INTERNATIONAL STANDARD

IEC 60044-7

First edition
1999-12

Instrument transformers –

Part 7:
Electronic voltage transformers

*This **English-language** version is derived from the original **bilingual** publication by leaving out all French-language pages. Missing page numbers correspond to the French-language pages.*

Reference number
IEC 60044-7:1999(E)

Publication numbering

As from 1 January 1997 all IEC publications are issued with a designation in the 60000 series. For example, IEC 34-1 is now referred to as IEC 60034-1.

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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INSTRUMENT TRANSFORMERS –

Part 7: Electronic voltage transformers

FOREWORD

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International Standard IEC 60044-7 has been prepared by IEC technical committee 38: Instrument transformers

The text of this standard is based on the following documents:

FDIS	Report on voting
38/242/FDIS	38/243/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 3.

The committee has decided that this publication remains valid until 2002. At this date, in accordance with the committee's decision, the publication will be

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- withdrawn;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

INSTRUMENT TRANSFORMERS –

Part 7: Electronic voltage transformers

1 General

1.1 Scope

This part of International Standard IEC 60044 applies to newly manufactured electronic voltage transformers with analogue output, for use with electrical measuring instruments and electrical protective devices at frequencies from 15 Hz to 100 Hz.

NOTE 1 Optical arrangements usually include electronic components and are therefore considered to be within the application of this standard.

NOTE 2 Detailed information is given in annex B.

NOTE 3 Requirements specific to three-phase voltage transformers are not included in this standard but, so far as they are relevant, the requirements in clauses 3 to 11 apply to these transformers and a few references to them are included in those clauses (e.g. see 2.1.5, 5.1.1, 5.2, 11.2.1 and 11.2.2).

1.2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 60044. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of IEC 60044 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60038:1983, *IEC standard voltages*

IEC 60044-2:1997, *Instrument transformers – Part 2: Inductive voltage transformers*

IEC 60050(161):1990, *International Electrotechnical Vocabulary (IEV) – Chapter 161: Electromagnetic compatibility*

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

IEC 60050(601):1985, *International Electrotechnical Vocabulary (IEV) – Chapter 601: Generation, transmission and distribution of electricity – General*

IEC 60050(604):1987, *International Electrotechnical Vocabulary (IEV) – Chapter 604: Generation, transmission and distribution of electricity – Operation*

IEC 60060 (all parts), *High-voltage techniques*

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 60186:1987, *Voltage transformers*

IEC 60255-5:1977, *Electrical relays – Part 5: Insulation tests for electrical relays*

IEC 60255-6:1988, *Electrical relays – Part 6: Measuring relays and protection equipment*

IEC 60255-11:1979, *Electrical relays – Part 11: Interruptions to and alternating component (ripple) in d.c. auxiliary energizing quantity of measuring relays*

IEC 60255-22-1:1988, *Electrical relays – Part 22: Electrical disturbance tests for measuring relays and protection equipment – Section 1: 1 MHz burst disturbance tests*

IEC 60270:1981, *Partial discharges measurements*

IEC 60617-1:1985, *Graphical symbols for diagrams – Part 1: General information, general index. Cross-reference tables*

IEC 60694:1996, *Common specifications for high-voltage switchgear and controlgear standards*

IEC 60721 (all parts), *Classification of environmental conditions*

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

IEC 61000 (all parts), *Electromagnetic compatibility (EMC)*

IEC 61000-4-1:1992, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 1: Overview of immunity test. Basic EMC publication*

IEC 61000-4-2:1995, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 2: Electrostatic discharge immunity test. Basic EMC publication*

IEC 61000-4-3:1995, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 3: Radiated, radio-frequency, electromagnetic immunity test*

IEC 61000-4-4:1995, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 4: Electrical fast transient/burst immunity test. Basic EMC publication*

IEC 61000-4-5:1995, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 5: Surge immunity test*

IEC 61000-4-8:1993, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 8: Power frequency magnetic field immunity test. Basic EMC publication*

IEC 61000-4-9:1993, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 9: Pulse magnetic field immunity test. Basic EMC publication*

IEC 61000-4-10:1993, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 10: Damped oscillatory magnetic field immunity test. Basic EMC publication*

IEC 61000-4-11:1994, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 11: Voltage dips, short interruption and voltage variation immunity test*

IEC 61000-4-12:1995, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 12: Oscillatory waves immunity tests. Basic EMC publication*

CISPR 11 (EN 55011), *Industrial, scientific and medical (ISM) radio-frequency equipment – Electromagnetic disturbance characteristics – Limits and methods of measurement*

EN 50081-2:1993, *Electromagnetic compatibility – Generic immunity standard – Part 2: Industrial environment*

1.3 General block diagram of electronic voltage transformers

The applied technology decides which parts are necessary for realisation of an electronic voltage transformer, i.e. it is not absolutely essential that all parts described be in the transformer (see figures 1 and 2).

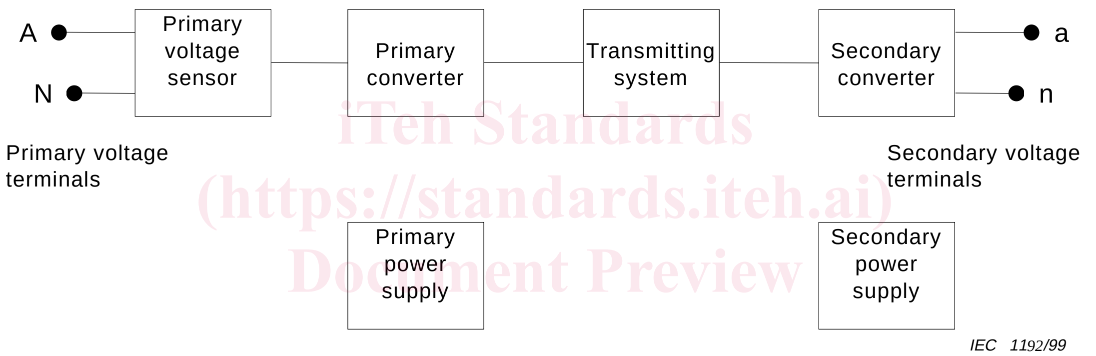

Figure 1 – General block diagram of earthed single-phase electronic voltage transformers

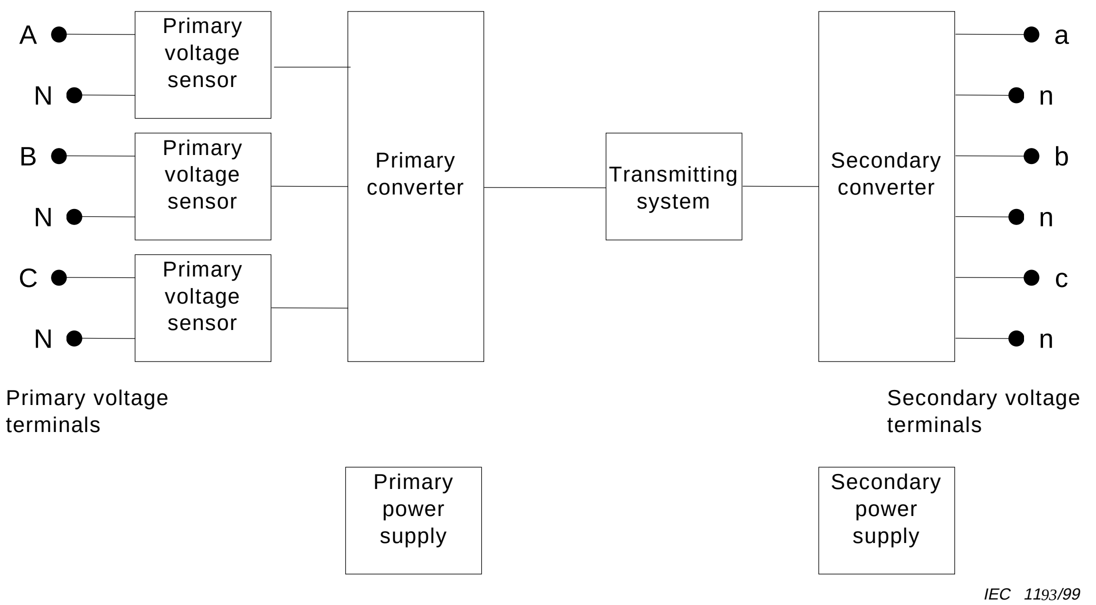

Figure 2 – General block diagram of earthed three-phase electronic voltage transformers

2 Definitions

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

2.1 General definitions

2.1.1
electronic instrument transformer
an arrangement consisting of one or more current or voltage sensors which may be connected to a transmitting system and a secondary converter, all intended to transmit a measuring quantity in a proportional quantity to supply measuring instruments, meters and protective or control devices

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

2.1.3
electronic measuring voltage transformer
an electronic voltage transformer intended to transmit an information signal to measuring instruments and meters

2.1.4
unearthed electronic voltage transformer
an electronic voltage transformer in which all parts of the primary voltage sensor, including terminals, are insulated from earth to a level corresponding to its rated insulation level

2.1.5
earthed electronic voltage transformer
a single-phase electronic voltage transformer intended to have one primary voltage terminal directly earthed, or a three-phase electronic voltage transformer intended to have the primary star-point directly earthed

2.1.6
secondary circuit
the external circuit receiving the information signals supplied by the secondary converter of an electronic voltage transformer [IEV 321-01-08 modified]

2.1.7
rated primary voltage (U_{pn})
the r.m.s. value of the component at frequency f_n of the primary voltage on which the performance of an electronic voltage transformer is based [IEV 321-01-12 modified]

NOTE See clause B.2.

2.1.8
rated secondary voltage (U_{sn})
the r.m.s. value of the component at frequency f_n of the secondary voltage on which the performance of an electronic voltage transformer is based [IEV 321-01-16 modified]

NOTE See clause B.2.

2.1.9
residual voltage
the vector sum of all phase-to-earth voltages in a three-phase system [IEV 321-03-09 modified]

2.1.10
rated voltage factor (k_u)
the 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 relevant accuracy requirements [IEV 321-03-12]

2.1.11
actual transformation ratio
the ratio of the actual primary voltage to the actual secondary voltage [IEV 321-01-18 modified]

2.1.12
rated transformation ratio (K_n)
the ratio of the rated primary voltage to the rated secondary voltage [IEV 321-01-20 modified]

2.1.13
burden
the admittance of the secondary circuit [IEV 321-01-25 modified]

NOTE The burden is usually expressed as the apparent power in volt-amperes, absorbed at a specified power factor and at the rated secondary voltage.

2.1.14
rated burden
the value of the burden on which the accuracy requirements of a specification are based [IEV 321-01-26]

2.1.15
rated output (S_n)
the value of the apparent power (in volt-amperes at a specified power factor) which the electronic voltage transformer is intended to supply to the secondary circuit at the rated secondary voltage and with rated burden connected to it [IEV 321-01-27 modified]

2.1.16
accuracy class
a designation assigned to an electronic voltage transformer, the voltage error and phase displacement of which remain within specified limits under prescribed conditions of use [IEV 321-01-24 modified]

2.1.17
rated frequency (f_n)
the value of frequency on which the requirements of this standard are based

2.1.18
rated auxiliary power supply voltage (U_{an})
the auxiliary power supply voltage value on which the requirements of this standard are based

2.1.19
highest voltage for equipment (U_m)
the highest r.m.s. value of phase-to-phase voltage for which the equipment is designed in respect of its insulation as well as other characteristics relating to this voltage in the relevant equipment standards [IEV 604-03-01]

NOTE It is the maximum value of the highest voltage of the system for which the equipment may be used.

2.1.20
rated insulation level
the combination of voltage values which characterizes the isolation of a transformer with regard to its capability to withstand dielectric stresses

2.1.21
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. value of 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]

2.1.22
isolated neutral system
system where the neutral point is not intentionally connected to earth, with the exception of high impedance connections for protection or measurement purposes [IEV 601-02-24]

2.1.23
resonant earthed (neutral) system
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]

2.1.24
solidly earthed (neutral) system
system whose neutral point or points are directly earthed [IEV 601-02-25]

2.1.25
impedance earthed (neutral) system
system whose neutral point or points are earthed through impedances to limit earth fault currents [IEV 601-02-26]

2.1.26
earthed neutral system
system in which the neutral is connected to earth either solidly or through a resistance or reactance of low enough value to reduce transient oscillations and to give a current sufficient for selective earth-fault protection

a) A three-phase system with effectively earthed neutral at a given location is a system characterised by an earth-fault factor at this point which does not exceed 1,4.

   NOTE This condition is obtained approximately when, for all system configurations, the ratio of zero-sequence reactance to the positive-sequence reactance is less than three and the ratio of zero-sequence resistance to positive-sequence reactance is less than one.

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

2.1.27
exposed installation
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, and not protected by surge arresters.

2.1.28
non-exposed installation
installation in which the apparatus is not subject to overvoltages of atmospheric origin

2.1.29
voltage in steady state condition
the primary voltage and the secondary voltage in an electrical steady state condition, as defined respectively by the following equations:

$$u_p(t) = U_p \cdot \sqrt{2} \cdot \sin(2\pi \cdot f \cdot t + \varphi_p) + U_{p\,dc} + u_{p\,res}(t);$$

$$u_s(t) = U_s \cdot \sqrt{2} \cdot \sin(2\pi \cdot f \cdot t + \varphi_s) + U_{s\,dc} + u_{s\,res}(t);$$

where

U_p is the r.m.s. value of primary voltage when $U_{p\,dc} = 0$ and $u_{p\,res}(t) = 0$;

U_s is the r.m.s. value of secondary converter when $U_{s\,dc} = 0$ and $u_{s\,res}(t) = 0$;

f is the fundamental frequency of the network;

$U_{p\,dc}$ is the primary direct voltage;

$U_{s\,dc}$ is the secondary direct voltage;

φ_p is the primary phase displacement;

φ_s is the secondary phase displacement;

$u_{p\,res}(t)$ is the primary residual voltage including harmonic and subharmonic components;

$u_{s\,res}(t)$ is the secondary residual voltage including harmonic and subharmonic components;

t is the instantaneous value of time.

f, U_p, U_s, $U_{p\,dc}$, $U_{s\,dc}$, φ_p, φ_s being constant for steady-state condition.

NOTE 1 Steady-state condition is a particular case of the general situation described in 2.2.4 and in annex B.

NOTE 2 Electronic voltage transformers can exhibit specific characteristics as voltage offset, delay time, etc. Hence, while not present within IEC 60044-2, the above equations are required for an accurate presentation of the requirements related to electronic voltage transformers. The definitions of errors, while compatible with those of IEC 60044-2, are also improved.

2.1.30
secondary direct voltage offset ($U_{s\,dc0}$)
direct voltage component of the secondary voltage of an electronic voltage transformer when $U_p(t) = 0$

2.1.31
voltage error for steady-state conditions(ε_u)
the error which a transformer introduces into the measurement of a voltage and which arises when the actual transformation ratio is not equal to the rated transformation ratio
[IEV 321-01-22 modified]

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

$$\text{Voltage error \%} = \frac{K_n U_s - U_p}{U_p} \times 100$$

where

K_n is the rated transformation ratio;

U_p is the actual primary voltage;

U_s is the actual secondary voltage when U_p is applied under the conditions of measurement.

NOTE This definition is only related to components at rated frequency of both primary and secondary voltages, and does not take into account direct voltage components. This definition is compatible with IEC 60044-2.

2.1.32
phase displacement for steady-state conditions (φ_u)

$$\varphi_u = \varphi_s - \varphi_p$$

the difference in phase between the primary voltage and the secondary voltage phasors, the direction of the phasors being so chosen that the angle is zero for a perfect transformer. The phase displacement is said to be positive when the secondary voltage leads the primary voltage phasor. It is usually expressed in minutes or centiradians. φ_u can be considered to be made up of two components: the rated phase offset φ_{0n} and the rated delay time t_{dn} [IEV 321-01-23 modified]

2.1.33
rated phase offset (φ_{0n})
constant phase displacement value of the electronic voltage transformer

2.1.34
rated delay time (t_{dn})
time t_d needed for digital data transmission and processing, included by some electronic voltage transformers

2.1.35
phase error (φ_e)
the actual phase displacement without the displacement caused by the rated phase offset and the rated delay time. The phase error is expressed in angular units relative to the rated frequency

$$\varphi_e = \varphi - \varphi_{0r} + 2\,\pi \cdot f \cdot t_{dr}$$
$$= \varphi_s - \varphi_p - \varphi_{0r} + 2\,\pi \cdot f \cdot t_{dr}$$

The phase error is usually expressed in minutes or centiradians [IEV 321-01-23 modified].

2.1.36
secondary limiting current
maximum secondary current at rated primary voltage which the transformer can supply continuously

2.1.37
short circuit withstand capability
capability of an electronic voltage transformer to withstand a short circuit between the secondary terminals without damage

2.1.38
connecting point
point specified by the manufacturer and provided to the user for connecting electrical cables at site installation or for testing purposes. Where a coaxial cable is used, only the external shield is considered to be a connecting point