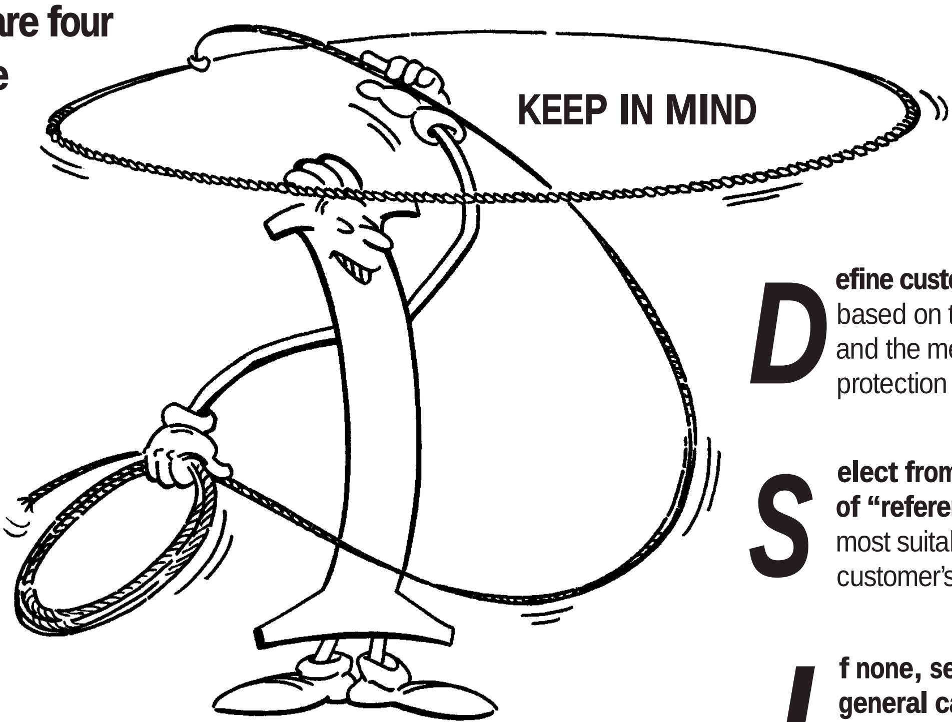
MT Partenaire

Current transformer selection guide

The selection of a current transformer is a simple task. There are four phases in the selection procedure.

KEEP IN MIND



Define customer requirements based on the primary circuit and the metering and protection chains.

Select from the catalogue of “referenced” CT’s the most suitable unit for the customer’s need.

If none, select from the general catalogues the standardised CT’s the most suitable unit for the customer need.

If none are suitable, ask for a feasibility study. However, even if the special unit can be manufactured, it will nevertheless be a special make-up with all the problems which this may engender.

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DETERMINATION OF THE CUSTOMER'S NEED

SUMMARY

1 - Electrical characteristics of the primary circuits

2 - IEC metering and protection standards

3 - BS specifications for differential protection

Client's needs are determined by the electrical characteristics of the primary circuit, the use to be made of the secondary circuits and the standards used to define the CT.

1 - ELECTRICAL CHARACTERISTICS OF THE PRIMARY CIRCUITS SUIVANT NORME IEC

The primary circuits of the current transformer must withstand the constraints related to the medium voltage network to which it is connected.

☞ **Remark :** *all the electrical characteristics used for CTs are defined in binder B, chapter 1, topic 3.*

Rated frequency (f) :

This is the frequency of the installation.

A CT defined for 50 Hz can be installed on a 60 Hz network with the same level of accuracy. However, the opposite is not true.

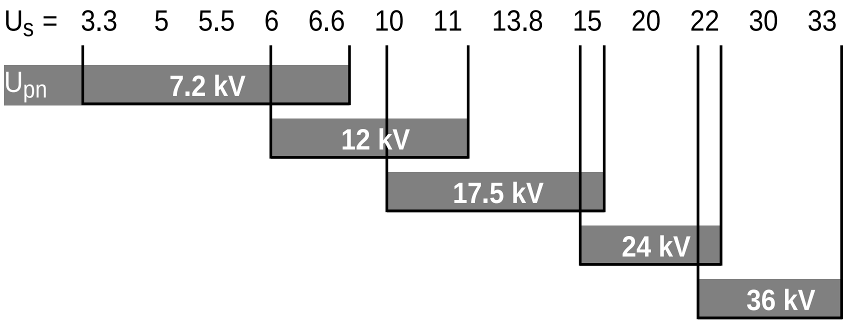
For a non-referenced unit, it is vital to indicate the rated frequency on the order from.

Rated voltage of the primary circuit (U_{pn})

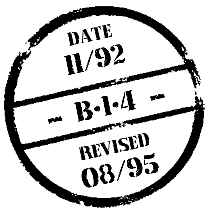
General case:

Insulation level continuity for the whole installation will be ensured if the rated voltage of the CT used is ≥ the rated voltage of the installation.

The rated voltage determines the insulation level of the equipment (see binder B, chapter 1, topic 1).
Generally we choose the rated voltage based on the duty voltage, U_S, according to the following table:



Specific case:
If the CT is installed on a bushing or a cable providing insulation, the CT can be LV ring type.



DETERMINATION OF THE CUSTOMER'S NEED

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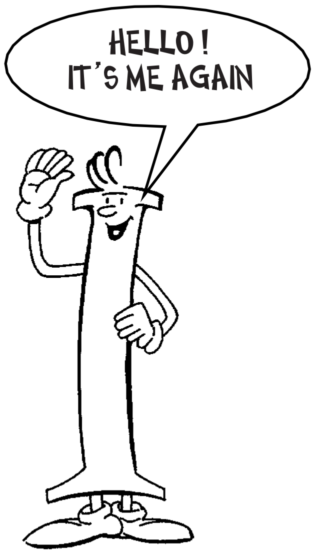


Primary service current (I_{ps})

Knowledge about the primary service current will enable us to determine the rated primary current for the CT taking into account any eventual derating.

General case:

The service current depends on the power traversing the primary windings of the CT.

If
S = apparent power in VA
U_{ps} = primary service voltage in V
P = active power of the motor in W
Q = reactive power of the capacitors in VAR
I_{ps} = primary service current in Amp

We will have :

- incoming cubicle:

$$I_{ps} = \frac{S}{\sqrt{3} \times U_s}$$

- generator incomer:

$$I_{ps} = \frac{S}{\sqrt{3} \times U_s}$$

- transformer feeder:

$$I_{ps} = \frac{S}{\sqrt{3} \times U_s}$$

- motor feede:

$$I_{ps} = \frac{P}{\sqrt{3} \times U_s \times \cos\varphi \times \eta}$$

η = efficiency of the motor

If you do not know exact values for φ and η as a first approximation, you can assume that: $\cos\varphi = 0.8$; $\eta = 0.8$

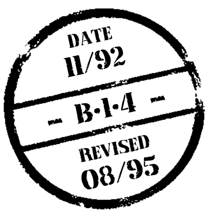
- capacitor feeder:

$$I_{ps} = \frac{1.3 \times Q}{\sqrt{3} \times U_s}$$

1.3 is a de-rating factor of 30% which compensates for heat-up due to harmonics in the capacitors.

- bus tie:

The I_{ps} current in the CT is the highest permanent current that can circulate in the connection.



DETERMINATION OF THE CUSTOMER'S NEED

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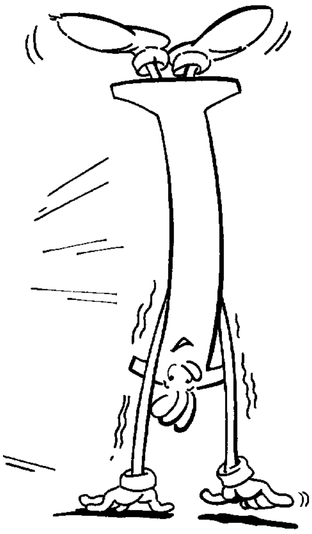
Rated primary current (I_{pn})

The rated current will always be greater than or equal to the service current.

If the ambient temperature around the CT exceeds 40 °C, the rated CT current must be higher than the I_{ps} multiplied by the de-rating factor for the cubicle. (see binder B, chapter 1, topic 1).

For a transformer differential protection, the rated currents of the two CT sets must be inversely proportional to the voltages.



The calibrating CTs are calculated to re-establish currents and phases to match the coupling to the power transformer.
In the somewhat infrequent case in which it is not possible to use a calibration CT (as the accuracy power is too high), the rated current depends on the transformer coupling.
Determination of the calibrating CTs will be studied subsequently in binder C.

For a line or bus bar differential protection, the rated primary current of the CT should be higher than the highest service current.

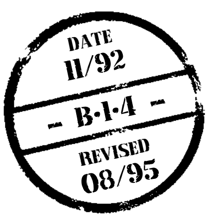
All CTs must have the same rated current.
They will be connected in parallel, phase by phase.

It should be noted that in bus bar differential protections:

- the permanent primary service current will generally speaking be much lower than the rated current.
- CT primary coil dimensions should be based on the service current.

Example:

A CT 2000/1 A installed on a 300 A outgoing will be thermally dimensioned for 300 but will have a 2000/1 A ratio.



DETERMINATION OF THE CUSTOMER'S NEED

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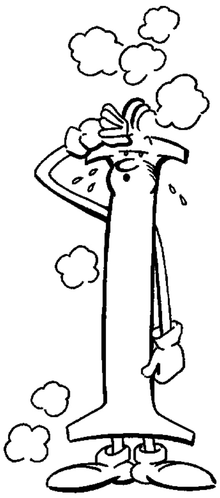

Single or double primary?

Use a double primary:

- to meet a customer request
- to rationalise the appliances supplied
- **to enable the use of referenced MG transformers if they do not exist with a single primary.**

Rated thermal short-circuit current (I_{th})

The rated thermal short-circuit current is usually the short-circuit current of the installation and its duration is usually assumed to be 1 s.

All CTs must be able to resist the rated short-circuit current in the primary winding both thermally and dynamically until the malfunction induces shut-down.

If P_{cc} is the network short-circuit power expressed in MVA, then:

$$I_{th} = \frac{P \times 10^3}{U_S \times \sqrt{3}}$$

Example:

P_{cc} = 250 MVA; U_S = 15 kV

$$I_{th\,1\,s} = \frac{P \times 10^3}{U_S \times \sqrt{3}} = \frac{250 \times 10^3}{15 \times \sqrt{3}} = 9600\ \text{A}$$

When the CT is installed in a cubicle protected by fuses, the I_{th} to consider equals 80 I_n .
If 80 I_n > $I_{th\,1\,s}$ of the isolating switching device, then $I_{th\,1\,s}$ of the CT = $I_{th\,1\,s}$ of the device.

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DETERMINATION OF THE CUSTOMER'S NEED

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It is often useful to use surge current coefficient

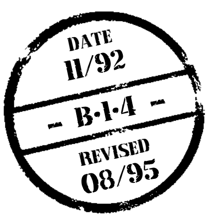
$$K_{si} = \frac{I_{th\ 1\ s}}{I_{pn}}$$

The lower surge current factor K_{si} is the higher the feasibility of current transformers will be.

Incidence K_{si} on CT manufacturing

Scale order K_{si}	**manufacturing**
$K_{si} < 100$	standard
$100 < K_{si} < 300$	sometimes difficult for some secondary characteristics
$100 < K_{si} < 400$	difficult
$400 < K_{si} < 500$	limited to some secondary characteristics
$K_{si} > 500$	very often impossible

A high K_{si} leads to over-dimensioning of primary winding cross-sections. This will limit the number of windings in the primary coil as will be induced electromotive force of the CT; the CT will be harder to manufacture.



DETERMINATION OF THE CUSTOMER'S NEED
(cont'd)

For easier production we can, in order:

- ■ reduce the secondary characteristics as far as possible.
- ■ over-rate the primary rated current.
- ■ reduce the thermal resistance time whilst complying with the time required to eliminate the fault.

The rated thermal short-circuit current is generally the installation's short-circuit current and the duration of this is generally taken to equal 1 s.

Each CT must be able to thermally and dynamically withstand the defined short-circuit current passing through its primary circuit until the fault is effectively broken.

I_{th} in kAeff.
Duration (seconds)
I_{Dyn} in kA (peak)

$$I_{th} = \frac{P_{cc}}{U \bullet \sqrt{3}}$$

$$I_{th} = I_{th}\sqrt{t}$$

In very exceptional cases, and subject to the agreement of protection engineers, the duration can be reduced down to 0.25 s.
In normal cases, do not go below 0.8.

Example for a calculation to reduce K_{si}

P_{cc} (short-circuit current) = 250 MVA
U_S (operational voltage) = 15 kV
I_{pn} (rated primary current) = 20 A

$$I_{th\,1\,s} = \frac{250 \times 10^3}{15 \times \sqrt{3}} = 9600\ A$$

$K_{si} = I_{th}/I_{pn} = 9600/20 = 480$

Production is probably difficult in this case and even impossible if the characteristics of the secondary are high.

If the short-circuit time can be limited to 0.8 s, we would obtain:

$$9600 \times \sqrt{0.8} = I_{th\,1\,s} \times \sqrt{1}$$

$$I_{th\,1\,s} = 9600 \times \sqrt{0.8} = 8586\ A \text{ et } K_{si} = 8586/20 = 429$$

This transformer would be easier to produce.

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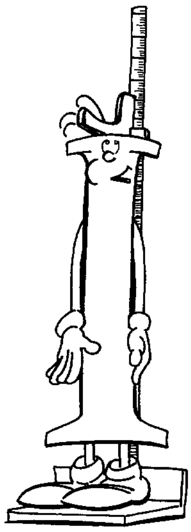


2 - SECONDARY CIRCUIT CHARACTERISTICS UNDER IEC STANDARDS

The secondary circuits of a CT must be suitable for the constraints related to its application for metering or protection purposes.

Rated secondary current (I_{sn}) 5 or 1 A?

General case:

for use in a local situation I_{sn} = 5 A
for use in a remote situation I_{sn} = 1 A

Specific case:
for use in a local situation I_{sn} = 1 A

☞ **Remark:** *the use of 5 A in a remote situation is not forbidden but involves the increase the cross section of the line or the sizes of the transformer (lost in line).*

Accuracy class (Cl)

metering: class 0.5
metering on the residual current: class 1
amp protection: class 10P sometimes 5P
differential residual current protection: class X
homopolar protection: class 5P

The effective power that the CT must apply in VA

This is the total of consumption by the line and the consumption of each appliance connected to the secondary circuit of the CT.

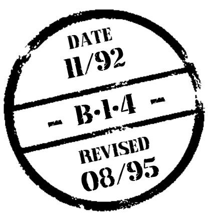
■ consumption by copper cable

line drop $(VA) = k \times \frac{L}{S}$

k = 0.5 if I_{sn} = 5 A
k = 0.02 if I_{sn} = 1 A
L = length of the connection cables (input/output loop) in metres
S = section of cables in mm^2

Examples: for I_{sn} = 5 A

type of cubicle	F100 - F200	F300	F400
cable section (mm^2)	2.5	2.5	2.5
cable lenght	5 m	5.7 m	5.8 m
power loss due to cable	0.1 VA	1.14 VA	1.16 VA



■ consumption of the protection and metering apparatus
The consumption has to be taken in the manufacturer's leaflets.

DETERMINATION OF THE CUSTOMER'S NEED

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Rated burden

Take the rated burden which is immediatlely above the effective power supplied by the CT.

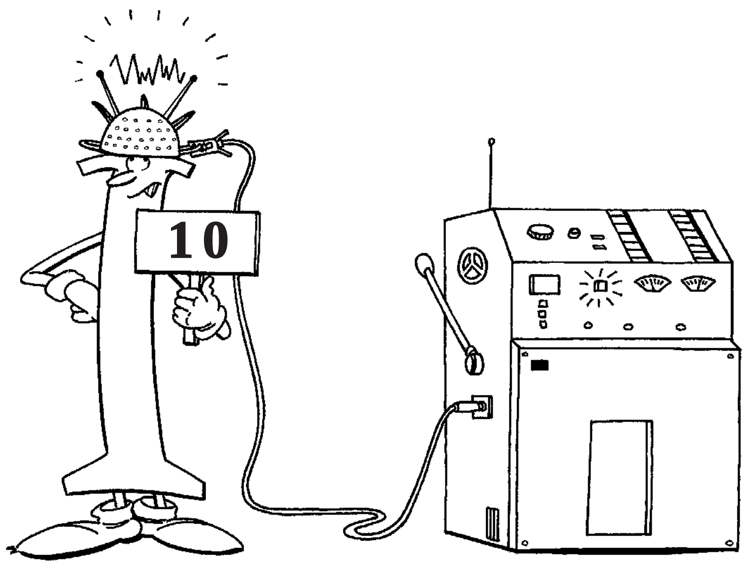
The rated burden for accuracy power are:
2.5 VA - 5 VA - 10 VA - 15 VA - 30 VA.

Safety factor in metering (SF)

The SF value will be selected depending on the short time current withstand of the receivers: 5 ≤ SF ≤ 10

An ammeter is usually guaranteed to support a short time current of 10 I_n i.e. 50 A for a 5 A device.
To ensure that the appliance is not destroyed should a fault occur in the primary the current transformer must be able to saturate before 10 I_n in the secondary.
For this reason, a SF of 5 is sufficient.

In accordance with the standard, our CT's have an SF ≤ 10. However, depending on the characteristics of the current consumer, a lower SF value may be requested.



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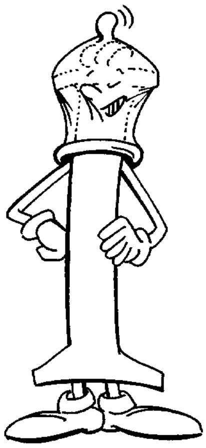


Accuracy limit factor in protection (ALF)

The ALF required for the circuit will be determined as follows:

■ **overcurrent protection independent time**

> **The relay will operate perfectly provided that:**
>
> $$\text{(effective ALF of the CT)} > 2 \times \frac{I_r}{I_{sn}}$$

I_r = the set point of the relay
I_{sn} = the rated secondary current of the CT

For a relay with two set-points, we will use the highest set point.

For a transformer outgoing, there will usually be a high instantaneous set-point set on 14 I_n maximum which means that the *necessary effective ALF is > 28.*

For a motor feeder, we will generally have a high set-point set on 8 I_n maximum which means that the *necessary effective ALF > 16.*

■ **overcurrent protection dependent time**

In every case, refer to the relay vendor's technical data sheet.

> **For these protections, CT accuracy must be ensured throughout the whole relay trip range up to 10 I_n which is the highest instantaneous set-point used.**
> **In this case, the effective ALF must be > 20 x I_r.**

Specific cases:

if the maximum short-circuit current is greater than or equal to 10 I_r

$$\text{effective ALF} > 20 \times \frac{I_r}{I_{sn}}$$

I_r = the set-point of the relay

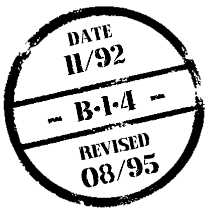
if the maximum short-circuit current is under10 I_r, for the 1 set-point:

$$\text{effective ALF} > 2 \times \frac{I_{cc\ secondary}}{I_{sn}}$$

if the protection has a high instantaneous set-point (never effective on incomings and feeder outgoings):

$$\text{effective ALF} > 2 \times \frac{I_{r2}}{I_{sn}}$$

I_{r2} = instantaneous high module set point



DETERMINATION OF THE CUSTOMER'S NEED

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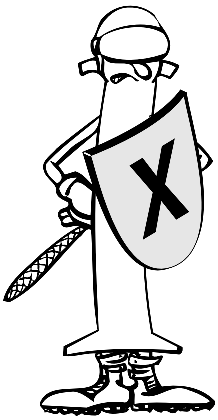


3 - BS SPECIFICATIONS FOR DIFFERENTIAL PROTECTION (CLASS X)

Many differential protection relay manufacturers recommend class X CTs.

Class X is often requested in the form:

$$V_k \geq a \cdot I_f (R_{ct} + R_b + R_r)$$

The exact formula is given by the manufacturer of the relay.

Values which characterise the CT

V_k = knee-point voltage in volts
a = the coefficient which refers to the asymmetrical configuration
R_{ct} = maximum resistance of the secondary winding in Ohms
R_b = resistance of the loop (i.e. the return line) in Ohms
R_r = resistance of the relay outside the differential part of the circuit in ohms
I_f = the maximum fault current value measured by the CT in the secondary circuit for a fault outside the zone to be protected in Amps

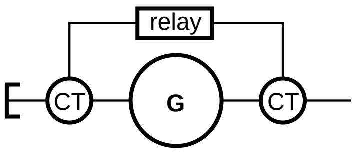
$$I_f = \frac{(I_{cc})}{K_n}$$

I_{cc} = short-circuit current of the primary circuit
K_n = CT ratio

What is the value for I_f* when determining *V_k?

The short-circuit current is selected for the application:
- generator differential protection
- motor differential protection
- transformer differential protection
- busbar differential protection

■ **for a generator differential protection:**



If I_{cc} is known:
I_{cc} is the short-circuit current of the generator alone

$$I_f = \frac{(I_{cc})}{K_n}$$

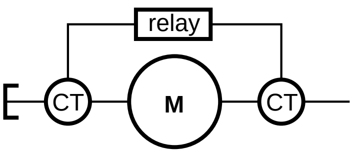
If the $I_{n\ generator}$ is known:
it will be evaluated by excess as

$$I_f = \frac{7 \times I_{n\ generator}}{K_n}$$

If the $I_{n\ generator}$ is not known:
it will be evaluated by excess as

$I_f = 7 \times I_{sn(CT)}$
$I_{sn(CT)}$ = 1 or 5 A

■ **for a motor differential protection:**



If the starting current is known:
we will use $I_{cc} = I_{starting}$

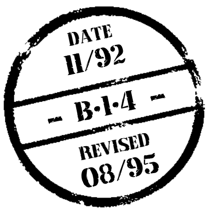
$$I_f = \frac{I_{cc}}{K_n}$$

If the motor I_n is known:
it will be evaluated by excess as

$$I_f = \frac{7 \times I_n}{K_n}$$

If the motor I_n is not known:
it will also be evaluated by excess as:

$I_f = 7 \times I_{sn(CT)}$
$I_{sn(CT)}$ = 1 or 5 A

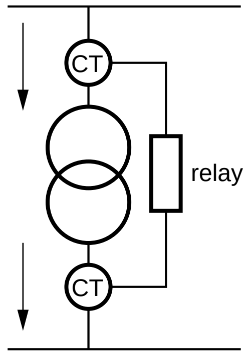


DETERMINATION OF THE CUSTOMER'S NEED

(cont'd)

■ **for a transformer differential protection**

The I_{cc} to be considered is the current in the CT in the feeder side.
In every case, the fault current I_f will be lower as 20 $I_{sn(CT)}$
If we don't know the exact value, it will be evaluated by excess as:
$I_f = 20\ I_{sn\ (CT)}$



■ **for busbar differential protection**

The I_{cc} to be considered is the I_{th} of the board

$$I_f = \frac{I_{th}}{K_n}$$

■ **for feeder differential protection**

The I_{cc} to be considered is the I_{cc} at the other end of the cable. If the impedance of the cable is unknown, it will be evaluated by excess the I_{th} of the board.

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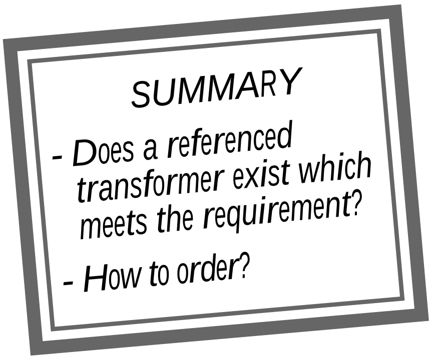
CATALOGUE OF REFERENCED CT'S



Select from the catalogue of "referenced" CT's the most suitable unit for the customer's need.

You have determined the minimum characteristics required for your need. Now, you should determine the CT that you are going to order.

There are three phases to this decision:
- does a referenced transformer exist which meet the requirement ?
- if not, is there a transformer in the general catalogue that meets the requirement?
- if not, you should request a feasibility study.

Let us examine these three phases.

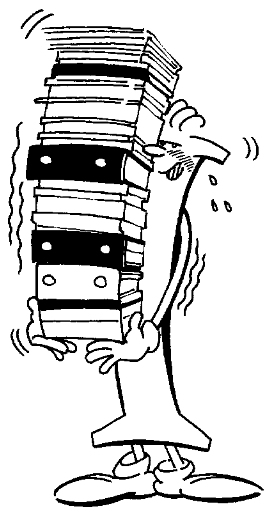
DOES A REFERENCED TRANSFORMER EXIST WHICH MEETS THE REQUIREMENT?

These are what we call referenced transformers.

The most frequently used current transformers meeting virtually all needs have been selected and referenced.

Referenced transformers are:
- simple to order: one reference, one quantity, one price
- delivered more rapidly
- interchangeable between contracts which means that it is easier to obtain rush deliveries.

We strongly recommend using referenced CTs and convincing your clients to do likewise.



CATALOGUE OF REFERENCED CT'S (cont'd)

WHICH UNITS HAVE BEEN REFERENCED?

Referenced transformers are shown in the appendix.

They can all be used for both 50 Hz and 60 Hz.

These are appliances which should be installed in our cubicles.
We know the insulation and thermal withstand levels.

If you require a non-referenced CT with a single core, it is often more advantageous to use a standard appliance with two secondary windings than to order a special unit.
In this case, you must shunt the redundant secondary winding.

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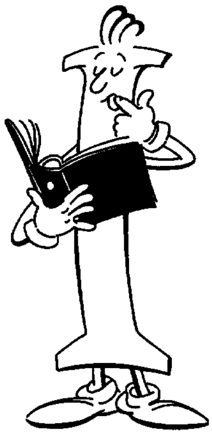
CATALOGUE OF REFERENCED CT'S (cont'd)



WHAT VALUE SHOULD YOU TAKE FOR THE RATED PRIMARY CURRENT?

Choose the transformer which has a rated primary current immediately higher than the service current.

Check that the rated primary current selected includes the de-rating factor.

primary service current (I_{ps})	primary rated current (I_{pn})
$10 < I_{ps} < 15$	15
$15 < I_{ps} < 20$	20
$20 < I_{ps} < 30$	30
$30 < I_{ps} < 50$	50
$50 < I_{ps} < 75$	75
$75 < I_{ps} < 100$	100
$100 < I_{ps} < 150$	150
$150 < I_{ps} < 200$	200
$200 < I_{ps} < 250$	250
$250 < I_{ps} < 300$	300
$300 < I_{ps} < 400$	400
$400 < I_{ps} < 500$	500
$500 < I_{ps} < 600$	600
$600 < I_{ps} < 750$	750
$750 < I_{ps} < 1000$	1000
$1250 < I_{ps} < 1500$	1500
$1500 < I_{ps} < 2000$	2000
$2000 < I_{ps} < 2500$	2500
$2500 < I_{ps} < 3000$	3000
$3000 < I_{ps} < 3150$	3150

For metering and normal Amp protection the rated primary current should not exceed the service current by a factor greater than 1.5.
In the case of protection, check that the setting of the relay may be reached with the primary rated current.

☞ **Remark:** *current transformers can withstand a continual current of 1.2 times the rated current and remain in conformity with the standards.*

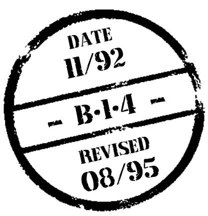
Example:

The setting of a thermal protection motor relay is between 0.6 and 1.2 I_{nCT}.
To have a good protection of the motor, the setting must be $I_{n\ motor}$.

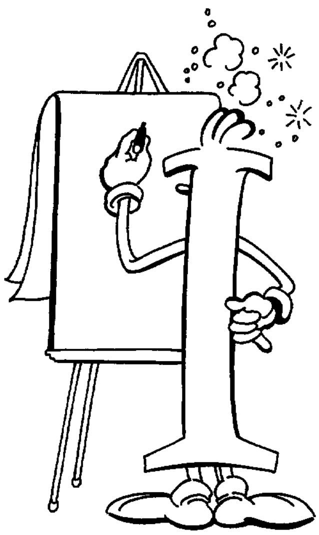
If $I_{n\ motor}$ = 45 Amps, the setting of the relay must be 45 Amps.
If we choose a CT 100/5, we cannot adjust the relay
(minimum setting 0.6 x 100 = 60 > 45 Amps).
If we choose a CT 75/5, we will have:

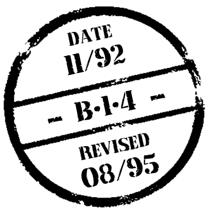
$0.6 < \frac{45}{75} < 1.2$ we can adjust the relay.

The CT is correct.



CATALOGUE OF REFERENCED CT'S (cont'd)





CHECKING OF THE I_{TH}

Check that the thermal withstand of the referenced CT is compatible with the requirement .

In extreme cases, it may be advantageous to consider the probable maximum time of the fault and to verify the thermal withstand of the CT using the following formula: $I_{th\ 1\ s} = I_{th} \cdot \sqrt{t}$ (see page 7).

CHOICE OF THE SECONDARY CHARACTERISTICS

For metering purposes, all referenced CTs are class 0.5.

Class 0.5 CT's may be used for class 1 needs.

The accuracy power should be the next highest value to your requirement in accordance with the standardised values.

For protective purposes, use the equivalence rules to check that the characteristics of the referenced transformers are suitable for your requirement.

A simplified equation will allow you to equate these values in order to choose referenced equipment:

$LAF (VA + Rct\ I^2) = C^{te}$

LAF: limit of accuracy factor
VA: rated output
Rct: internal resistance of secondary circuit
I: secondary current, 1 or 5 A

Example:

The calculation shows us that the requirement is: 10 VA 10P10
Device reference no. 3731105 has the following characteristics:
200 - 400/5 - 5
30 VA Cl 0.5
7.5 VA 5P15
The internal winding resistance is 0.3 Ω; we can write:

$$LAF (VA + Rct\ I^2) = C^{te}$$

$$15 (7.5 + 0.3 \times 5^2) = 10 (VA + 0.3 \times 5^2)$$

Referenced transformers	New requirement-related characteristics

We find: 10.6 VA. It is in accordance with the requirement.
The customer's requirement is satisfied with a referenced device and a technical explanation. For amore detailed calculation, refer to binder B, chapter 1, topic 3, appendix 1.

HOW TO ORDER A REFERENCED CT?

You have found a CT description that corresponds to your requirement, how can you order it? Simply give the CT reference on your order form together with the price and the quantity required.

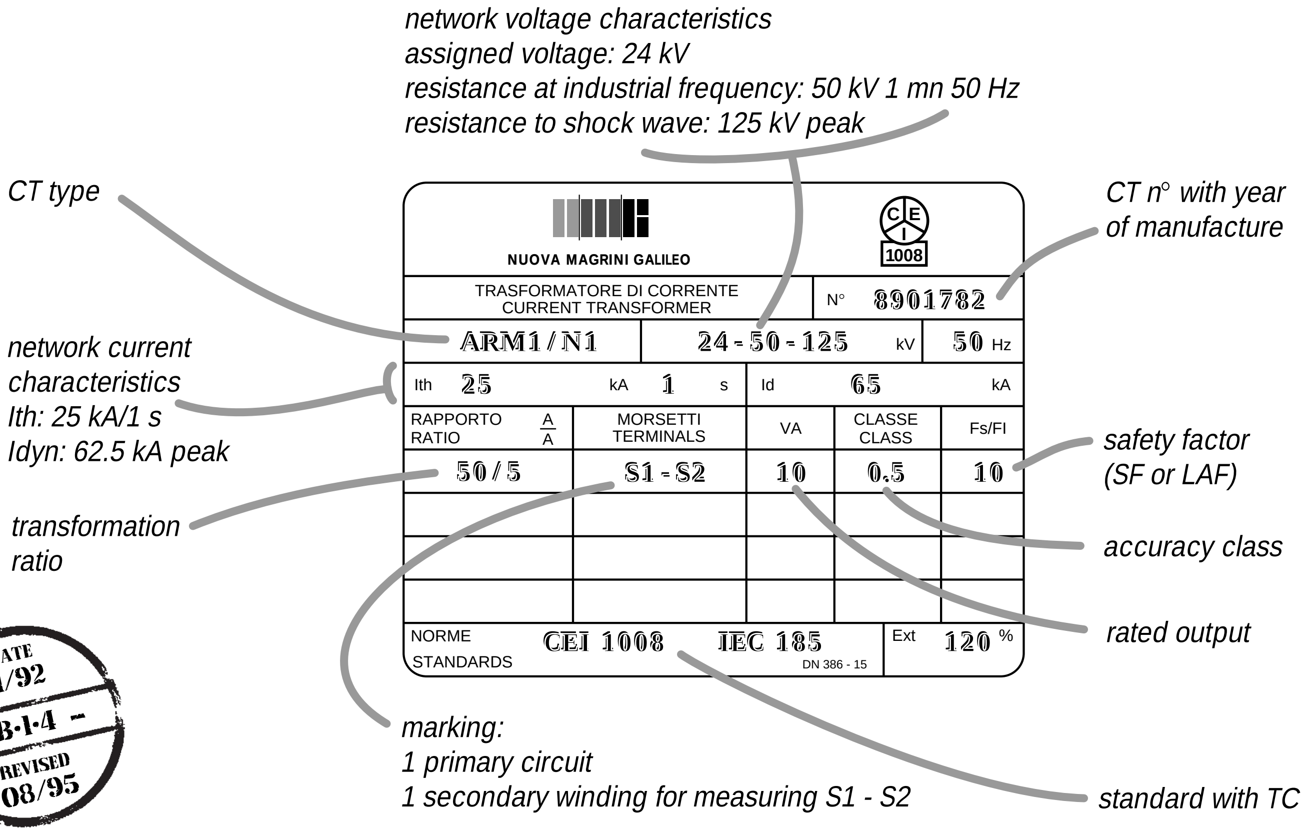
CATALOGUE OF REFERENCED CT'S (cont'd)

WHAT CHARACTERISTICS ARE SHOWN ON THE IDENTIFICATION PLATE ON THE REFERENCED CT SUPPLIED ?

The characteristics defining the referenced CT are shown on the identification plate.

	effective requirement	unit standardised
CT type	ARM3	ARM3
reference standard	IEC 185	IEC 185
frequency	50 Hz	50 Hz
service voltage	11 kV	
insulation level	12 kV/28/75 kV	24 kV/50/125 kV
short-circuit current	12.5 kA	16 kA
acceptable short-circuit current time	1 s	1 s
primary current	78 A	100 A - 200 A
1st secondary winding used for metering rated secondary current accuracy class	5 A 20 VA 0.5	5 A 30 VA 0.5
2nd secondary winding used for protection accuracy power accuracy class	5 A 25 VA 10P5	5 A 15 VA and 7.5 VA 5P15 5P10

Identification plate of the delivered CT



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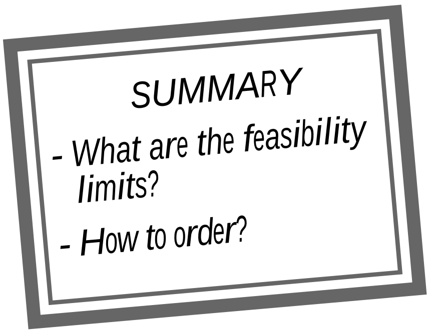
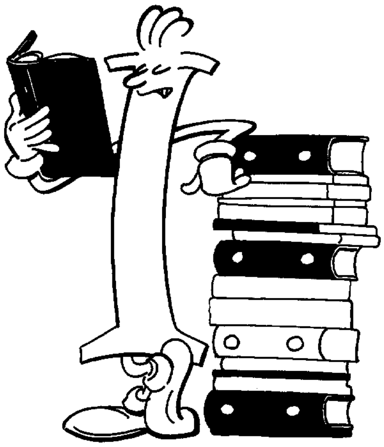
GENERAL CATALOGUE AND DIMENSIONS





If you have not found referenced appliance?

Select from the general catalogue the standardised CT's the most suitable unit for the customer need.

If you have not found referenced CT, check that the CT needed to meet the requirement is within the manufacturer's feasibility limits.

Examples:

You need a CT to install

■ case 1
in an F300 cubicle with the following specifications:
CT 300/5A metering: 30 VA cl. 1; protection: 15 VA 10P10 $I_{th\ 1\ s}$ = 31.5 kA
Look at your general catalogue page F300.
This CT can be manufactured as it is inside the feasibility zone for TCF3D CTs.

■ case 2
in an F200 cubicle with the following specifications:
CT 50/1A metering: 15 VA cl. 0.5; protection: 15 VA 10P15 $I_{th\ 1\ s}$ = 25 kA
overcurrent factor = K_{si} = 25 000: 50 = 500
Look at your general catalogue page F200.
This CT is outside the feasibility zone. A feasibility study will be necessary to know if it can be manufactured.

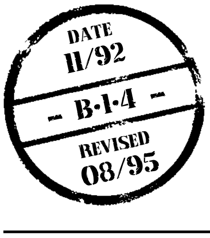
Order using the model order form.

How should you order the CT you need from the manufacturer's catalogue?

You can order using the order form in the appendix.

What characteristics are shown on the identification plate on the CT supplied?

The identification plate on the CT supplied will show the specifications listed on the order form.



REQUEST FOR A SPECIFIC FEASIBILITY STUDY

SUMMARY

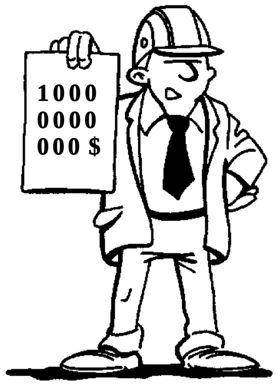
- My requirement is very specific

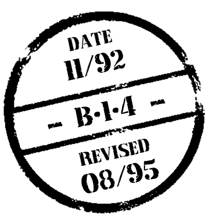
Your requirement cannot be covered from the manufacturer catalogue:

have a feasibility study carried out in consultation

You must supply the information required for this study. To do this fill out the feasibility request form in appendices 4 and 5.

Your contact will then make you a technical offer, with prices and delivery times, but… be ready for a nasty surprise !!





model order or feasibility study request for current transformers

types :

characteristics

- standard .... ____________
- rated insulation level .... ____________ kV
- frequency .... ____________ Hz
- short-circuit current .... ____________ kA
- short-circuit time .... ____________ s
- rating of first primary .... ____________ A
- rating of second primary .... ____________ A
- rating of third primary .... ____________ A

■ 1st secondary .... metering .... protection

- associated primary rating(s) .... ____________
- first secondary current .... ____________ A
- rated burden .... ____________ VA
- accuracy class .... ____________
- accuracy limiting factor ALF for secondary protection .... ____________
- for class X : formula required : Vk = f(Rct) .... ____________
  - or knee-point voltage Vk .... ____________ V
  - and secondary withstand Rct .... ____________
  - magnetising current Iex (if necessary) .... ____________ mA

■ 2nd secondary .... metering .... protection

- associated primary rating(s) .... ____________
- second secondary current .... ____________ A
- rated burden .... ____________ VA
- accuracy class .... ____________
- accuracy limiting factor ALF .... ____________
- for class X : formula required : Vk = f(Rct) .... ____________
  - or knee-point voltage Vk .... ____________ V
  - and secondary withstand Rct .... ____________
  - magnetising current Iex (if necessary) .... ____________ mA

■ 3rd secondary .... metering .... protection

- associated primary rating(s) .... ____________
- third secondary current .... ____________ A
- rated burden .... ____________ VA
- accuracy class .... ____________
- accuracy limiting factor ALF .... ____________
- for class X : formula required : Vk = f(Rct) .... ____________
  - or knee-point voltage Vk .... ____________ V
  - and secondary withstand Rct .... ____________
  - magnetising current Iex (if necessary) .... ____________ mA

- lead-sealable housing for secondary connections .... ____________
- support base .... ____________
- specific requirements .... ____________

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