SENSORS

CURRENT & VOLTAGE MEASUREMENT FOR THE GRID OF THE FUTURE

GERMANY HAMBURG • WIRGES • KIRCHAICH • DRESDEN
AUSTRIA MARCHTRENK | **HUNGARY** KECSKEMÉT | **CHINA** SHANGHAI | **USA** HARTWELL

RITZ INSTRUMENT TRANSFORMERS GMBH – EXPERIENCE AND SOLUTIONS | TOGETHER!

Experience

RITZ is one of the leading specialists worldwide in the field of instrument transformers, cast resin applications, cast resin insulated busbar systems and cast resin insulated power transformers.

The origins of the company date back to 1904. Today, the RITZ parent company in Hamburg combines the experience of "RITZ Messwandler (RITZ)", "Messwandlerbau Bamberg (MWB)", the "Transformatoren- und Röntgenwerk" in Dresden (TuR and Duromer) and the "Wandler- und Transformatoren-Werk Wirges (WTW)".

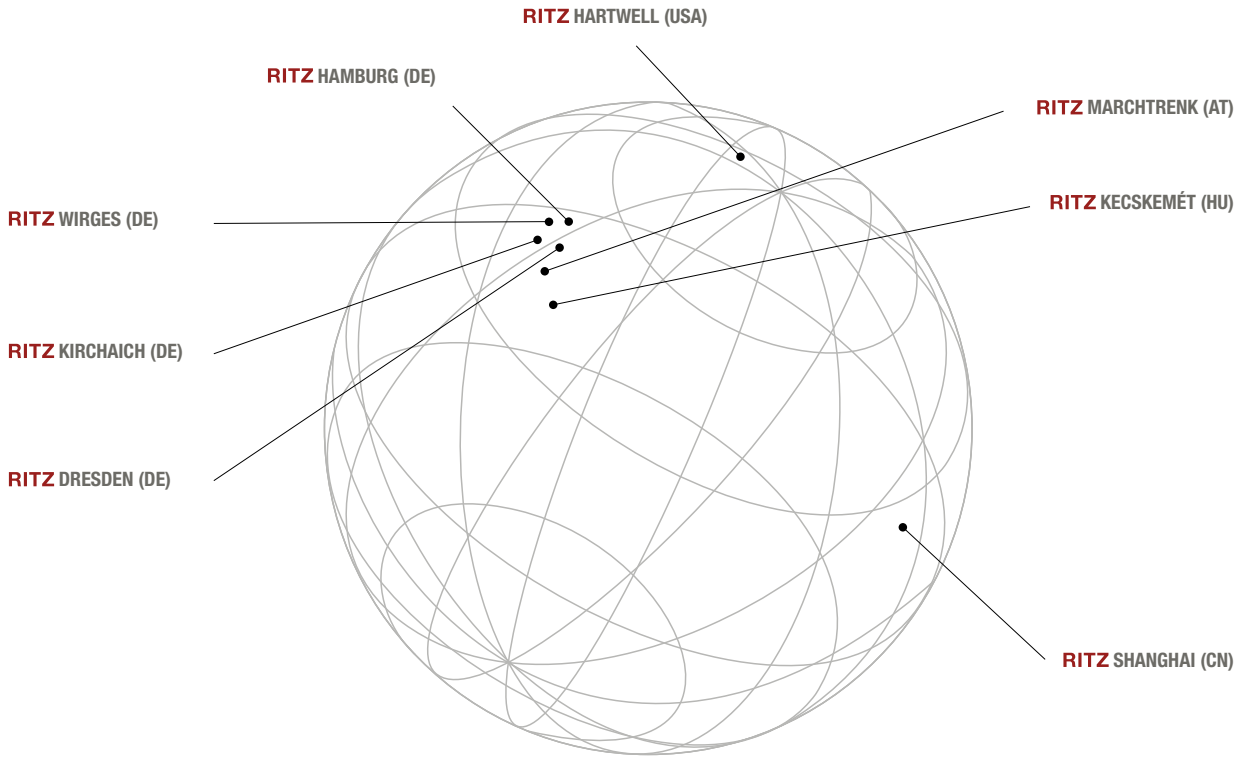
RITZ owns seven production sites, spread across Europe, China and the United States of America. Our customers include well known companies from the energy supply and electrical industries throughout the world.

Solutions

RITZ offers a broad portfolio. We develop your standard equipment, but also transform your specific ideas into customised products. Both small and large quantities can be supplied.
To achieve this, we rely on the knowledge and commitment of our employees at all our locations.
Tell us your requirements and we will develop the solution.

Together!

Our top priority at RITZ is always to find the best solution – together with our customers.



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1.0 DESIGN AND PROPERTIES OF SENSORS

1.1 WHAT ARE SENSORS?

In power engineering, instrument transformers based on the inductive principle are used to measure current and voltage. In addition to these conventional instrument transformers, there are other, non-conventional instrument transformers, some of which use other operating principles. RITZ generally refers to the passive versions under the umbrella term "sensors". They are characterised by the following properties:

- Sensors only transfer low power levels, typically ≤ 1 VA.
- Sensors have a voltage output. Standard values are 22.5 mV, 150 mV or 225 mV for current sensors and 3.25/√3 V for voltage sensors.
- Sensors can exhibit improved linearity characteristics over a wide dynamic range.

1.2 CURRENT TRANSFORMER OR CURRENT SENSOR?

Current sensors are low power, inductive current transformers with integrated burden or Rogowski coils. The voltage signal at the output is proportional to the primary current or, in the case of Rogowski coils, proportional to the derivative of the primary current. In this case, an electronic system is required on the secondary side, which integrates the voltage signal. This is important so that the actual mains frequency does not influence the measurement result. As with current transformers, current sensors can only measure alternating currents, in accordance with the principles described above. The small integrated burden of inductive current sensors allows reduced core dimensions and therefore smaller sizes. Saturation effects can occur with these current sensors, as is also the case with current transformers. Rogowski coils cannot saturate since they are wound over an air core as opposed to an iron core. Just like current transformers, current sensors do not require any auxiliary power and are maintenance-free. All current sensors from RITZ undergo a routine test before delivery.

1.3 VOLTAGE TRANSFORMER OR VOLTAGE SENSOR?

Voltage sensors consist of a resistive, resistive-capacitive or capacitive voltage divider. This divides the primary voltage such that a low voltage proportional to the primary voltage is applied at the output. In this way, not only alternating but also direct voltages can be measured. In contrast to a voltage transformer, a voltage sensor does not have galvanic isolation between the primary and secondary sides, so there are integrated surge arresters to protect the downstream devices. The accuracy of voltage sensors is influenced both by the connected burden and by the type and length of the connecting cable. The stated accuracy therefore only applies to the specified condition. Just like voltage transformers, voltage sensors do not require any auxiliary power and are maintenance-free. All voltage sensors from RITZ undergo a routine test before delivery.

1.4 SENSORS AND POWER QUALITY

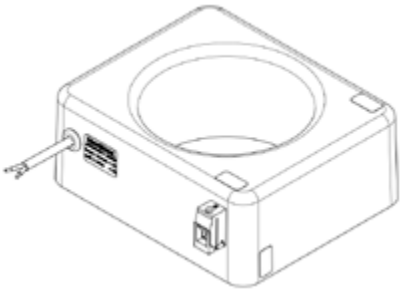
The term "power quality" is generally used to describe the electrical energy quality of electrical networks. In addition to an uninterruptible supply, this includes high current and voltage quality with low flicker, transients and harmonics, as well as a constant mains frequency. Sensors can be used to measure harmonics in order to determine current and voltage quality. These are referred to as "PQ measurements" and can be carried out with sensors that have transmission characteristics optimised for accurate measurement results even at frequencies in the kHz range. Sensors suitable for PQ measurements are marked in the catalogue with a corresponding symbol. Depending on the sensor, up to three frequency options are available: 3 kHz, 20 kHz or 150 kHz.

	Inductive instrument transformer	Sensor
Power	Up to several 100 VA	≤ 1 VA
Output signal	Current or voltage	Voltage
Standard values	1 A | 5 A	22.5 mV | 150 mV | 225 mV
Output	or 100/√3 V | 110/√3 V	or 3.25/√3 V
Primary variable	AC	DC and/or AC
Electrical isolation	Yes	Partially
Frequency	16.7 Hz | 50 Hz | 60 Hz + frequency option up to 9 kHz	0 Hz | 16.7 Hz | 50 Hz | 60 Hz + frequency option up to 150 kHz

2.0 CURRENT SENSORS – INDOOR

2.1 KSOH-S 1082

Low power passive current transformer
according to IEC 61869-10



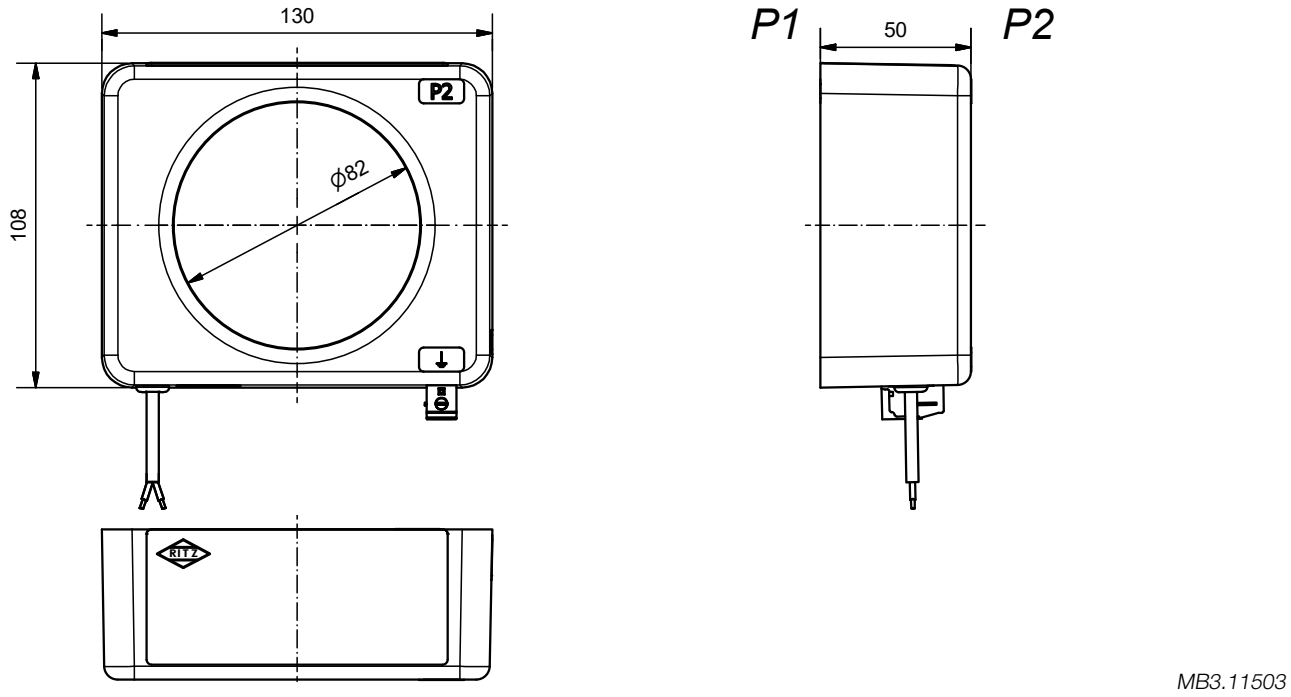
PQ
3 kHz

- **For installation in local network stations**
- **Straightforward installation**
- **With earth terminal**

TYPE	KSOH-S 1082
Rated frequency f_r	50 Hz | 60 Hz
Rated insulation level	0.72/3/- kV
Temperature category	-5 °C / +40 °C
Weight	1.0 kg
Thermal class	A
Insulation level at secondary terminals	820/1500 V
Rated primary current I_{pr}	300 A
Rated secondary voltage U_{sr}	225 mV
Factor of the extended primary rated current K_{pcr}	2
Rated short-time thermal current I_{th}	25 kA 3 s
Rated peak current I_{dyn}	63 kA
Rated continuous thermal current I_{cth}	600 A
Accuracy class	0.2-A3 * | 0.5-A3 * / 5P 6000 A
Output signal	Proportional
Rated burden R_{br}	2 MΩ / 50 pF
Rated phase offset φ_{or}	0°

** See 7.3 Accuracy depending on primary conductor position*

DIMENSIONAL DRAWING



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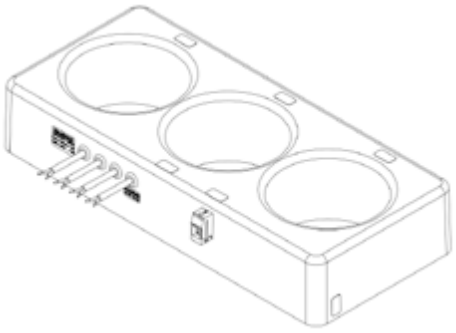
CURRENT SENSORS – INDOOR

2.2 MKSOH-S 1384

Low power passive current transformer
according to IEC 61869-10



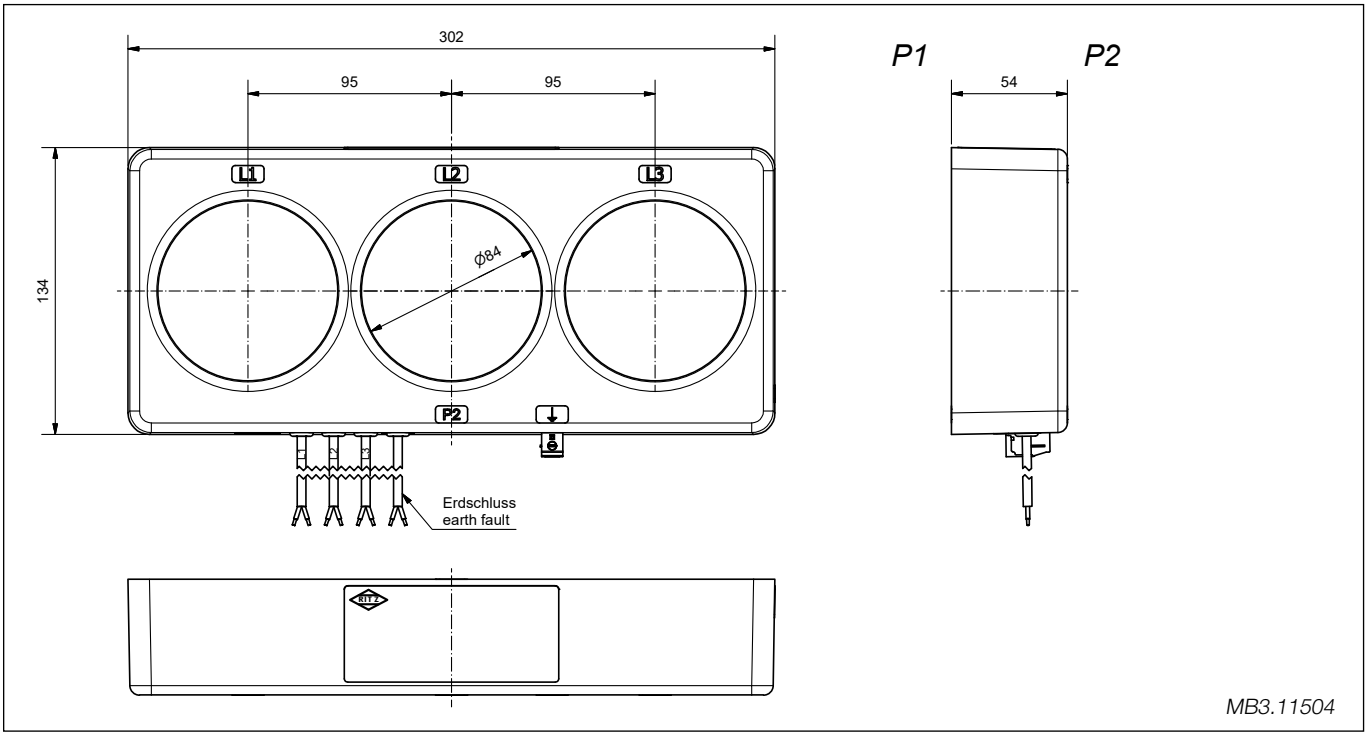
PQ
3 kHz

- **Compact solution**
- **3 phase current sensors**
- **1 earth fault detection sensor**

TYPE	PHASE CURRENT	MKSOH-S 1384	EARTH FAULT
Rated frequency f_r		50 Hz | 60 Hz	
Rated insulation level		0.72/3/- kV	
Temperature category		-5 °C / +40 °C	
Weight		2.8 kg	
Thermal class		A	
Insulation level at secondary terminals		820/1500 V	
Rated primary current I_{pr}	300 A		60 A
Rated secondary voltage U_{sr}		225 mV	
Factor of the extended primary rated current K_{pcr}		2	
Rated short-time thermal current I_{th}		25 kA 3 s	
Rated peak current I_{dyn}		63 kA	
Rated continuous thermal current I_{cth}	600 A		120 A
Accuracy class	0.5-A3 * / 5P 3000 A		1-A3 *
Output signal		Proportional	
Rated burden R_{br}		2 MΩ / 50 pF	
Rated phase offset φ_{or}		0°	

** See 7.3 Accuracy depending on primary conductor position*

DIMENSIONAL DRAWING



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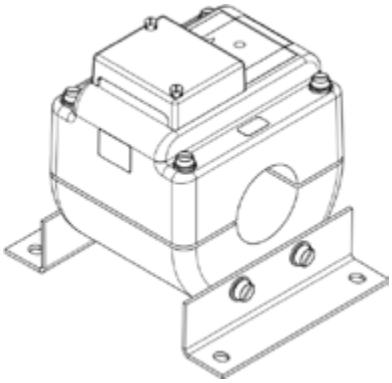
CURRENT SENSORS – INDOOR

2.3 UGSS-S 104 size 1

Low power passive current transformer
according to IEC 61869-10



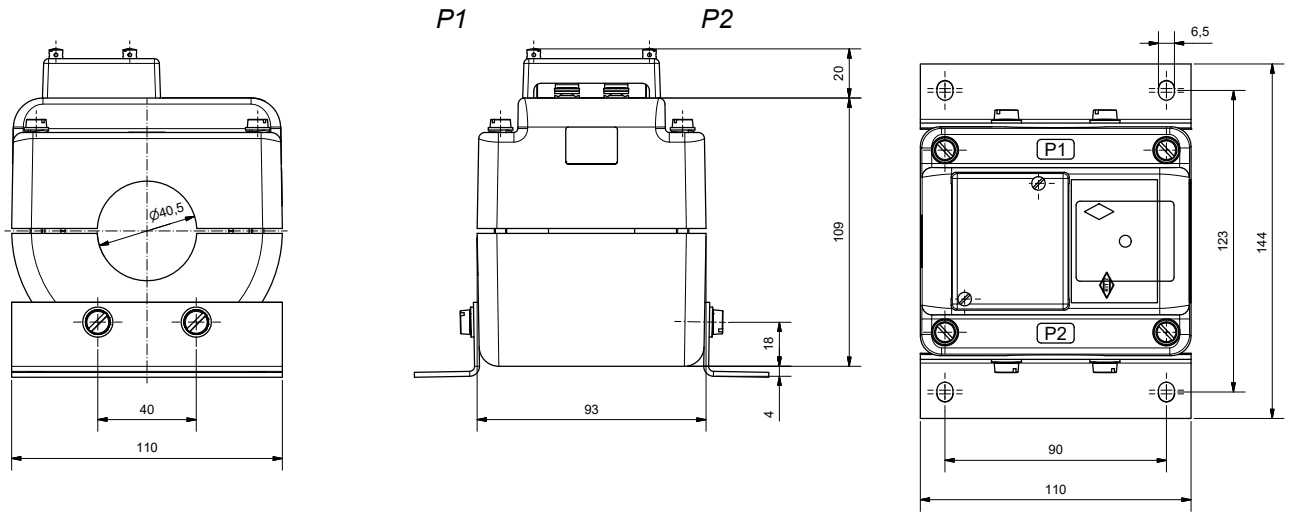
PQ
3 kHz

- **For retrofitting**
- **Straightforward installation**
- **Can be split**

TYPE	UGSS-S 104 size 1
Rated frequency f_r	50 Hz | 60 Hz
Rated insulation level	0.72/3/- kV
Temperature category	-5 °C / +40 °C
Weight	1.7 kg
Thermal class	E
Insulation level at secondary terminals	820/1500 V
Rated primary current I_{pr}	300 A
Rated secondary voltage U_{sr}	225 mV
Factor of the extended primary rated current K_{pcr}	2
Rated short-time thermal current I_{th}	25 kA 3 s
Rated peak current I_{dyn}	63 kA
Rated continuous thermal current I_{cth}	600 A
Accuracy class	0.5-A2 * / 5P 3000 A
Output signal	Proportional
Rated burden R_{br}	2 MΩ / 50 pF
Rated phase offset φ_{or}	0°

** See 7.3 Accuracy depending on primary conductor position*

DIMENSIONAL DRAWING



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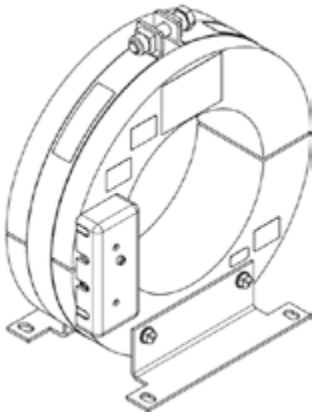
2.4 RKU-S 2012

Low power passive current transformer
according to IEC 61869-10



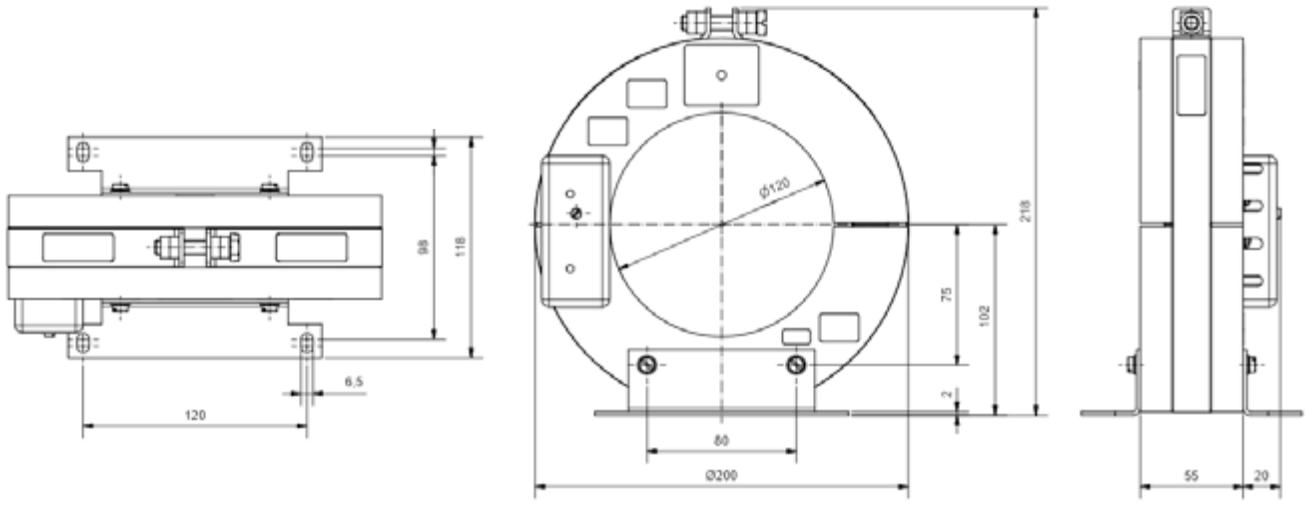
PQ
3 kHz

- **For retrofitting**
- **Straightforward installation**
- **Can be split**

TYPE	RKU-S 2012
Rated frequency f_r	50 Hz | 60 Hz
Rated insulation level	0.72/3/- kV
Temperature category	-5 °C / +40 °C
Weight	2.7 kg
Thermal class	E
Insulation level at secondary terminals	820/1500 V
Rated primary current I_{pr}	60 A
Rated secondary voltage U_{sr}	225 mV
Factor of the extended primary rated current K_{pcr}	2
Rated short-time thermal current I_{th}	25 kA 3 s
Rated peak current I_{dyn}	63 kA
Rated continuous thermal current I_{cth}	120 A
Accuracy class	0.5-A3 * / 5P 600 A
Output signal	Proportional
Rated burden R_{br}	2 MΩ / 50 pF
Rated phase offset φ_{or}	0°

** See 7.3 Accuracy depending on primary conductor position*

DIMENSIONAL DRAWING



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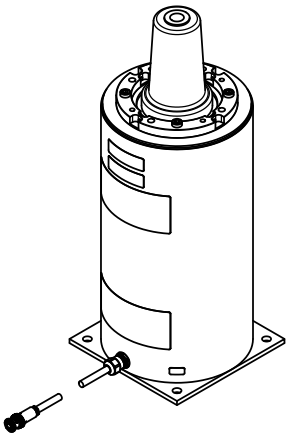
3.0 VOLTAGE SENSORS – INDOOR

3.1 GBERA 12 | 24 | 36

Low power passive voltage transformer
according to IEC 61869-11



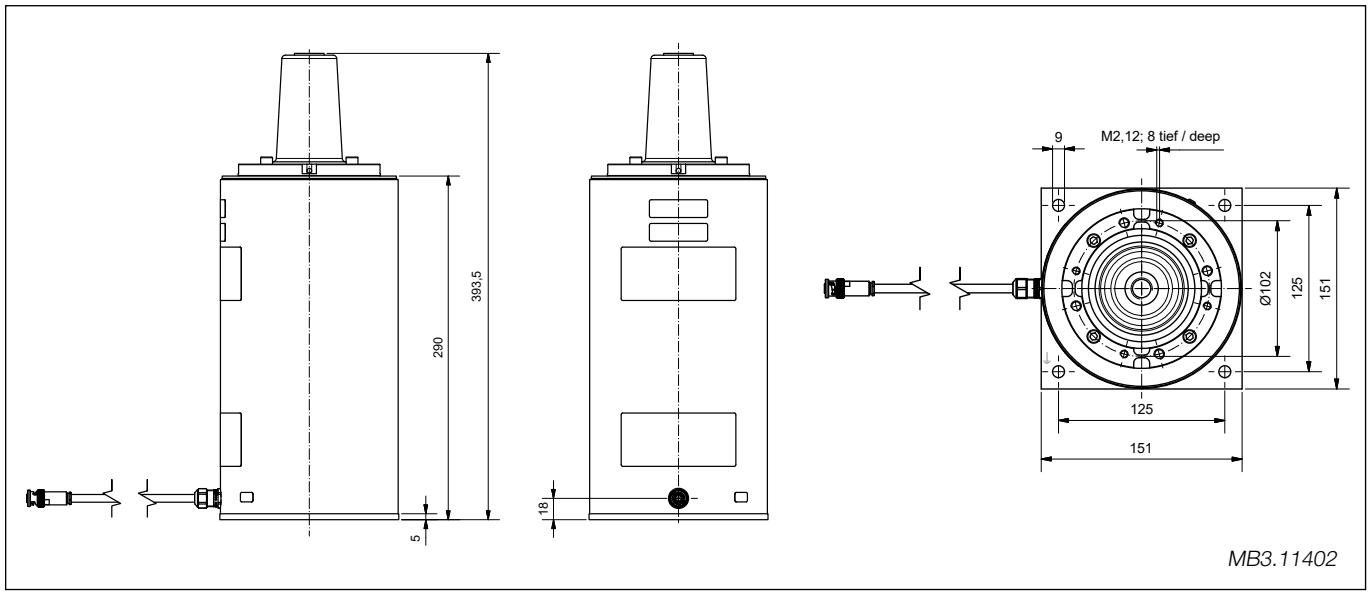
PQ
150 kHz

- **Primary terminal outer cone type C according to EN 50181**
- **Metal-clad**
- **Suitable for PQ measurements**

TYPES	GBERA 12	GBERA 24	GBERA 36
Rated frequency f_r		50 Hz | 60 Hz *	
Rated insulation level	12/28/75 kV	24/50/125 kV	36/70/170 kV
Temperature category		-5 °C / +40 °C	
Weight		9 kg	
Thermal class		E	
Insulation level at secondary terminals		n/a	
Rated primary voltage U_{pr}	10/√3 kV *	20/√3 kV *	30/√3 kV *
Rated secondary voltageU_{sr}		3.25/√3 V *	
Rated voltage factor F_V		1.2 / 1.9 8 h	
Rated burden R_{br}		2 MΩ / 50 pF *	
Accuracy class		0.5P	
Rated phase offset φ_{or}		0°	

** Other values available on request*

DIMENSIONAL DRAWING



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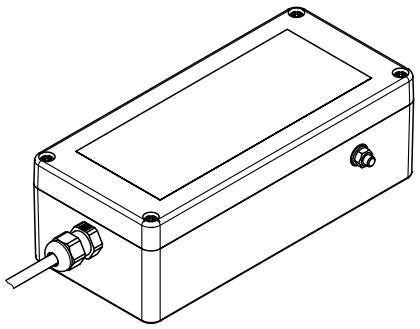
VOLTAGE SENSORS – INDOOR

3.2 GSER 3

Low power passive voltage transformer
according to IEC 61869-11



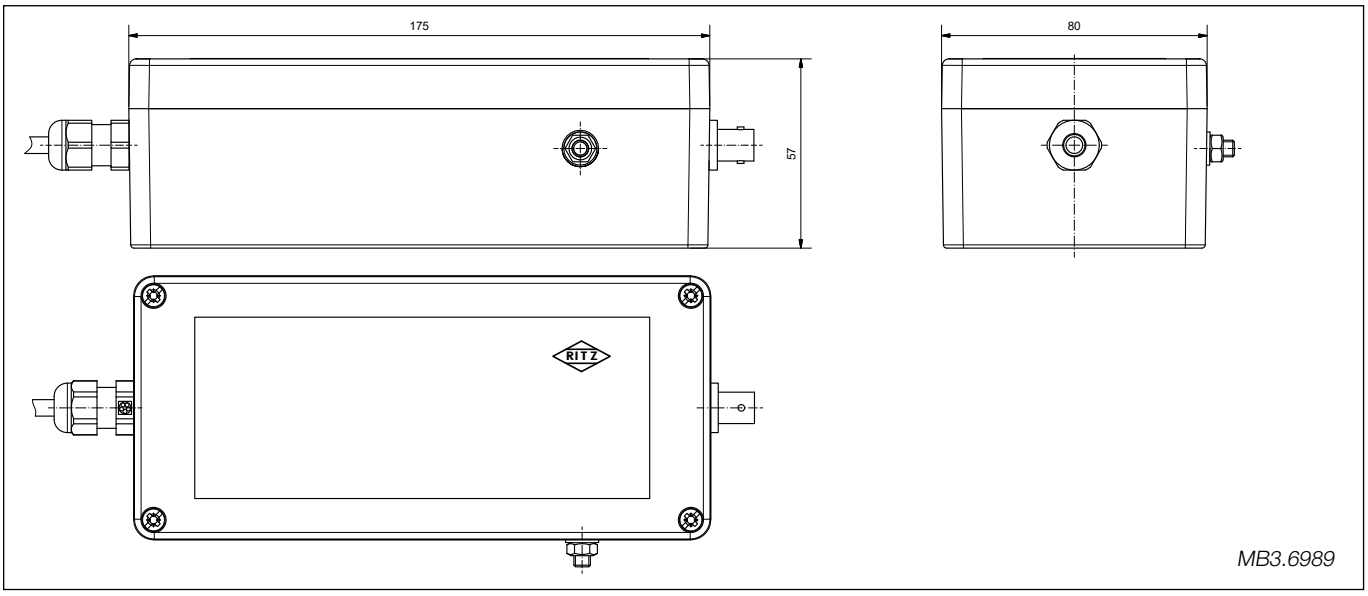
PQ
150 kHz

- **For high-precision measurements with class 0.1**
- **Accessories for power analysers**
- **Suitable for PQ measurements**

TYPE	GSER 3
Rated frequency f_r	50 Hz | 60 Hz *
Rated insulation level	6/10/20 kV
Temperature category	-5 °C / +40 °C
Weight	1.2 kg
Thermal class	E
Insulation level at secondary terminals	n/a
Rated primary voltage U_{pr}	5/√3 kV *
Rated secondary voltageU_{sr}	3.25/√3 V *
Rated voltage factor F_V	1.2 / 1.9 8 h
Rated burden R_{br}	2 MΩ / 50 pF *
Accuracy class	0.1P
Rated phase offset φ_{or}	0°

** Other values available on request*

DIMENSIONAL DRAWING



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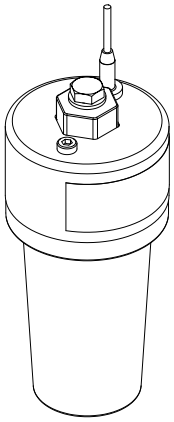
VOLTAGE SENSORS – INDOOR

3.3 MGTK 12 | 17.5 | 24

Low power passive voltage transformer
according to IEC 61869-11



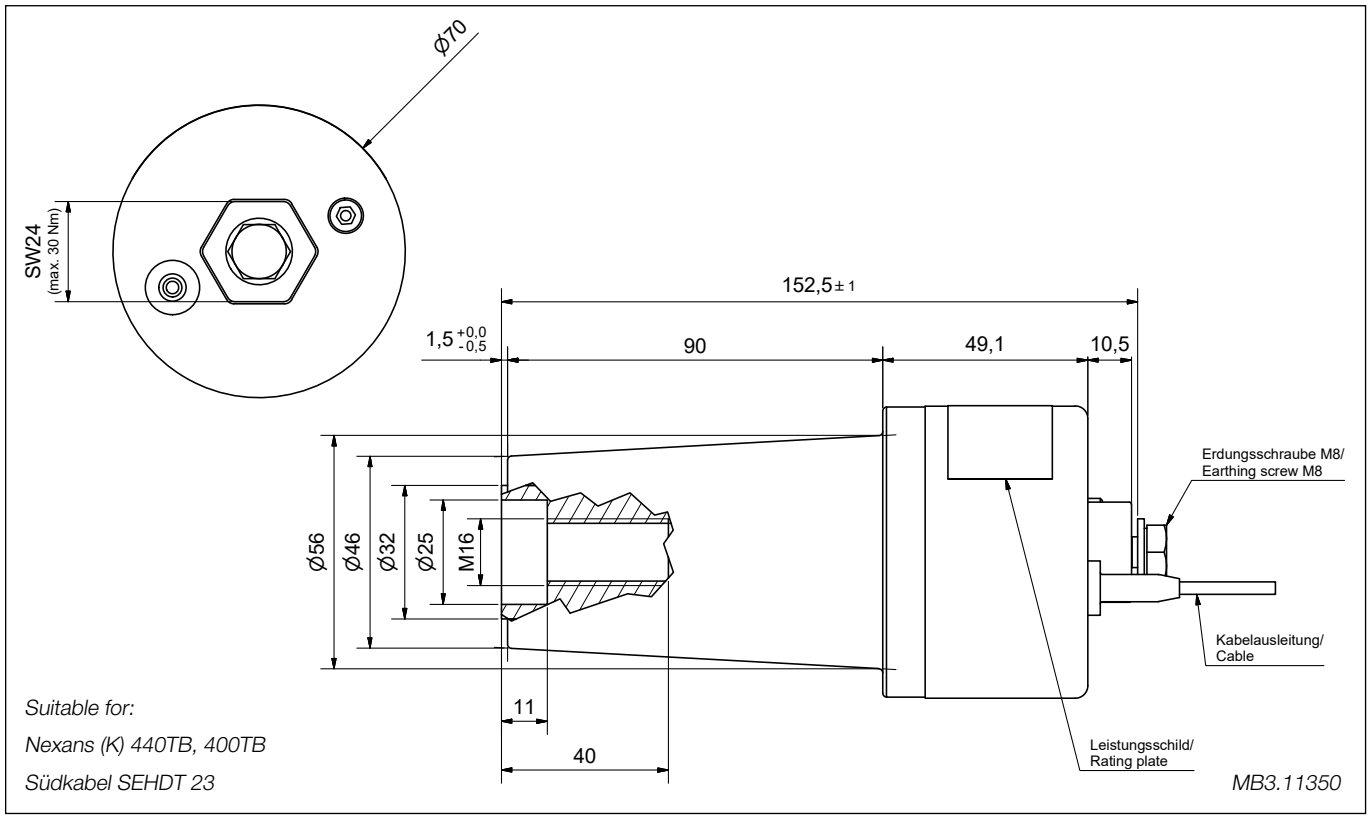
PQ
20 kHz

- **Primary terminal outer cone type C according to EN 50181**
- **For installation in symmetrical T-connectors**
- **Suitable for PQ measurements**

TYPES	MGTK 12	MGTK 17.5	MGTK 24
Rated frequency f_r		50 Hz | 60 Hz	
Rated insulation level	12/28/75 kV	17.5/38/95 kV	24/50/125 kV
Temperature category		-5 °C / +40 °C	
Weight		1 kg	
Thermal class		E	
Insulation level at secondary terminals		n/a	
Rated primary voltage U_{pr}	10/√3 kV	15/√3 kV	20/√3 kV
Rated secondary voltage U_{sr}		3.25/√3 V	
Rated voltage factor F_V		1.2 / 1.9 8 h	
Rated burden R_{br}		200 kΩ ±1 % *	
Accuracy class		0.5P	
Rated phase offset φ_{or}		0°	

** Other values available on request*

DIMENSIONAL DRAWING



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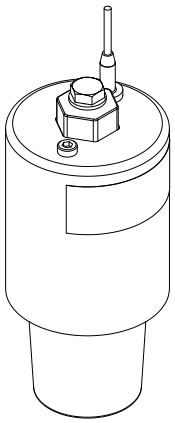
VOLTAGE SENSORS – INDOOR



PQ 20 kHz

3.4 MGTK-V 12 | 17.5 | 24

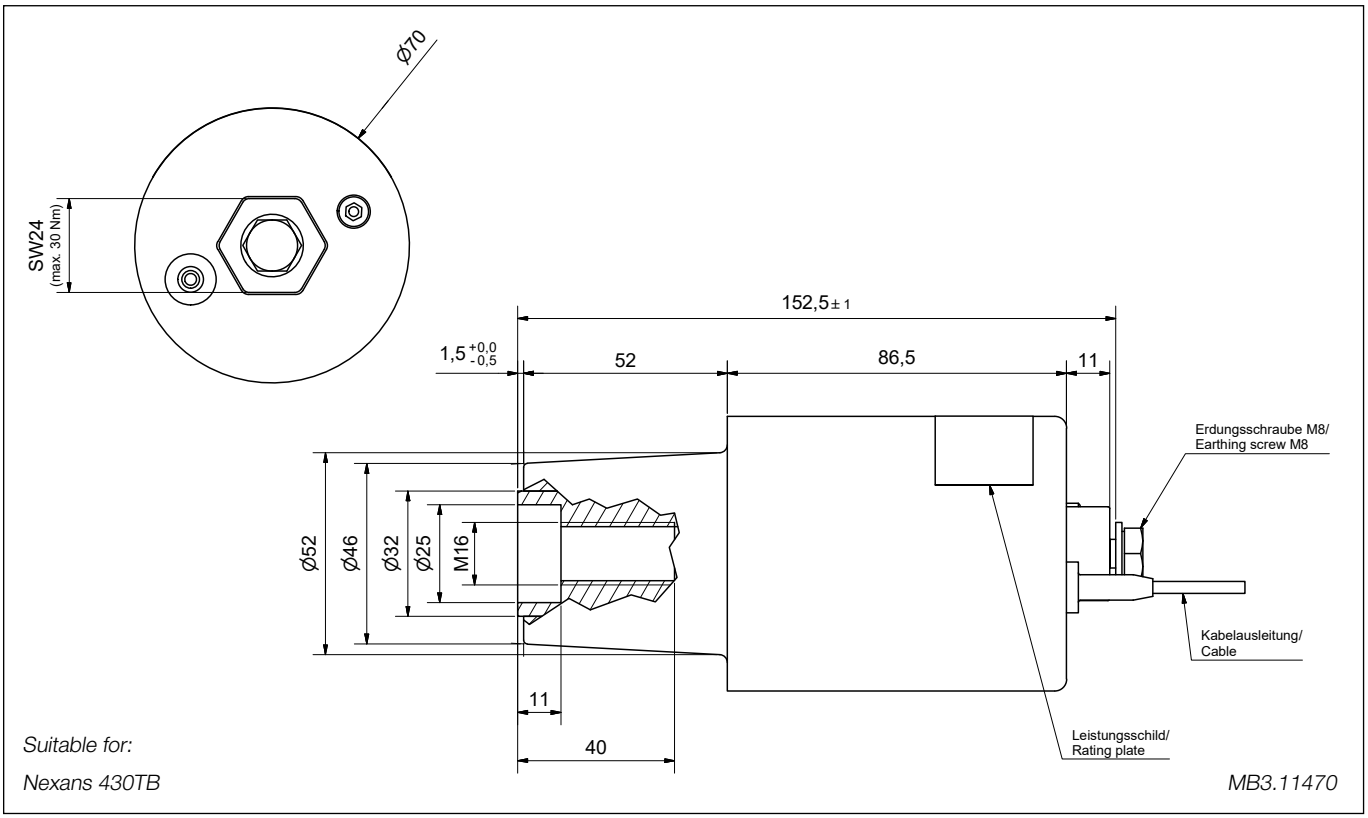
Low power passive voltage transformer according to IEC 61869-11

- **Primary terminal outer cone shortened**
- **For installation in asymmetrical T-connectors**
- **Suitable for PQ measurements**

TYPES	MGTK-V 12	MGTK-V 17.5	MGTK-V 24
Rated frequency f_r		50 Hz | 60 Hz	
Rated insulation level	12/28/75 kV	17.5/38/95 kV	24/50/125 kV
Temperature category		-5 °C / +40 °C	
Weight		1 kg	
Thermal class		E	
Insulation level at secondary terminals		n/a	
Rated primary voltage U_{pr}	10/√3 kV	15/√3 kV	20/√3 kV
Rated secondary voltage U_{sr}		3.25/√3 V	
Rated voltage factor F_V		1.2 / 1.9 8 h	
Rated burden R_{br}		200 kΩ ±1 % *	
Accuracy class		0.5P	
Rated phase offset φ_{or}		0°	

** Other values available on request*

DIMENSIONAL DRAWING



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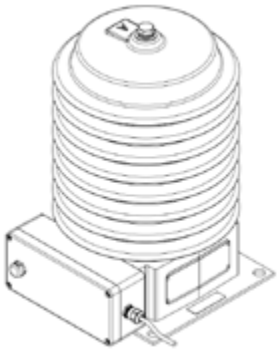
4.0 VOLTAGE SENSORS – OUTDOOR

4.1 GSER(F) 16

Low power passive voltage transformer
according to IEC 61869-11

- **Indoor or outdoor version**
- **Also available as an electronic voltage transformer**
- **Suitable for PQ measurements**



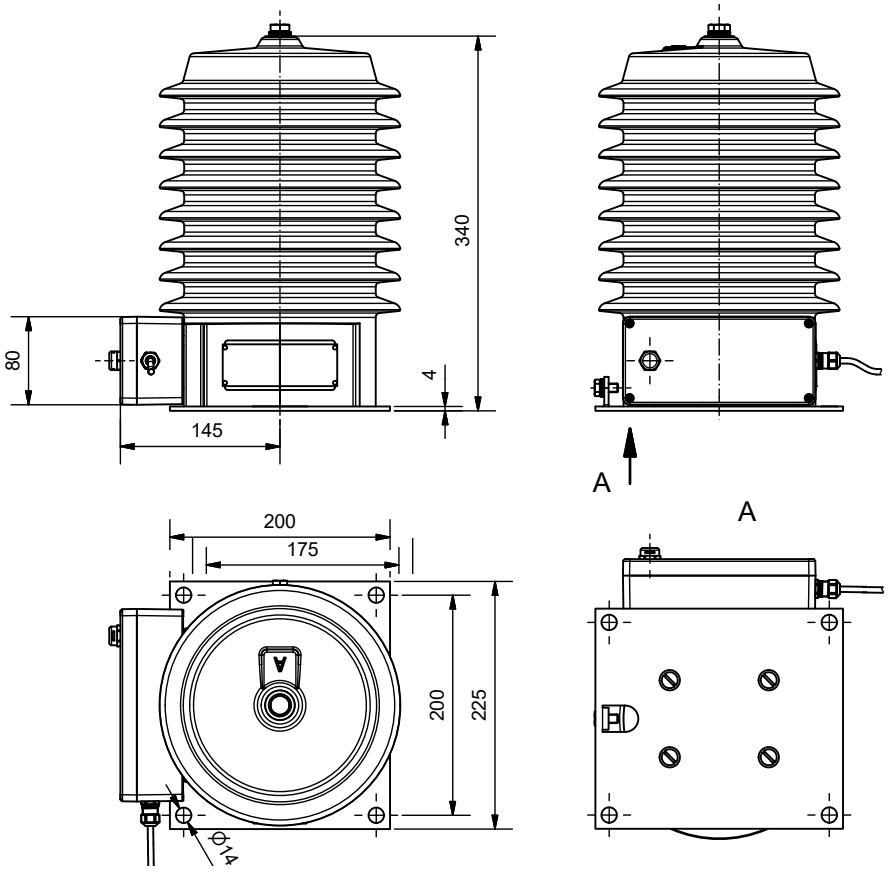
PQ
150 kHz

TYPE	GSER(F) 16
Rated frequency f_r	50 Hz | 60 Hz *
Rated insulation level	36/70/170 kV *
Temperature category	-25 °C / +40 °C
Weight	20 kg
Thermal class	E
Insulation level at secondary terminals	n/a
Rated primary voltage U_{pr}	30/√3 kV *
Rated secondary voltageU_{sr}	3.25/√3 V *
Rated voltage factor F_V	1.2 / 1.9 8 h
Rated burden R_{br}	2 MΩ / 50 pF *
Accuracy class	0.2P ** | 1P
Rated phase offset φ_{or}	0°

** Other values available on request*

*** Temperature category: -5 °C / +40 °C*

DIMENSIONAL DRAWING



Mounting:
vertical or horizontal
with terminal box downward

Flashover distance 325 min.
Creepage distance 572 min.

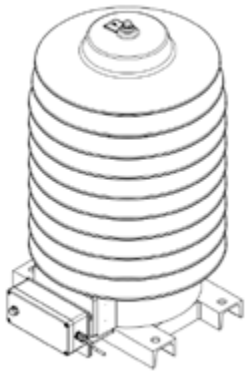
Einbaulage:
senkrecht oder waagerecht
mit Klemmenkasten nach unten

Schlagweite 325 min.
Kriechweg 572 min.

MB3.11247 | MB3.11554

Subject to technical modifications. Images for reference only.

VOLTAGE SENSORS – OUTDOOR



PQ 150 kHz

4.2 GSER(F) 52

Low power passive voltage transformer
according to IEC 61869-11

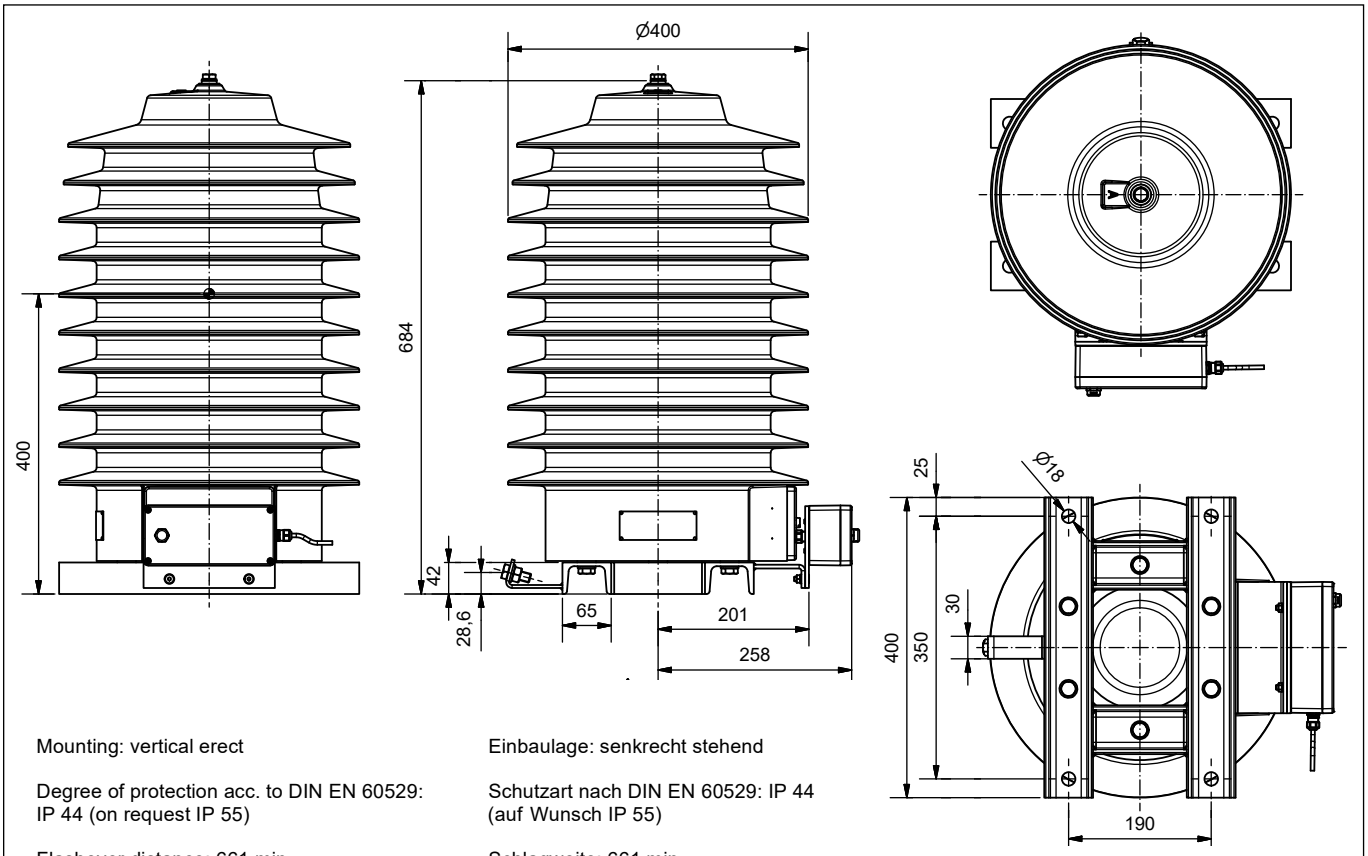
- **Indoor or outdoor version**
- **Also available as an electronic voltage transformer**
- **Suitable for PQ measurements**

TYPE	GSER(F) 52
Rated frequency f_r	50 Hz | 60 Hz *
Rated insulation level	52/95/250 kV *
Temperature category	-25 °C / +40 °C
Weight	100 kg
Thermal class	E
Insulation level at secondary terminals	n/a
Rated primary voltage U_{pr}	45/√3 kV *
Rated secondary voltageU_{sr}	3.25/√3 V *
Rated voltage factor F_V	1.2 / 1.9 8 h
Rated burden R_{br}	2 MΩ / 50 pF *
Accuracy class	0.2P ** | 1P
Rated phase offset φ_{or}	0°

** Other values available on request*

*** Temperature category: -5 °C / +40 °C*

DIMENSIONAL DRAWING



Mounting: vertical erect

Einbaulage: senkrecht stehend

Degree of protection acc. to DIN EN 60529: IP 44 (on request IP 55)

Schutzart nach DIN EN 60529: IP 44 (auf Wunsch IP 55)

Flashover distance: 661 min.
Creepage distance: 1433 min.

Schlagweite: 661 min
Kriechweg: 1433 min.

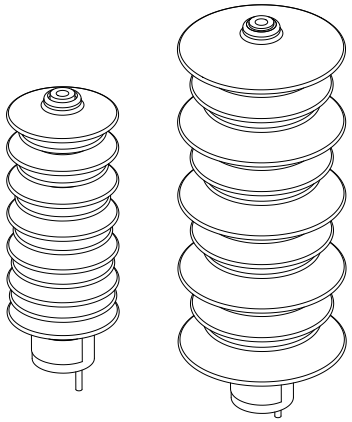
MB3.11555 | MB3.11532

Subject to technical modifications. Images for reference only.

VOLTAGE SENSORS – OUTDOOR

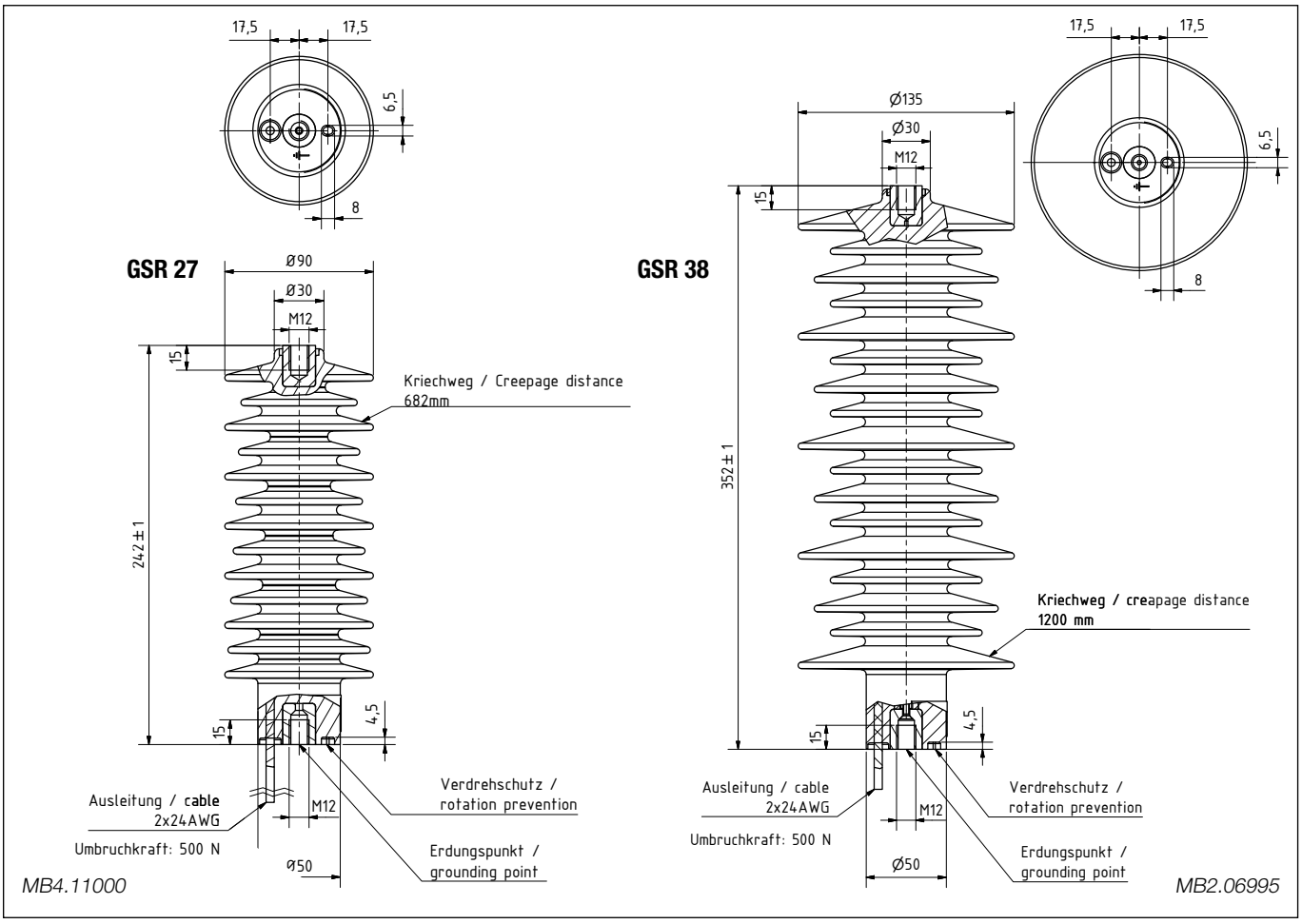
4.3 GSR 27 | 38

Low power passive voltage transformer
according to IEC 61869-11



TYPES	GSR 27	GSR 38
Rated frequency f_r	50 Hz | 60 Hz	
Rated insulation level	27/70/150 kV	38/95/200 kV
Temperature category	-40 °C / +60 °C	
Weight	1.6 kg	3.5 kg
Thermal class	E	
Insulation level at secondary terminals	820/1500 V	
Rated primary voltage U_{pr}	27/√3 kV	38/√3 kV
Rated secondary voltage U_{sr}	3.25/√3 V	
Rated voltage factor F_V	1.2 / 1.9 8 h	
Rated burden R_{br}	> 1 MΩ	
Accuracy class	3	
Rated phase offset φ_{or}	-	

DIMENSIONAL DRAWING

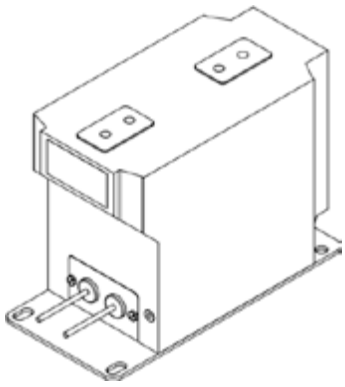


Subject to technical modifications. Images for reference only.

5.0 COMBI SENSORS – INDOOR

5.1 ABS 12 | 17.5 | 24 | 36

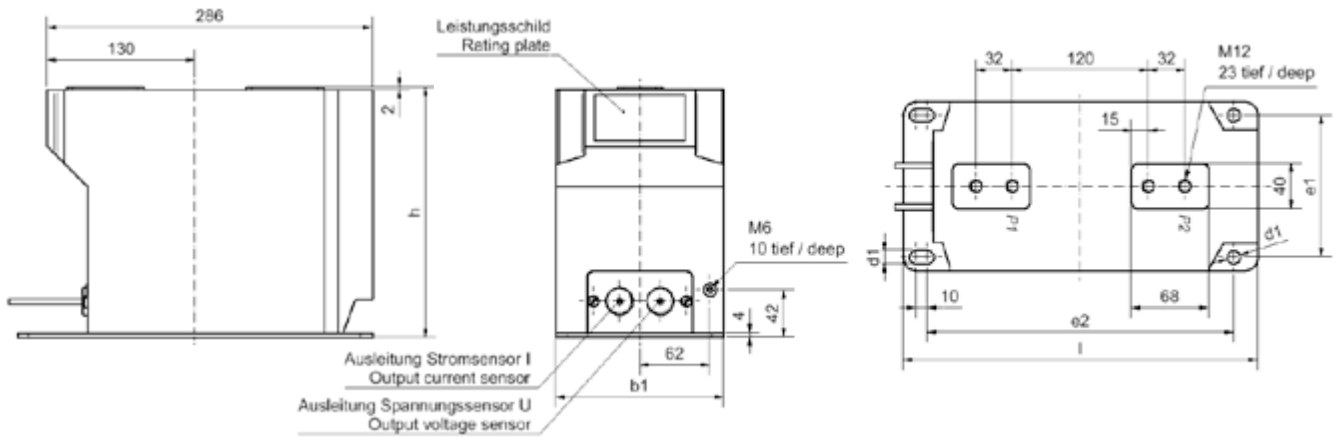
- **Support design according to DIN 42600**
- **For installation in air-insulated switchgear**
- **With coupling electrode for voltage indication**



TYPES	ABS 12	ABS 17.5	ABS 24	ABS 36
Rated frequency f_r	50 Hz | 60 Hz			
Rated insulation level	12/28/75 kV	17.5/38/95 kV	24/50/125 kV	36/70/170 kV
Temperature category	-5 °C / +40 °C			
Weight	18 to 22 kg		26 to 36 kg	45 kg
Thermal class	E			
Insulation level at secondary terminals	820/1500 V			
Rated primary current I_{pr}	250 A *			
Rated secondary voltage U_{sr}	150 mV			
Factor of the extended primary rated current K_{pcr}	10			
Rated short-time thermal current I_{th}	31.5 kA 3 s			
Rated peak current I_{dyn}	100 kA			
Rated continuous thermal current I_{cth}	2500 A			
Current sensor accuracy class	0.5			
Output signal	Proportional | derivative			
Rated primary voltage U_{pr}	10/√3 kV	15/√3 kV	20/√3 kV	30/√3 kV
Rated secondary voltage U_{sr}	1/√3 V	1.5/√3 V	2/√3 V	1,5/√3 V
Rated voltage factor F_V	1.2 / 1.9 8 h			
Voltage sensor accuracy class	0.5 | 1 | 3P			
Rated burden R_{br}	2 MΩ / 50 pF *			
Rated phase offset φ_{or}	0° | 90°			

** Other values available on request*

DIMENSIONAL DRAWING



TYPE		b_1	d_1	e_1	e_2	h	l
ABS 12 | 17.5	Narrow design (DIN 42600-8)	148	11	125	270	220	335
ABS 24	Narrow design (DIN 42600-8)	178	14	150	280	280	355
ABS 36	Large design (DIN 42600-5)	300	14	225	300	390	410

Subject to technical modifications. Images for reference only.

6.0 SECONDARY TERMINALS

The following table lists the cables, connectors and cable lengths used for the secondary terminals. Other configurationsare also possible on request.

	CABLE	CONNECTION / CONNECTOR	LENGTH
KSOH-S 1082	LiYCY 2 x 0.25 mm^2	Open ends	5 m
MKSOH-S 1384	LiYCY 2 x 0.25 mm^2	Open ends	5 m
RKU-S 2012 *	-	Terminals	-
UGSS-S 104 *	-	Terminals	-
GBERA 12 | **24** | **36**	RG 58C/U	BNC	5 m
GSER 3 *	-	BNC	-
MGTK 12 | **17.5** | **24**	LiYCY-OB	M8, 3-pole	0.2 m
MGTK-V 12 | **17.5** | **24**	LiYCY-OB	M8, 3-pole	0.2 m
GSER(F) 16	RG 58C/U	BNC	5 m
GSER(F) 52	RG 58C/U	BNC	5 m
GSR 27 | **38**	LS9YC11Y 2x24 AWG	Open ends	< 10 m
ABS 12 | **17.5** | **24** | **36**	LiYSTCYC11Y / YDDY cat6	Twin BNC / RJ45	5 m

** The connecting cable is not included in the scope of delivery. It can be ordered in addition if required.*

Subject to technical modifications. Images for reference only.

7.0 ACCURACY CLASSES ACCORDING TO IEC 61869

7.1 LIMITS AT RATED FREQUENCY

CURRENT SENSORS FOR MEASURING PURPOSES

	RATIO ERROR ε [%]					PHASE ERROR φ_e [']				
Accuracy class	**0.01 I_{pr}**	**0.05 I_{pr}**	**0.2 I_{pr}**	**I_{pr}**	**K_{pcr} x I_{pr}**	**0.01 I_{pr}**	**0.05 I_{pr}**	**0.2 I_{pr}**	**I_{pr}**	**K_{pcr} x I_{pr}**
0.1	-	±0.4	±0.2	±0.1		-	±15	±8	±5	
0.2	-	±0.75	±0.35	±0.2		-	±30	±15	±10	
0.2S	±0.75	±0.35	±0.2			±30	±15	±10		
0.5	-	±1.5	±0.75	±0.5		-	±90	±45	±30	
0.5S	±1.5	±0.75	±0.5			±90	±45	±30		
1	-	±3.0	±1.5	±1.0		-	±180	±90	±60	
3	-	-	±4.5	±3.0		-	-	-	-	-

Permissible ratio and phase error for current sensors according to IEC 61869-10:2017, Table 1001

CURRENT SENSORS FOR PROTECTION PURPOSES

	RATIO ERROR ε [%]	PHASE ERROR φ_e [']	COMPOSITE ERROR [%]
Accuracy class	**I_{pr}**	**I_{pr}**	**rated accuracy limit primary current**
5P	1	60	5
10P	3	60	10

Permissible ratio and phase error for current sensors according to IEC 61869-10:2017, Table1002

VOLTAGE SENSORS FOR MEASURING PURPOSES

	RATIO ERROR ε [%]			PHASE ERROR φ_e [']		
Accuracy class	**0.8 U_{pr}**	**U_{pr}**	**1.2 U_{pr}**	**0.8 U_{pr}**	**U_{pr}**	**1.2 U_{pr}**
0.1		±0.1			±5	
0.2		±0.2			±10	
0.5		±0.5			±20	
1		±1.0			±40	
3		±3.0			-	

Permissible ratio and phase error for voltage sensors according to IEC 61869-11:2017, Table 1101

VOLTAGE SENSORS FOR MEASURING AND/OR PROTECTION PURPOSES

	RATIO ERROR ε [%]					PHASE ERROR φ_e [']				
Accuracy class	**0.02 U_{pr}**	**0.2 U_{pr}**	**0.8 U_{pr}**	**U_{pr}**	**F_V x U_{pr}**	**0.02 U_{pr}**	**0.2 U_{pr}**	**0.8 U_{pr}**	**U_{pr}**	**F_V x U_{pr}**
0.1P	±0.5	±0.2	±0.1			±20	±10	±5		
0.2P	±1	±0.4	±0.2			±40	±20	±10		
0.5P	±2	±1	±0.5			±80	±40	±20		
1P	±4	±2	±1			±160	±80	±40		
3P	±6	±3				±240	±120			
6P	±12	±6				±480	±240			

Permissible ratio and phase error for voltage sensors according to IEC 61869-11:2017, Table 1102

7.2 LIMITS FOR HARMONICS

			RATIO ERROR ε [%] Harmonic					Δφ [°]	PHASE ERROR φ_e [°] Harmonic			
Accuracy class	**0 Hz**	**1 Hz**	**2 to 4**	**5 and 6**	**7 to 9**	**10 to 13**	**> 13**	**1 Hz**	**2 to 4**	**5 and 6**	**7 to 9**	**10 to 13**
0.1	+1 -100	+1 -30	±1	±2	±4	±8	+8 -100	±45	±1	±2	±4	±8
0.2 I 0.2S	+2 -100	+2 -30	±2	±4	±8	±16	+16 -100	±45	±2	±4	±8	±16
0.5 I 0.5S	+5 -100	+5 -30	±5	±10	±20	±20	+20 -100	±45	±5	±10	±20	±20
1	+10 -100	+10 -30	±10	±20	±20	±20	+20 -100	±45	±10	±20	±20	±20

Accuracy classes according to IEC 61869-6:2016, Table 6A.2

3 kHz

	RATIO ERROR ε [%]			PHASE ERROR φ_e [°]		
Accuracy class	**0.1 ≤ f < 1 kHz**	**1 ≤ f < 1.5 kHz**	**1.5 ≤ f < 3 kHz**	**0.1 ≤ f < 1 kHz**	**1 ≤ f < 1.5 kHz**	**1.5 ≤ f < 3 kHz**
0.1	±1	±2	±5	±1	±2	±5
0.2 I 0.2S	±2	±4	±5	±2	±4	±5
0.5 I 0.5S	±5	±10	±10	±5	±10	±20
1	±10	±20	±20	±10	±20	±20

Accuracy class extension up to 3 kHz according to IEC 61869-6:2016, Table 6A.3

20 kHz

	RATIO ERROR ε [%]			PHASE ERROR φ_e [°]		
Accuracy class	**0.1 ≤ f < 5 kHz**	**5 ≤ f < 10 kHz**	**10 ≤ f < 20 kHz**	**0.1 ≤ f < 5 kHz**	**5 ≤ f < 10 kHz**	**10 ≤ f < 20 kHz**
0.1	±1	±2	±5	±1	±2	±5
0.2 I 0.2S	±2	±4	±5	±2	±4	±5
0.5 I 0.5S	±5	±10	±10	±5	±10	±20
1	±10	±20	±20	±10	±20	±20

Accuracy class extension up to 20 kHz according to IEC 61869-6:2016, Table 6A.4

150 kHz

	RATIO ERROR ε [%]			PHASE ERROR φ_e [°]		
Accuracy class	**0.1 ≤ f < 5 kHz**	**5 ≤ f < 10 kHz**	**10 ≤ f < 150 kHz**	**0.1 ≤ f < 5 kHz**	**5 ≤ f < 10 kHz**	**10 ≤ f < 150 kHz**
0.1	±1	±2	±5	±1	±2	-
0.2 I 0.2S	±2	±4	±5	±2	±4	-
0.5 I 0.5S	±5	±10	±10	±5	±10	-
1	±10	±20	±20	±10	±20	-

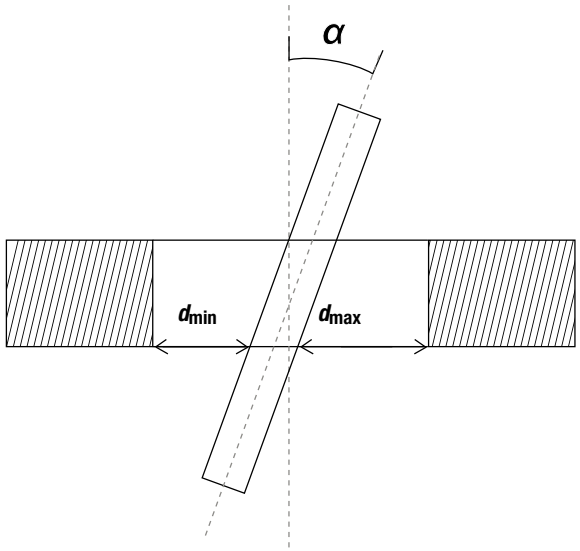
Accuracy class extension up to 150 kHz

7.3 ACCURACY DEPENDING ON PRIMARY CONDUCTOR POSITION

ADDITION	MAX. POSITION FACTOR *PF*	MAX. ANGLE α [°]
A1	0	0
A2	0.5	15
A3	1	45

According to IEC 61869-10:2017, Table 10D.1

CALCULATION OF POSITION FACTOR



$$PF = (d_{max} - d_{min}) / (d_{max} + d_{min})$$

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