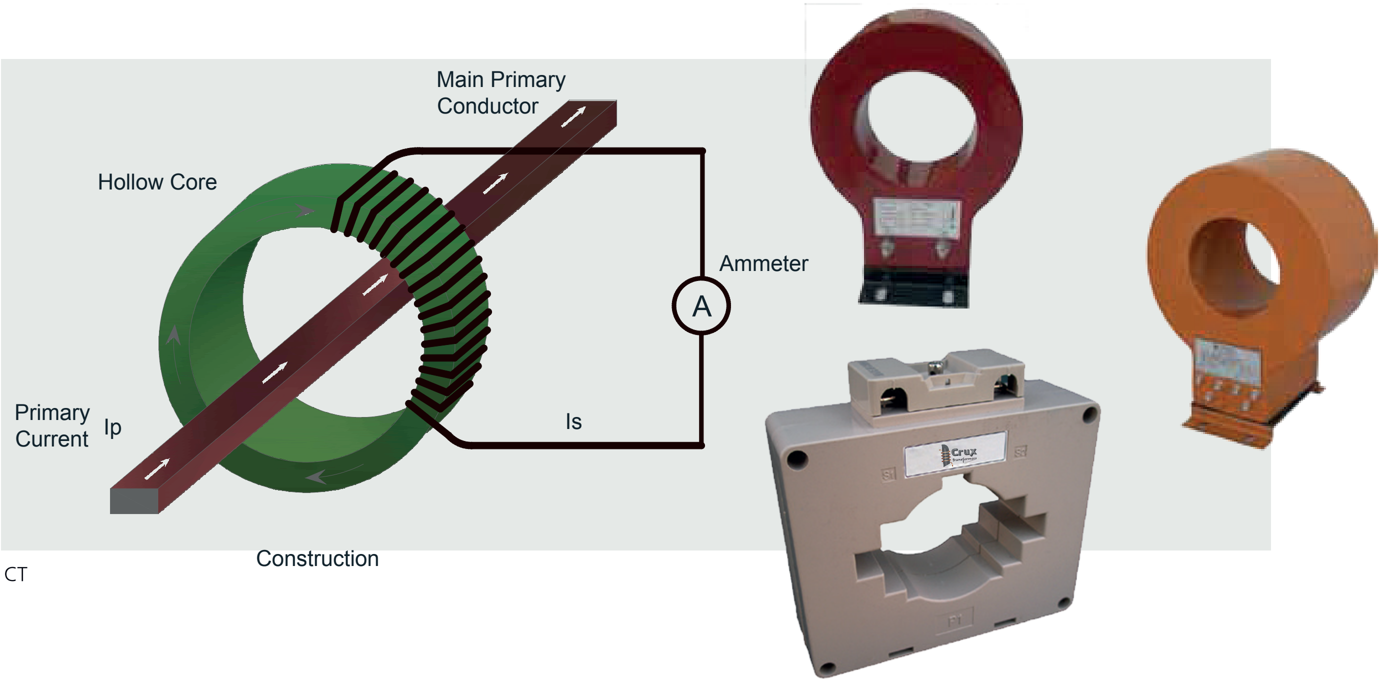
Current Transformer

A current transformer produces a reduced current accurately proportional to the current in the circuitis which is too high to apply directly to metering and protecting instruments.

A current transformer isolates the measuring instruments from what may be very high voltage in the monitored circuit. Current transformers are commonly used in metering and protective relays in the electrical power industry.

A current transformer can be equipped with one or more independent magnetic cores with equal or different characteristics for measuring, metering and/or protective purposes.

there are two main standards to which current transformers are designed. IEC 1-60044 (BSEN 1-60044) & IEEE C57.13 (ANSI)



Burden of current transformer

The secondary load of a current transformer is usually called the "burden" to distinguish it from the load of the circuit whose current is being measured.

$$P_N = \frac{(AW)^2 \cdot Q_{Fe} \cdot K}{l_{Fe}} \, [VA]$$

AW	primary ampere turns
Q_{Fe}	iron cross section (mm^2)
K	constant
l_{Fe}	ferromagnetic circuit (cm)

The burden, in a CT is the (largely resistive) impedance presented to its secondary winding. Typical burden ratings for IEC CTs are 1.5 VA, 3 VA, 5 VA, 10 VA, 15 VA, 20 VA, 30 VA, 45 VA and 60 VA. As for ANSI/IEEE burden ratings are B0.1-, B0.2-, B0.5-, B1.0-, B2.0- and B4.0-. Items that contribute to the burden of a current measurement circuit are switch-blocks, meters and intermediate conductors. The most common source of excess burden is the conductor between the metering or protecting instruments and the CT. The excessive length of wire creates a large resistance. This problem can be reduced by using CTs with lower ampere secondaries, which will produce less voltage drop between a CT and the metering or protecting instruments.

Knee-point core-saturation voltage

The knee-point voltage of a current transformer is the voltage at which a 10% increase in applied voltage increases the magnetizing current by 50%. At this point output current ceases to linearly follow the input current within declared accuracy. The knee-point voltage is less applicable for metering current transformers as their accuracy is generally much higher, but constrained within a very small range of the current transformer rating, typically 1.2 to 1.5 times rated current. However, the concept of knee point voltage is very pertinent to protection current transformers, since they are necessarily exposed to fault currents of 20 to 30 times rated current.

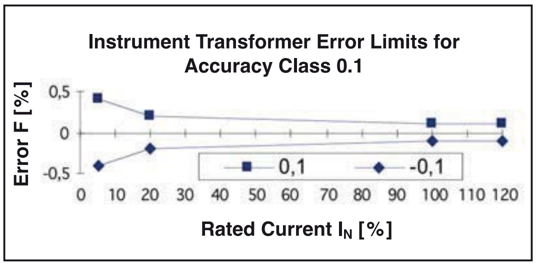
Accuray Class, rating factor and phase shift

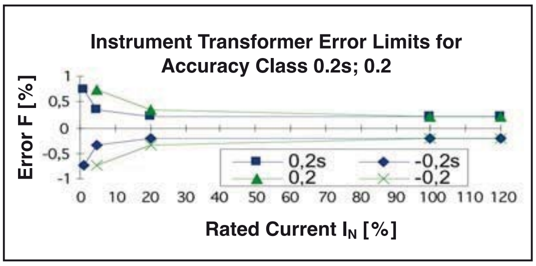
Accuray class is the limit of the permisible percentage current error at the rated current,rating factor is a factor by which the nominal full load current of a CT can be multiplied to determine its absolute maximum measurable primary current. The rating factor of a CT is largely dependent upon ambient temperature.

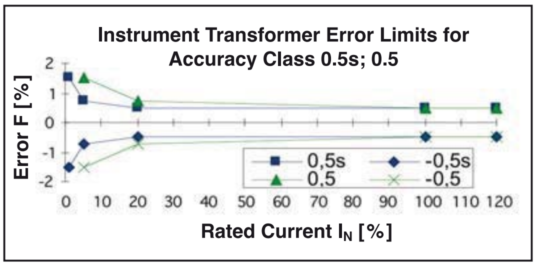
Ideally the secondary current of a current transformer should be perfectly in phase with the primary current. In practice, this is impossible to achieve, but phase shifts as low as a few tenths of a degree for well constructed transformers up to as much as six degrees for simpler designs may be encountered. For the purposes of current measurement, any phase shift is immaterial as the indicating ammeter, only displays the magnitude of the current However, if the current transformer is used in conjunction with the current circuit of a wattmeter, energy meter or power factor meter, any phase shift in the measured current can affect the accuracy of the target measurement.

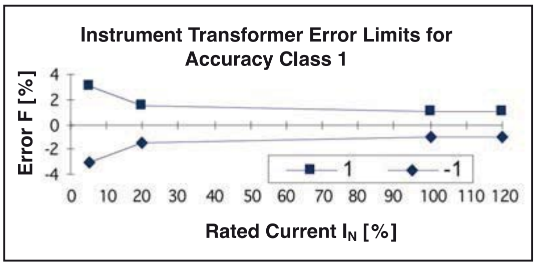
Permissible limits for current error (F_i) and phase displacement (δ_i) according to IEC 60044-1

Accuracy Class	± percentage of current error at percentage of rated current					± phase displacement in minutes at percentage of rated current				
	1	5	20	100	120	1	5	20	100	120
Measuring Current Transformers										
0,1	-	0,4	0,2	0,1	0,1	-	15	8	5	5
0,2 S	0,75	0,35	0,2	0,2	0,2	30	15	10	10	10
0,2	-	0,75	0,35	0,2	0,2	-	30	15	10	10
0,5 S	1,5	0,75	0,5	0,5	0,5	90	45	30	30	30
0,5	-	1,5	0,75	0,5	0,5	-	90	45	30	30
1	-	3,0	1,5	1,0	1,0	-	180	90	60	60
Protective Current Transformers										
5 P	-	-	-	1	-	-	-	-	60	-
10 P	-	-	-	3	-	-	-	-	-	-









Crux transformers

Technical Notices

Error limits of CT class due to IEC 60044-1

The error limits at rated frequency apply to the classes 0.1 ... 1 at burden between 25% and 100% of rated burden (minimum 1 VA);
3 and 5 at burden between 50% and 100% of rated burden (minimum 1 VA);
5P and 10P at 100% of rated burden.
Power-factor = 1 at burden between 1 and 5 VA,
0.8 lagging at burden ≥ 5 VA.

Kind	Class	Current error in % at ...								total error at	Phase displacement in minutes at ...						
		1	5	20	50	100	120	150	200	n x I_N in %	1	5	20	100	120	150	200
		Percent of rated current									Percent of rated current						
1	0.1		0.4	0.2		0.1	0.1			≥ 10		15	8	5	5		
	0.2		0.75	0.35		0.2	0.2			≥ 10		30	15	10	10		
	0.2 S	0.75	0.35	0.2		0.2	0.2			≥ 10	30	15	10	10	10		
	0.5		1.5	0.75		0.5	0.5			≥ 10		90	45	30	30		
	0.5 S	1.5	0.75	0.5		0.5	0.5			≥ 10	90	45	30	30	30		
	1		3	1.5		1	1			≥ 10		180	90	60	60		
	3				3		3			≥ 10							
	5				5		5			≥ 10							
2	0.1 ext.120%		0.4	0.2		0.1	0.1			≥ 10		15	8	5	5		
	0.1 ext.150%		0.4	0.2		0.1	0.1	0.1		≥ 10		15	8	5	5	5	
	0.1 ext.200%		0.4	0.2		0.1	0.1		0.1	≥ 10		15	8	5	5		5
	0.2 ext.120%		0.75	0.35		0.2	0.2			≥ 10		30	15	10	10		
	0.2 ext.150%		0.75	0.35		0.2	0.2	0.2		≥ 10		30	15	10	10	10	
	0.2 ext.200%		0.75	0.35		0.2	0.2		0.2	≥ 10		30	15	10	10		10
	0.5 ext.120%		1.5	0.75		0.5	0.5			≥ 10		90	45	30	30		
	0.5 ext.150%		1.5	0.75		0.5	0.5	0.5		≥ 10		90	45	30	30	30	
	0.5 ext.200%		1.5	0.75		0.5	0.5		0.5	≥ 10		90	45	30	30		30
	1 ext.120%		3	1.5		1	1			≥ 10		180	90	60	60		
	1 ext.150%		3	1.5		1	1	1		≥ 10		180	90	60	60	60	
	1 ext.200%		3	1.5		1	1		1	≥ 10		180	90	60	60		60
3	5P					1				≤ 5				60			
	10P					3				≤							

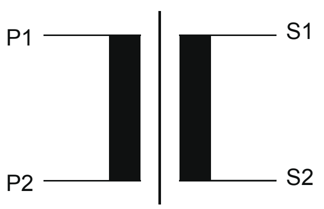
1: Classes for measuring CT s
2: Classes for measuring CT s with extended current ratings
3: Classes for protective CT s

Terminal markings of current transformers: **IEC**

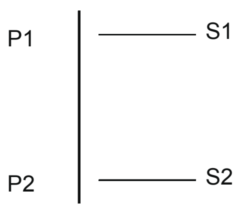
	IEC
Primary	P1 -- P2
Primary with taps	P1 -- P2 -- P3 .....
Secondary	S1 -- S2

Connection diagrams:

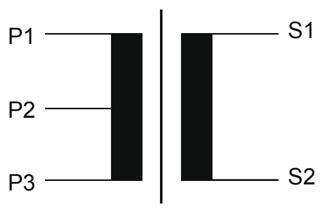
Wound primary C.T.



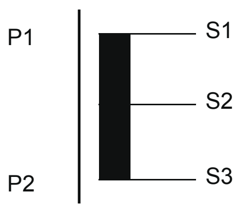
Window type C.T.

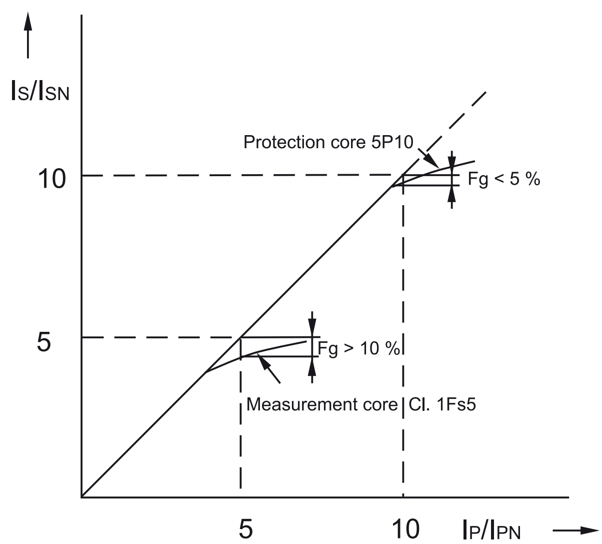


With primary tap



With secondary tap





Technical Notices

current carrying capacity of busbars

Material / dimensions in mm		numbers and placement of bars 1 (I)	2 (II)	3 (III)	4 (IIII)	4 (II 50 II)
				A		
Copper	20 × 5	400	700			
Copper	20 × 10	620	990	1360		1860
Copper	30 × 5	560	970			
Copper	30 × 10	820	1360	1860		2480
Copper	40 × 5	740	1240			
Copper	40 × 10	1050	1860	2550		3470
Copper	50 × 5	890	1510	2170		2850
Copper	50 × 10	1280	2230	3040		4130
Copper	60 × 5	1050	1770	2420		3200
Copper	60 × 10	1490	2600	3470		4590
Copper	80 × 10	1930	3100	4090	~ 4800	5580
Copper	100 × 10	2330	3840	4960	~ 5800	6700
Copper	120 × 10	2750	4340	5580	~ 6600	7560
Copper	160 × 10	3470	5450	7190	~ 8000	9670
Aluminium	20 × 5	320	550			
Aluminium	20 × 10	500	820			
Aluminium	30 × 5	450	780			
Aluminium	30 × 10	620	1090			
Aluminium	40 × 5	570	990			
Aluminium	40 × 10	830	1490	2050		2790
Aluminium	50 × 5	690	1200	1740		2290
Aluminium	50 × 10	1020	1790	2430		3300
Aluminium	60 × 5	830	1440	1980		2600
Aluminium	60 × 10	1190	2080	2830		3770
Aluminium	80 × 10	1550	2650	3550	~ 4100	4710
Aluminium	100 × 10	1880	3160	4220	~ 4800	5330
Aluminium	120 × 10	2230	3720	4770	~ 5400	6200
Aluminium	160 × 10	2850	4710	6200	~ 6800	7690

due to **DIN 43670 / DIN 43671**

Continous current (50 Hz),
deduced and calculated for surface treated busbars, edgewise and horizontally installed, busbar temperature of 85° C, ambient temperature 50° C.
Short sections, e.g. in the aperture of a CT, can carry higher currents when the connected busbars have an appropriate cross section ("Isthmus" effect).

Reduction of current carrying capacity:

Vertical installation > 3 m:	factor 0.85...0.9
Horizontal installation > 2 m:	factor 0.70...0.9
Plain bars (not treated):	factor 0.9 approx.

Burden presented by copper leads

Length / leads	**Burden in VA** cross section 1...10 mm² at **1 A**				at **5 A**			
m	**1 ²**	**2.5 ²**	**4 ²**	**6 ²**	**2.5 ²**	**4 ²**	**6 ²**	**10 ²**
1	0.04	0.01			0.36	0.22	0.15	0.09
2	0.07	0.03			0.71	0.45	0.30	0.18
3	0.10	0.04			1.07	0.67	0.45	0.27
4	0.14	0.06			1.43	0.89	0.60	0.36
5	0.18	0.07			1.78	1.12	0.74	0.44
6	0.21	0.09			2.14	1.34	0.89	0.54
7	0.25	0.10			2.50	1.56	1.04	0.63
8	0.29	0.11			2.86	1.79	1.19	0.71
9	0.32	0.13			3.21	2.01	1.34	0.80
10	0.36	0.14	0.09	0.06	3.57	2.24	1.49	0.89
20	0.71	0.29	0.18	0.12	7.10	4.50	3.00	1.80
30	1.07	0.43	0.27	0.18	10.7	6.70	4.50	2.70
40	1.43	0.57	0.36	0.24	14.3	8.90	6.00	3.60
50	1.78	0.72	0.45	0.30	17.8	11.2	7.40	4.40
60	2.14	0.86	0.54	0.36		13.4	8.90	5.40
70	2.50	1.00	0.63	0.42		15.6	10.4	6.30
80	2.86	1.14	0.71	0.48		17.9	11.9	7.10
90	3.21	1.29	0.80	0.54		20.1	13.4	8.00
100	3.57	1.43	0.89	0.60		22.4	14.9	8.90

$$P_w = (I^2 * 2 * L) \; / \; (A_{cu} * 57)$$

when a common three-phase return conductor is used: P_w x 0.5).

P_w = burden presented by copper leads in VA

I = Amperage
L = Distance in m
A_{cu} = Cross section in mm²