General description current transformers

Application

Current transformers mainly are used where it is impossible or difficult to measure currents directly. They are special configurations of transformers which transform the primary current into a (mostly) lower secondary current and which separate (galvanically) both currents.
By means of the physical principal of saturation of the core material additional a protection of the secondary circuit from high currents produced in the event of system fault is enable.
The accuracy and safety of the connected devices is directly dependent on the quality of the current transformer used.

Special notes

Rated burden, secondary currents
In the case of current transformers, the rated burden that is made available at the secondary terminals is specified in VA. The selection of the rated burden is determined by the consumption of the connected measuring device and its feed line. In particular with secondary currents of 5 A and a long measuring line, considerable losses occur (see pages 7 and 8). In this case, current transformers with a secondary current of 1 A are preferable.
„Site-winding" current transformer
With plug-in current transformers, the smaller the CT ratio, the lower the rated burden in VA. By passing through the primary conductor several times, a smaller CT ratio can be achieved with the rated burden (VA) unchanged. Example: CT with a ratio of 50/5 A at 1.5 VA rated burden - after threading the primary conductor 5 times, a CT with a ratio of 10/5 A at 1.5 VA rated burden results. In comparison to wound primary current transformers, this measure enables cost savings to be achieved.
Grounding of secondary terminals
According to VDE 0141, paragraph 5.3.4, current and voltage transformers should be grounded starting from measuring voltages of ≥ 3.6 kV. In case of low voltages (up to a measuring voltage of ≤ 1.2 kV), no grounding is necessary unless the transformer housing has large accessible metal surfaces.
Caution: Current transformers may conduct voltages which are dangerous to touch at the „open" secondary terminals. Therefore, operating the transformers „open" should be avoided under all circumstances.

Technical terms

Primary nominal current	Value of the primary current which characterizes the CT and for which it is dimensioned.
Secondary nominal current	Value of the secondary current which characterizes the CT and for which it is dimensioned.
Rated transformation ratio	Ratio of the primary current and secondary current. The ratio of a current transformer is indicated on the label as an unabridged fraction.
Rated burden	The burden is the impedance of the exterior secondary circuit including wires. The rated burden is decisive in determining the error limits of the current transformer. Usual the burden is expressed as its volt-ampere rating.
Load	Impedance of the secondary circuit, expressed in ohms with indication of the power factor.
Nominal burden	Value of the burden on which the accuracy information of the CT is based.
Nominal rated frequency	Value of the frequency on which the rating of the CT is based.
Accuracy class	Information for a current transformer that its measurement deviations under prescribed conditions are within defined limits.
Phase displacement (δ)	Phase displacement is the angle of the phase shift between the secondary and primary current. It is specified in angle minutes and positively calculated if the secondary size goes after the primary one.
Current error	The current error is the deviation of the nominal transmission multiplied by the secondary from that of the primary current. The current error is calculated positively, in the actual value of the secondry current exceeds the nominal value.

$$F_i[\%] = \frac{(K_n \ I_s - I_p) \times 100}{I_p}$$

$F_i =$ Current error in %
$K_n =$ Current transformer ratio
$I_s =$ Actual secondory current, if I_p is under measurment conditions
$I_p =$ Actual primary current

Total measurement error	The total measurement error is the momentary value of the ratio of the r.m.s. difference from the secondary current multiplied with the transmission to the primary current, refered to the r.m.s. primary current.
Rated limit instrument primary current I_{pl}	is the primary current attached to the excess current limiting factor. In case of CTs for measuring it is defined that the total error is eqal to or greater 10% of the secondary current which should apprear according to the transmission
Instrument security factor FS	expresses the physical attribute of a CT to go into saturation
Rated continious thermal current I_{cth}	is the primary continuous current which the CT will operate with, if it is connected to the rated burden without its temperature exceeding specified values.
Rated short time thermal current I_{th}	is the r.m.s. value of the primary current which the CT can withstand for 1 second with short-circuited secondary winding without incurring damage
Rated dynamic current I_{dyn}	is the peak value of the first amplitude of the primary current whose mechanical and electromagnetic impact is resisted by the transformer with short-circuited secondary winding.

Technical data

General data	Standards	DIN EN 60044-1, DIN 42 600, IEC 185, DIN EN 61 010 part 1
	Max. operating voltage	0,72 kV, Types CSW and XCSW 1,2 kV
	Test voltage	3 kV, Types CSW and XCSW 6 kV
	Rated frequency	50 / 60 Hz, 16 2/3 and 400 Hz on request
	Instrument security factor	FS5 up to 1500 A, FS10 from 1600 A and above
	Rated cont. thermal current Icth	1,0 x IN, Types CSW and XCSW 1,2 x IN
	Rated short time thermal current Ith	60 x IN (1 s), max. 100 kA 40 x IN (1 s), max. 100 kA at wound primary and summary CTs
	Rated dynamic current Idyn	2,5 x Ith
	Operating temperature	-5 °C to +50 °C
	Storage temperature	-25 °C to +70 °C
	Insulation class	E
	Housing	Polycarbonate black or grey, acc. to UL 94 V 0, self extinguishing
	Connection	Combi-srews M5 x 10 on the secondary terminals Types CSW und XCSW with spring loaded terminals up to 4 mm²

Marking of terminals for current transformers

The terminals for current transformers have standardized markings. These are in detail:

For the primary terminals: **K - P1** and **L - P2,** the direction of energy is always from K-P1 to L-P2!
For the secondary terminals: **k - s1** und **l - s2** (in lower case)

In case of summary CTs with several input circuits, the usual terminal markings „K" and „L" are preceded by the capital letters „A", „B", „C" ...
This serves to clearly differentiate the input circuits.
In case of input circuits with different main transformers, the main transformer with the highest transformation ratio is connected to the terminals „AK - AL" and then in descending order to terminal „BK - BL" etc.
The correct connection assignment can also be found on the rating plate.

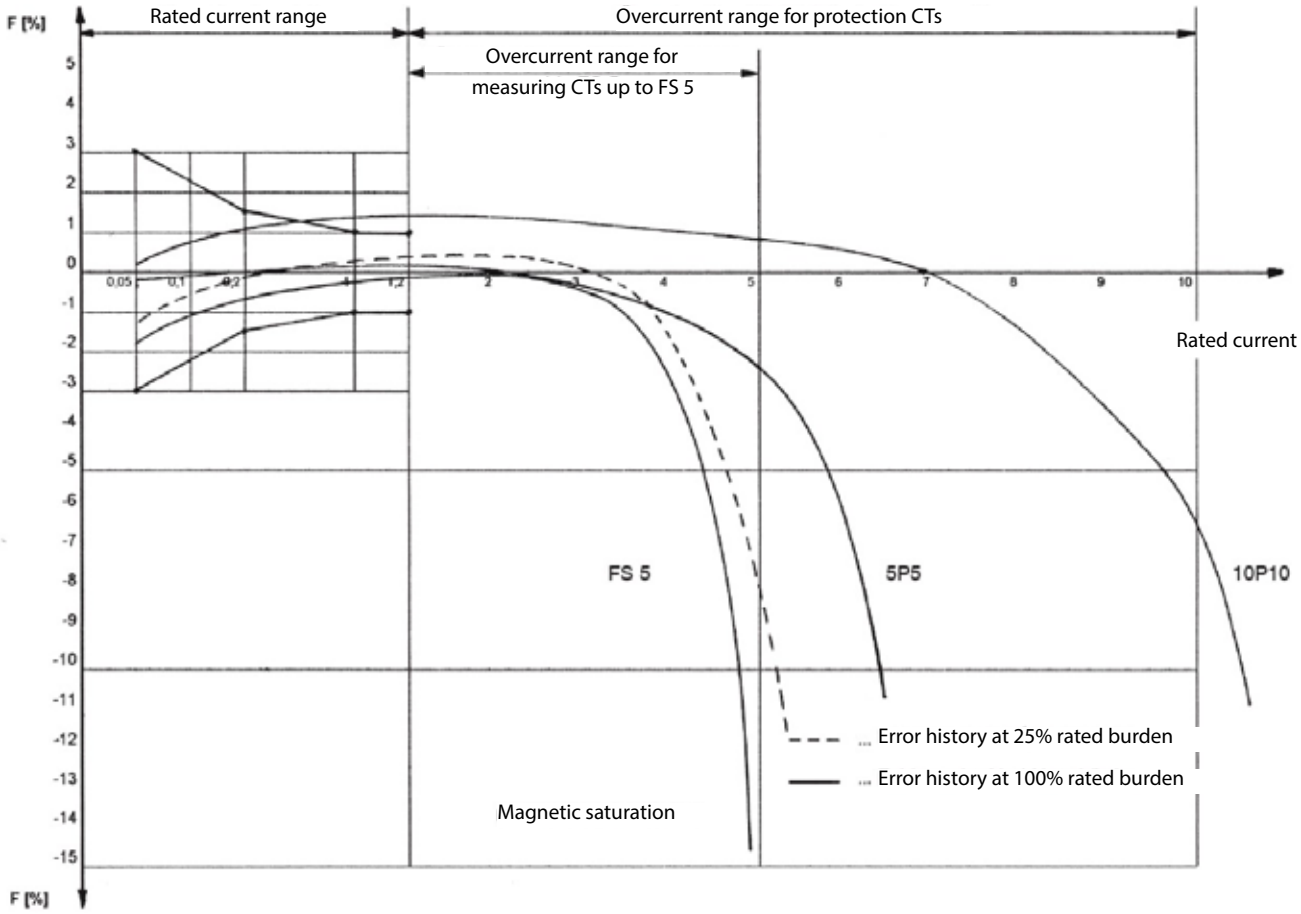
Error limits for current transformers

class 0,2 to 3, acc. to IEC 61869/2, version 09/2012

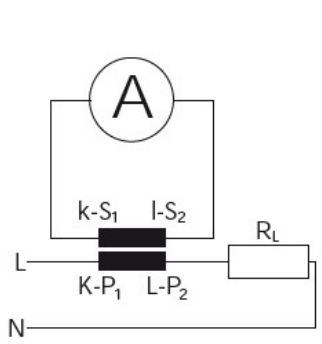
Accuracy class	Current error $\pm\Delta_I$ at					Phase displacement $\pm\Delta_\varphi$ at				
	1,2 I_n 1,0 I_n	0,2 I_n	0,1 I_n	0,05 I_n	0,01 I_n	1,2 I_n 1,0 I_n	0,2 I_n	0,1 I_n	0,05 I_n	0,01 I_n
	%	%	%	%	%	min	min	min	min	min
0,2	0,2	0,35		0,75		10	15		30	
0,2s	0,2	0,2		0,35	0,75	10	10		15	30
0,5	0,5	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*									

* at 0,5 I_n and thermal rated current

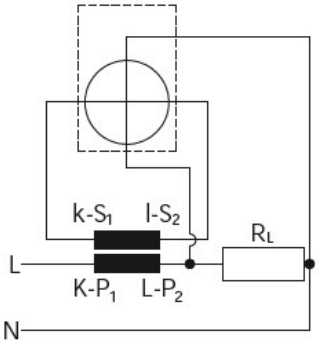
Current transformer error curve



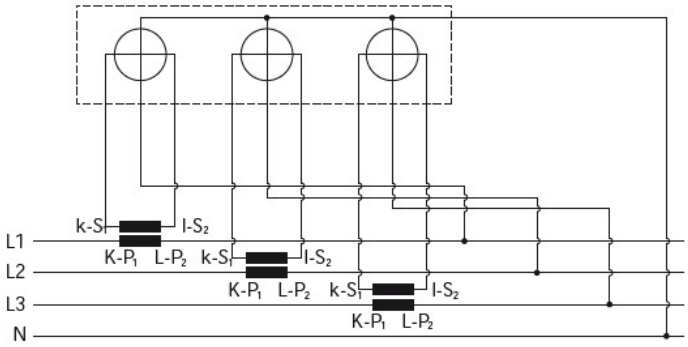
Connection



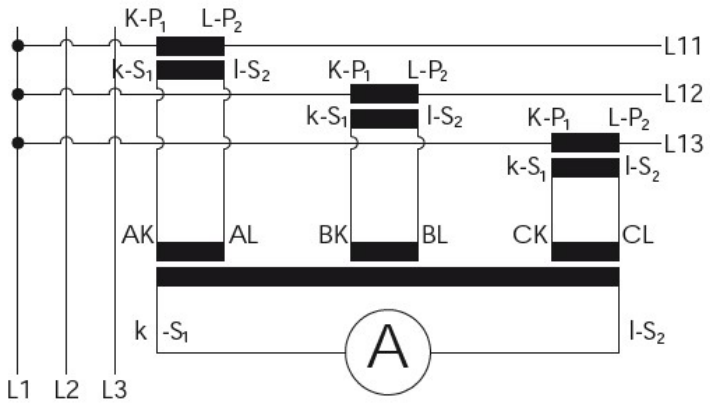
Measuring connection



Single phase energy meter



Three phase energy meter connection



Connection of summary CTs

Power requirements of measurement devices and relays

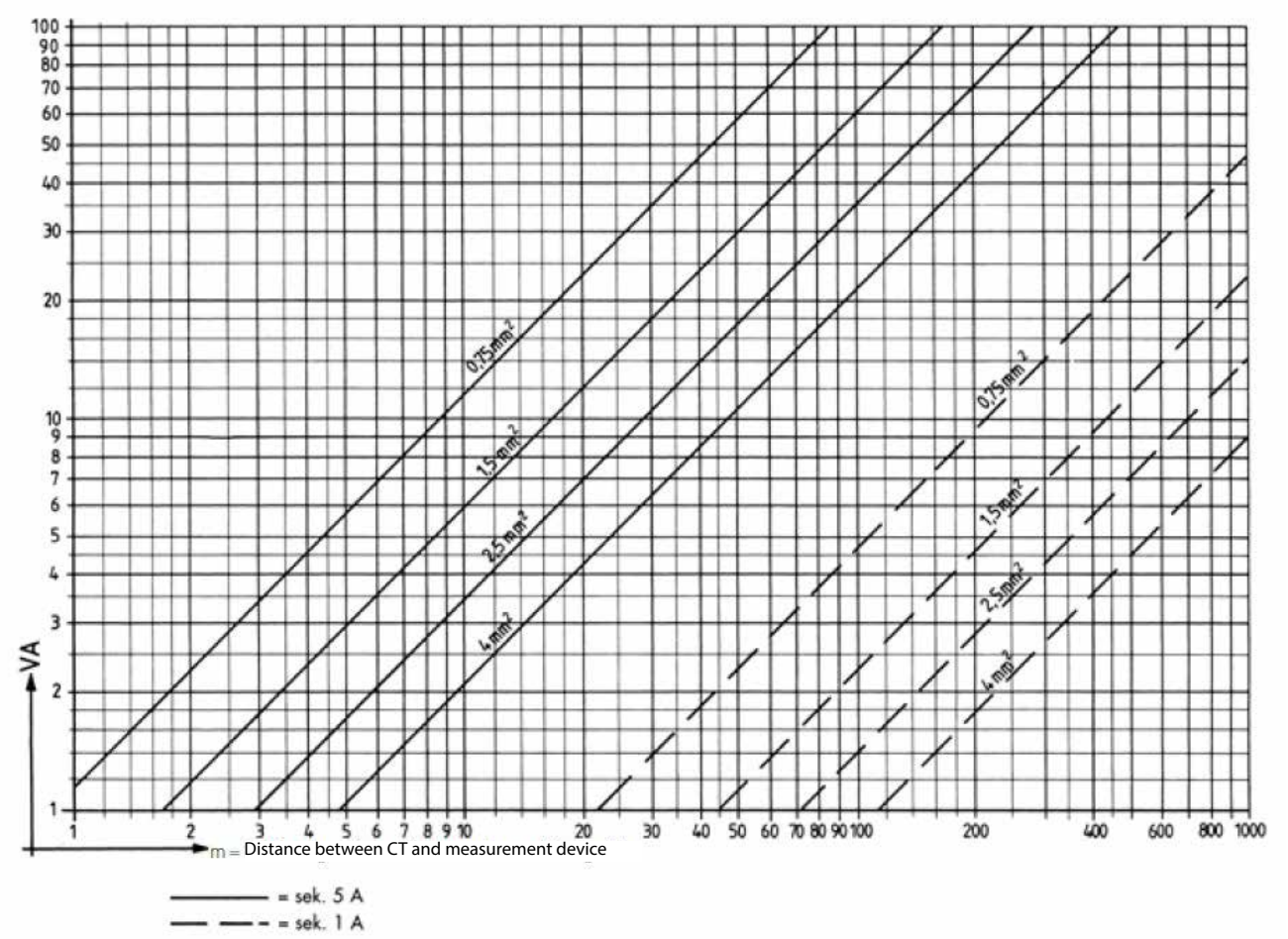
When using current transformers, the user has two main requirements:
- high measurement accuracy in the nominal current range
- protectiv function in the overcurrent range

In order to meet these requirements, it is necessary that the range of services (the nominal apparent power) of the current transformer is adapted as close as possible to the actual power requirement of the measuring arrangement. To determine the actual power requirement, in addition to the internal power requirement of the connected measuring devices, the line losses of the measuring lines connected to the secondary circuit of the converter must also be taken into account.

Internal power requirement of typical measuring devices

Moving iron current meter 100 mm		0,700	-	1,50 VA
Moving coil current meter with rectifier	0,001	-	0,25 VA	
Multiple current meter		0,005	-	5,00 VA
Current recorder		0,300	-	9,00 VA
Bimetall current meter		2,500	-	3,00 VA
Power meter		0,200	-	5,00 VA
Power recorder		3,000	-	12,00 VA
Power factor meter		2,000	-	6,00 VA
Power facotr recorder		9,000	-	16,00 VA
Energy meter		0,400	-	1,00 VA
N-Relay				14,00 VA
Overcurrent relay		0,200	-	6,00 VA
Overcurrent time relay		3,000	-	6,00 VA
Directional relay				10,00 VA
Bimetall relay		7,000	-	11,00 VA
Distance relay		1,000	-	30,00 VA
Differential relay		0,200	-	2,00 VA
Current transformer trip switch		5,000	-	150,00 VA
Regulator		5,000	-	180,00 VA

Auxiliary diagram for determining the power loss (secondary line)



Outside dimensions of cables and wires

Depending on the manufacturer, the diameters can differ from the information!

Cross section	Type NYM..	Type NYY..	Type H07V-K
1 x 1,5 mm²	5,2 mm	-	3,4 mm
1 x 2,5 mm²	6,0 mm	-	4,1 mm
1 x 4 mm²	6,7 mm	-	4,8 mm
1 x 6 mm²	7,2 mm	-	5,3 mm
1 x 10 mm²	8,6 mm	-	6,8 mm
1 x 16 mm²	9,6 mm	-	8,1 mm
1 x 25 mm²	12,5 mm	13,0 mm	10,2 mm
1 x 35 mm²	-	14,0 mm	11,7 mm
1 x 50 mm²	-	15,0 mm	13,9 mm
1 x 70 mm²	-	17,0 mm	16,0 mm
1 x 95 mm²	-	-	18,2 mm
1 x 120 mm²	-	21,0 mm	20,2 mm
1 x 150 mm²	-	-	22,5 mm
1 x 185 mm²	-	25,0 mm	24,9 mm
1 x 240 mm²	-	-	28,4 mm