

Instrument transformers —

Part 7: Electronic voltage transformers

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British Standard

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National foreword

This British Standard is the official English language version of EN 60044-7:2000. It is identical with IEC 60044-7:1999.

The UK participation in its preparation was entrusted to Technical Committee PEL/38, Instrument transformers, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this committee can be obtained on request to its secretary.

The UK National Committee voted against publication of this standard and submitted a list of objections. In general, the standard does not include the detail and content of the equivalent standard, for current transformers which is in preparation in IEC. Items to which objections were raised included the following:

- The term “Transformers” in the title was felt to be inappropriate and the term “Transducers” was recommended in its place.
- The properties of the inherent wide bandwidth of some non-conventional sensors are ignored.
- Insufficient attention is given to the effects of vibration on sensors, for example those which are installed as intergral parts of switchgear.
- Digital outputs are not standardized.
- Temperature rise test acceptance and modality are not detailed.

From 1 January 1997, all IEC publications have the number 60000 added to the old number. For instance, IEC 27-1 has been renumbered as IEC 60027-1. For a period of time during the change over from one numbering system to the other, publications may contain identifiers from both systems.

Cross-references

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Summary of pages

This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 72, an inside back cover and a back cover.

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Foreword

The text of document 38/242/FDIS, future edition 1 of IEC 60044-7, prepared by IEC TC 38, Instrument transformers, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 60044-7 on 1999-12-01.

The following dates were fixed:

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- latest date by which the national standards conflicting
with the EN have to be withdrawn (dow) 2002-12-01

Annexes designated "normative" are part of the body of the standard.

Annexes designated "informative" are given for information only.

In this standard, annexes A and ZA are normative and annexes B and C are informative.

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 60044-7:1999 was approved by CENELEC as a European Standard without any modification.

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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).

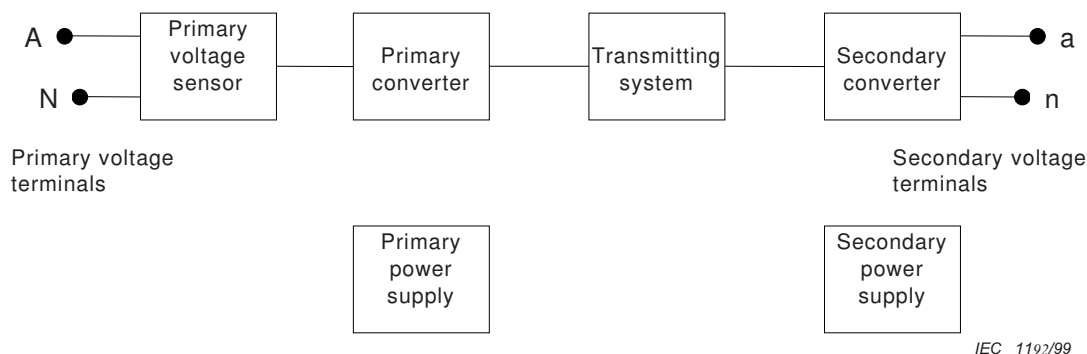


Figure 1 – General block diagram of earthed single-phase electronic voltage transformers

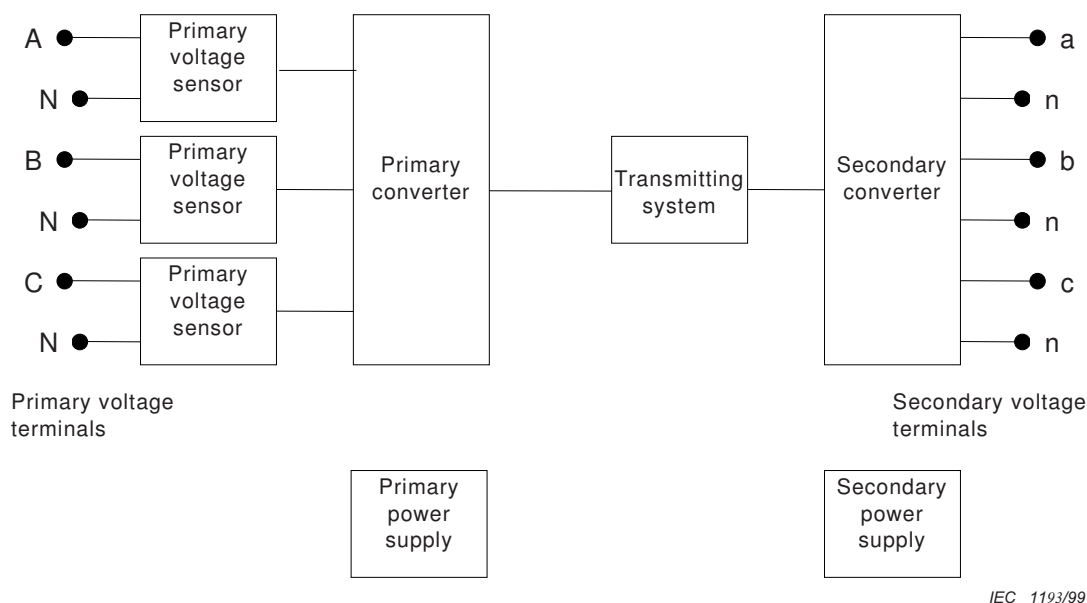


Figure 2 – General block diagram of earthed three-phase electronic voltage transformers

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:

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

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

where

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

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

f is the fundamental frequency of the network;

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

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

φ_p is the primary phase displacement;

φ_s is the secondary phase displacement;

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

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

t is the instantaneous value of time.

$f, U_p, U_s, U_{p\text{ dc}}, U_{s\text{ dc}}, \varphi_p, \varphi_s$ 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 ($U_{s\text{ dc}0}$)

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

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

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

2.1.39

primary voltage terminals

terminals by means of which the primary voltage is supplied to the electronic voltage transformer

2.1.40

primary voltage sensor

electric, electronic, optical or other device intended to transmit to the secondary equipment, either directly or by means of a primary converter, a signal corresponding to the voltage between the primary voltage terminals

2.1.41

primary converter

arrangement that converts the signal, coming from one or more primary voltage sensors into a signal suitable for the transmitting systems

2.1.42

primary power supply

power supply to the primary converter and/or primary voltage sensor (can be combined with the secondary power supply)

2.1.43

transmitting system

short- or long-distance coupling arrangement between primary and secondary parts intended to transmit the signal. Depending on the technology used, the transmitting system can also be used for power transmission

2.1.44

secondary converter

arrangement that converts the signal transmitted through the transmitting system into a quantity proportional to the voltage between the primary terminals, in order to supply measuring instruments, meters and protective or control devices

2.1.45

secondary power supply

power supply to the secondary converter (can be combined with the primary power supply)

2.1.46

secondary voltage terminals

terminals by means of which the voltage circuits of measuring instruments, meters and protective or control devices are supplied

2.1.47

low-voltage components

all components other than the primary voltage sensor

2.1.48

rated supply current (I_{an})

value of the current required by the auxiliary power supply in the rated conditions

2.1.49

maximum supply current ($I_{a\ max}$)

maximum value of the current required by the auxiliary power supply in the worst conditions

2.2 Additional definitions for single-phase electronic protective voltage transformers

2.2.1

electronic protective voltage transformer

electronic voltage transformer intended to transmit an information signal to protective and control devices

2.2.2

electronic residual voltage transformer

three-phase electronic voltage transformer or group of three single-phase electronic voltage transformers intended to transmit an information signal representative of the residual voltage existing in the three-phase voltages applied to the primary terminals

2.2.3

transient response

response of the secondary voltage to a transient change of the primary voltage

2.2.3.1

short circuit on the primary

decay of the secondary voltage of an electronic voltage transformer in the event of a short-circuit between a high-voltage terminal and earth

2.2.3.2

reclosing on a line with trapped charges

transient response of an electronic voltage transformer subjected to a d.c. charge retained by an overhead line, due to the opening and subsequent reclosing of the adjacent circuit-breaker

2.2.4

voltage in transient conditions

in the transient condition, primary and secondary voltages are defined as follows:

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

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

NOTE Transient conditions are induced by a sudden change of one or more parameters of the primary voltage equation given in 2.1.29 (see clause B.4).

2.2.5

instantaneous voltage error for transient conditions

$$\text{Voltage error } \varepsilon_u(t) \% = \frac{K_n \cdot u_s(t) - u_p(t - t_{dn})}{u_p \sqrt{2}} \times 100$$

where $u_p(t)$ and $u_s(t)$ are described for a limited range of time by the equations given in 2.2.4.

The chosen origin of the time is the instant of the sudden change of the parameters described in 2.2.4.

NOTE See clause B.4.

2.3 Index of symbols

f	frequency	2.1.29
f_n	rated frequency	2.1.17
I_{an}	rated supply current	2.1.48

$I_{a \max}$	maximum supply current	2.1.49
k_u	rated voltage factor	2.1.10
K_n	rated transformation ratio of an electronic voltage transformer	2.1.12
S_n	rated output	2.1.15
t	instantaneous value of time	2.1.29
t_{dn}	rated delay time	2.1.34
U_{an}	rated auxiliary power supply voltage	2.1.18
U_m	highest voltage for equipment	2.1.19
U_p	r.m.s. value of primary voltage in steady-state condition, when $U_{p \text{ dc}} = 0$ and $u_{p \text{ res}}(t) = 0$	2.1.29
$U_{p \text{ dc}}$	primary direct voltage	2.1.29
U_{pn}	rated primary voltage	2.1.7
$u_p(t)$	primary voltage	2.1.29 and 2.2.4
$u_{p \text{ res}}(t)$	primary residual voltage including harmonic and subharmonic components	2.1.29
U_s	r.m.s. value of secondary converter output voltage when $U_{s \text{ dc}} = 0$ and $u_{s \text{ res}}(t) = 0$	2.1.29
$U_{s \text{ dc}}$	secondary direct voltage	2.1.29
$U_{s \text{ dc}0}$	secondary direct voltage offset	2.1.30
U_{sn}	rated secondary voltage	2.1.8
$u_s(t)$	secondary voltage	2.1.29 and 2.2.4
$u_{s \text{ res}}(t)$	secondary residual voltage including harmonic and subharmonic components	2.1.29
φ_p	primary phase displacement	2.1.29
φ_s	secondary phase displacement	2.1.29
φ	phase displacement for steady-state conditions	2.1.32
φ_{0n}	rated phase displacement offset	2.1.33
φ_e	phase error	2.1.35
ε_u	voltage error for steady-state conditions	2.1.31
$\varepsilon_u(t)$	instantaneous voltage error for transient conditions	2.2.5

3 General requirements

3.1 General

All electronic voltage transformers shall be suitable for measuring purposes, but, in addition, certain types may be suitable for protection purposes. Electronic voltage transformers for the dual purpose of measurement and protection shall comply with all clauses of this standard.

3.2 Information to be given for enquiries, tenders and orders

When specifying an electronic voltage transformer for an enquiry or an order, the listed items in table 1 are necessary to determine its performances.

Table 1 – Designation of an electronic voltage transformer

Rating	Abbreviation	Definition	Clause or subclause
Rated mechanical strength	F_R		6.11
Highest voltage for equipment	U_m	2.1.19	6.1
Rated insulation level		2.1.20	6.1
Service conditions			4
Rated frequency	f_n	2.1.17	5.5.1
Rated primary voltage	U_{pn}	2.1.7	5.1.1
Rated secondary voltage	U_{sn}	2.1.8	5.1.2
Rated voltage factor	k_u	2.1.10	5.3
Corresponding permissible duration			5.3
Secondary limiting current		2.1.36	
Rated output	S_n	2.1.15	5.2
Accuracy class		2.1.16	12
Rated auxiliary power supply voltage	U_{an}	2.1.18	5.5.2
Rated phase offset and rated delay time	φ_{0n}, t_{dn}	2.1.33, 2.1.34	12

4 Normal and special service conditions

Detailed information concerning the classification of environmental conditions is given in the IEC 60721 series.

4.1 Normal service conditions

4.1.1 Ambient air temperature

Voltage transformers are classified in three categories as given in table 2.

Table 2 – Temperature categories

Category	Minimum temperature °C	Maximum temperature °C
–5/40	– 5	40
–25/40	– 25	40
–40/40	– 40	40
NOTE When choosing the temperature category, storage and transportation conditions should also be considered.		

4.1.2 Altitude

The altitude does not exceed 1 000 m.

4.1.3 Vibrations or earth tremors

Vibrations due to causes external to the electronic voltage transformer or earth tremors are negligible. However, it should be realised that some designs of electronic voltage transformers may be sensitive to vibrations. Appropriate vibration tests may be specified by agreement between manufacturer and purchaser.

4.1.4 Other service conditions for indoor electronic voltage transformers

Other considered service conditions are as follows:

- a) the influence of solar radiation may be neglected;
- b) the ambient air is not significantly polluted by dust, smoke, corrosive gases, vapours or salt;
- c) the conditions of humidity are as follows:
 - 1) the average value of the relative humidity, measured during a period of 24 h does not exceed 95 %;
 - 2) the average value of the water vapour pressure for a period of 24 h does not exceed 2,2 kPa;
 - 3) the average value of the relative humidity for a period of one month does not exceed 90 %;
 - 4) the average value of the water vapour pressure for a period of one month does not exceed 1,8 kPa.

For these conditions, condensation may occasionally occur.

NOTE 1 Condensation can be expected where sudden temperature changes occur in periods of high humidity.

NOTE 2 In order to withstand the effects of high humidity and condensation, such as the breakdown of insulation or the corrosion of metallic parts, electronic voltage transformers designed for such conditions should be used.

NOTE 3 Condensation may be prevented by special design of the housing, by suitable ventilation and heating or by the use of dehumidifying equipment.

4.1.5 Other service conditions for outdoor electronic voltage transformers

Other considered service conditions are as follows:

- a) the average value of the ambient air temperature, measured over a period of 24 h, does not exceed 35 °C;
- b) solar radiation up to a level of 1 000 W/m² (on a clear day at noon) should be considered;
- c) the ambient air may be polluted by dust, smoke, corrosive gases, vapours or salt. The pollution does not exceed the pollution levels given in table 8;
- d) the wind pressure does not exceed 700 Pa (corresponding to a 34 m/s wind speed);
- e) the presence of condensation or precipitation should be taken into account.

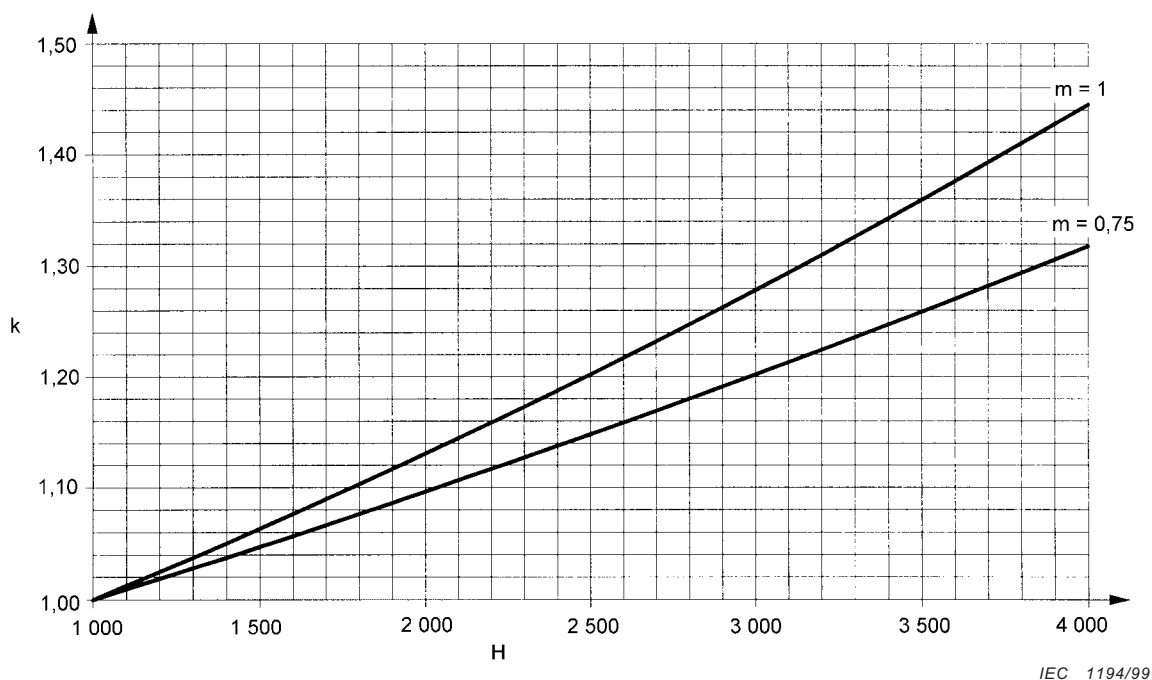
4.2 Special service conditions

When electronic voltage transformers may be used under conditions different from the normal service conditions given in 4.1, the user's requirements should refer to standardised steps given hereafter.

4.2.1 Altitude

For installations at an altitude higher than 1 000 m, the arcing distance under the standardised reference atmospheric conditions shall be determined by multiplying the withstand voltages required at the service location by a factor k in accordance with figure 3.

NOTE As for the internal insulation, the dielectric strength is not affected by altitude. The method used for checking the external insulation should be agreed between manufacturer and purchaser.



These factors can be calculated using the following equation:

$$k = e^{m(H - 1\,000)/8\,150}$$

where

H is the altitude in meters;

$m = 1$ for power-frequency and lightning impulse voltage;

$m = 0,75$ for the switching impulse voltage.

Figure 3 – Altitude correction factor

4.2.2 Ambient temperature

For installations located in a place where the ambient temperature can be significantly outside the normal service condition range stated in 4.1.1, the preferred ranges of minimum and maximum temperature to be specified should be

- a) $-50\text{ }^{\circ}\text{C}$ and $40\text{ }^{\circ}\text{C}$ for very cold climates;
- b) $-5\text{ }^{\circ}\text{C}$ and $50\text{ }^{\circ}\text{C}$ for very hot climates.

In certain regions with a frequent occurrence of warm humid winds, sudden changes of temperature may occur, resulting in condensation, even indoors.

NOTE Under certain conditions of solar radiation, appropriate measures, e.g. roofing, forced ventilation, etc., may be necessary, in order not to exceed the specified temperature rises.

4.2.3 Earthquakes

Requirements and testing are under consideration.

4.3 Earthing system

4.3.1 General

The considered earthing systems are as follows:

- a) isolated neutral system (see 2.1.22);
- b) resonant earthed system (see 2.1.23);
- c) earthed neutral system (see 2.1.26):
 - 1) solidly earthed neutral system;
 - 2) impedance earthed neutral system.

5 Ratings

5.1 Standard values of rated voltages

5.1.1 Rated primary voltage

The standard rated primary voltage values of three-phase and single-phase transformers for use in a single-phase system, or between lines in a three-phase system, shall be one of the nominal system voltage values designated as usual by IEC 60038. The standard rated primary voltage values of a single-phase transformer connected between one line of a three-phase system and earth, or between a system neutral point and earth, shall be $1/\sqrt{3}$ times one of the nominal system voltage values.

NOTE The performance of an electronic voltage transformer as a measuring or protection transformer is based on the rated primary voltage, whereas the rated insulation level is based on one of the highest voltages for equipment of IEC 60038.

5.1.2 Rated secondary voltage

The standard values of rated secondary voltage given in IEC 60044-2 are applicable to electronic voltage transformers also.

In addition the following values, in volts, are considered standard values for single-phase transformers in single-phase systems or connected line-to-line in three-phase systems, and for three-phase transformers:

1,625 – 2 – 3,25 – 4 – 6,5

For single-phase transformers intended to be used line-to-ground in three-phase systems where the rated primary voltage is a number divided by $\sqrt{3}$, the following values, in volts, are considered standard values.

$$1,625/\sqrt{3} - 2/\sqrt{3} - 3,25/\sqrt{3} - 4/\sqrt{3} - 6,5/\sqrt{3}$$

Rated secondary voltages for terminals intended to be connected in broken-delta with similar terminals to produce a residual voltage are as given below, in volts.

For three-phase networks

$$1,625/3 - 2/3 - 3,25/3 - 4/3 - 6,5/3$$

For two-phase networks

$$1,625/2 - 2/2 - 3,25/2 - 4/2 - 6,5/2$$

NOTE Explanations regarding low-voltage values are given in clause B.2.

5.2 Standard values of rated output

The standard values of rated output, with reference to annex A, are given in voltamperes below.

$$0,001 - 0,01 - 0,1 - 0,5 - 1 - 2,5 - 5 - 10 - 15 - 25 - 30$$

The recommended rated output values are given in voltamperes below.

For an electronic voltage transformer with a secondary voltage ≤ 10 V

$$0,001 - 0,01 - 0,1 - 0,5$$

For an electronic voltage transformer with a secondary voltage > 10 V

$$1 - 2,5 - 5 - 10 - 15 - 25 - 30$$

In special cases other values may be used. The rated output of a three-phase transformer shall be the rated output per phase.

NOTE 1 Attention is drawn to the fact that

- increasing the rated output induces:
 - decreased reliability;
 - increased power consumption;
 - price increase;
- decreasing the rated output increases sensitivity to electromagnetic disturbances.

NOTE 2 For a given electronic voltage transformer, provided one of the values of rated output is standard and associated with a standard accuracy class, the declaration of the other rated outputs, which may be non-standard values, but associated with other standard output accuracy classes, is not precluded.

5.3 Standard values of rated voltage factor

5.3.1 Earthed electronic voltage transformers

The rated voltage factor for an earthed electronic voltage transformer depends on the earth-fault factor of the three-phase system.

The standard voltage factors corresponding to the different earthing conditions are given in table 3 below, together with the permissible duration.

Table 3 – Standard values of rated voltage factor (k_u)

Rated voltage factor	Rated time	Method of connecting the primary terminals and system earthing conditions
1,2	Continuous	Between phases in any network Between transformer star point and earth in any network
1,2 1,5	Continuous 30 s	Between phase and earth in an effectively earthed neutral system (2.1.26 a)
1,2 1,9	Continuous 30 s	Between phase and earth in a non-effectively earthed neutral system (2.1.26 b) with automatic earth-fault tripping
1,2 1,9	Continuous 8 h	Between phase and earth in an isolated neutral system (2.1.22) without automatic earth-fault tripping or in a resonant earthed system (2.1.23) without automatic earth-fault tripping
NOTE Reduced rated times are permissible by agreement between manufacturer and user.		

5.3.2 Unearthed electronic voltage transformers

The rated voltage factor for unearthed electronic voltage transformers is 1,2 with continuous operation.

5.4 Standard values of rated auxiliary power supply voltage

Standard values given in subclause 3.2 of IEC 60255-6 are applicable.

NOTE It is not a common practice to refer to an other product standard. A reference to common clauses applicable to all electronic equipments within substations will be made when the relevant standard will be available.

5.5 Standard reference values of other influencing parameters

5.5.1 Standard reference range of frequency

The standard reference range of frequencies shall be from 99 % to 101 % of the rated frequency for the accuracy classes for measurement, and from 96 % to 102 % for the accuracy classes for protection.

NOTE This applies to all types of electronic voltage transformers. Extended frequency ranges are under consideration, in order to cope with new applications like supply quality metering, for which the measurement of sub-harmonics and harmonics is required.

5.5.2 Standard reference range of auxiliary power supply voltage

The standard reference range of auxiliary power supply shall be from 80 % to 110 % of the rated auxiliary power supply voltage.

5.5.3 Standard reference range of burden

The standard reference range of burden shall be from 25 % up to 100 % of the rated burden at a power factor of 0,8 lagging for rated outputs greater than or equal to 5 VA. For a rated burden below 5 VA, the electronic voltage transformers shall have an error that is within the class limit for any phase angle of the rated burden.

NOTE The above power factor values do not take into account the effect of the capacitance of connecting cables. For low-rated output values, this effect can also be neglected because the length of connecting cables is generally very short.