Current transformers – Technical characteristics

Current transformers are special transformers for the proportional transformation of high currents into directly measurable values. Their construction and physical operating principle enables a galvanic separation of the primary circuit from the measured circuit, thereby providing a protection for sequentially connected instruments in the event of a fault.

Rated limit current **[I_{PL}]**
value of the lowest primary current where, by the secondary measuring burden, the total deviation of the current transformer for measuring purposes is equal to or greater than 10 %.

Rated current intensity **[I_N]**
is the noted specified value of the primary and secondary current on the rating plate. Standardized primary nominal currents have the following values: 5 A, 10 A, 15 A, 20 A, 25 A, 30 A, 40 A, 50 A, 60 A, 75 A, 100 A with a decadic multiple of the previously mentioned value to a max. of 7500 A. Standardized secondary nominal currents have the values 5 A and 1 A.

Rated power
the value of the apparent power (in a VA specified power factor), which the current transformer is intended to supply to the secondary circuit and rated burden at the rated secondary current.

Earthing of secondary terminals
according to VDE 0141, section 5.3.4., current- and voltage transformers have to be earthed, starting from U_m = 3.6 kV. With low voltage (up to U_m – 1.2 kV) no earthing is required, as long as the transformer housings have no visible exposed metal surfaces.

Phase displacement error **[δ]**
signifies the phase shift of the primary current and the secondary current. The direction of the indicator is arranged in such a way, that with an optimum produced current transformer the phase displacement error is equal to zero (IEV 321-01-23 modified).
The phase displacement error is to be regarded as positive when the indicator of the secondary current is ahead compared to the indicator of the primary current. The phase displacement error is specified in minutes or hundredths of a radiant. Note: Strictly speaking this definition is only valid for sinus type currents.

Accuracy class
the denotation for a current transformer whose measuring deviation remains below the prescribed operating condition.

Total measuring deviation (Current error)
is the effective value in stationary position, and the difference between:
a) the momentary value of the primary current and
b) the momentary value of the measuring transmission of the multiplied actual secondary current, whereby the positive indicators of the primary and secondary current correspond to the accord for the connection denotation. The total deviation F_1 is generally rendered in the percentages of the effective value of the primary current, as per the following mathematical equation.

$$F_I = \frac{100}{I_P} \sqrt{\frac{1}{T} \int_O^T (K_N i_S - i_P)^2 \, dt}$$

F_I = total measuring deviation in %	i_P = momentary value of the primary current
K_N = rated measuring transmission	i_S = momentary value of the secondary current
I_P = effective value of the primary current	T = duration of period

Max. voltage for electrical equipment U_m
this denotes the highest constant permitted value for phase to phase voltage for which the current transformers isolation is rated.

Burden
the impedance of the secondary current is declared in ohms and power factor. The burden is usually expressed as the apparent power in voltamperes, absorbed at a specified power-factor and at the rated secondary current.

Rated burden
the value of the burden upon which the accurate requirements of this specifications are based.

Rated surge current **[I_{DYN}]**
peak value of the primary current, whose electro-mechanical impact is resisted by the current transformer with short circuited secondary winding. The value of the nominal search current I_{DYN} has to be 2.5 x I_{TH}. Only when there is a deviation from this value, the rating plate has to state I_{DYN}.

Actual transformation ration
is the ratio of the primary nominal current to the secondary current. It is specified as an unabridged break on the rating plate.

Open circuit voltage of current transformers	Current transformers, which are not directly encumbered with a burden, are generally secondarily short circuited. A secondary open current transformer operates like a loaded one with an almost infinitely high burden. The curve shape of the secondary current is extremely deformed and under certain conditions voltage surges occur which can be harmful to human beings. The amount of the induced "loss motion" depends on the core cross-section and the number of secondary turns. For MBS current transformers of lower ratings and with a nominal transmission ratio up to 500/5, the peak value of this voltage is Û ≤ 200 V. For reasons of hazard protection and to prevent magnetization of the iron core, an open secondary circuit is to be avoided.
Bus bar cross section	The openings of our individual plug-in transformers for the acceptance of primary bus bars or their cross-sections – even when supplied with copper bus bars – are not decisive for the dimensioning of the bus bar units. The cross section of the bus bar is permitted to be smaller over a short distance in the transformer area, provided the adjacent bus bar cross sections are dimensioned in such a manner that any possible excess heat can easily be absorbed.

Special configurations

Saturation transformers	upon request
Tropicalized versions	upon request
Primary nominal currents deviating from the standard series	upon request
Secondary change-over units	refer to the relevant types of ct's
Deviating frequency (16 $^{2}/_{3}$ Hz up to 400 Hz)	upon request
Resin hardened for extreme mechanical demands (shakeproof)	upon request

Current error

is the percentage deviation of the nominal transmission multiplied by the secondary current from that of the primary current. The current error is calculated positively, should the actual value of the secondary current exceed the nominal value.

$$F_I = \frac{I_S K_N - I_P}{I_P} \, 100\,\%$$

F_I = current error in % I_S = secondary current in A (effective value)

I_P = primary current in A (effective value) K_N = rated measuring ratio

Thermal nominal continuous rated current [I_D]

is the primary current which allows the continuous operation of the current transformer. When using this current value, the temperature of the secondary wiring must not exceed the prescribed values mentioned in the actual technical norms. These values are in direct relation to the isolation material class. Should a thermal rated current be defined which is larger than the primary rated current, the preference values of 120 %, 150 % and 200 % should reflect those of the primary rated current.

Thermal rated short-time current [I_{TH}]

This value indicates the effective value of the primary current which the current transformers can withstand with short circuited secondary winding.
Other rated measuring values as 1s, e.g. 0.5s, 2s and 3s are acceptable. The thermal short time rated current I_{th} has to be stated for each current transformer.

Over-current rated limiting factor (FS)

is the ratio of the limit rated current to the primary rated current.
Note 1: It ought to be noted that the actual over-load rated current is influenced by the burden.
Note 2: Should the primary winding of the current transformer be short-circuited, the safety is greatest, when the value of the over-load current limit factor "FS" is small.
The excess current limiting factor is indicated on the rating plate of a measuring transformer with a nominal value after the letters "FS".

The specification "FS 5" signifies that the total measurement deviation of the current transformer with 5 times the primary nominal current arising from the magnetic saturation of the iron core amounts at least at to 10 %.

Important:

All MBS current transformers are in accordance with DIN EN 60044/1 for a thermal nominal current of I_d = 1.0 x I_N.

MBS current transformer range for tariff applications

In addition to a comprehensive selection of standard current transformers in the accuracy classes 0.5 and 1, MBS AG manufactures an extensive product range of tariff transformers for currents between 25 A and 3200 A in the classes 0.2s, 0.2, 0.5s, and 0.5.

These approved current transformers have the national certificate of Germany and of several European countries.

The current transformers which have been approved by the Physikalisch Technische Bundesanstalt (PTB) Braunschweig (an authorized German testing laboratory) are recognizable by a stylized plus a construction series number. An **"E"** is placed before the usual MBS type mark.

The calibration of the transformers is documented by an official lead seal as well as an additional affixed yellow calibration stamp. The fees for the calibration are calculated in accordance with the applicable official regulation.

The calibration of the transformers is performed upon request at the
"Staatlich anerkannte Prüfstelle für Messgeräte für Elektrizität EA90"
State Approved Testing Laboratories for Measuring Appliances for Electricity EA90
as represented by MBS AG.

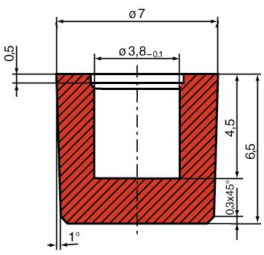
Configuration of MBS low voltage current transformers

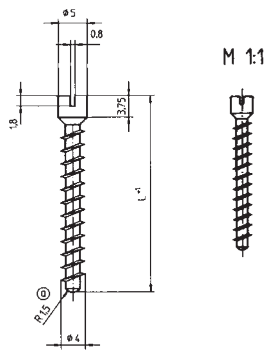
All at MBS AG manufactured low voltage current transformers correspond to
DIN VDE 0414/1; DIN 42600; and DIN EN 60044/1 edition 12/2003 as well as regulation VBG 4.

Characteristics of the current transformers:
- unbreakable plastic housings
- black polycarbonate
- flame resistant
- self-extinguishing
- transformer housings are ultrasonically welded
- nickel-plated secondary terminals
  with plus-minus nickel-plated screw M 5x10 mm
- integrated secondary locking caps.

Foot angle and bus bar mounting screws with isolating protection caps (protection-proof) are supplied free of charge. All transformers are suitable for use on massive primary conductors as well as on flexible isolated copper strips.

Isolating protecting cap





Bus bar mounting screw,
screw length (L)
25, 32, 36, 46, 54, 80 mm,
torque 0.5 Nm

General technical specifications:

Nominal frequency	50 Hz ($16\frac{2}{3}$ Hz up to 400 Hz upon request)
Isolation class	E
Thermal nominal short-time current	$I_{th} = 60 \times I_N$
Maximum operating voltage	$U_m \leq 0.72$ kV
Over-current limiting factor	FS 5 up to 1500 A nominal current FS 10 from 1600 A nominal current
Secondary nominal current	5 A or 1 A
Operating temperature	-5 °C $\leq \vartheta \leq$ +40 °C
Storage temperature	-25 °C $\leq \vartheta \leq$ +70 °C

Error limit values for measuring transformers for classes 0.2 .... 3 according to DIN IEC 60044/1

Class accuracy	Current error ± ∂_F by					Phase displacement error ± ∂_F by				
	1.2 I_n 1.0 I_n	0.2 I_n	0.1 I_n	0.05 I_n	0.01 I_n	1.2 I_n 1.0 I_n	0.2 I_n	0.1 I_n	0.05 I_n	0.01 I_n
	%	%	%	%	%	min	min	min	min	min
0.2	0.2	0.35		0.75		10	15		30	
0.2s	0.2	0.2		0.35	0.75	10	10		15	30
0.5	0.5	0.75		1.5		30	45		90	
0.5s	0.5	0.5		0.75	1.5	30	30		45	90
1	1	1.5		3		60	90		180	
3	3					120.0*				

* by 0.5 I_N and thermal nominal continuous current

Error limit values for current transformers for protection applications

Class accuracy	Current error ± F_i by				Phase displacement error ± F_i by			
	1.0 I_N and thermal nominal continuous current	0.5 I_N	0.2 I_N	0.05 I_N	1.0 I_N and thermal nominal continious current	0.5 I_N	0.2 I_N	0.05 I_N
	%	%	%	%				
5 P ...	1		1.5	3	60		90	120
10 P ...	3	3			120	120		

Current error F_g at nominal error current limit and nominal burden class 5P ... ≤ 5 %
class 10P ... ≤ 10 %

Maximum permissible current of copper bus bars
Dimensions and current values according to DIN 43671

Bus bar cross section	1 bus bar	2 bus bars	3 bus bars
20 x 10	427 A	825 A	1180 A
30 x 05	379 A	672 A	896 A
30 x 10	573 A	1060 A	1480 A
40 x 05	482 A	836 A	1090 A
40 x 10	715 A	1290 A	1770 A
50 x 10	852 A	1510 A	2040 A
60 x 10	985 A	1720 A	2300 A
80 x 10	1240 A	2110 A	2790 A
100 x 10	1490 A	2480 A	3260 A
bus bar surface		clear	

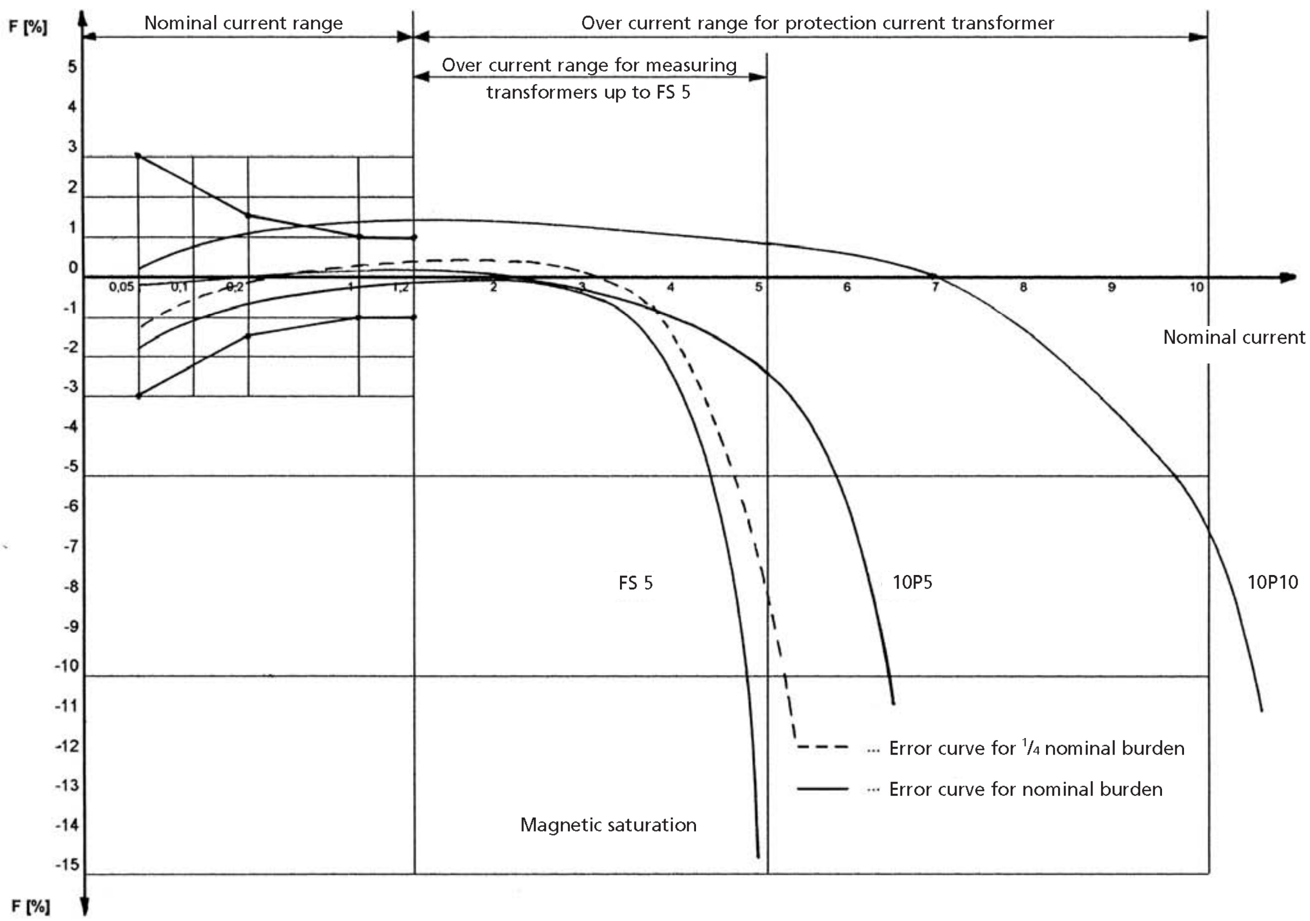
Above values are valid for continuous current burden at approx. 30 °C ambient temperature.

Markings of the current transformers connection terminals

The connections of all primary windings are marked with capital letters “K-P_1”, and “L-P_2”.
The connections of all secondary windings are marked with the corresponding lower case letters “k-s_1” and “l-s_2”.
By current transformers with a multiple secondary tappings the winding end is marked “l”, followed by the prefix letter “l_1” , the tappings with a decreasing number of windings are sequencially numbered “2”, “3” etc.

By current transformers with a multiple of independent primary windings, the terminals of the individual windings are distinguishable from the additional capital letters set before “K” and “L” and the additional capital letters “A”, “B”, “C” etc.; i.e. “AK” – “AL” for the highest primary circuit, “BK” – “BL” for the second primary circuit etc.; or on each terminal pair the transmission or the ratio transmission of the individual primary windings to each other is to be specified.

Error curves of low voltage current transformers



Power requirements of measuring units and relays

Two main requirements are cited by the user for the principle demands of current transformers:

– a high degree of measuring precission in the range of nominal current
– a protection function in the over-load range

In order to fulfill these demands it is necessary for the assumed nominal power of a current transformer to fully achieve the actual power requirements of the prescribed measurements.
In ascertaining the actual power requirements, consideration is to be given to power losses of the appliances to be connected, as well as to the losses of the measuring conductor.

Power requirements of typical measuring units

Current meter soft ironed up to 100 mm Ø		0.700	–	1.500 VA
Rectifier current meter		0.001	–	0.250 VA
Multi-range current meter		0.005	–	5.000 VA
Current recorder		0.300	–	9.000 VA
Bimetal current meter		2.500	–	3.000 VA
Power meter		0.200	–	5.000 VA
Power recorder		3.000	–	12.000 VA
Power factor meter		2.000	–	6.000 VA
Power factor recorder		9.000	–	16.000 VA
Energy meter (current path)		0.400	–	1.000 VA
Relay	N-relay			14.000 VA
	Over current relay	0.200	–	6.000 VA
	Over current time relay	3.000	–	6.000 VA
	Direction relay			10.000 VA
	Bimetal relay	7.000	–	11.000 VA
	Distance relay	1.000	–	30.000 VA
	Differential relay	0.200	–	2.000 VA
		1.000	–	15.000 VA
Transformer current trip switch		5.000	–	150.000 VA
Controler		5.000	–	180.000 VA

Power consumption of copper wires

$$P = \frac{I^2 \times 2l}{q_{cu} \times 56} \text{ [VA]}$$

I = secondary nominal current
l = distance in m
q_{cu} = wire cross section in mm²

Comment: With a joint three phase current return conductor the values of P are halved.

Chart for values referring to 5 A

Nominal cross section	1 m	2 m	3 m	4 m	5 m	6 m	7 m	8 m	9 m	10 m
2.5 mm²	0.36	0.71	1.07	1.43	1.78	2.14	2.50	2.86	3.21	3.57
4.0 mm²	0.22	0.45	0.67	0.89	1.12	1.34	1.56	1.79	2.01	2.24
6.0 mm²	0.15	0.30	0.45	0.60	0.74	0.89	1.04	1.19	1.34	1.49
10.0 mm²	0.09	0.18	0.27	0.36	0.44	0.54	0.63	0.71	0.80	0.89

Chart for values referring to 1 A

Nominal cross section	10 m	20 m	30 m	40 m	50 m	60 m	70 m	80 m	90 m	100 m
1.0 mm²	0.36	0.71	1.07	1.43	1.78	2.14	2.50	2.86	3.21	3.57
2.5 mm²	0.14	0.29	0.43	0.57	0.72	0.86	1.00	1.14	1.29	1.43
4.0 mm²	0.09	0.18	0.27	0.36	0.45	0.54	0.63	0.71	0.80	0.89
6.0 mm²	0.06	0.12	0.18	0.24	0.30	0.36	0.42	0.48	0.54	0.60
10.0 mm²	0.04	0.07	0.11	0.14	0.18	0.21	0.25	0.29	0.32	0.36