4M Protective and Measuring Transformers

Medium-Voltage Equipment
Selection and Ordering Data

Catalog HG 24 · 2009

Answers for energy.

SIEMENS

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4M Protective and Measuring Transformers

Medium-Voltage Equipment
Catalog HG 24 · 2009

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Protective and Measuring Transformers – The Adaptable

The task of instrument transformers is to transform high currents and voltages proportionally and in-phase into small current or voltage values for measuring or protection purposes. So they are used either to measure and record the transmitted power or to feed protection devices with evaluable signals, which enable the protection device to e.g. trip a switching device depending on the situation. Furthermore, they isolate the connected measuring or protection equipment electrically from live parts of the switchgear.

Current transformer

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Voltage transformer

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Current transformers can be regarded as transformers working in short-circuit, with the full normal current flowing through their primary side. Devices connected on the secondary side are series-connected. Current transformers can have several secondary windings with magnetically separated cores of the same or different characteristics. They can, for example, be equipped with two measuring cores of different accuracy class, or with measuring and protection cores with different accuracy limit factors.

Due to the risk of overvoltages, current transformers must not be operated with open secondary terminals, but only in short circuit or with the burden of the measuring equipment.

Voltage transformers contain only one magnet core and are normally designed with one single secondary winding. If necessary, earthed (single-phase) voltage transformers are provided with an additional residual voltage winding (earth-fault winding) beside the secondary winding (measuring winding).

In contrast to current transformers, voltage transformers must never be short-circuited on the secondary side. The earth-side terminal of the primary winding is effectively earthed in the terminal box, and must not be removed in operation.

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Types of construction

Protective and measuring transformers are designed in different types of construction for the multiple installation requirements and operating conditions they are subjected to. They are electrical devices which convert primary electrical values – currents or voltages – into proportional and in-phase values that are adequate for the connected devices such as measuring instruments, meters, protection relays and similar. A distinction is made here between current and voltage transformers.

The following transformer types are available for selection in this catalog:

Current transformers

- Indoor support-type current transformer in block-type design
- Indoor support-type current transformer in single-turn design (e.g. bar-primary transformer)
- Indoor bushing-type current transformer in single-turn design
- Indoor bar-primary bushing-type current transformer
- Outdoor support-type current transformer

Voltage transformers

- Earthed (single-phase) or unearthed (double-phase) indoor transformers in different sizes
- Earthed (single-phase) or unearthed (double-phase) outdoor transformers in different sizes

The transformers offered in the selection are only a part of the possible variations. If the transformer required is not shown, please clarify the feasibility with the responsible sales partner or the order processing department in the Switchgear Factory Berlin. The same applies to transformers according to the ANSI standard.

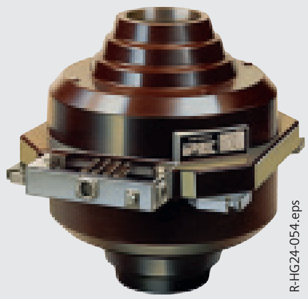
Approvals/Certifications

In Germany, instrument transformers may only be used for commercial purposes, such as billing metering of electricity, if they have been approved once (type approval) by the Physikalisch-Technische Bundesanstalt (PTB) (Federal Physical-Technical Institute), and if every transformer is calibrated by an officially recognised inspecting authority.

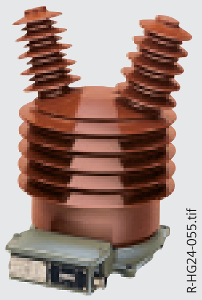
Calibration is done by a calibration office, or by the transformer manufacturer on behalf of a calibration office. The test is documented by means of a test mark as well as a calibration certificate.

The calibration costs are charged in accordance with the official scale of fees.

Example for transformer in block-type design



Example for bushing-type transformer



Example for outdoor transformer

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Current transformers

Current transformers can be regarded as transformers operating in short circuit, which carry the full rated current on the primary side. The devices on the secondary side are series-connected. They can have several secondary windings with mechanically separated cores of the same or different characteristics. Thus, current transformers can be designed e.g. with two measuring cores of different accuracy class, or with measuring or protection cores with different accuracy limit factors.

Due to the risk of overvoltages, current transformers must not be operated with open secondary terminals, but only in short circuit or with the burden of the measuring equipment.

Glossary of terms

Rated current I_N (r.m.s. value in A)

The rated primary (I_{PN}) and secondary (I_{SN}) current is the current that characterises the transformer, or the current it is designed for. Both values are given on the transformer rating plate. The rated primary current (I_{PN}) depends on the power system and is defined by the system operator.

Usual values for primary currents (in A):

10; 12.5; 15; 20; 25; 30; 40; 50; 60; 75

and their decimal multiples (preferred values are underlined).

Usual values for secondary currents: 1 and 5 A.

For technical reasons, but above all for economical reasons, 1 A is recommended as secondary current, especially if there are long measuring leads.

Rated continuous thermal current I_D (thermal strength)

The value of the current which can be permitted to flow continuously in the primary winding, the secondary winding being connected to the rated burden, without the temperature rise exceeding the values specified.

I_D is often equal to I_N, but it can also be defined as a multiple thereof.

Rated short-time thermal current I_{th}

The r.m.s. value of the primary current, flowing in case of short circuit, which a current transformer will withstand for 1 or 3 seconds without suffering harmful effects, the secondary winding being short-circuited.

Rated dynamic current I_{dyn}

The peak value of the primary current which a transformer will withstand, without being damaged electrically or mechanically by the resulting electromagnetic forces, the secondary winding being short-circuited.

Rated transformation ratio K_N

The ratio of the rated primary current to the rated secondary current. It is expressed as an unreduced fraction, e.g. 500 A/1 A.

Rated output S_N

The value of the apparent power (in VA at a specified power factor), for which the current transformer has to keep the accuracy class at the rated secondary current and with rated burden. Thus, the rated output describes the capacity of a current transformer to "drive" the secondary current within the error limits by means of a burden.

Current transformers can feature the following preferred rated outputs: 2.5 VA; 5 VA; 10 VA; 15 VA; 30 VA.

Rated burden Z_N

The burden is the apparent resistance of the devices connected on the secondary side (including all connection leads), for which the current transformer has to keep the stipulated class limits. The burden is normally expressed as apparent power in VA.

Current error F_i

The current error of a current transformer is (in %):

$$F_i = 100 \cdot \frac{K_N \cdot I_{sec} - I_{prim}}{I_{prim}}$$

K_N Rated transformation ratio
I_{prim} Actual primary current
I_{sec} Actual secondary current

Phase displacement d_i

The difference in phase between the primary and secondary current vectors, the direction of the vectors being so chosen that the angle is zero for a perfect transformer.

The phase displacement is said to be positive when the secondary current vector leads the primary current vector. It is usually expressed in minutes.

Limits of current error and phase displacement according to IEC 60044-1

Accuracy class	± current error in percent at rated current I_n				± phase displacement in minutes at rated current I_n			
	120 %	100 %	20 %	5 %	120 %	100 %	20 %	5 %
Measuring current transformers								
0.2	0.2	0.2	0.35	0.75	10	10	15	30
0.5	0.5	0.5	0.75	1.5	30	30	45	80
1	1	1	1.5	3	60	60	90	100
Protective current transformers								
5P	–	1	–	–	–	60	–	–
10P	–	3	–	–	–	–	–	–

Measuring current transformers

Current transformers provided for the connection of measuring instruments, meters and similar devices (e.g. 10 VA Cl. 0.5 FS5).

Rated instrument limit primary current

The value of the primary current at rated burden and a composite error of 10 %.

Instrument security factor n

The ratio of rated instrument limit primary current to the rated primary current

Note:

In the event of short-circuit currents flowing through the primary winding of a current transformer, the thermal stress to the measuring instruments supplied by the current transformer is smallest when the value of the rated instrument security factor is small.

Accuracy class

The limit of the percentage current error at rated current I_N (see table).

Generally, current transformers are used for a measuring range of 5 % to 120 % of the rated primary current.

Special designs

Extended current ratings

Current transformers with ext. 200 % can be continuously operated at 2 x I_N, and keep the error limits of their class in the range up to 200 % of the rated primary current.

Protective current transformers

Current transformers intended to supply protection relays (e.g. 15 VA Cl. 10 P 10).

Accuracy class (identification P)

The limit of the percentage current error for the rated accuracy limit primary current.

Rated accuracy limit primary current

The value of primary current up to which the transformer will comply with the requirements for composite error.

Accuracy limit factor

The ratio of the rated accuracy limit primary current to the rated primary current.

Multi-ratio current transformers

If the ratio of current transformers has to be variable, e.g. for planned switchgear extensions, it is possible to use multi-ratio current transformers.

Primary multi-ratio

Only possible for wound-primary transformers (transformers with several primary turns) with a ratio of 1:2 (e.g. 2 x 600 A/1 A). Reconnection is made by re-arrangement of copper lugs in the primary connection area. Ratings, instrument security factors as well as the secondary internal resistance remain constant during reconnection.

Secondary multi-ratio

In single-turn and wound-primary transformers, this can be implemented by taps of the secondary windings (e.g. 2000–1000 A/1 A).

Ratings or instrument security factors change almost linearly with the ratio. If not stated otherwise, the specified rated data is always referred to the lower current value.

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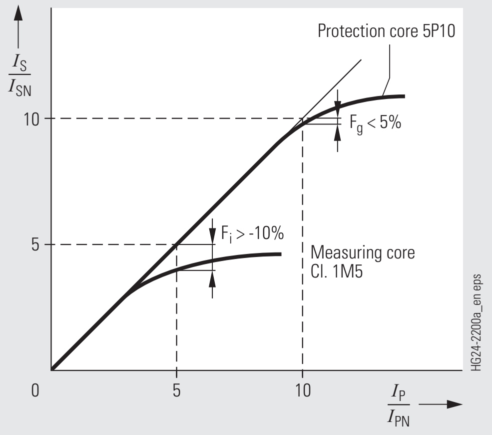
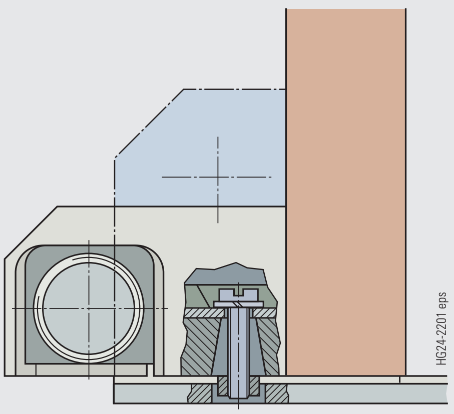


Overcurrent performance of current transformers when loaded with rated burden

F_i Current error
F_g Composite error



Earthing of the secondary winding, for example, in a 4MA7 current transformer

Performance in the event of overcurrent

In the event of an overcurrent, the rated secondary current increases proportionally with the rated primary current up to the rated instrument limit primary current.

The ratio of the rated instrument limit primary current to the rated primary current provides the instrument security factor assigned to the core. In accordance with this factor, the rated instrument limit primary current is subjected to specific error limits.

The measuring and protection cores place different demands on these error limits.

For measuring cores, the current error F_i is > –10 % in order to protect the supplied measuring devices, meters, etc. safely in case of overcurrent.

In protection cores, the composite error F_g is max. 5 % (5P) or 10 % (10P) in order to ensure the desired protection tripping.

The specified limits are only fulfilled at the rated burden of the transformer. If the operating burden differs from the rated burden of the transformer, the instrument security factor changes as follows:

$$n' = n \cdot \frac{Z_N + S_E}{S + S_E}$$

n′ Actual instrument security factor
n Rated instrument security factor
Z_N Rated burden in VA
S_E Internal power consumption of the transformer in VA (approx. 5 % to 20 % of Z_N)
S Actually connected burden in VA

Operation and earthing

The secondary circuits of current transformers must never be open during operation, as dangerously high voltages can occur, especially at high currents and cores with high ratings.

All metal parts of a transformer that are not live, but accessible, must be earthed. Therefore, the transformers have earth connection points identified with the earthing symbol. Also, one terminal of the secondary winding (for current transformers, normally k or 1s, etc.) must be earthed.

For earthing the secondary windings, a thread is provided under each secondary terminal. The earth connection required is made by fitting a special screw.