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Edition 1.2
2003-02

Edition 1:1996 consolidated with amendments 1:2000 and 2:2002

Instrument transformers –

Part 1:
Current transformers

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CONTENTS

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INSTRUMENT TRANSFORMERS –

Part 1: Current transformers

FOREWORD

1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, the IEC publishes International Standards. Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. The IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.

2) The formal decisions or agreements of the IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested National Committees.

3) The documents produced have the form of recommendations for international use and are published in the form of standards, technical specifications, technical reports or guides and they are accepted by the National Committees in that sense.

4) In order to promote international unification, IEC National Committees undertake to apply IEC International Standards transparently to the maximum extent possible in their national and regional standards. Any divergence between the IEC Standard and the corresponding national or regional standard shall be clearly indicated in the latter.

5) The IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with one of its standards.

6) Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. The IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 60044-1 has been prepared by IEC technical committee 38: Instrument transformers.

This consolidated version of IEC 60044-1 consists of the first edition (1996) [documents [documents 38/161/FDIS and 38/174/RVD, its amendment 1 (2000) [documents 38/245/FDIS and 38/257/RVD] and its amendment 2 (2002) [documents 38/285/FDIS and 38/289/RVD].

The technical content is therefore identical to the base edition and its amendments and has been prepared for user convenience.

It bears the edition number 1.2.

A vertical line in the margin shows where the base publication has been modified by amendments 1 and 2.

Annex A forms an integral part of this standard.

Annex B is for information only.

The committee has decided that the contents of the base publication and its amendments will remain unchanged until 2005-12. At this date, the publication will be

- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

INSTRUMENT TRANSFORMERS –

Part 1: Current transformers

1 General

1.1 Scope

This part of IEC 60044 applies to newly manufactured current transformers for use with electrical measuring instruments and electrical protective devices at frequencies from 15 Hz to 100 Hz.

Although the requirements relate basically to transformers with separate windings, they are also applicable, where appropriate, to autotransformers.

Clause 11 covers the requirements and tests, in addition to those in clauses 3 to 10, that are necessary for current transformers for use with electrical measuring instruments.

Clause 12 covers the requirements and tests, in addition to those in clauses 3 to 10, that are necessary for current transformers for use with electrical protective relays, and in particular for forms of protection in which the prime requirement is the maintenance of accuracy up to several times the rated current.

For certain protective systems, where the current transformer characteristics are dependant on the overall design of the protective equipment (for example high-speed balanced systems and earth-fault protection in resonant earthed networks), additional requirements are given in clause 13 for class PR transformers and in clause 14 for class PX transformers.

Clause 13 covers the requirements and tests in addition to those in clauses 3 to 10 that are necessary for current transformers for use with electrical protective relays, and in particular for forms of protection in which the prime requirement is the absence of remanent flux.

Clause 14 covers the requirements and tests in addition to those in clauses 3 to 10 that are necessary for current transformers for use with electrical protective relays, and in particular for forms of protection for which knowledge of the transformer's secondary excitation characteristic, secondary winding resistance, secondary burden resistance and turns ratio is sufficient to assess its performance in relation to the protective relay system with which it is to be used.

Current transformers intended for both measurement and protection shall comply with all the clauses of this standard.

1.2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60028:1925, *International standard of resistance for copper*

IEC 60038:1983, *IEC standard voltages*

IEC 60044-6:1992, *Instrument transformers – Part 6: Requirements for protective current transformers for transient performance*

IEC 60050(321):1986, *International Electrotechnical Vocabulary – Chapter 321: Instrument transformers*

IEC 60060-1:1989, *High-voltage test techniques – Part 1: General definitions and test requirements*

IEC 60071-1:1993, *Insulation co-ordination – Part 1: Definitions, principles and rules*

IEC 60085:1984, *Thermal evaluation and classification of electrical insulation*

IEC 60121:1960, *Recommendation for commercial annealed aluminium electrical conductor wire*

IEC 60270:1981, *Partial discharge measurements*

IEC 60567:1992, *Guide for the sampling of gases and of oil from oil-filled electrical equipment and for the analysis of free and dissolved gases*

IEC 60599:1978, *Interpretation of the analysis of gases in transformers and other oil-filled electrical equipment in service*

IEC 60721: *Classification of environmental conditions*

IEC 60815:1986, *Guide for the selection of insulators in respect of polluted conditions*

CISPR 18-2:1986, *Radio interference characteristics of overhead power lines and high-voltage equipment – Part 2: Methods of measurement and procedure for determining limits*

2 Definitions

For the purpose of this part of IEC 60044, the following definitions apply:

2.1 General definitions

2.1.1
instrument transformer
a transformer intended to supply measuring instruments, meters, relays and other similar apparatus

[IEV 321-01-01 modified]

2.1.2
current transformer
an instrument transformer in which the secondary current, in normal conditions of use, is substantially proportional to the primary current and differs in phase from it by an angle which is approximately zero for an appropriate direction of the connections

[IEV 321-02-01]

2.1.3
primary winding
the winding through which flows the current to be transformed

2.1.4
secondary winding
the winding which supplies the current circuits of measuring instruments, meters, relays or similar apparatus

2.1.5
secondary circuit
the external circuit supplied by the secondary winding of a transformer

2.1.6
rated primary current
the value of the primary current on which the performance of the transformer is based
[IEV 321-01-11 modified]

2.1.7
rated secondary current
the value of the secondary current on which the performance of the transformer is based
[IEV 321-01-15 modified]

2.1.8
actual transformation ratio
the ratio of the actual primary current to the actual secondary current
[IEV 321-01-17 modified]

2.1.9
rated transformation ratio
the ratio of the rated primary current to the rated secondary current
[IEV 321-01-19 modified]

2.1.10
current error (ratio error)
the error which a transformer introduces into the measurement of a current and which arises from the fact that the actual transformation ratio is not equal to the rated transformation ratio
IEV 321-01-21 modified]

The current error expressed in per cent is given by the formula:

$$\text{Current error } \% = \frac{(K_n I_s - I_p)\, x\, 100}{I_p}$$

where

K_n is the rated transformation ratio;

I_p is the actual primary current;

I_s is the actual secondary current when I_p is flowing, under the conditions of measurement.

2.1.11
phase displacement
the difference in phase between the primary and secondary current vectors, the direction of the vectors being so chosen that the angle is zero for a perfect transformer
[IEV 321-01-23 modified]

The phase displacement is said to be positive when the secondary current vector leads the primary current vector. It is usually expressed in minutes or centiradians.

NOTE This definition is strictly correct for sinusoidal currents only.

2.1.12
accuracy class
a designation assigned to a current transformer the errors of which remain within specified limits under prescribed conditions of use

2.1.13
burden
the impedance of the secondary circuit 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.

2.1.14
rated burden
the value of the burden on which the accuracy requirements of this specification are based

2.1.15
rated output
the value of the apparent power (in voltamperes at a specified power-factor) which the transformer is intended to supply to the secondary circuit at the rated secondary current and with rated burden connected to it

2.1.16
highest voltage for equipment
the highest r.m.s. phase-to-phase voltage for which a transformer is designed in respect of its insulation

2.1.17
highest voltage of a system
highest value of operating voltage which occurs under normal operating conditions at any time and at any point in the system

2.1.18
rated insulation level
the combination of voltage values which characterizes the insulation of a transformer with regard to its capability to withstand dielectric stresses

2.1.19
isolated neutral system
a system where the neutral point is not intentionally connected to earth, except for high impedance connections for protection or measurement purposes

[IEV 601-02-24]

2.1.20
solidly earthed neutral system
a system whose neutral point(s) is(are) earthed directly

[IEV 601-02-25]

2.1.21
impedance earthed (neutral) system
a system whose neutral point(s) is(are) earthed through impedances to limit earth fault currents

[IEV 601-02-26]

2.1.22
resonant earthed (neutral) system
a system in which one or more neutral points are connected to earth through reactances which approximately compensate the capacitive component of a single-phase-to-earth fault current

[IEV 601-02-27]

NOTE With resonant earthing of a system, the residual current in the fault is limited to such an extent that an arcing fault in air is usually self-extinguishing.

2.1.23
earth fault factor
at a given location of a three-phase system, and for a given system configuration, the ratio of the highest r.m.s. phase-to-earth power frequency voltage on a healthy phase during a fault to earth affecting one or more phases at any point on the system to the r.m.s. phase-to-earth power frequency voltage which would be obtained at the given location in the absence of any such fault

[IEV 604-03-06]

2.1.24
earthed neutral system
a system in which the neutral is connected to earth, either solidly, or through a resistance or reactance of low enough value to reduce materially transient oscillations and to give a current sufficient for selective earth fault protection:

a) a system with effectively-earthed neutral at a given location is a system characterized by an earth fault factor at this point which does not exceed 1,4;

NOTE This condition is obtained in general when, for all system configurations, the ratio of zero-sequence reactance to positive-sequence reactance is less than 3 and the ratio of zero-sequence resistance to positive-sequence reactance is less than 1.

b) a system with non-effectively earthed neutral at a given location is a system characterized by an earth fault factor at this point that may exceed 1,4.

2.1.25
exposed installation
an installation in which the apparatus is subject to overvoltages of atmospheric origin

NOTE Such installations are usually connected to overhead transmission lines, either directly, or through a short length of cable.

2.1.26
non-exposed installation
an installation in which the apparatus is not subject to overvoltages of atmospheric origin

NOTE Such installations are usually connected to cable networks.

2.1.27
rated frequency
the value of the frequency on which the requirements of this standard are based

2.1.28
rated short-time thermal current (I_{th})
the r.m.s. value of the primary current which a transformer will withstand for one second without suffering harmful effects, the secondary winding being short-circuited

2.1.29
rated dynamic current (I_{dyn})
the peak value of the primary current which a transformer will withstand, without being damaged electrically or mechanically by the resulting electromagnetic forces, the secondary winding being short-circuited

2.1.30
rated continuous thermal current (I_{cth})
the value of the current which can be permitted to flow continuously in the primary winding, the secondary winding being connected to the rated burden, without the temperature rise exceeding the values specified

2.1.31
exciting current
the r.m.s. value of the current taken by the secondary winding of a current transformer, when a sinusoidal voltage of rated frequency is applied to the secondary terminals, the primary and any other windings being open-circuited

2.1.32
rated resistive burden (R_b)
rated value of the secondary connected resistive burden in ohms

2.1.33
secondary winding resistance (R_{ct})
secondary winding d.c. resistance in ohms corrected to 75 °C or such other temperature as may be specified

2.1.34
composite error*
under steady-state conditions, the r.m.s. value of the difference between:

a) the instantaneous values of the primary current, and

b) the instantaneous values of the actual secondary current multiplied by the rated transformation ratio, the positive signs of the primary and secondary currents corresponding to the convention for terminal markings.

The composite error ε_c is generally expressed as a percentage of the r.m.s. values of the primary current according to the formula:

$$\varepsilon_c = \frac{100}{I_p}\sqrt{\frac{1}{T}\int_0^T (K_n i_s - i_p)^2 \, dt}$$

where

K_n is the rated transformation ratio;

I_p is the r.m.s. value of the primary current;

i_p is the instantaneous value or the primary current;

i_s is the instantaneous value of the secondary current;

T is the duration of one cycle.

2.1.35
multi-ratio current transformer
current transformer on which more ratios are obtained by connecting the primary winding sections in series or parallel or by means of taps on the secondary winding

2.2 Additional definitions for measuring current transformers

2.2.1
measuring current transformer
a current transformer intended to supply indicating instruments, integrating meters and similar apparatus

2.2.2
rated instrument limit primary current (*IPL*)
the value of the minimum primary current at which the composite error of the measuring current transformer is equal to or greater than 10 %, the secondary burden being equal to the rated burden

NOTE The composite error should be greater than 10 %, in order to protect the apparatus supplied by the instrument transformer against the high currents produced in the event of system fault.

* See annexe A.

2.2.3
instrument security factor (FS)
the ratio of rated instrument limit primary current to the rated primary current

NOTE 1 Attention should be paid to the fact that the actual instrument security factor is affected by the burden.

NOTE 2 In the event of system fault currents flowing through the primary winding of a current transformer, the safety of the apparatus supplied by the transformer is greatest when the value of the rated instrument security factor (FS) is small.

2.2.4
secondary limiting e.m.f
the product of the instrument security factor FS, the rated secondary current and the vectorial sum of the rated burden and the impedance of the secondary winding

NOTE 1 The method by which the secondary limiting e.m.f. is calculated will give a higher value than the real one. It was chosen in order to apply the same test method as in 11.6 and 12.5 for protective current transformers.

Other methods may be used by agreement between manufacturer and purchaser.

NOTE 2 For calculating the secondary limiting e.m.f., the secondary winding resistance should be corrected to a temperature of 75 °C.

2.3 Additional definitions for protective current transformers

2.3.1
protective current transformer
a current transformer intended to supply protective relays

2.3.2
rated accuracy limit primary current
the value of primary current up to which the transformer will comply with the requirements for composite error

2.3.3
accuracy limit factor
the ratio of the rated accuracy limit primary current to the rated primary current

2.3.4
secondary limiting e.m.f.
the product of the accuracy limit factor, the rated secondary current and the vectorial sum of the rated burden and the impedance of the secondary winding

2.3.5
class PR protective current transformer
a current transformer with limited remanence factor for which, in some cases, a value of the secondary loop time constant and/or a limiting value of the winding resistance may also be specified

2.3.6
saturation flux (Ψ_s)
that peak value of the flux which would exist in a core in the transition from the non-saturated to the fully saturated condition and deemed to be that point on the B-H characteristic for the core concerned at which a 10 % increase in B causes H to be increased by 50 %

2.3.7
remanent flux (Ψ_r)
that value of flux which would remain in the core 3 min after the interruption of an exciting current of sufficient magnitude to induce the saturation flux (Ψ_s) defined in 2.3.6