Current and Energy

Measurement Technology

WAGO®
INNOVATIVE CONNECTIONS

Current Measurement and Evaluation

WAGO's Solution for Energy Monitoring and Conservation

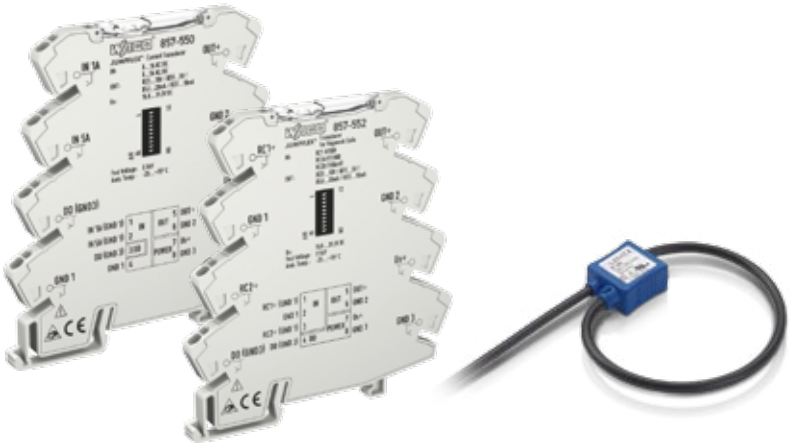
Rogowski Coils, 855 Series
– Conversion of AC currents up to 500 A/2000 A

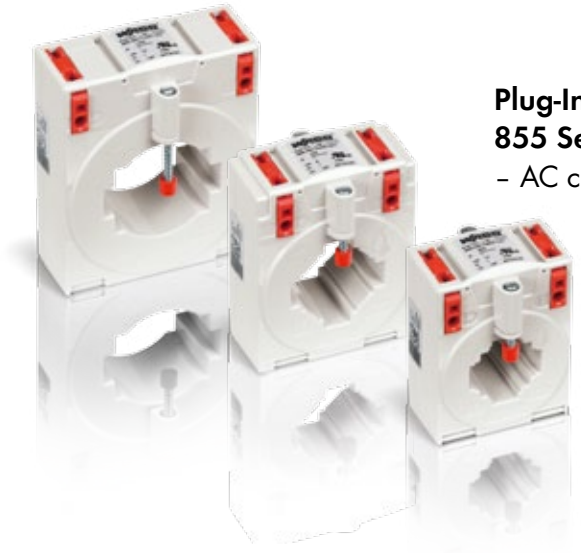
Rogowski Current Transducers, 789 Series
– AC current measurement up to 500 A or 2000 A via three Rogowski coils
– In-phase conversion to 100 mA AC current signals for connection to the 750 Series WAGO-I/O-SYSTEM

Intelligent Current Sensors, 789 Series
– DC/AC current monitoring up to 140 A
– Data transmission via MODBUS communication interface (RS-485)

WAGO-I/O-SYSTEM, 750 Series
3-Phase Power Measurement Modules
– Voltage, current, power and energy measurement in 3-phase networks

***JUMPFLEX*® Current Transducers, 857 Series**
– DC/AC current measurement and conversion into analog standard signals (e.g., 0 ... 10 V, 4 ... 20 mA)





Plug-In Current Transformers
855 Series
– AC current conversion up to 1000 A

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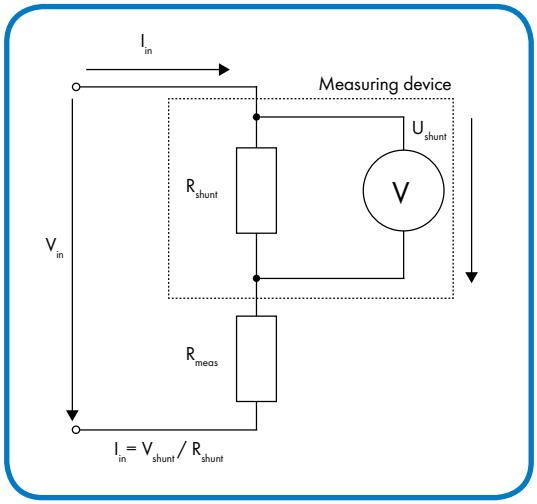
The Different Measuring Methods

Shunt Measurement (AC/DC)

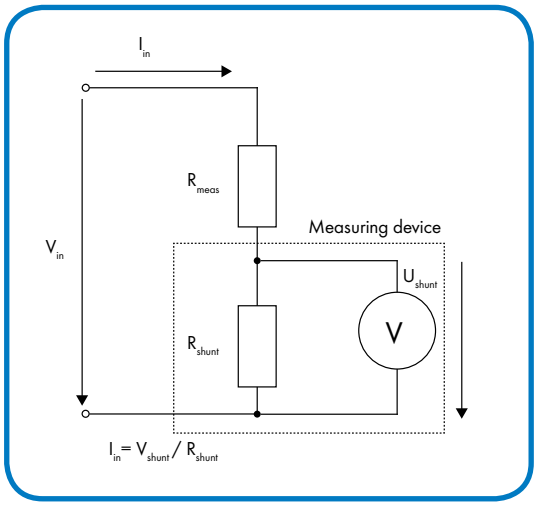
Current measurement is performed using a low-ohm resistor (shunt), which is connected in parallel to a voltmeter. The current is proportional to the current measured at the shunt resistor, I = V/R.

The shunt can be located upstream or downstream of the load (high-side/low-side method). WAGO products are equipped for both methods, giving users the freedom to decide where the conductor section should be disconnected. In addition to DC and AC currents, shunt measurements are also suitable for measuring superimposed signals (DC + AC). Accuracies of 0.1 % and better can be achieved. WAGO's 855 Series Plug-In Current Transformers with predefined division ratio can be used to expand the measurement range for pure AC measurements.

High-Side Method



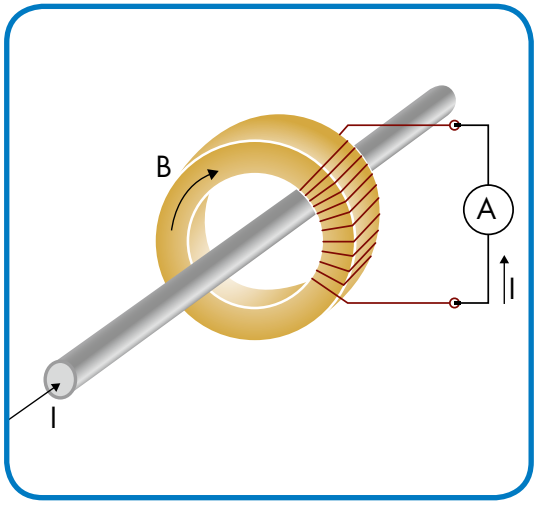
Low-Side Method



Shunt Measurement in Combination with Plug-In Current Transformer (AC)

Plug-In Current Transformers are used at higher measurement currents. They function according to the transformer principle and expand the range of an existing measurement system (usually a shunt transformer). The number of secondary windings mirrors the fixed setting of the division ratio. The electrically isolated output AC is proportional and in phase with the input AC. The measuring error typically lies below 1 %.

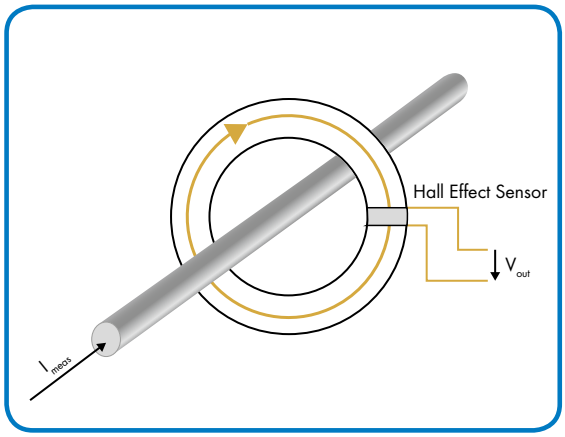
Transformer Principle

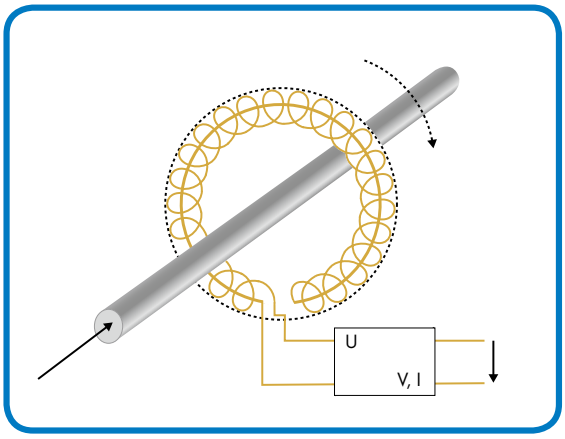


Hall Effect Sensors (AC/DC)

A soft-magnetic core is applied around the conductor. The core has a small air gap in which the Hall effect sensor is located. A magnetic flux is generated in the ring-shaped core by the current flowing through the conductor. The magnetic flux also flows through the Hall effect sensor, which outputs a voltage signal proportional to the current measured. This signal is prepared and forwarded for processing. Using the Hall method, different signals (AC/DC) and measuring ranges can be mapped, depending on the design. Measurement accuracy lies between 0.5 % and 1 %.

Hall Effect Sensor





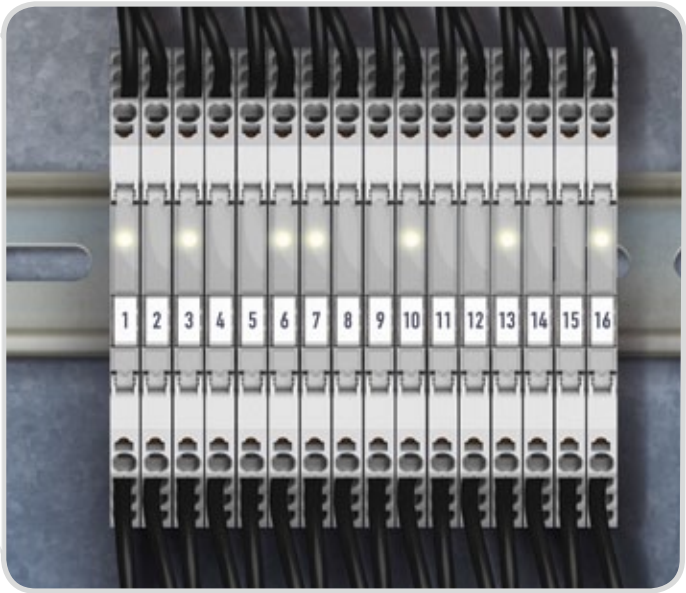
Rogowski Coil (AC)

A closed-air coil (i.e., coil without iron core) is applied around the conductor to be measured. The AC current flowing through the conductor induces a proportional voltage in the Rogowski coil. The output voltage is amplified and conditioned. A measurement error of less than 2 % and a response threshold of only a few amps guarantee a straightforward measurement of high to very high AC currents.

Measuring Method:	Advantages:	Application Areas:
Shunt	– Very high accuracy – Suitable for DC and AC currents	– Integration into control and regulation systems – Process and energy technology
Shunt + Current transformer	– Suitable for higher AC currents – Potential-free measurement	– Installations and systems technology – Network monitoring and analysis
Hall effect	– Potential-free measurement – For higher currents – DC and AC versions	– PV systems and general energy technology – Control processing of several individual systems
Rogowski	– No circuit disconnection – Potential-free current measurement – For high alternating currents	– Network quality analysis – Network deflections and network drops – Check energy efficiency

The 857-550 Current Transducer measures 0–1 A and 0–5 A AC/DC currents and converts the input signal to an analog standard signal at the output (e.g., 4–20 mA).

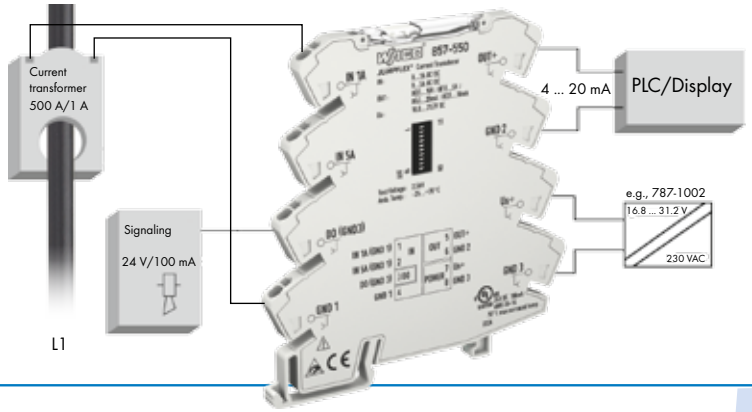
The 857-552 Rogowski Transducer records RMS values from alternating currents via a Rogowski coil, converting the input signal into an analog standard signal on the output side (e.g., 4–20 mA).



	Current Transducer	Rogowski Transducer
		
Item no.	857-550	857-552
Input signal	0 ... 1 A AC/DC; 0 ... 5 A AC/DC	Rogowski coils 500 A/2000 A
Frequency range	16 Hz ... 400 Hz	16 Hz ... 1000 Hz
Output signal	Voltage: 0 ... 5 V, 1 ... 5 V, 0 ... 10 V, 2 ... 10 V Current: 0 ... 10 mA, 2 ... 10 mA, 0 ... 20 mA, 4 ... 20 mA	
Digital output DO	24 VDC/100 mA	
Load impedance	Current ≤ 600 Ω, Voltage ≥ 2000 Ω	Current ≤ 600 Ω, Voltage ≥ 1000 Ω
Supply voltage	24 VDC	

Current Transducer/Rogowski Transducer

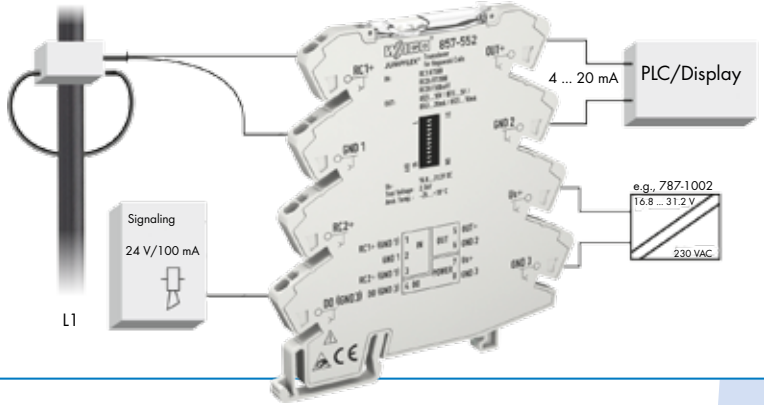
Current Transducer, 857-550



Configuration via:

- DIP switches/PC configuration tool/smartphone app
- Digital switching output (switching thresholds are freely configurable)
- Output signal (configurable)
- True RMS measurement (TRMS) or arithmetic mean value
- No current bar interruption is necessary during installation
- Calibrated measurement range switching
- Signaling measurement range overrun
- Safe, 3-way isolation with 2.5 kV test voltage according to EN 61140

Rogowski Transducer, 857-552



Configuration via:

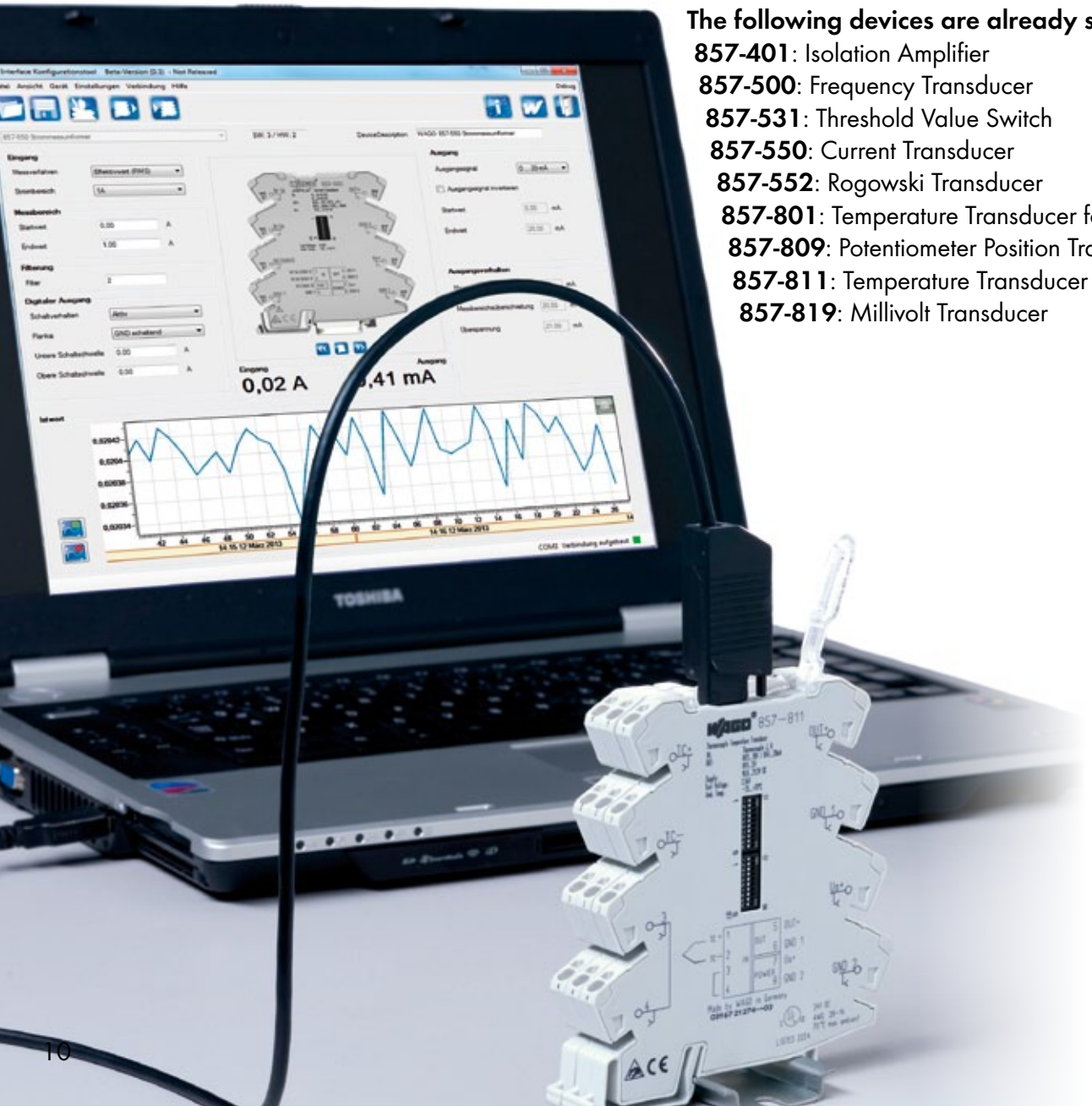
- DIP switches/PC configuration tool/smartphone app
- Digital switching output (switching thresholds are freely configurable)
- Output signal (configurable)
- Use of different Rogowski coils is possible
- True RMS measurement (TRMS)
- No current bar interruption is necessary during installation
- Calibrated measurement range switching
- Signaling measurement range overrun/line break in the measuring equipment
- Safe, 3-way isolation with 2.5 kV test voltage according to EN 61140

Interface Configuration Software

The interface configuration software – DIP switch alternative

The software offers:

- Simple EXE application
- Automatic module recognition
- Visualization of process values
- Parameterization of the digital switch output (threshold functionality)
- Communication via WAGO 750-923 USB Service Cable or WAGO 750-921 *Bluetooth*® Adapter



The following devices are already supported:

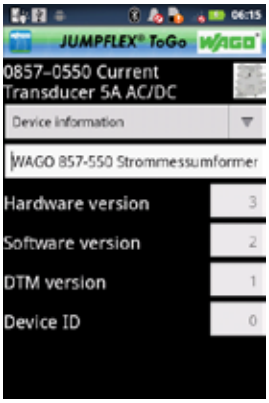
857-401: Isolation Amplifier
857-500: Frequency Transducer
857-531: Threshold Value Switch
857-550: Current Transducer
857-552: Rogowski Transducer
857-801: Temperature Transducer for Pt Sensors
857-809: Potentiometer Position Transducer
857-811: Temperature Transducer for TC Sensors
857-819: Millivolt Transducer

***JUMPFLEX*® ToGo**

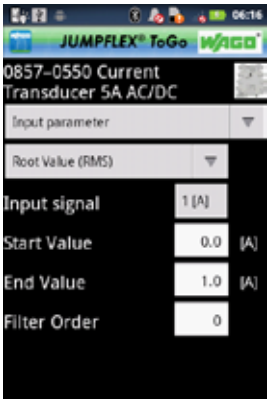
The *JUMPFLEX*® ToGo configuration app – DIP switch alternative

The free "*JUMPFLEX*® ToGo" app brings the power of a PC-based configuration software to your mobile device. Configure 857 Series Transducers' input and output parameters via finger swipe on your Android-based smartphone or tablet. You can also easily view both configuration data and actual measured value. The WAGO 750-921 *Bluetooth*® Adapter communicates between your smartphone and transducer.

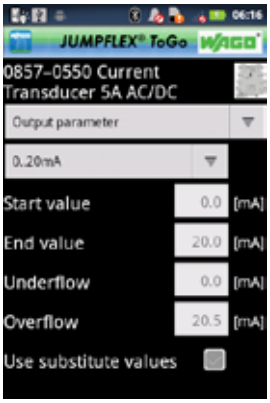
Device information:



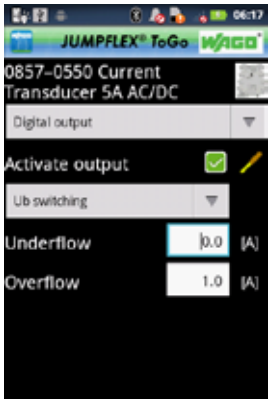
Input parameter:



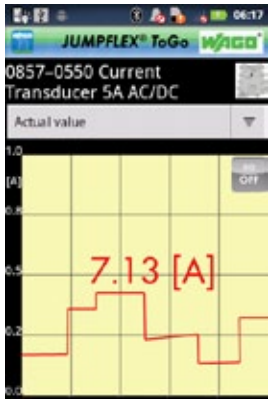
Output parameter:



Digital output:

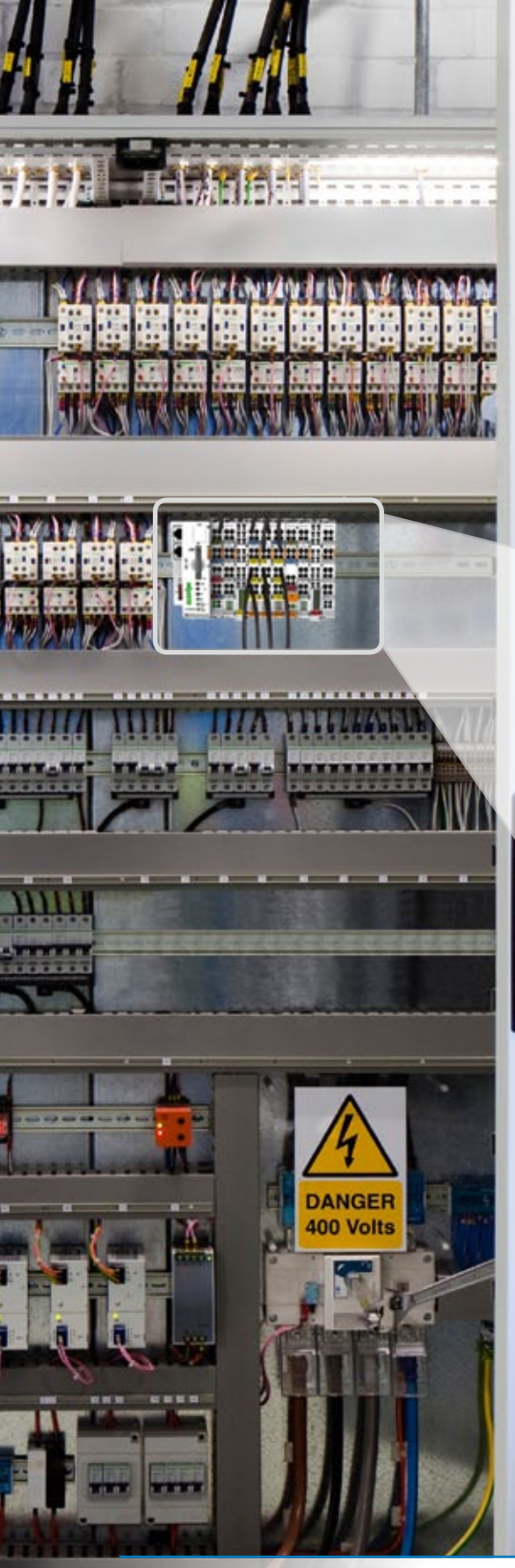


Actual value:



750-921
Bluetooth®
Adapter

Meas



- Measuring energy consumption values for machines and systems
- Collecting and processing all relevant variables
- Comprehensive network analysis
- Integration into the WAGO-I/O-SYSTEM: fieldbus-independent, compact and flexible

3-Phase Power Measurement Modules, 750 Series

The WAGO-I/O-SYSTEM 750 offers a comprehensive range of perfectly tuned solutions for your energy measurement applications. WAGO's 3-Phase Power Measurement Modules measure and process all relevant variables in a three-phase supply network. They provide system operators with increased insight into energy consumption by specific machines and systems, as well as ability to perform comprehensive network analysis.

- **Energy Cost Reduction**

Additionally, metrics allow the operator to optimize the supply to a drive or machine, protecting the system from damage and failure. For this purpose, WAGO's 3-Phase Power Measurement Modules can be integrated into existing systems.

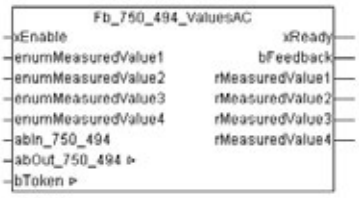
- **Equipment Protection**

	3-Phase Power Measurement Modules, 750 Series		
Product picture			
Item no.	750-493	750-494	750-495
Energy consumption	✓	✓	✓
Voltage	3~ 480 V	3~ 480 V	3~ 480 V/ 690 V
Current	1 A (750-493) 5 A (750-493/000-001)	1 A (750-494) 5 A (750-494/000-001)	1 A (750-495) 5 A (750-495/000-001)
Active energy/power	✓	✓	✓
Phase position	✓	✓	✓
Reactive power/energy	via function block	✓	✓
Apparent power/energy	via function block	✓	✓
Rotary field detection		✓	✓
Power factor	(✓)	✓	✓
Frequency measurement	✓		
Four-quadrant operation (inductive, capacitive, consumer, generator)		✓	✓
Harmonic analysis (up to the 41st harmonic)		✓	✓
N-conductor measurement			✓
Housing width	12 mm	12 mm	24 mm

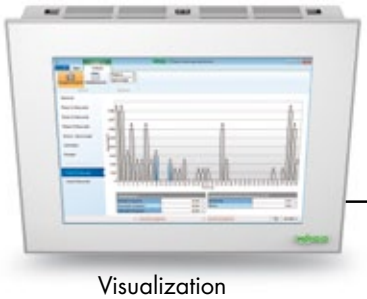
3-Phase Power Measurement Modules, 750 Series

Application examples:

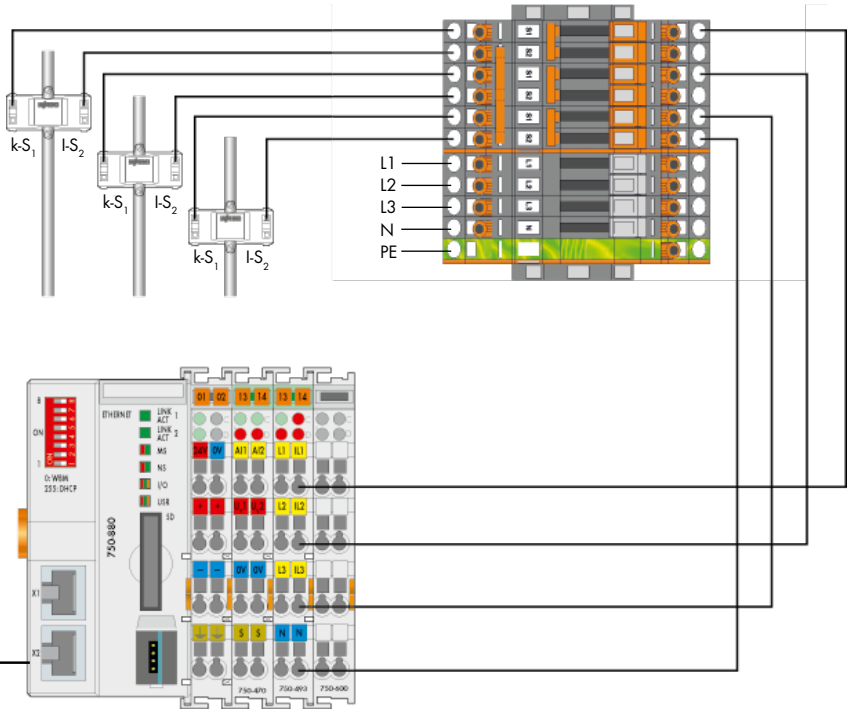
2007-8873
Terminal block assembly for
current transformers



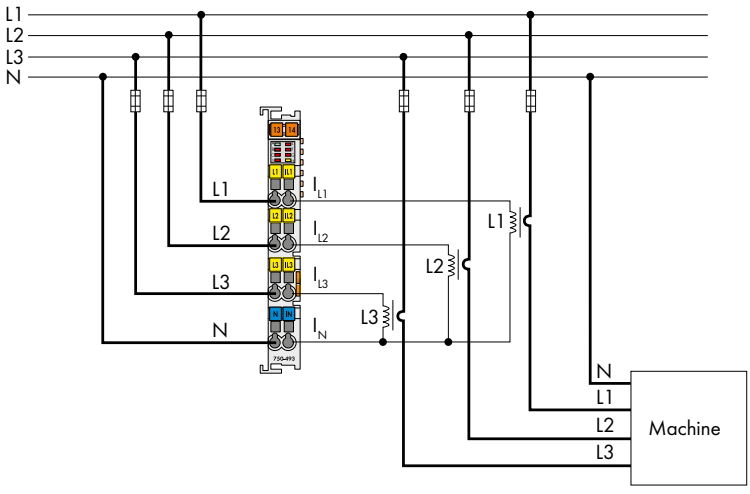
Configuration via function block
or using WAGO-I/O-CHECK



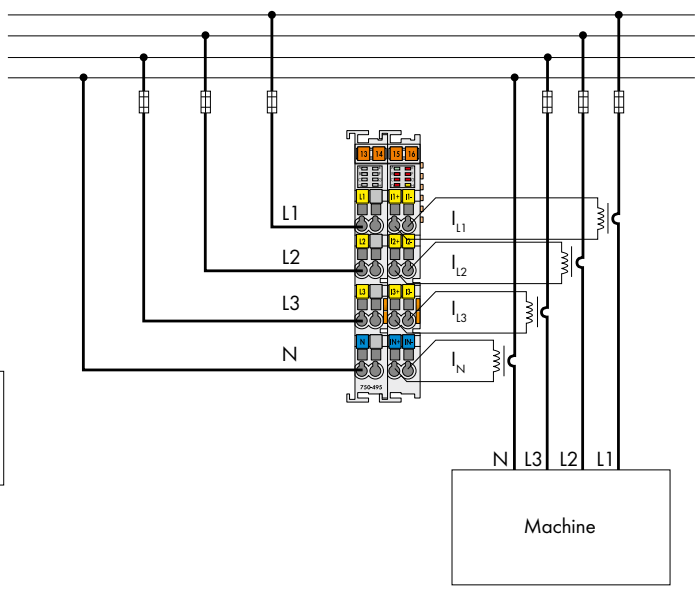
Visualization



Power and energy measurement on a machine in a 480 VAC mains network:

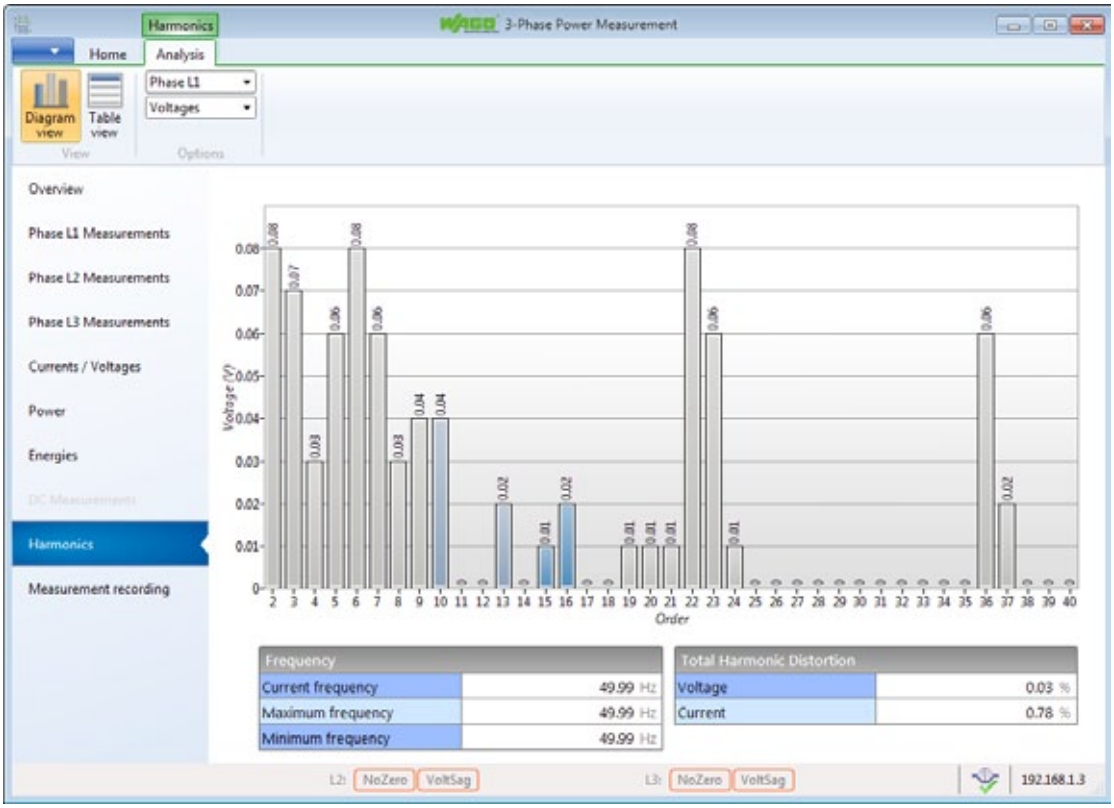


Power, energy and N-conductor measurement on a machine in a 480/690 VAC mains network:

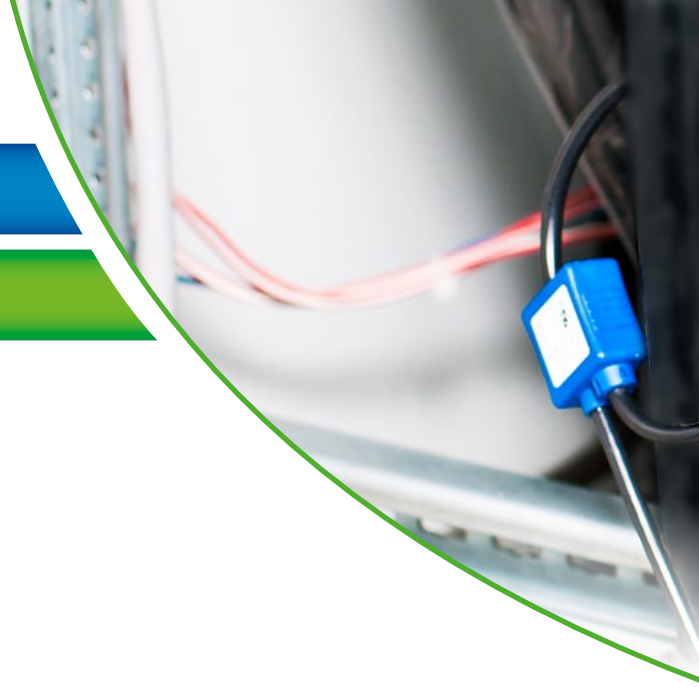


- Configuration via WAGO-I/O-CHECK or function block:

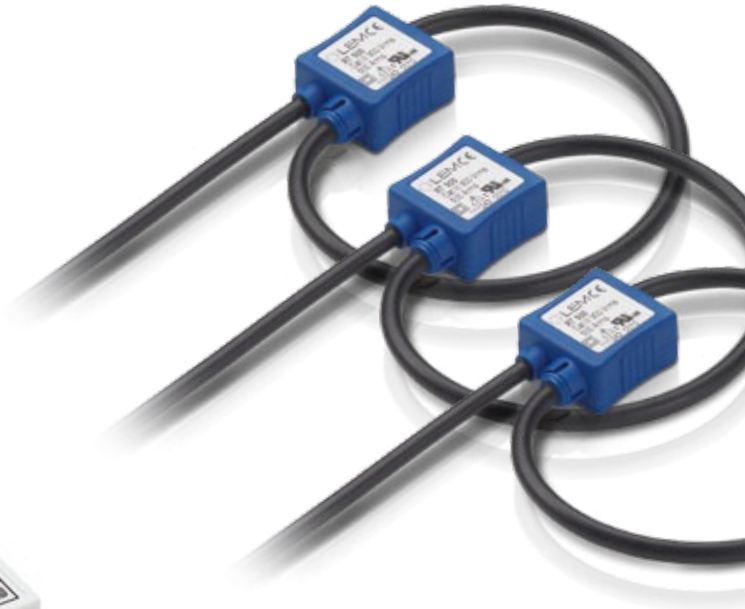
- Displaying measured values via WAGO-I/O-CHECK:

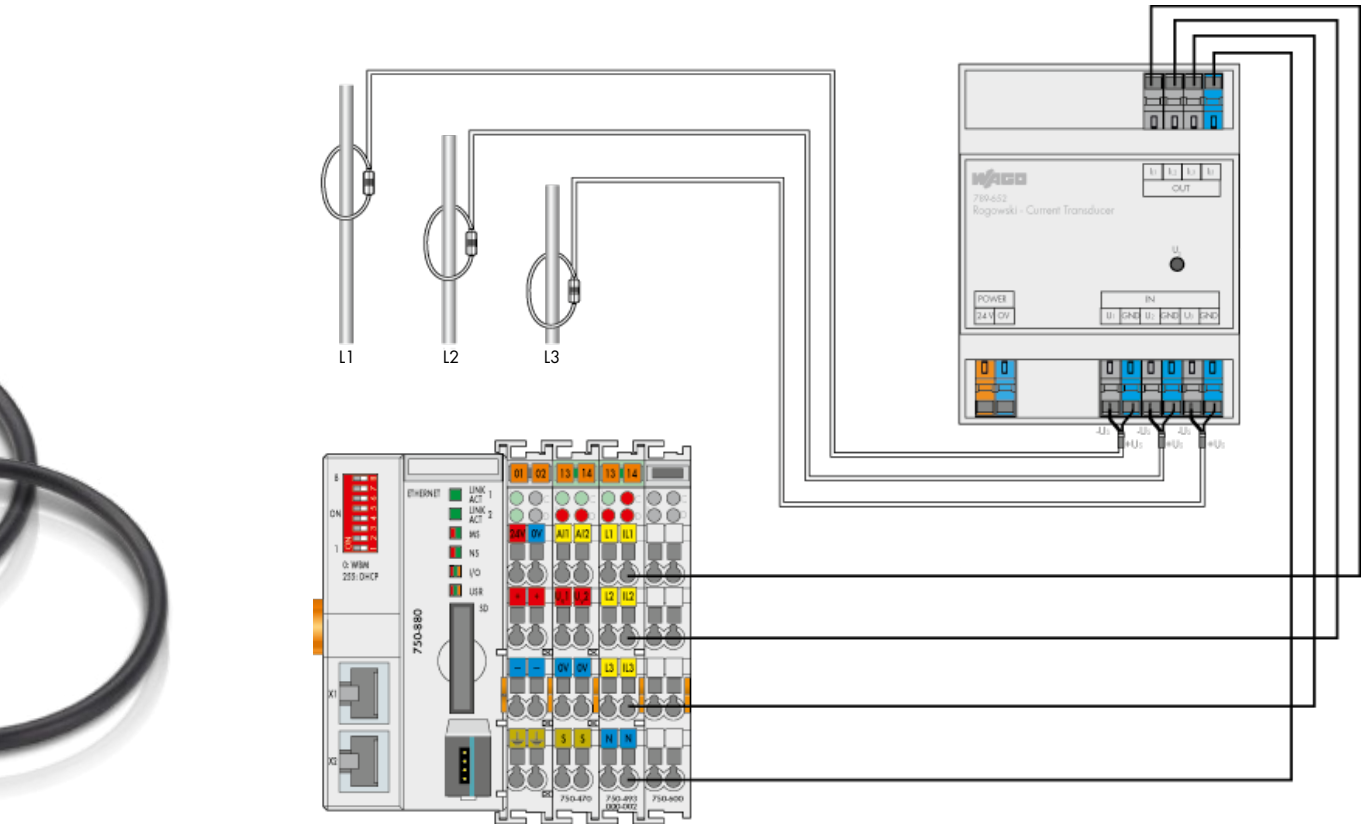


Rogowski Current Transducer



The Rogowski Current Transducer records 5–2000 A alternating currents in a three-phase system. The magnetic field generated around each conductor is detected via three non-contact Rogowski coils and provided as a proportional voltage signal to the transducer. The current transducer adjusts the phase of each of the three voltage signals, converting them into 100 mA alternating current signals, which are then transmitted to the 3-Phase Power Measurement Modules. Within the WAGO-I/O-SYSTEM, the 3-Phase Power Measurement Module measures electrical data (e.g., voltage, current, effective power and energy consumption) in a three-phase supply network. Thus, the user is always able to determine the load condition (imbalance, reactive components), to optimize consumption and protect machines or systems from damage and breakdowns. Easy installation of Rogowski coils also allows existing systems to be retrofitted without process interruption.





Item no.	789-652	789-654	750-4xx	855-9xxx
				
Input signal	3 x RT 500 (500 A)	3 x RT 2000 (2000 A)	see pages 12 – 13	see pages 24 – 25
Sensitivity	10.05 mV; 50 Hz, sinusoidal	40.2 mV; 50 Hz, sinusoidal		
Output signal	3 x 100 mA AC			
Overcurrent	750 A	3000 A		

Intelligent current sensors monitor solar plants or inverters for DC measurements within a large current measurement range.

Addressing

Status indicator

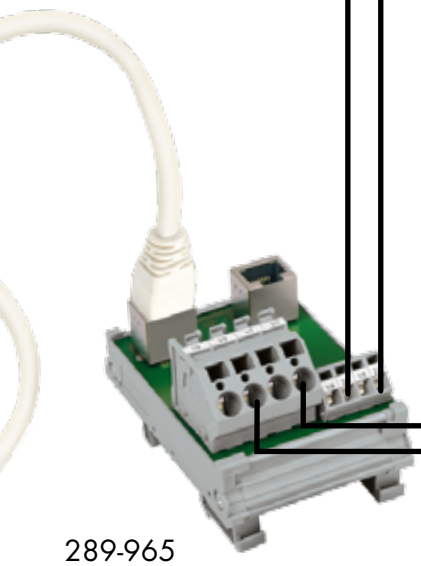
1 ... 32 sensors

... Monitor Solar Plants via MODBUS Communication

Item no.	789-620	789-621	789-622
Product picture			
Measuring range	0 ... 80 A DC	0 ... 140 A DC	0 ... 50 A AC rms
Transmission error	≤ 0.5% of upper range value		
Power supply	12 ... 34 V (via RJ-45)		
Feedthrough	15 mm (for electrical lines)		
Interface	RS-485		
Protocol	MODBUS over serial line		
Addressing	1 ... 32		
Max. bus length	≤ 1200 m		

Connection to a WAGO *PERSPECTO*® Control Panel

Serial Interface
RS-485



Supply voltage

289-965
RJ-45 Interface Module for
Current Sensor Modules

E.g., 787-1002
EPSITRON® COMPACT Power

Anywhere high currents have to be measured and processed, WAGO's 855 Series Plug-In Current Transformers are the first choice.

The 855 Series units transform primary rated currents into electrically isolated secondary currents of 1 A or 5 A, with a measuring accuracy of one percent (accuracy class 1). They can be used in temperatures ranging from -5 to +50 °C and may be permanently loaded with up to 120 % of the nominal current. The 855 Series´ UL-recognized components are suitable for 230 V, 400 V and 690 V low-voltage applications.

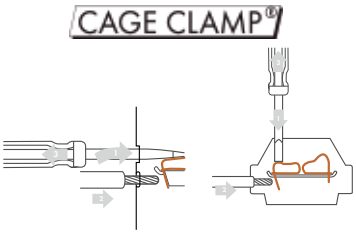
WAGO's plug-in units are inductive, single-conductor current transformers. The special feature is the screwless, shock- and vibration-resistant CAGE CLAMP® connection technology. CAGE CLAMP® provides screwless termination of conductors ranging from 0.08 to 4 mm² (AWG 28–12). Conductors can be terminated from both the front side and the rear side of the transformers. The 855 Series plastic housing is extremely robust and can be mounted in four different ways on: round cables, copper current bars, mounting plates and – depending on the version – carrier rails.

- Screwless CAGE CLAMP® connection technology
- Continuous overload of 120 % the nominal primary current
- Low-voltage current transformer for max. operating voltages up to 1.2 kV
- UL-recognized components

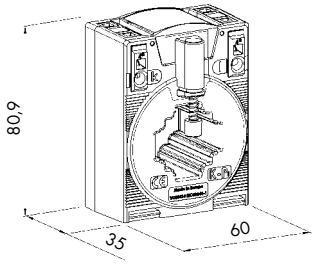
Item Number	Product Picture	Primary Rated Current	Secondary Rated Current	Rated Power	Accuracy Class	Pack. Unit
855-0301/0050-0103		50 A	1 A	1.25 VA	3	1
855-0305/0050-0103			5 A			
855-0301/0060-0101		60 A	1 A	1.25 VA	1	1
855-0305/0060-0101			5 A			
855-0301/0075-0201		75 A	1 A	2.5 VA	1	1
855-0305/0075-0201			5 A			
855-0301/0100-0201		100 A	1 A	2.5 VA	1	1
855-0305/0100-0201			5 A			
855-0301/0150-0501		150 A	1 A	5 VA	1	1
855-0305/0150-0501			5 A			
855-0301/0200-0501		200 A	1 A	5 VA	1	1
855-0305/0200-0501			5 A			
855-0301/0250-0501		250 A	1 A	5 VA	1	1
855-0305/0250-0501			5 A			
855-0301/0400-1001		400 A	1 A	10 VA	1	1
855-0305/0400-1001			5 A			
855-0301/0600-1001		600 A	1 A	10 VA	1	1
855-0305/0600-1001			5 A			
855-0401/0400-0501		400 A	1 A	5 VA	1	1
855-0405/0400-0501			5 A			
855-0501/1000-1001		1000 A	1 A	10 VA	1	1
855-0505/1000-1001			5 A			
Accessories						
855-9900		Carrier Rail Adapter for Plug-In Current Transformers (for 855-3xx/xxxx-xxxx and 855-4xx/xxxx-xxxx)				1
855-9910		Quick-Mount Kit				1

WAGO Plug-in Current Transformers – Time-Saving Installation

CAGE CLAMP® connection

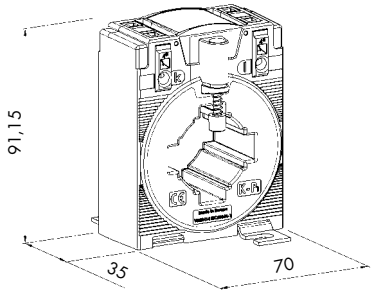


Quick-mount kit



855-03xx/xxxx-xxxx

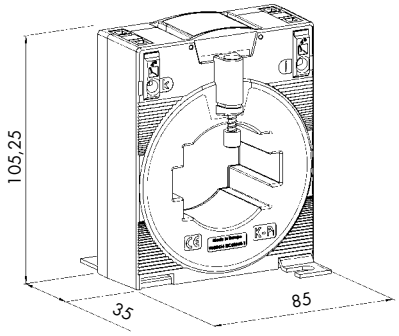
Rail 1: 30 x 10 mm
Rail 2: 25 x 12 mm
Rail 3: 20 x 20 mm
Round cable: 26 mm



855-04xx/xxxx-xxxx

Rail 1: 40 x 10 mm
Rail 2: 30 x 15 mm

Round cable: 32 mm



855-05xx/xxxx-xxxx

Rail 1: 50 x 12 mm
Rail 2: 40 x 30 mm

Round cable: 44 mm

Mounting on round cable

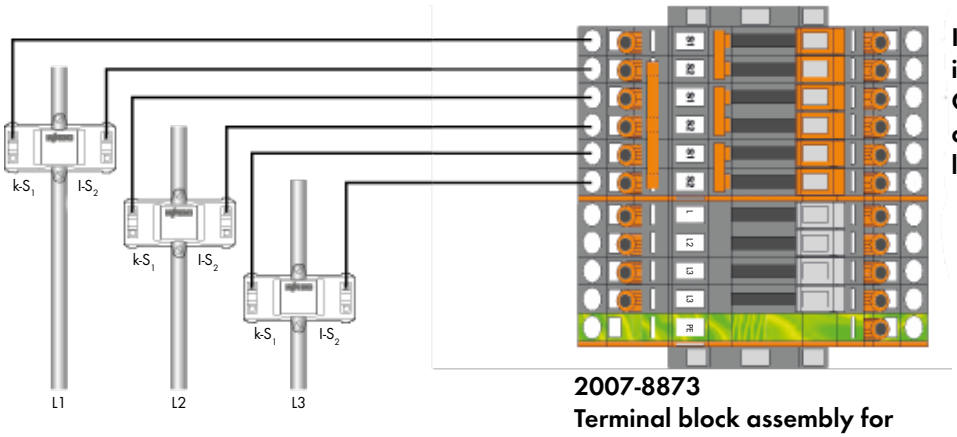
Mounting on copper current bar

Mounting on carrier rail with carrier rail adapter

Mounting on mounting plate

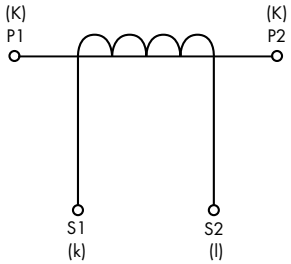
Quick-mount kit

Current transformers, which are not directly connected to a consumer, must be short-circuited on the secondary side for safety reasons! If there is no low-resistance load on the secondary side, then significant increases in voltages can occur. These present a danger for people and may possibly impair the functional safety of the current transformer. WAGO's terminal block assembly for current transformers (2007-8873) provide the required safety and functionality. Simple actuation of the lever automatically short-circuits the current transformer via inserted circuit jumper.



2007-8873
Terminal block assembly for current transformers

Implementation of the primary winding is designated with "K-P1" and "L-P2." Connections of the secondary winding are designated with the corresponding lower case letters "k-S1" and "I-S2."



Current transformer power requirements:
Both power losses from the measuring conductors and from connected devices must be considered when determining actual power requirements. It is therefore necessary to calibrate the power supply of the current transformer (nominal apparent power) to the actual power requirement of the measuring device. To determine actual power requirements, both the power requirements of the connected measuring devices and the power losses from the measuring conductors connected to the transformer's secondary circuit must be taken into account.

Power calculation of copper conductors between measuring device and current transformer:

$$P_V = \frac{I_S^2 \times 2 \times l}{A_{CU} \times 56}\ VA$$

I_S = Secondary rated measuring current strength [A]
l = Simple conductor length in m
A_{CU} = Conductor cross-section in mm²
P_V = Conductor power loss

Note: When using a common three-phase current return conductor, the values for P_V are halved.

Example:
A 1 amp or 5 amp current transformer is used, with an ammeter on the secondary circuit, at a distance of 10 m between the transformer and the measuring device.

Current transformer 1 A

$$P_V = \frac{1^2 \times 2 \times 10}{1.5 \times 56}\ VA = 0.24\ VA$$

Current transformer 5 A

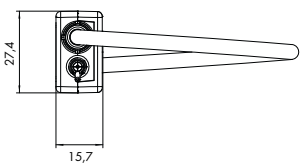
$$P_V = \frac{5^2 \times 2 \times 10}{1.5 \times 56}\ VA = 5.95\ VA$$

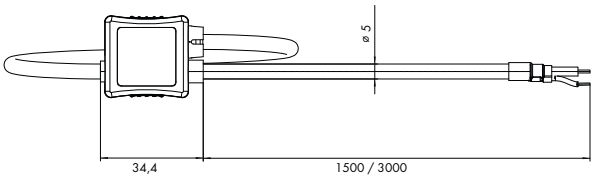
Rogowski Coils, 855 Series

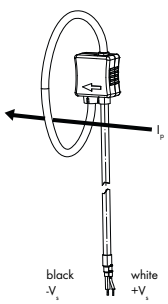
Slim, Light-Weight, Flexible, Hinged Current Sensor

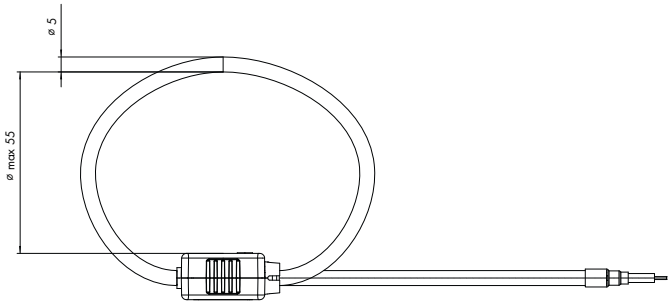
The Rogowski coil is a closed-air coil with non-magnetic split core. The coil is placed around a conductor or current bar. The magnetic field produced by the AC current flowing through the conductor induces an output voltage in the coil. This measurement procedure provides galvanic isolation between the primary circuit (power) and secondary circuit (measurement). Easy installation of the Rogowski coils allows existing systems to be retrofitted without time-consuming installation or process interruption.

Description	Product Picture	Item Number	Pack. Unit	Input	Output
Rogowski Coil RT 500, Conductor length 1.5 m		855-9100/500-000	3	500 A	10.05 mV
Rogowski Coil RT 500 Conductor length: 3 m		855-9300/500-000	3		
Rogowski Coil RT 2000 Conductor length: 1.5 m		855-9100/2000-000	3	2000 A	40.2 mV
Rogowski Coil RT 2000 Conductor length: 3 m		855-9300/2000-000	3		









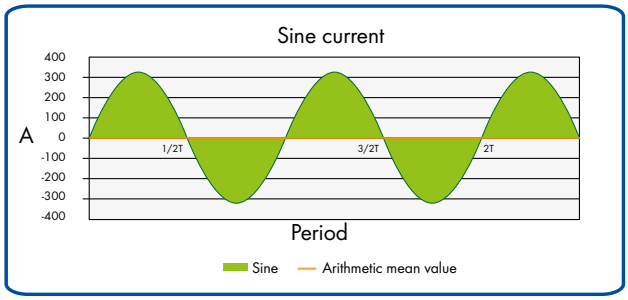
- Easy installation of Rogowski coils for retrofitting existing machines and systems without process interruption.
- Broad measuring range: only two types of Rogowski coils instead of several different current transformers.
- Reduced footprint: ideal for measuring high currents.
- Connection to the WAGO-I/O-SYSTEM links measurement results with controls (e.g., for optimizing consumption or preventing damage), unlike a system that only provides measurements.
- Existing CODESYS function blocks can be used, minimizing engineering time.

Rogowski Coils – Time-Saving Installation

Arithmetic Mean Value

The arithmetic mean value (also average) is the quotient of the sum of all measured values detected and the number of measured values.

For periodic variables (e.g., sine waves) the arithmetic mean is zero. For this reason, it is not meaningful for use with periodic variables, or it only provides information about a possibly present constant. For DC variables, the arithmetic mean value corresponds to the average measured value viewed over time.



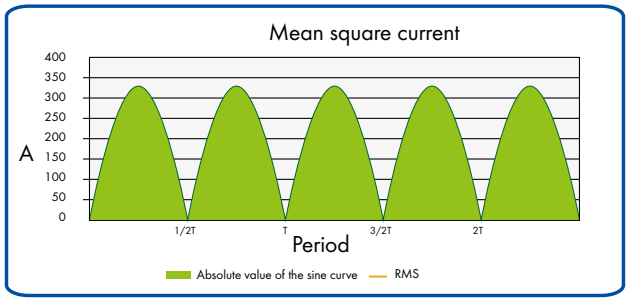
Effective Value

The effective value – RMS (root-mean-square), also the TRMS (true root-mean-square) – is the square root of the quotient of the sum of squares of the measured values and number of measured values (square root of the average of the measured value).

$$I_{rms} \approx \sqrt{\frac{1}{n}\sum_{i=1}^{n} x_i^2}$$

In electrical engineering, the effective value of an periodic quantity corresponds to the effective value of the DC variable. It is characteristic of the power transformed in the consumer.

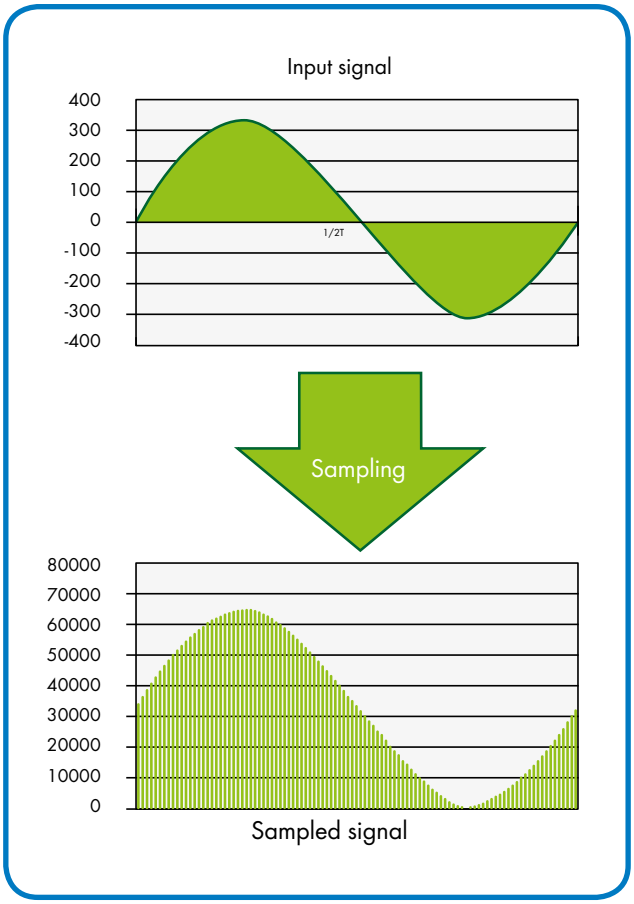
A differentiation is frequently made between the terms RMS and TRMS. This is merely historical conditioning, so that newer measuring procedures are preferred over form factor based methods. In principle, WAGO measures according to the TRMS method. However, no special differentiation is made, as both terms describe the same mathematical equation, and one merely indicates the specific accuracy of the measurement.



Digital Processing

During digital processing, the signal is sampled in defined, very short time intervals (digitized). The sampled values are processed and, e.g., converted into an analog standard signal.

Digital processes are becoming increasingly common, since high reproducibility and signal-authentic mapping true to signal can be guaranteed due to the high sampling rates. In addition, further processing or transmission of the digitized information is easier, less susceptible to interference and more flexible, due to the software.



Analog Processing

During analog processing, the input signal is fed directly to a processing unit and prepared according to a fixed transfer function. The processing takes place using an operational amplifier (OpAmp) and a few passive components.

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