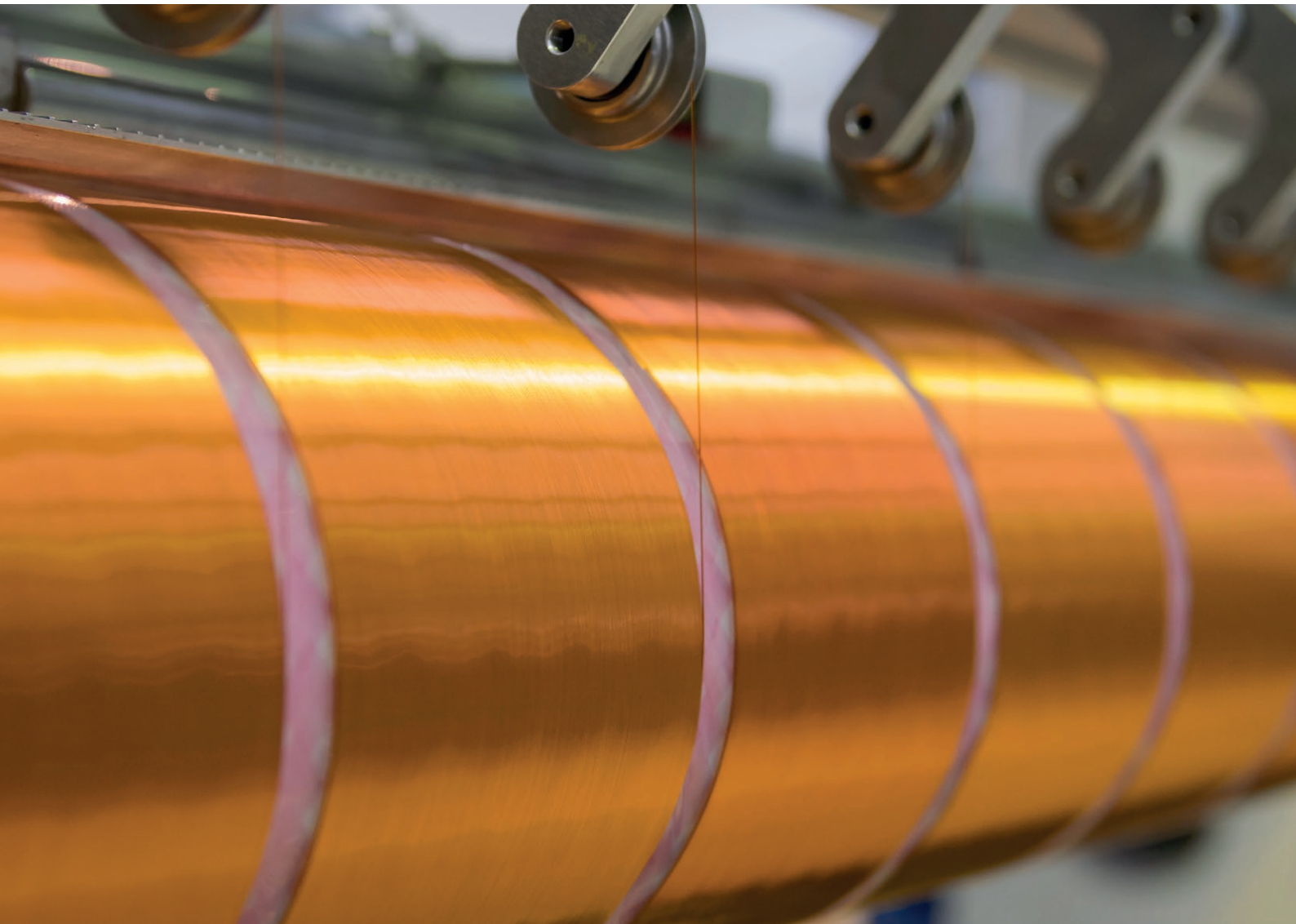
MEDIUM VOLTAGE PRODUCT

PARAMETERS GUIDE

How to specify the indoor instrument transformers correctly



The range of electric values in the power supply systems is very extensive. This is why it is necessary to match the respective currents and voltages to the values appropriate to connected measuring, protection, and control instruments.

The basic role of instrument transformers (ITs) is to transform voltage or current from the high levels in electrical transmission and distribution systems to the low values that can be used by low voltage measuring and protection apparatus.

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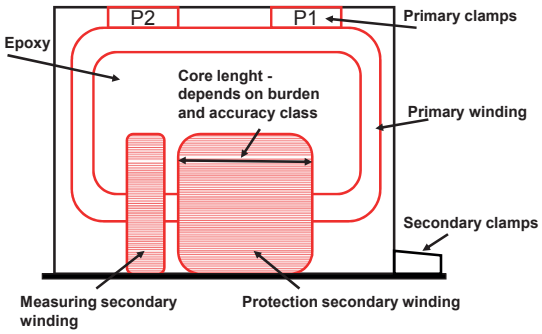
Current transformer

Current transformers provide a secondary circuit with a current proportional to a primary current. A secondary current is usually of the value 1 A or 5 A. Transformers are connected in the series and secondary winding is connected mainly to amp-meters and protection relays.

Current transformers are manufactured in many different shapes and dimensional variations, according to the application. For the product overview, contact our sales representatives.



Transformation ratio (K)

$$K = \frac{I_{Pr}}{I_{sr}} = \frac{N_2}{N_1}$$

Where:
- I_{pr} Primary current
- I_{sr} Secondary current
- N_1 Turns on a primary winding
- N_2 Turns on a secondary winding

From which we get equation for secondary current:

$$I_{sr} = I_{pr} \frac{N_1}{N_2}$$

- It is possible to have one or several secondary windings each with their own magnetic circuit and each of them for another purpose like metering or protection.

Standards
All instrument transformers are produced in compliance with IEC 61869 standard. However, other standards like GOST, IEEE, etc. are possible too. Just ask your sales representative.

Rated Primary current (I_{pr})
The value of the primary current on which the performance of the transformer is based. Rated primary current has to be equal to or higher than highest primary current of the system.

Standard values are defined by IEC standard: 10; 12.5; 15; 20; 25; 30; 40; 50; 60; 75 and their decimal multiplies. Upon agreement, any ratio can be produced.

Current transformers are standardly construct with extended current range 120 % to avoid high temperature rise within an installation.

Frequency
The transformers can be defined either at 50 Hz or 60 Hz, it depends on the network in each country. Combination of both values 50/60 Hz is also possible, frequency 16⅔ Hz is possible too.

Highest voltage for equipment (U_m)
The highest voltage for equipment U_m sets the insulation level and is chosen as equal as or higher than the highest voltage of the system U_{sys} where the equipment will be installed. The rule is not applicable for cable current transformers, where dielectric insulation is provided by an application.

$$U_m \geq U_{sys}$$

The table below shows standardized values:

U_m	U_{sys}
3.6 kV	Up to 3.3 kV
7.2 kV	Up to 6.6 kV
12 kV	Up to 11 kV
17.5 kV	10 – 15 kV
24 kV	18 – 22 kV
36 kV	30 – 35 kV

Insulation levels
Insulation levels are based on U_m value. For example IEC insulation levels:

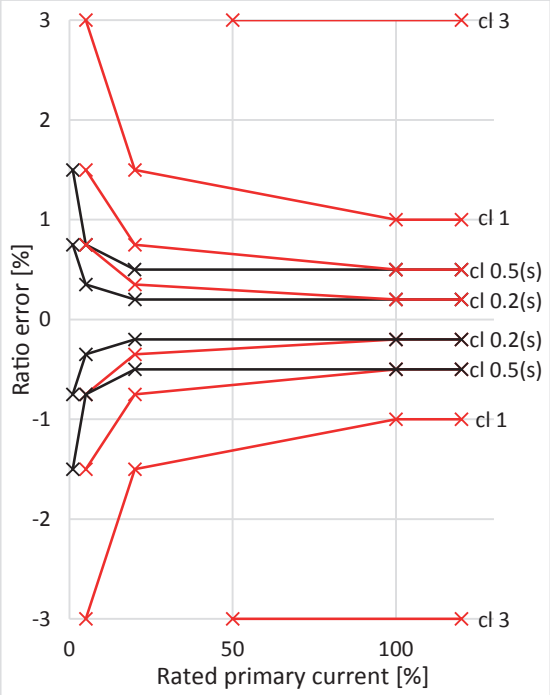
12/28/75 kV

Where
- 12 Highest voltage for equipment U_m
- 28 Power frequency withstand voltage (r.m.s)
- 75 Lightning impulse withstand voltage (peak)

Do you know what EXT and I_{cth} means?
EXT (extended current rating) means range of current increase in which current transformer is able to measure in an accuracy class, for example 120 %.
I_{cth} means maximum continuous thermal current in which current transformer still operates, but not in an accuracy class.

Accuracy class
Classes are divided according to their usage. Each class is suitable for something else (tariff metering, laboratory metering, protection, etc.). For IEC the accuracy classes are follows:
- Measuring: 0.2; 0.2S; 0.5; 0.5S; 1; 3
- Protecting: 5P; 10P; PX, TPX, TPY, TPZ

Chart below describes the limits for current ratio error of most used measuring classes. Lines for classes 0.2S and 0.5S are in black.



Secondary current and number of windings
Secondary current transmits an information signal to measuring instruments, meters and protective or control devices or similar apparatus. Secondary current can be 1 or 5 A.
- Number of secondary winding depends on a body dimension, for example the biggest 36 kV TPU 7x.6x can contain up to 8 cores.

Primary current of the system (I_{sys})
Current of the system, where transformer will be installed I_{sys}, has to be equal to I_{pr}.
I_{sys} calculation for various applications:
- Transformer feeder

$$I_{sys} = \frac{S}{\sqrt{3} * U_{sys}}$$

- Capacitor feeder

$$I_{sys} = \frac{1.3 * Q}{\sqrt{3} * U_{sys}}$$

Where
S Apparent power in kVA
U_{sys} Voltage of the system in kV
Q Reactive power of capacitor in kVar

Rated short-time thermal current (I_{th})
The maximum value of the primary current which a transformer will withstand for a specified short time without suffering harmful effects.

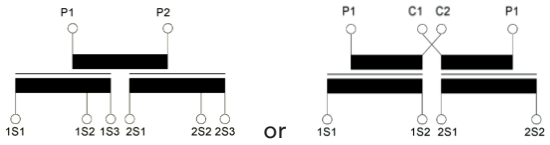
Standardly used values are follows:
2; 4; 6.3; 8; 10; 12.5; 16; 20; 25; 31.5; 40; 50; 63; 80; 100 kA

The standard value for the duration of the short-time thermal current I_{th} is 1 s, possibility also 3 s.

The standard value of the rated dynamic current I_{dyn} is 2.5 times I_{th} for 50 Hz.

Capacitive divider
In ABB portfolio, the capacitive divider is integrated in a current transformer body and voltage indication is easier than ever before.

Reconnection
Possibility of reconnection is shown below, it can be realized either on secondary or primary side:



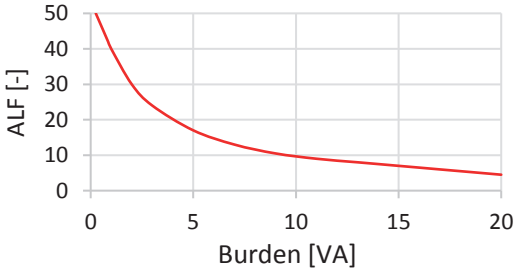
On the left is double-core design with taps for secondary reconnection (for example, between 1S1-1S2 the ratio is 50//1 and between 1S1-1S3 the ratio is 100//1). On the right is reconnection on primary side. An instrument transformer with reconnection on primary side must be reconnected manualy.

ALF
Protection classes are defined by 2 values. First defines a composite error (5% or 10% = 5P, 10P) and second one stands for an accuracy limit factor (ALF). ALF defines multiple of primary current up to which the error must be fulfilled.

5P20 – 5P defines that composite error must be lower or equal to 5% (10% for 10P)
– 20 defines that error limit must be fulfilled from 100% of primary current to 20 times of primary current

How to choose ALF?
You have a current transformer with ratio 100//1 A and protection core 5P20.
In normal situation protection core is measuring with 1% (3% for 10P) ratio error at primary current, but if some problem appears in system and primary current rise above 100 A (100% of rated primary current) then we guarantee that up to 20 times primary current (20 x 100 = 2 000 A) the error will be lower or equal to 5% (10% for 10P). It means core saturation shall be after 2 000 A.

Table below shows dependency on burden, unexpected burden causes a decrease of ALF.



Burden
Remember that it is always necessary to calculate the real burden needed for secondary core, sec. circuit and connected apparatus.

Type of instrument	Burden
Amp-meter	0.5 to 4 VA
Volt-meter	2 to 5 VA
Watt-meter	1 to 5 VA
Electronic protection relay	0.2 – 1 VA
Protection relay	15 to 30 VA

- Older mechanical relays required higher values of VA to operate.

Compensation of cable losses
Burden [VA] needed for covering the losses in a secondary circuit with different cross-section and cable lengths:

Ø	1.5 mm²		2.5 mm²		4 mm²	
Current	5 A	1 A	5 A	1 A	5 A	1 A
1 m	0.59	0.02	0.36	0.01	0.22	0.01
3 m	1.78	0.07	1.07	0.04	0.67	0.03
5 m	2.97	0.12	1.78	0.07	1.12	0.04
9 m	5.34	0.21	3.21	0.13	2.01	0.08

FS
Security factor (FS) is used for the measuring classes. FS helps to protect all equipment connected to a secondary side by setting core saturation and avoids a transmission of the big currents on a secondary during fault conditions.

FS 5 – for 5 times of rated prim. current the error must be bigger or equal to 10% at rated burden.
FS 10 – for 10 times of rated prim. current the error must be bigger or equal to 10% at rated burden.

How to choose FS?
You have a current transformer with defined ratio 100//1 A and measuring core 0.5 FS5. To a secondary terminal is connected Amp-meter with maximal input 5 A.
If some error in a network appears and primary current grows for example to 700 A instead of 100 A, according to the transformer ratio you should get 7 A on secondary side. However, the security factor does not allow this situation and at 5 times of rated primary (500 A) the secondary current starts to be transmitted with 10% error and a core is saturated. It means that secondary current never grows over 5 A, no matter how big is a growth of prim. current. Correctly selected FS guarantees safety for your measuring devices in every condition.

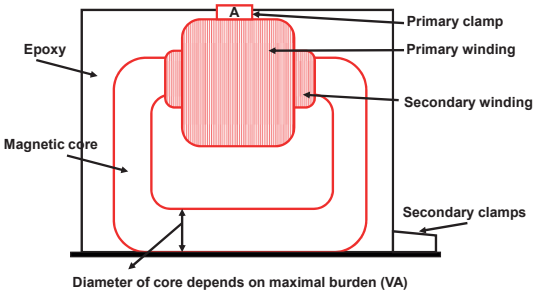
Ambient temperature and Insulation class
Ambient temperature is classified by IEC for all instrument transformers in 3 categories:
- -5 / 40 °C
- -25 / 40 °C
- -40 / 40 °C

Insulation class for ABB portfolio corresponds to class E, it refers to maximal temperature rise of all active parts about 75 K.

Voltage transformer

Voltage transformers provide a secondary circuit with a secondary voltage proportional to a primary voltage. The secondary voltage is usually either 100 V, 110 V or 120 V.

Basic parts of any type of voltage transformer is the epoxy resin body, primary winding, secondary winding and the magnetic core.



Single pole VT: connection is between phase and earth, e.g. $\frac{10\,000}{\sqrt{3}} // \frac{100}{\sqrt{3}} / \frac{100}{3}$ V

Double pole VT: connection is between two phases, e.g. 10 000 // 100 V

- Parameters as frequency, insulation level, ambient temperature, standards, cable losses and burden are the same for current and voltage transformers. For these information please see previous pages.

Transformation ratio (K)

$$K = \frac{U_{Pr}}{U_{sr}} = \frac{N_1}{N_2}$$

Where:
U_{pr} Primary voltage
U_{sr} Secondary voltage
N_1 Turns on a primary winding
N_2 Turns on a secondary winding

As seen from the equation above, the ratio between primary and secondary winding is opposite to a current transformer and more turns are on a primary coil of a voltage transformer.

Rated primary voltage U_{pr}
From the view of a connection, we distinguish:

- Phase to phase voltage, e.g. 10 000 // 100 V

Where $U_{pr} = U$

- Phase to earth voltage, e.g. $\frac{10\,000}{\sqrt{3}} // \frac{100}{\sqrt{3}}$ V

Where: $U_{pr} = \frac{U}{\sqrt{3}}$

According to IEC, the values are usually: 3.3; 6.6; 7.2; 12; 17.5; 20; 24; 30; 33; 36 (40.5) kV

Rated secondary voltage
There is a possibility to produce any kind of ratio, but standardized secondary voltage as 100, 110 or 120 V are preferred considering to the connected instruments.

For a single phase transformer with a phase to earth connection, the rated secondary voltage must be divided by √3 in star connection and by 3 in open delta connection.

- It is possible to produce a voltage transformer with mixture of ratios, for example:

$\frac{100}{\sqrt{3}} / \frac{100}{3}$ or $\frac{110}{\sqrt{3}} / \frac{110}{3}$ or $\frac{120}{\sqrt{3}} / \frac{120}{3}$

Rated voltage factor
Multiplying factor to be applied to the rated primary voltage to determine the maximum voltage at which a transformer must comply with the relevant thermal requirements for a specified time and with the accuracy requirements.

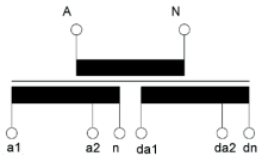
- ABB single pole voltage transformers are designed with rated voltage factor 1.9*U_{pr} / 8 h and double pole with 1.2*U_{pr} / continuous.

Different voltage factors are possible and shall be discussed with our sales representatives.

Number of windings and reconnection
It is possible to produce voltage transformer with maximal three secondary windings that can be used for measuring, protection purposes or earth fault indication, for example:

$\frac{10\,000}{\sqrt{3}} // \frac{100}{\sqrt{3}} / \frac{100}{\sqrt{3}} / \frac{100}{3}$ V

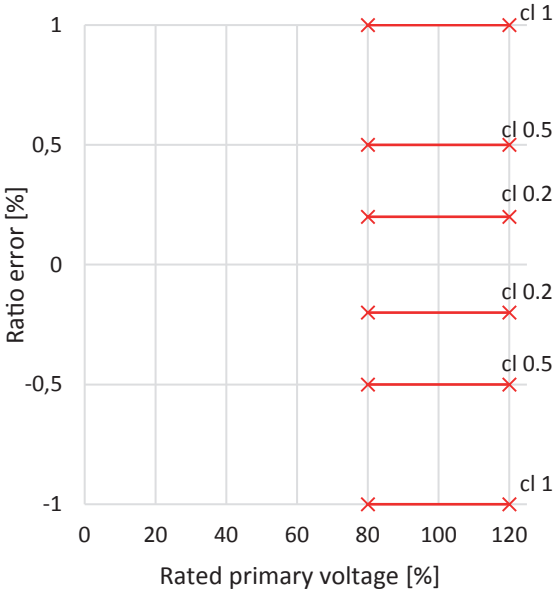
Reconnection is also possible for ABB voltage transformers, for example a single pole insulated transformer, with two secondary tapped windings, one which being the residual winding:



Accuracy classes
By area of the use, voltage transformers can have following classes:

- measuring classes: 0.2; 0.5; 1; 3
- protection (a-n) and/or residual (da-dn): 3P; 6P

For measuring classes, the voltage error at rated frequency shall not exceed the values given by IEC between 80 % and 120 % of rated voltage. Measuring classes are drawn in chart below:



- For protecting classes, the voltage ratio error can not exceed 3 % (class 3P) or 6 % (class 6P) in range of the 5 % of rated primary voltage and at rated primary voltage multiplied by the rated voltage factor (e.g. 190 % for factor 1.9).

Fuses
A fuse can be part of a supply of single pole voltage transformers with fuse:

Rated current	Rated voltage	Striker pin
0.5 – 6.3 A	12 / 17.5 kV	YES*/NO
0.5 – 6.3 A	24 kV	YES*/NO
2 or 4 A	36 kV	NO
0.3 or 0.6 A	12 / 24 kV	NO

Marking of terminals acc. to IEC
Different use of transformers leads to varieties of terminal marking, which is follows:

- Single pole:
  Primary winding A-N
  Sec. winding a-n (star), da-dn (open delta)
- Double pole:
  Primary winding A-B
  Sec. winding a-b

Thermal output
Maximal power, which can be achieve by a transformer in a star connection at rated primary voltage U_{pr}, with ratio error +/-10%.

- 12 – 17.5kV (TJC 4 & TJC 5) = 400 VA
- 24 kV (TJC 6) = 500 VA
- 36 kV (TJC 7.x) = 600 VA
- 36 kV (TJC 7) = 700 VA

Example of purchasing order
Current transformer
- TPU 40.13
- 50//5/5 A, EXT 120 %, 15/15 VA, class 0.5FS5/5P10
- I_{th} = 40 kA/1 sec, I_{dyn} = 100 kA
- 12/28/75 kV, frequency 50 Hz
- IEC 61869-2
- Ambient temperature 40 °C
- Polarity P1-P2
- Capacitive divider

Voltage transformer
- TJC 4
- 6000/√3//100/√3/100/3 V 50/100 VA, class 0.5/6P
- 7.2/20/60, frequency 50 Hz
- 1.9*U_n / 8 h
- IEC 61869-3
- Ambient temperature 40 °C

Additional information to be specified together with our sales representatives.

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