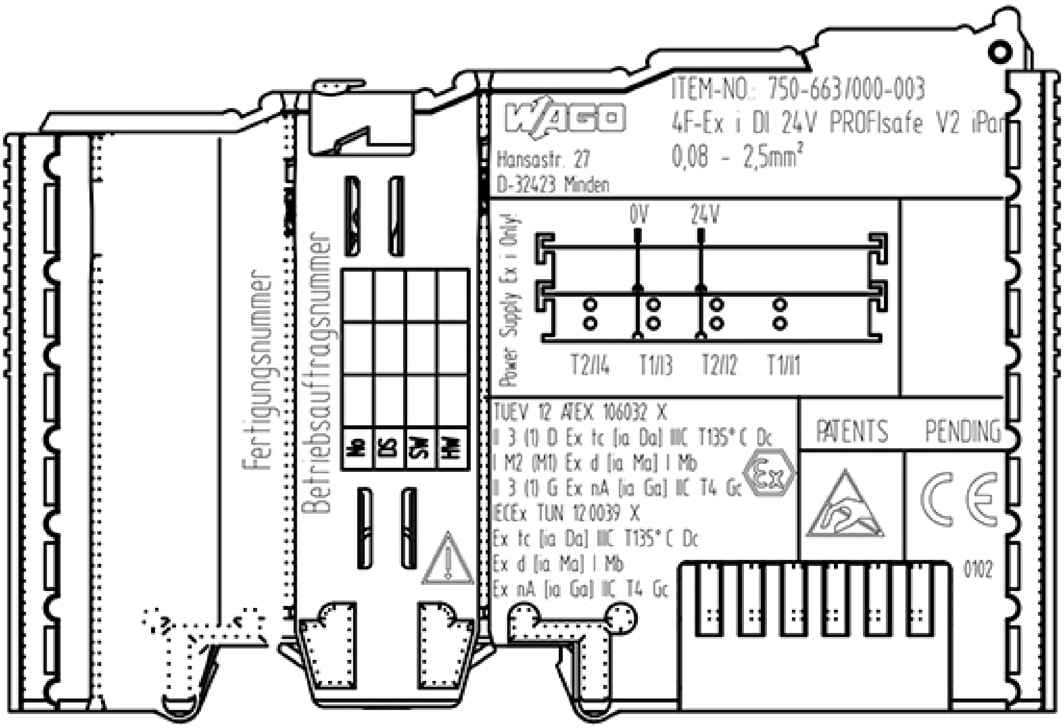


Figure 38: Side Marking Example for Approved Ex i I/O Modules According to ATEX and IECEx.

TUEV 12 ATEX 106032 X
II 3 (1) D Ex tc [ia Da] IIIC T135°C Dc
I M2 (M1) Ex d [ia Ma] I Mb
II 3 (1) G Ex nA [ia Ga] IIC T4 Gc
IECEx TUN 12.0039 X
Ex tc [ia Da] IIIC T135°C Dc
Ex d [ia Ma] I Mb
Ex nA [ia Ga] IIC T4 Gc

Figure 39: Text Detail – Marking Example for Approved Ex i I/O Modules According to ATEX and IECEx.

Table 75: Description of Marking Example for Approved Ex i I/O Modules According to ATEX and IECEx

Marking	Description
TÜV 07 ATEX 554086 X IECEx TUN 09.0001X TÜV 12 ATEX 106032 X IECEx TUN 12.0039 X	Approving authority and certificate numbers
Dust	
II	Equipment group: All except mining
3(1)D	Category 3 (Zone 22) equipment containing a safety device for a category 1 (Zone 20) equipment
3(2)D	Category 3 (Zone 22) equipment containing a safety device for a category 2 (Zone 21) equipment
Ex	Explosion protection mark
tc Dc	Type of protection and equipment protection level (EPL): protection by enclosure
[ia Da]	Type of protection and equipment protection level (EPL): associated apparatus with intrinsic safety circuits for use in Zone 20
[ib Db]	Type of protection and equipment protection level (EPL): associated apparatus with intrinsic safety circuits for use in Zone 21
IIIC	Explosion group of dust
T 135°C	Max. surface temperature of the enclosure (without a dust layer)
Mining	
I	Equipment Group: Mining
M2 (M1)	Category: High level of protection with electrical circuits which present a very high level of protection
Ex d Mb	Explosion protection mark with Type of protection and equipment protection level (EPL): Flameproof enclosure
[ia Ma]	Type of protection and equipment protection level (EPL): associated apparatus with intrinsic safety electrical circuits
I	Explosion group for electrical equipment for mines susceptible to firedamp

Table 75: Description of Marking Example for Approved Ex i I/O Modules According to ATEX and IECEx

Gases	
II	Equipment group: All except mining
3(1)G	Category 3 (Zone 2) equipment containing a safety device for a category 1 (Zone 0) equipment
3(2)G	Category 3 (Zone 2) equipment containing a safety device for a category 2 (Zone 1) equipment
Ex	Explosion protection mark
nA Gc	Type of protection and equipment protection level (EPL): Non-sparking equipment
[ia Ga]	Type of protection and equipment protection level (EPL): associated apparatus with intrinsic safety circuits for use in Zone 0
[ia Gb]	Type of protection and equipment protection level (EPL): associated apparatus with intrinsic safety circuits for use in Zone 1
IIC	Explosion group of gas and vapours
T4	Temperature class: Max. surface temperature 135°C

11.1.2 Marking for America According to NEC 500

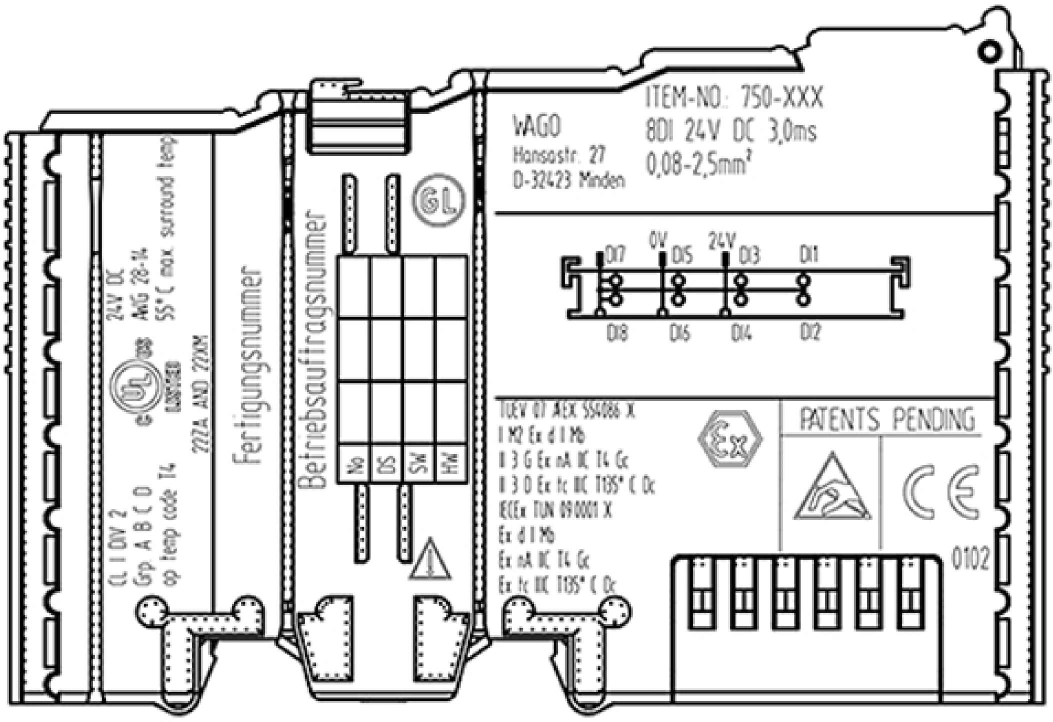


Figure 40: Side Marking Example for I/O Modules According to NEC 500

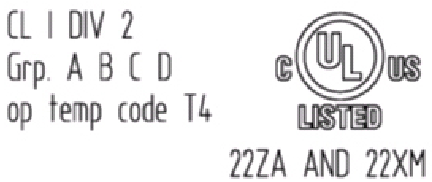


Figure 41: Text Detail – Marking Example for Approved I/O Modules According to NEC 500

Table 76: Description of Marking Example for Approved I/O Modules According to NEC 500

Marking	Description
CL I	Explosion protection group (condition of use category)
DIV 2	Area of application
Grp. ABCD	Explosion group (gas group)
Op temp code T4	Temperature class

11.2 Installation Regulations

For the installation and operation of electrical equipment in hazardous areas, the valid national and international rules and regulations which are applicable at the installation location must be carefully followed.

11.2.1 Special Notes Regarding Explosion Protection

The following warning notices are to be posted in the immediately proximity of the WAGO-I/O-SYSTEM 750 (hereinafter "product"):

WARNING – DO NOT REMOVE OR REPLACE FUSED WHILE ENERGIZED!

WARNING – DO NOT DISCONNECT WHILE ENERGIZED!

WARNING – ONLY DISCONNECT IN A NON-HAZARDOUS AREA!

Before using the components, check whether the intended application is permitted in accordance with the respective printing. Pay attention to any changes to the printing when replacing components.

The product is an open system. As such, the product must only be installed in appropriate enclosures or electrical operation rooms to which the following applies:

- Can only be opened using a tool or key
- Inside pollution degree 1 or 2
- In operation, internal air temperature within the range of 0 °C ≤ Ta ≤ +55 °C or −20 °C ≤ Ta ≤ +60 °C for components with extension number …/025-xxx or −40 °C ≤ Ta ≤ +70 °C for components with extension number …/040-xxx
- Minimum degree of protection: min. IP54 (acc. to EN/IEC 60529)
- For use in Zone 2 (Gc), compliance with the applicable requirements of the standards EN/IEC/ABNT NBR IEC 60079-0, -11, -15
- For use in Zone 22 (Dc), compliance with the applicable requirements of the standards EN/IEC/ABNT NBR IEC 60079-0, -11, -15 and -31
- For use in mining (Mb), minimum degree of protection IP64 (acc. EN/IEC 60529) and adequate protection acc. EN/IEC/ABNT NBR IEC 60079-0 and -1
- Depending on zoning and device category, correct installation and compliance with requirements must be assessed and certified by a "Notified Body" (ExNB) if necessary!

Explosive atmosphere occurring simultaneously with assembly, installation or repair work must be ruled out. Among other things, these include the following activities

- Insertion and removal of components
- Connecting or disconnecting from fieldbus, antenna, D-Sub, ETHERNET or USB connections, DVI ports, memory cards, configuration and programming interfaces in general and service interface in particular:
  - Operating DIP switches, coding switches or potentiometers
  - Replacing fuses

Wiring (connecting or disconnecting) of non-intrinsically safe circuits is only permitted in the following cases

- The circuit is disconnected from the power supply.
- The area is known to be non-hazardous.

Outside the device, suitable measures must be taken so that the rated voltage is not exceeded by more than 40 % due to transient faults (e.g., when powering the field supply).

Product components intended for intrinsically safe applications may only be powered by 750-606 or 750-625/000-001 bus supply modules.

Only field devices whose power supply corresponds to overvoltage category I or II may be connected to these components.

11.2.2 Special Notes Regarding ANSI/ISA Ex

For ANSI/ISA Ex acc. to UL File E198726, the following additional requirements apply:

- Use in Class I, Division 2, Group A, B, C, D or non-hazardous areas only
- ETHERNET connections are used exclusively for connecting to computer networks (LANs) and may not be connected to telephone networks or telecommunication cables
- **WARNING** – The radio receiver module 750-642 may only be used to connect to external antenna 758-910!
- **WARNING** – Product components with fuses must not be fitted into circuits subject to overloads!
  These include, e.g., motor circuits.
- **WARNING** – When installing I/O module 750-538, “Control Drawing No. 750538” in the manual must be strictly observed!

Information

Additional Information
Proof of certification is available on request.
Also take note of the information given on the operating and assembly instructions.
The manual, containing these special conditions for safe use, must be readily available to the user.

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WE INNOVATE!

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