

BS EN 61481-1:2014

Incorporating corrigendum July 2015



BSI Standards Publication

Live working — Phase comparators

Part 1: Capacitive type to be used for voltages exceeding 1 kV a.c.

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National foreword

This British Standard is the UK implementation of EN 61481-1:2014. It is identical to IEC 61481-1:2014, incorporating corrigendum July 2015. Together with BS EN 61481-2:2014 it supersedes BS EN 61481:2001, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee PEL/78, Tools for live working.

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

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English Version

Live working - Phase comparators -
Part 1: Capacitive type to be used for voltages
exceeding 1 kV a.c.
(IEC 61481-1:2014)

Travaux sous tension - Comparateurs de phase -
Partie 1: Type capacitif pour usage sur des tensions
alternatives de plus de 1 kV
(CEI 61481-1:2014)

Arbeiten unter Spannung - Phasenvergleich -
Teil 1: Kapazitive Ausführung für Wechselspannungen
über 1 kV
(IEC 61481-1:2014)

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European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

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Foreword

The text of document 78/1051/FDIS, future edition 1 of IEC 61481-1, prepared by IEC/TC 78 "Live working" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 61481-1:2014.

The following dates are fixed:

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standard or by endorsement
- latest date by which the national (dow) 2017-11-28
standards conflicting with the
document have to be withdrawn

This document supersedes EN 61481:2001 (partially).

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Endorsement notice

The text of the International Standard IEC 61481-1:2014 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 60071-1:2006	NOTE	Harmonized as EN 60071-1:2006 (not modified).
IEC 60743:2013	NOTE	Harmonized as EN 60743:2013 (not modified).
IEC 61235:1993	NOTE	Harmonized as EN 61235:1995 (modified).
IEC 61936-1:2010	NOTE	Harmonized as EN 61936-1:2010 (modified).
ISO/IEC 17025	NOTE	Harmonized as EN ISO/IEC 17025 (not modified).

Annex ZA (normative)

Normative references to international publications with their corresponding European publications

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

NOTE 1 When an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
CISPR 11	-	Industrial, scientific and medical equipment - Radio-frequency disturbance characteristics - Limits and methods of measurement	EN 55011	-
IEC 60060-1	2010	High-voltage test techniques - Part 1: General definitions and test requirements	EN 60060-1	2010
IEC 60068-1	-	Environmental testing - Part 1: General and guidance	EN 60068-1	-
IEC 60068-2-6	-	Environmental testing - Part 2-6: Tests - Test Fc: Vibration (sinusoidal)	EN 60068-2-6	-
IEC 60068-2-14	-	Environmental testing - Part 2-14: Tests - Test N: Change of temperature	EN 60068-2-14	-
IEC 60068-2-31	-	Environmental testing - Part 2-31: Tests - Test Ec: Rough handling shocks, primarily for equipment-type specimens	EN 60068-2-31	-
IEC 60068-2-75	-	Environmental testing - Part 2-75: Tests - Test Eh: Hammer tests	EN 60068-2-75	-
IEC 60304	-	Standard colours for insulation for low-frequency cables and wires	HD 402 S2	-
IEC 60417-DB	-	Graphical symbols for use on equipment	-	-
IEC 60942	-	Electroacoustics - Sound calibrators	EN 60942	-
IEC 61000-4-2	-	Electromagnetic compatibility (EMC) - Part 4-2: Testing and measurement techniques - Electrostatic discharge immunity test	EN 61000-4-2	-
IEC 61000-4-3	-	Electromagnetic compatibility (EMC) - Part 4-3: Testing and measurement techniques - Radiated, radio-frequency, electromagnetic field immunity test	EN 61000-4-3	-
IEC 61260	-	Electroacoustics - Octave-band and fractional-octave-band filters	EN 61260	-

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 61318	-	Live working - Conformity assessment applicable to tools, devices and equipment	EN 61318	-
IEC 61326-1	-	Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 1: General requirements	EN 61326-1	-
IEC 61477	-	Live working - Minimum requirements for the utilization of tools, devices and equipment	EN 61477	-
IEC 61672-1	-	Electroacoustics - Sound level meters - Part 1: Specifications	EN 61672-1	-
ISO 354	-	Acoustics - Measurement of sound absorption in a reverberation room	EN ISO 354	-
ISO 3744	2010	Acoustics - Determination of sound power levels and sound energy levels of noise sources using sound pressure - Engineering methods for an essentially free field over a reflecting plane	EN ISO 3744	2010
ISO 3745	-	Acoustics - Determination of sound power levels and sound energy levels of noise sources using sound pressure - Precision methods for anechoic rooms and hemi-anechoic rooms	EN ISO 3745	-
CIE 15	-	Colorimetry	-	-

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INTRODUCTION

This International Standard has been prepared in accordance with the requirements of IEC 61477.

Taking into consideration the two different functioning principles of portable *phase comparators* of capacitive type available on the market, the maximum a.c. *nominal voltage* to be associated with each of them has been considered for delimiting the scope of this standard.

The following table presents the rationale for the resulting maximum *nominal voltage* to be associated with each functioning principle of *phase comparator of capacitive type*.

Functioning principle	Maximum nominal voltage kV rms	Rationale
Single-pole <i>phase comparators</i> operating with a memory system	36	– With this principle of functioning, the <i>clear indication</i> of the <i>phase comparator</i> is limited by the <i>memory holding time</i>. With higher <i>nominal voltages</i> , the distance between phases of the installation increases and the time necessary to move the pole of the <i>phase comparator</i> between the two parts to be compared becomes the limitation.
Two-pole <i>phase comparators</i> operating with a wireless connection	245	– With this principle of functioning, there is no theoretical limit for the maximum <i>nominal voltage</i>. – The definition of 245 kV corresponds to the present limit of validation of the electric test set-up.

The product covered by this standard may have an impact on the environment during some or all stages of its life cycle. These impacts can range from slight to significant, be short-term or long-term, and occur at the global, regional or local level.

In terms of environmental improvement, this standard includes neither requirements nor test provisions for the manufacturers of the product nor recommendations to the users of the product. However, all parties intervening in its design, manufacture, packaging, distribution, use, maintenance, repair, reuse, recovery and disposal are invited to take account of environmental considerations.

LIVE WORKING – PHASE COMPARATORS –

Part 1: Capacitive type to be used for voltages exceeding 1 kV a.c.

1 Scope

This part of IEC 61481 is applicable to portable *phase comparators* of capacitive type to be used on electrical systems for voltages exceeding 1 kV a.c. and frequencies of 50 Hz and/or 60 Hz.

This standard is applicable to:

- single-pole *phase comparators* of capacitive type operating with a memory system up to 36 kV a.c.,
- two-pole *phase comparators* of capacitive type operating with a wireless connection up to 245 kV a.c.

This standard is applicable to *phase comparators* of capacitive type used in contact with the bare conductive parts to be compared:

- as a complete device including its *insulating element* or
- as a separate device, adaptable to an *insulating stick* which, as a separate tool, is not covered by this standard.

NOTE Some parts such as the *contact electrode* or the *insulating element* of a *phase comparator* as a complete device may be dismantled.

Some restrictions on their use are applicable in the case of factory-assembled switchgear and on overhead systems of electrified railways (see Annex A).

A device that is designed to provide other functions than phase comparison is a different device and is not covered by this standard. For example a device designed to be also used as a voltage detector is not covered by this standard (see Annex A).

Products designed and manufactured according to this standard contribute to the safety of users provided they are used by persons trained for the work, in accordance with the hot stick working method and the instructions for use.

Except when otherwise specified, all the voltages defined in this standard refer to phase-to-phase voltages of three-phase systems. In other systems, the applicable phase-to-phase or phase-to-earth (ground) voltages should be used to determine the operating voltage.

2 Normative references

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

CISPR 11, *Industrial, scientific and medical equipment – Radio-frequency disturbance characteristics – Limits and methods of measurement*

IEC 60060-1:2010, *High-voltage test techniques – Part 1: General definitions and test requirements*

IEC 60068-1, *Environmental testing – Part 1: General and guidance*

IEC 60068-2-6, *Environmental testing – Part 2-6: Tests – Test Fc: Vibration (sinusoidal)*

IEC 60068-2-14, *Environmental testing – Part 2-14: Tests – Test N: Change of temperature*

IEC 60068-2-31, *Environmental testing – Part 2-31: Tests – Test Ec: Rough handling shocks, primarily for equipment-type specimens*

IEC 60068-2-75, *Environmental testing – Part 2-75: Tests – Test Eh: Hammer tests*

IEC 60304, *Standard colours for insulation for low-frequency cables and wires*

IEC 60417, *Graphical symbols for use on equipment* (Available from: <http://www.graphical-symbols.info/equipment>)

IEC 60942, *Electroacoustics – Sound calibrators*

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

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

IEC 61260, *Electroacoustics – Octave-band and fractional-octave-band filters*

IEC 61318, *Live working – Conformity assessment applicable to tools, devices and equipment*

IEC 61326-1, *Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 1: General requirements*

IEC 61477, *Live working – Minimum requirements for the utilization of tools, devices and equipment*

IEC 61672-1, *Electroacoustics – Sound level meters – Part 1: Specifications*

ISO 354, *Acoustics – Measurement of sound absorption in a reverberation room*

ISO 3744:2010, *Acoustics – Determination of sound power levels and sound energy levels of noise sources using sound pressure – Engineering method for an essentially free-field over a reflecting plane*

ISO 3745, *Acoustics – Determination of sound power levels and sound energy levels of noise sources using sound pressure – Precision methods for anechoic and hemi-anechoic rooms*

CIE 15, *Colorimetry*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 61318, as well as the following apply.

3.1

accessory

supplementary item not necessary for the functioning of the *phase comparator* and provided by the manufacturer to facilitate its use under certain operating conditions

Note 1 to entry: An *accessory* is not considered as a part of a device. Without the *accessory*, the device is still functional. An item that is required each time a device is used is not an *accessory* but a part of the device which may be disassembled.

Note 2 to entry: For example an *accessory* is used to lengthen the handle, to improve the efficiency of the *contact electrode*, to enable the *contact electrode* to reach the parts to be compared, etc.

3.2

active signal

visual phenomenon, and optionally audible phenomenon, whose presence, absence or variation is considered as representing information on the condition “correct phase relationship” or “incorrect phase relationship”

Note 1 to entry: A signal indicating that the *phase comparator* is ready to operate is not considered as an *active signal*.

[SOURCE: IEC 60050-101:1998, 101-12-02, modified – the definition of “signal” has been modified to fit the specific context of diagnostic of phase relationship and Note 1 to entry has been added.]

3.3

adaptor

part of a *phase comparator* as a separate device which permits attachment of an *insulating stick*

3.4

clear indication

unambiguous detection and indication of “incorrect phase relationship” and/or “correct phase relationship” between the parts to be compared

3.5

clear perceptibility

case when the indication is unmistakably discernible by the user under specific environmental conditions when the *phase comparator* is in its operating position

3.6

contact electrode

bare conductive part of the *phase comparator* which establishes the electric connection to the part to be compared

3.7

contact electrode extension

externally insulated conductive part to enable the *contact electrode* to reach the parts of the installation to be compared

Note 1 to entry: For a certain installation configuration, the *contact electrode extension* is used to increase the *insertion depth* (see Figure 1d).

Note 2 to entry: The *contact electrode extension* is an *accessory* of the *phase comparator*.

3.8

end fittings

part of an *insulating stick* permanently fitted to the end of an insulating tube or rod

[SOURCE: IEC 60050-651:2014, 651-22-02]

3.9

family of phase comparators

for testing purposes, a group of *phase comparators*, delimited by a minimum and a maximum *rated voltage* and/or by the two frequencies (50 Hz and 60 Hz), that are identical in design (including dimensions) and only differ by their *nominal voltages* or *nominal voltage ranges* and/or their nominal frequency

3.10

hand guard

distinctive physical guard separating the handle of a *phase comparator* as a complete device from its *insulating element*

Note 1 to entry: The purpose of a *hand guard* is to prevent the hands from slipping and passing into contact with the *insulating element*.

3.11

indicator

part of the *phase comparator* that indicates the status of the phase relationship between two parts to be compared

Note 1 to entry: In the case of single-pole *phase comparators*, the *indicator* also indicates that the *phase comparator* is ready to be moved to the second part to be compared ("memory ready").

Note 2 to entry: In the case of two-pole-wireless *phase comparators*, the *indicator* also indicates the communication status.

3.12

indicator unit

additional unit of a two-pole *phase comparator* with wireless connection, normally intended to be hand-held and which is either an indicator or repeater that brings the indication and possibly other information close to the user

3.13

indoor type

phase comparator designed for use in dry conditions, normally indoors

3.14

insertion depth

A_i
distance between the *limit mark* and the top of the *contact electrode* for a *phase comparator* as a complete device

3.15

insulating element

part of a *phase comparator* as a complete device that provides adequate safety distance and insulation to the user

3.16

insulating stick

insulating tool made essentially of an insulating tube and/or rod with *end fittings*

Note 1 to entry: For phase comparison, an *insulating stick* is intended to be attached to a *phase comparator* as a separate device in order to provide the length to reach the installation to be tested and adequate safety distance and insulation to the user.

[SOURCE: IEC 60050-651:2014, 651-22-01, modified – the Note 1 to entry has been added.]

3.17

interference field

superposed electric field which may affect the indication

Note 1 to entry: The *interference field* may result from the parts to be compared or other adjacent parts and may have any phase relationship.

Note 2 to entry: The extreme cases for the tests are:

- an in-phase *interference field*. This occurs as a result of the dimensions and/or configuration of the parts of the installation to be compared or of adjacent parts of the installation having voltages in the same phase as the parts to be compared;
- an *interference field* in phase opposition. This occurs as a result of the adjacent parts of the installation having voltages in phase opposition to the parts to be compared.

3.18

limit mark

distinctive location or mark to indicate to the user the physical limit to which the *phase comparator* may be inserted between live parts or may touch them

3.19

maintenance test

test carried out periodically on a device or equipment to ascertain and, if necessary, make certain adjustments to ensure that its performance remains within specified limits

[SOURCE: IEC 60050-151:2001, 151-16-25, modified – the definition has been modified to fit the specific context of maintenance of device or equipment.]

3.20

memory holding time

for a single-pole *phase comparator*, maximum available time to contact the second part to be compared, after the indication “memory ready” appears when the *phase comparator* is in contact with the first part to be tested

3.21

nominal voltage

U_n

suitable approximate value of voltage used to identify a system or device

Note 1 to entry: The *nominal voltage* of the *phase comparator* is a parameter associated with its *clear indication*. When a *phase comparator* has more than one *nominal voltage*, or a *nominal voltage* range the limit values of the *nominal voltage* range are named $U_{n \min}$ and $U_{n \max}$.

[SOURCE: IEC 60050-601:1985, 601-01-21, modified – the definition has been modified to fit the specific context of device or equipment and Note 1 to entry has been added.]

3.22

outdoor type

phase comparator designed for use in wet conditions, either indoors or outdoors

3.23

permanent contact electrode extension

externally insulated conductive element located between the *indicator* and the *contact electrode* of some designs of *phase comparator* to move back the *indicator* from the live part to be compared

Note 1 to entry: The *permanent contact electrode extension* may contain impedances.

Note 2 to entry: The *permanent contact electrode extension* is not an *accessory*.

3.24

phase comparator

portable device used to provide clear evidence of the presence or the absence of the correct phase relationship between two energized parts at the same *nominal voltage* and frequency

[SOURCE: IEC 60050-651:2014, 651-24-03, modified – the definition has been modified to specify that the device herein defined is a portable device.]

3.25

phase comparator of capacitive type

capacitive phase comparator

device whose operation is based on the current passing through the stray capacitance to earth

Note 1 to entry: *Phase comparators* of capacitive type are either two-pole *phase comparators* operating with a wireless connection or single-pole *phase comparators* operating with a memory system.

Note 2 to entry: *Phase comparators* of capacitive type mainly work on the basis of angle measurement (frequency-based).

3.26

protection against bridging

protection against flashover or breakdown, when the insulation between the parts of the installation, at different potentials, is reduced by the presence of the *phase comparator*

3.27

rated voltage

U_r

value of voltage to which certain operating specifications are referred

Note 1 to entry: The *rated voltage* of the *phase comparator* is the voltage selected from IEC 60071-1:2006, Tables 2 and 3, column 1, which should either be equal to the *nominal voltage* (or the highest *nominal voltage* of its *nominal voltage* range), or the next higher voltage selected from those tables.

3.28

response time

delay between the time when the *phase comparator* makes contact with the second part to be compared and the relevant *clear indication*

3.29

testing element

built-in element or separate device, by means of which the functioning of the *phase comparator* can be checked by the user

[SOURCE: IEC 60743:2013, 11.3.7, modified – the definition has been modified to specify its application to the *phase comparator*.]

3.30

threshold parameter

minimum phase angle φ_p between the two parts to be compared which gives a change of the status of the *active signal*

3.31

wireless connecting system

communication system used to exchange information between the different units of a *phase comparator* without physical link

4 Requirements

4.1 Indication

The *phase comparator* shall clearly indicate the state "incorrect phase relationship" and/or "correct phase relationship" by means of the change of the status of one or more *active signals*.

The indication shall be visual. An audible indication may be additional.

For a *phase comparator* with *nominal voltage* above 36 kV it is recommended to have both visual and audible indication.

In the case of a single-pole *phase comparator*, the state “memory ready” shall be indicated.

In the case of a two-pole *phase comparator* operating with wireless connection the communication status shall be indicated.

4.2 Functional requirements

4.2.1 Clear indication

4.2.1.1 General

The following requirements apply when both parts to be compared have the same *nominal voltage* and frequency.

The indication “incorrect phase relationship” shall not appear for an angle difference up to $\pm 10^\circ$.

The indication “correct phase relationship” shall not appear for an angle difference above $\pm 30^\circ$, $\pm 60^\circ$ or $\pm 110^\circ$ according to the class of the *phase comparator*.

To fulfil the above requirements, the *threshold parameter* shall satisfy the following relationship:

Class A: $\pm 10^\circ < \varphi_p \leq \pm 30^\circ$

Class B: $\pm 10^\circ < \varphi_p \leq \pm 60^\circ$

Class C: $\pm 10^\circ < \varphi_p \leq \pm 110^\circ$, see Note 1.

Class D: If it is not possible to use any of the above-mentioned classes, the manufacturer and the customer shall reach an agreement to set the appropriate value of the phase-angle difference. In such a case the upper limit of the *threshold parameter* shall exceed the one of class C.

For *phase comparators* with one *nominal voltage*, $U_{n \max}$ equals $U_{n \min}$.

NOTE 1 It has been recognized that for networks with small angle differences a device of class C could permit increasing the *memory holding time*.

NOTE 2 The required phase angle differences to give indication of incorrect phase relationship will depend on network situations.

NOTE 3 A *phase comparator* may not indicate properly in the presence of large harmonic and/or amplitude distortion (e.g. HV a.c./d.c. converters, non-linear loads, etc.). Relevant data, acceptable limits and performance requirements are under consideration.

4.2.1.2 Settings

The user shall not have access to the settings of the *indicator*.

A selector for different *nominal voltages* or different *nominal voltage* ranges is allowed, but for each position of the selector the user shall not have access to any settings.

On each unit of a wireless *phase comparator* there could be an accessible selector for setting a multi-channel connecting system (e.g.: radio communication).

4.2.1.3 Continuous indication

Once the *phase comparator* gives *clear indication* it shall continue to indicate as long as it is in direct contact with the live part.

4.2.1.4 Influence of interference fields

The presence of an *interference field* (adjacent live or earthed parts) shall not affect the indication when the *phase comparator* is used in accordance with the instructions for use.

NOTE The indication may not be reliable in the vicinity of large conductive parts that create equipotential zones.

4.2.1.5 Special marking in the case of limited use

In the case of a *phase comparator* that does not fulfil anyone of the tests of 5.2.2 or 5.2.5 when using the test set-up of Figure 4, it shall have a marking “LU” for limited use.

4.2.1.6 Electromagnetic compatibility (EMC)

Phase comparators shall comply with the requirements of class A for portable equipment according to IEC 61326-1.

NOTE In some countries additional requirements may be added to fulfil EMC regulations.

4.2.2 Distance range

Wireless operating *phase comparators* shall communicate properly within the limits of the distance range in free space (between the various units of the whole device) specified by the manufacturer in the instructions for use (see Annex A).

There are no radio communication requirements in this standard. Where relevant, the *phase comparator* should conform to the national radio communication regulations.

4.2.3 Clear perceptibility

4.2.3.1 Visual indication

The *phase comparator* shall give a clear visual indication to the user when in operating position and under normal light conditions.

When two or more visual *active signals* are used, the indication shall not rely solely on light of different colours for perceptibility. Additional characteristics, such as physical separation of the light sources, distinctive form of the light signals, or flashing light shall be used.

4.2.3.2 Audible indication (where relevant)

The *phase comparator* shall give a clear audible indication to the user when in the operating position and under normal noise conditions.

When two audible *active signals* are used, the indication shall not rely solely on sounds of different sound pressure level for perceptibility. Additional characteristics, such as tone or intermittence of the audible signals shall be used.

4.2.4 Temperature and humidity dependence of the indication

There are three categories of *phase comparators* according to the climatic conditions of operation: cold (C), normal (N) and warm (W). The *phase comparator* shall operate correctly in the temperature range of its climatic category, according to Table 1.

Table 1 – Climatic condition ranges

Climatic condition ranges (operation and storage)		
Climatic category	Temperature °C	Humidity %
Cold (C)	–40 to +55	20 to 96
Normal (N)	–25 to +55	20 to 96
Warm (W)	–5 to +70	12 to 96

4.2.5 Frequency dependence

4.2.5.1 General

At a given time the value of the frequency is considered to be the same all over a network. Then the following requirements apply when both parts to be compared have the same frequency.

4.2.5.2 Tolerance of nominal frequency

The *phase comparator* shall operate correctly at frequencies within a tolerance of at least $\pm 0,2$ % of the nominal frequency.

A *phase comparator* with two nominal frequencies shall operate correctly for each nominal frequency within a tolerance of at least $\pm 0,2$ %.

4.2.5.3 Frequency shift of single-pole phase comparator

Single-pole *phase comparators* shall operate correctly with variations of frequency up to 1 mHz/s during the *memory holding time* declared by the manufacturer after the indication "memory ready" appears.

The indication of a single-pole *phase comparator* shall not be assessed as "correct phase relationship" with variations of frequency above 10 mHz/s during at least 5 s after the indication "memory ready" appears.

The *memory holding time* shall be at least 5 s.

4.2.6 Response time

The *response time* of the *phase comparator* shall not be more than 1 s. In situations where the *response time* is above 1 s the phase comparator shall give a visual and/or audible indication that data processing is still running.

4.2.7 Power source dependability

The *phase comparator* with a built-in power source shall give a *clear indication* until a non-readiness signal appears or the device is automatically shut off, as mentioned in the instructions for use.

4.2.8 Testing element

The *testing element*, whether built-in or separate, shall be capable of testing all the electrical circuits, the *wireless connecting system*, the energy source and the functioning of the indication. When all circuits cannot be tested, any limitation shall be clearly stated in the instructions for use. These circuits shall be of high reliability construction. When there is a built-in *testing element*, the *phase comparator* shall give an indication of "ready" or "not ready".

4.2.9 Time rating

The *phase comparator* shall be able to perform during its specified time rating without failure and without giving incorrect indication when subjected to the maximum operating voltage.

The minimum time rating shall be:

- 5 min in the case of a *phase comparator* at a *nominal voltage* up to 36 kV;
- 15 min in the case of a *phase comparator* at a *nominal voltage* above 36 kV.

The manufacturer shall clearly state in the instructions for use the maximum time rating for the user.

4.3 Electrical requirements

4.3.1 Insulating material

The insulating materials shall be adequately rated (nature of material, dimensions) for the *nominal voltage* (or the maximum *nominal voltage* of the voltage range) of the *phase comparator*.

When tubes of insulating material with circular cross-section are used in the design of *phase comparators*, they should meet the requirements of IEC 60855-1 or IEC 61235, otherwise they shall demonstrate appropriate insulating performance by fulfilling the test of 5.3.1.

For a *phase comparator* as a complete device the user shall be provided with adequate insulation by means of an *insulating element*.

NOTE For a *phase comparator* as a separate device, the selection of an appropriate adaptable *insulating stick* will provide the user with adequate insulation.

4.3.2 Protection against bridging

Protection shall be such that the *phase comparator* cannot cause flashover or breakdown between live parts of an installation or between a live part of an installation and earth.

4.3.3 Resistance against sparking

The *phase comparator* shall be so constructed that the *indicator* cannot be damaged or shut-off as a result of a low energy electric arc.

4.3.4 Insulating element of phase comparator as a complete device

4.3.4.1 Dielectric strength

The *insulating element* shall be rated so that no flashover or breakdown occurs in use.

4.3.4.2 Leakage current

The *insulating element* of the *indoor type phase comparator* shall be so rated that leakage current shall be limited under dry conditions.

The *insulating element* of the *outdoor type phase comparator* shall be so rated that leakage current shall be limited under dry and wet conditions.

4.3.5 Indicator casing

The *indicator* casing shall be rated so that no flashover or breakdown occurs in use.

4.4 Mechanical requirements

4.4.1 General

For a *phase comparator* as a complete device the user shall be provided with adequate distance by means of an *insulating element*.

NOTE For a *phase comparator* as a separate device, the selection of an appropriate *insulating stick* will provide the user with adequate distance.

4.4.2 Design

The *phase comparator* shall be designed to allow operation by one person.

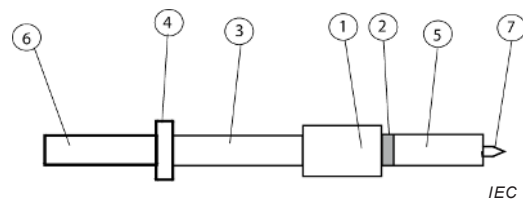
The *phase comparator* as a complete device shall include the following elements as a minimum:

- handle, *hand guard*, *insulating element*, *indicator*, *limit mark* and *contact electrode* (see Figure 1).

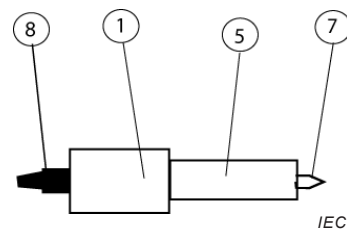
The position of the *limit mark* may be on either side of the *indicator*.

The *phase comparator* as a separate device shall include the following elements as a minimum:

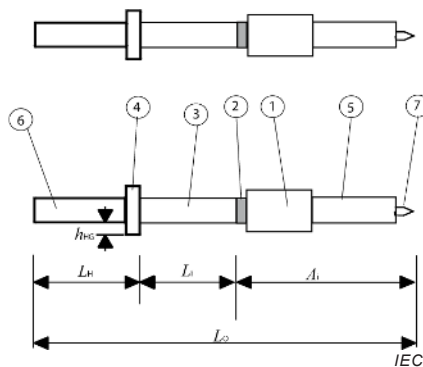
- *adaptor*, *indicator* and *contact electrode* (see Figure 1).



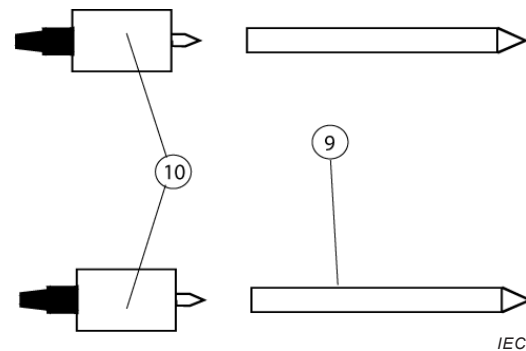
a) Example of a single-pole phase comparator as a complete device



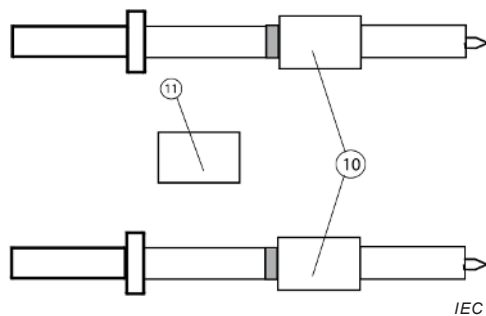
b) Example of a single-pole phase comparator as a separate device



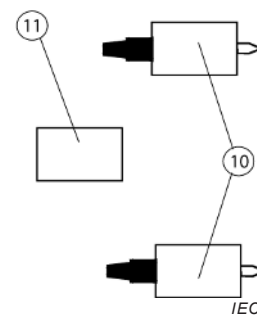
c) Example of a two-pole phase comparator with wireless connection as a complete device



d) Example of a two-pole phase comparator with wireless connection as a separate device



e) Example of a two-pole phase comparator with wireless connection and three communication units as a complete device



f) Example of a two-pole phase comparator with wireless connection and three communication units as a separate device

Key

1	indicator	9	contact electrode extension (accessory)
2	limit mark	10	two basic communications units
3	insulating element	11	indicator unit
4	hand guard	h_{HG}	height of hand guard
5	permanent contact electrode extension	L_H	length of handle
6	handle	L_i	length of insulating element
7	contact electrode	L_O	overall length of phase comparator
8	adaptor (can be used as limit mark)	A_i	insertion depth

Figure 1 – Illustration of different elements and different principles of functioning of phase comparators

4.4.3 Dimensions, construction

The minimum length of the *insulating element* of a *phase comparator* as a complete device shall be in accordance with Table 2.

Table 2 – Minimum length of the insulating element (L_i) of a phase comparator as a complete device

U_r kV	L_i mm
$1 < U_r \leq 7,2$	320
$7,2 < U_r \leq 12$	360
$12 < U_r \leq 17,5$	370
$17,5 < U_r \leq 24$	470
$24 < U_r \leq 36$	520
$36 < U_r \leq 72,5$	830
$72,5 < U_r \leq 123$	1 300
$123 < U_r \leq 170$	1 700
$170 < U_r \leq 245$	2 300

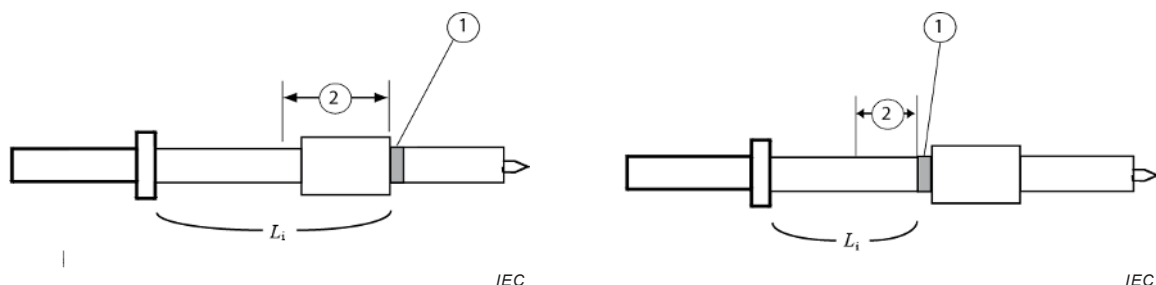
NOTE 1 The *nominal voltage* U_n is used when the parameters to be specified are related to the installation dimensioning or to the functional performance of the *phase comparator*, while the *rated voltage* U_r is used when insulation performance of the *phase comparator* is concerned.

NOTE 2 The L_i values of Table 2 correspond to the minimum distance in air (obtained from Tables 1 and 2 of IEC 61936-1:2010) plus an additional safety distance.

NOTE 3 The L_i values of Table 2 can be used as a guidance to determine the length of the *insulating stick* used with a *phase comparator* as a separate device. However, the length of the *insulating stick* for live working can be shortened for a *phase comparator* as a separate device taking into account the minimum approach distances or in accordance with national or regional regulations.

In the case of a *phase comparator* as a complete device and for L_i equal to or greater than 520 mm, conductive parts are allowed within the minimum length of the *insulating element* if they are completely externally insulated and are located immediately adjacent to the *limit mark* in one section of the *insulating element* not exceeding 200 mm (see Figure 2).

NOTE 4 The performance of the insulation covering the conductive parts is verified by the *protection against bridging* test of 5.3.2.



Key

- 1 limit mark
- 2 section of the *insulating element* where conductive parts are allowed (≤ 200 mm)
- L_i minimum length of the *insulating element*

Figure 2 – Location of allowed conductive parts within the minimum length of the insulating element of a pole of a phase comparator as a complete device

The *limit mark* shall be about 20 mm wide, permanent, and clearly recognizable by the user.

If there is no *limit mark* on a *phase comparator* as a separate device, the end of the *adaptor* can act as the *limit mark* (Figures 1b, 1d and 1f).

For a *phase comparator* as a complete device, the length of the handle (L_H) shall be 115 mm as a minimum.

NOTE 5 A longer handle facilitates two-hand operation.

For a *phase comparator* as a complete device, the *hand guard* shall be permanently fixed and have a minimum height (h_{HG}) of 20 mm.

In order to adapt the *phase comparator* to different uses, the *contact electrode* may readily be interchangeable with other types of *contact electrodes* depending on the type of installation to be compared and instructions for use.

When a *phase comparator* is intended to be disassembled by the user, the parts shall be clearly marked as belonging together.

4.4.4 Grip force and deflection

The *phase comparator* shall be designed to facilitate reliable operation with reasonable physical effort by the user.

The *phase comparator* shall be designed to allow a safe approach toward the parts of the installation to be compared. The deflection of the pole(s), under its(their) own weight, shall be as low as possible.

NOTE In the case of a *phase comparator* as a separate device, the choice of an *insulating stick* may greatly influence the grip force and deflection.

4.4.5 Vibration resistance

The *phase comparator* including the *indicator unit* (if any) shall be vibration resistant.

4.4.6 Drop resistance

The *phase comparator* including the *indicator unit* (if any) shall be drop resistant.

4.4.7 Shock resistance

The *phase comparator* including the *indicator unit* (if any) shall be shock resistant.

4.5 Marking

Each *phase comparator* shall have at least the following items of marking:

- *nominal voltage* and/or range of *nominal voltages*;
- nominal frequency or nominal frequencies;
- symbol for operational class (“A”, “B”, “C” or “D”);
- name or trade mark of the manufacturer;
- type reference, serial number;
- indication of type indoor or outdoor;
- symbol for climatic category or climatic categories (“C”, “N” or “W”);
- symbol “LU”, when relevant;
- year of production;

- symbol IEC 60417-5216 (2002-10) – Suitable for live working; double triangle (see Annex B);

NOTE The exact ratio of the height of the figure to the base of the triangle is 1,43. For the purposes of convenience, this ratio can be between the values of 1,4 and 1,5.

- number of the relevant IEC standard immediately adjacent to the double triangle symbol (“IEC 61481-1”).

To be marked with the number of this IEC standard, the product shall satisfy all the requirements specified herein.

With every *phase comparator* or with every batch of *phase comparators* to be delivered, the manufacturer shall provide information related to the number of the IEC standard with the year of publication.

In the case of a *phase comparator* with a built-in energy source, the type of power supply shall be indicated either on the *indicator* or inside the compartment designed to house it, and the polarity when required.

The marking shall be legible and permanent. The characters shall be at least 3 mm high. The marking shall not impair the quality of the *phase comparator*.

4.6 Instructions for use

The manufacturer shall provide written instructions for use with each *phase comparator* covered by this standard.

The instructions for use shall include as a minimum the information of Annex A.

These instructions shall be prepared in accordance with the general provisions of IEC 61477.

4.7 Requirements in the case of reasonably foreseeable misuse during live working

4.7.1 Voltage selection

In the case of incorrect position of the voltage selector, if any, the *phase comparator* shall give no incorrect indication of phase relationship.

4.7.2 Frequency selection

In the case of incorrect position of the frequency selector, if any, the *phase comparator* shall give no indication of phase relationship.

4.7.3 Channel selection for wireless connection

In the case of incorrect setting of the channel selectors, if any, the *phase comparator* shall give no indication of a phase relationship.

5 Tests

5.1 General

5.1.1 Testing provisions

This standard provides testing provisions to demonstrate compliance of the product to the requirements of Clause 4. These provisions are primarily intended to be used as type tests for the validation of the design input. Where relevant, alternative means (calculation, examination, tests, etc.), are specified within the test subclauses for *phase comparators* having completed the production phase.