

Live working — Portable phase comparators for voltages of 1 kV to 36 kV a.c.

The European Standard EN 61481:2001, with the incorporation of amendment A1:2002 and amendment A2:2005, has the status of a British Standard

ICS 13.260; 29.260.99

National foreword

This British Standard is the official English language version of EN 61481:2001, including amendment A1:2002 and amendment A2:2005. It is identical with IEC 61481:2001, including amendment 1:2002 and amendment 2:2005.

The start and finish of text introduced or altered by amendment is indicated in the text by tags **A1** **A1**. Tags indicating changes to IEC text carry the number of the IEC amendment. For example, text altered by IEC amendment 1 is indicated by **A1** **A1**.

The CENELEC common modifications have been implemented at the appropriate places in the text. The start and finish of each common modification is indicated in the text by tags **C** **C**. Where a common modification has been introduced by amendment, the tags carry the number of the amendment. For example, the common modifications introduced by CENELEC amendment A11 are indicated by **C11** **C11**.

The UK participation in its preparation was entrusted to Technical Committee PEL/78, Tools for live working, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible international/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.

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English version

**Live working —
Portable phase comparators for use on voltages
from 1 kV to 36 kV a.c.**

Travaux sous tension -
Comparateurs de phase portatifs
pour utilisation à des tensions
alternatives de 1 kV à 36 kV

Arbeiten unter Spannung –
Phasenvergleichler für
Wechselspannungen
Von 1 kV bis 36 kV

This European Standard was approved by CENELEC on 2001-03-01. Amendment A1 was approved by CENELEC on 2002-07-01. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this amendment the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

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CENELEC

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

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Foreword

The text of document 78/338/FDIS, future edition 1 of IEC 61481, prepared by IEC TC 78, Live working, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 61481 on 2001-03-01.

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

Annexes designated "informative" are given for information only.

In this standard, annexes A to E and ZA are normative and annexes F and G are informative.

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 61481:2001 was approved by CENELEC as a European Standard without any modification.

Foreword to amendment A1

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

In this standard, annex ZA normative.

Annex ZA has been added by CENELEC.

Endorsement notice

The text of amendment 1:2002 to the International Standard IEC 61481:2001 was approved by CENELEC as an amendment to the European Standard without any modification.

Foreword to amendment A2

The text of amendment 2:2004 to the International Standard IEC 61481:2001, prepared by IEC TC 78, Live working, together with the common modifications prepared by the Technical Committee CENELEC TC 78, Equipment and tools for live working, was submitted to the formal vote and was approved by CENELEC as amendment A2 to EN 61481:2001 on 2005-03-01.

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Annex ZA has been added by CENELEC.

Endorsement notice

The text of amendment 2:2004 to the International Standard IEC 61481:2001 was approved by CENELEC as an amendment to the European Standard with agreed common modifications.

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LIVE WORKING – PORTABLE PHASE COMPARATORS FOR USE ON VOLTAGES FROM 1 kV TO 36 kV AC

1 Scope

This International Standard is applicable to portable phase comparators with or without a built-in power source to be used on electrical systems for voltages from 1 kV to 36 kV a.c. and frequencies from 50 Hz to 60 Hz.

This standard is applicable to two-pole phase comparators having a connecting lead between them, two-pole phase comparators operating with a wireless connection and single-pole phase comparators operating with a memory system.

This standard is applicable to phase comparators used in contact with the part to be tested, as a single unit or as a separate device completed by an adaptable insulating pole covered in IEC 60855 or IEC 61235.

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

Devices which can be used as voltage detector and phase comparator are not covered by this standard.

NOTE Except when otherwise specified, all the voltages defined in this standard refer to phase-to-phase voltages of three-phase systems. Phase comparators may be used in other than three-phase systems, but the applicable phase-to-phase or phase-to-earth (ground) voltage must be used to determine the operating voltage.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard 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 ISO and IEC maintain registers of currently valid International Standards.

IEC 60050(151):1978, *International Electrotechnical Vocabulary (IEV) – Chapter 151: Electrical and magnetic devices*

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

IEC 60050(651):1999, *International Electrotechnical Vocabulary (IEV) – Part 651: Live working*

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

IEC 60068-1:1988, *Environmental testing – Part 1: General and guidance*

IEC 60068-2-6:1995, *Environmental testing – Tests – Test Fc and guidance: Vibration sinusoidal*

IEC 60068-2-14:1984, *Environmental testing – Part 2: Tests – Test N: Change of temperature*

IEC 60068-2-32:1975, *Environmental testing – Part 2: Tests – Test Ed: Free fall (Procedure 1)*
Amendment 2 (1990)

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

IEC 60417-DB:2002¹, *Graphical symbols for use on equipment*

IEC 60651:1979, *Sound level meters*

IEC 60855:1985, *Insulating foam-filled tubes and solid rods for live working*

IEC 61235:1993, *Live working – Insulating hollow tubes for electrical purposes*

IEC 61318:1994, *Live working – Guidelines for quality assurance plans*

ISO 3745:1977, *Acoustics – Determination of sound power levels of noise sources – Precision methods for anechoic and semi-anechoic rooms*

ISO 8402:1994, *Quality management and quality assurance – Vocabulary*

ISO 9000 (all parts), *Quality management and quality assurance standards*

ISO 9002:1994, *Quality systems – Model for quality assurance in production, installation and servicing*

ISO 9004 (all parts), *Quality management and quality system elements*

CIE 15.2:1986, *Colorimetry*

3 Definitions

For the purpose of this International Standard, the following definitions apply.

3.1

phase comparator

portable device used to detect and indicate the presence or absence of the correct phase relationship between two energized parts at the same nominal voltage and frequency

3.2

capacitive phase comparator

device used to detect and indicate the phase relationship whose operation is based on the current passing through the stray capacitance to earth (ground). Capacitive phase comparators are two-pole phase comparators operating with wireless connection and single-pole phase comparators operating with memory system

NOTE Capacitive phase comparators mainly work on the basis of angle measurement (frequency-based).

¹ "DB" refers to the IEC on-line database.

3.3

resistive phase comparator

device used to detect and indicate the phase relationship whose operation is based on the current passing through a resistor located in the resistive element. Resistive phase comparators are always two-pole phase comparators

NOTE Resistive phase comparators mainly work on the basis of voltage measurement (voltage-based).

3.4

types of phase comparators

single unit including its insulating elements and separate unit completed with an insulating pole; both devices with or without contact electrode extension

3.5

contact electrode

bare conductive part which makes the electrical connection to the part to be tested

[IEV 651-10-09, modified]

3.6

contact electrode extension

externally insulated conductive section between the resistive element and the contact electrode or between the indicator and the contact electrode intended to achieve the correct position of the indicator relative to the part to be tested

3.7

resistive element

element which contains the current-limiting resistor and conductive parts

NOTE Other current limiting components may be used.

3.8

indicator

part of the phase comparator which indicates the presence or absence of the correct phase relationship between two parts. In the case of single-pole phase comparators, it contains the electronics and the indication that the phase comparator is ready for the next measurement on the second part to be tested ("memory ready")

3.9

connecting lead

lead that connects the two poles electrically

3.10

connecting system

electronic arrangement used to send information between the two poles

3.11

earth lead

lead that connects the phase comparator to earth (ground). It includes an earth clip or clamp or another device suitable for establishing a permanent or semi-permanent contact

3.12

adaptor

part allowing the assembly of the phase comparator

3.13**insulating element**

section of insulating material which provides adequate distance and insulation to the user

3.14**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

3.15**hand guard**

distinctive physical guard separating the handle from the insulating element

3.16**insulating pole**

pole made of insulating material

3.17**testing element**

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

3.18**accessories**

items used to lengthen the contact electrode in order to improve its efficiency or to enable it to reach the part to be tested. Accessories may also be used to lengthen the handle

3.19**nominal voltage, U_n**

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

[IEV 601-01-21, modified]

The nominal voltage of the phase comparator is the parameter associated with its clear indication. A phase comparator may have more than one nominal voltage, or a nominal voltage range. Limit values of the nominal voltage range are named $U_{n \min}$ and $U_{n \max}$

3.20**threshold voltage**

minimum voltage between the two parts to be compared to give a change of signal state which indicates incorrect phase relationship (not applicable for capacitive phase comparator)

3.21**threshold angle**

minimum phase angle between the two parts to be compared which gives a change of signal state which indicates incorrect phase relationship

3.22**measurement time**

available time between indication "memory ready" and contact to the second part to be tested

3.23

rated voltage, U_r

value of voltage generally agreed upon by manufacturer and customer, to which certain operating specifications are referred. The rated voltage of the phase comparator is the voltage selected from IEC 60071-1, table 2, column 1, which should either be equal to the nominal voltage (or the highest nominal voltage of its nominal range), or the next higher voltage selected from those tables

3.24

interference field

electric or magnetic field capable of affecting the indication. It may result from the part to be tested or other adjacent parts

3.25

clear indication

unambiguous detection and indication of incorrect phase relationship between the parts to be tested

3.26

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

3.27

protection against bridging

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

3.28

indoor type

phase comparator designed for use in dry conditions, normally indoors

3.29

outdoor type

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

3.30

acceptance test

contractual test to prove to the customer that the device meets certain conditions of its specification

[IEV 151-04-20]

3.31

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

[IEV 151-04-22]

3.32

routine test

test to which each individual device is subjected during or after manufacture to ascertain whether it complies with certain criteria

[IEV 151-04-16]

3.33

sampling test

test on a number of devices taken at random from a batch

[IEV 151-04-17]

3.34

type test

test on one or more devices made to a certain design to show that the design meets certain specifications

[IEV 151-04-15]

4 Requirements

4.1 General requirements

4.1.1 Safety

The phase comparator shall be designed and manufactured to be safe for the user, provided it is used in accordance with safe methods of work and the instructions for use.

4.1.2 Indication

The phase comparator shall clearly indicate the states "incorrect phase relationship" and/or "correct phase relationship" by means of the change of the signal. The indication shall be visual; an audible indication may be additional. In the case of a single-pole phase comparator, the state "ready for measurement" (memory ready) shall be indicated.

4.2 Functional requirements

4.2.1 Clear indication

The phase comparator shall not indicate as incorrect phase relationship angle differences up to $\pm 10^\circ$.

The phase comparator shall clearly indicate incorrect phase relationship.

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

Manufacturer and customer shall agree on one of the four following classes.

Class A: Indication of incorrect phase relationship for phase angles between 30° and 330° ;

Class B: Indication of incorrect phase relationship for phase angles between 60° and 300° ;

Class C: Indication of incorrect phase relationship for phase angles between 110° and 250° ;

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.

These requirements shall be fulfilled for voltage-to-earth values between

$0,4 U_{n \min}$ up to $U_r / \sqrt{3}$ for capacitive phase comparator,

and $(U_{n \min} - 8 \%) / \sqrt{3}$ up to $(U_{n \max} + 8 \%) / \sqrt{3}$ for resistive phase comparator.

4.2.1.1 The user shall not have access to the settings of the indicator, except for those devices which are equipped with a selector for different nominal voltages or nominal voltage ranges.

4.2.1.2 The presence of an adjacent live or earthed part shall not affect the indication when the phase comparator is used in accordance with the instructions for use.

4.2.1.3 The presence of an interference field shall not affect the indication.

NOTE There is no specific EMC requirement in this International Standard. The phase comparator should conform with the National Regulations.

4.2.2 Clear perceptibility

The phase comparator shall give a clear indication under normal light and noise conditions.

4.2.2.1 Visual indication

The indication shall be clearly visible to the user in the operating position and under normal light conditions.

When two or more 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.

4.2.2.2 Audible indication

The indication shall be clearly audible to the user when in the operating position and under normal noise conditions.

4.2.3 Temperature and humidity dependence of the indication

There are three categories of phase comparators according to 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

4.2.4 Frequency dependence

4.2.4.1 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 more than one nominal frequency shall operate correctly for each frequency within a tolerance of at least $\pm 0,2$ %.

4.2.4.2 Frequency shift

The phase comparator shall operate correctly with variations of frequency up to 1 mHz/s during at least 5 s after indication "memory ready" appears. Greater variations up to 10 mHz/s shall not cause indication "correct phase relationship".

The measurement time shall be at least 5 s.

4.2.5 Power source dependability

The phase comparator with a built-in power source shall give clear indication until the source is exhausted, unless its usage is limited by an indication of non-readiness or automatic shut-off, as mentioned in the instructions for use.

4.2.6 Testing element

The testing element, whether built-in or separate, shall be capable of testing all the electrical circuits, including the resistive element, 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".

4.2.7 Time rating

The phase comparator shall be able to perform without failure and without giving incorrect indication when subjected to the rated voltage for 1 min.

4.3 Electrical requirements

4.3.1 Insulating material

The insulating material shall be adequately rated for the rated voltage.

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 constructed so that the indicator cannot be damaged or shut-off as a result of spark discharge.

4.3.4 Resistive element

The resistive element of a phase comparator shall be adequately rated with respect to voltage and power.

4.3.5 Leakage current

The phase comparator shall be so rated that the leakage current shall not exceed 0,5 mA.

4.3.6 Circuit current

For resistive phase comparator the maximum circuit current through the phase comparator shall be as low as possible and never exceed 3,5 mA when a test voltage of $1,2 U_r$ is applied between the contact electrodes.

4.3.7 Indicator casing

If an indicator casing is subject to dielectric stress, it shall maintain its dielectric strength for which it is designed, either in dry or wet conditions.

4.3.8 Insulation of leads

The earth lead and connecting lead shall be made of high-voltage flexible multistrand cable. The insulation of the leads and the connection of the leads to the phase comparator shall withstand a voltage of $1,2 U_r$.

4.4 Mechanical requirements

4.4.1 Design

The user shall be provided with adequate distance and insulation, either by the resistive element or by a combined resistive and insulating element. The phase comparator shall be designed to allow operation by one person.

The phase comparator as a single unit shall include at least the following elements:

- handle, handguard, insulating element and/or resistive element, indicator, limit mark and contact electrode. The resistive phase comparator shall additionally have a connecting lead and, possibly, an earth lead (see figure 1).

The phase comparator as a separate unit shall include at least the following elements:

- contact electrode, indicator, limit mark, adaptor and insulating pole. The resistive phase comparator shall additionally have a resistive element, a connecting lead and, possibly, an earth lead (see figure 1).

4.4.2 Dimensions, construction

The minimum length of insulation between the handguard and the limit mark shall be 525 mm and be achieved by the provision of an insulating element and/or a resistive element.

The distance from the limit mark to the contact electrode shall have the following minimum length:

Table 2 – Minimum lengths from the limit mark to the contact electrode

Minimum length mm	Voltage range kV
300	$1 < U_n \leq 12$
450	$12 < U_n \leq 24$
600	$24 < U_n \leq 36$
NOTE The specified values are selected in consideration of the extension that is necessary for the usual construction type of three-phase systems. In certain circumstances, larger lengths may be required and agreed between manufacturer and customer.	

The resistive phase comparator shall be so constructed that, if used as intended, a minimum distance of 100 mm can be maintained between the user and the connecting lead and earth lead. In certain circumstances, other distances may be required and agreed between manufacturer and customer.

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

When provided, the handle shall be at least 115 mm in length.

When provided, the handguard 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 and instructions for use.

A dismountable phase comparator and component parts of a phase comparator shall be clearly marked as belonging together.

Except for the earth and connecting lead, the phase comparator shall not have any other external lead or any means making such connection.

The connecting lead and the earth lead (when provided) shall be designed and guided to resist the forces occurring when used as intended. They shall be flexible, resistant to buckling and resistant to ageing.

4.4.3 Grip force and deflection

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

The grip force shall not exceed 200 N for each pole.

The phase comparator shall be designed to allow a safe approach toward the installation to be tested. The deflection, under its own weight, shall be as low as possible and shall not exceed 10 % of the total length of the complete unit, measured in a horizontal position.

NOTE A pole of a phase comparator includes the insulating pole and/or the resistive element, the contact electrode extension, and may include the indicator depending on the design.

4.4.4 Vibration resistance

The indicator, the resistive element, the contact electrode extension and, when provided, the connecting and/or earth lead shall be vibration resistant.

4.4.5 Drop resistance

The phase comparator shall be drop resistant.

4.4.6 Shock resistance

The indicator, the resistive element and the contact electrode extension shall withstand mechanical shocks according to annex D.

4.5 Markings

4.5.1 Markings on the phase comparator

Each phase comparator shall have at least the following markings:

- nominal voltage and/or range of nominal voltages;
- nominal frequency and/or range of nominal frequencies;
- operational class (A, B, C or D);
- name or trade mark of the manufacturer;
- type reference, serial number;
- indication of type "indoor" or "outdoor";
- climatic categories (C, N or W);
- year of production;
-  symbol IEC 60417-5216 (DB:2002-10) – Suitable for live working; double triangle;
NOTE The exact ratio of the height of the figure to the base of the triangle is 1,43. For the purpose of convenience, this ratio can be between the values of 1,4 and 1,5. 
-  number of the relevant European Standard immediately adjacent to the symbol (EN 61481-2001); 
- date of verification of operation and dielectric properties (periodic maintenance test);
- warning notice "earth lead must be connected to earth before use", in the case of a phase comparator with an earth lead.

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.

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

4.5.2 Instructions for use

Each phase comparator shall be accompanied by the manufacturer's instructions for use; see annex B.

5 Tests

5.1 General

Tests shall be performed on a phase comparator which has been completely assembled, including the contact electrode extension in accordance with instructions for use. When several contact electrodes are used, the relevant test shall be performed with each contact electrode (for example, protection against bridging tests, etc.).

For a phase comparator with an earth lead, the test shall be performed with the earth lead connected to earth, unless otherwise stated.

NOTE It is possible, for some functional tests, to use a low-voltage source if the same results are achieved. Example: this is possible for tests not involving interference fields.

5.1.1 Atmospheric conditions

Atmospheric conditions shall be in accordance with IEC 60068-1.

5.1.2 Standard atmospheric test conditions

Except when otherwise stated, tests are carried out under the following standard atmospheric conditions:

- ambient temperature 15 °C to 35 °C;
- relative humidity 45 % to 75 %;
- atmospheric pressure 86 kPa to 106 kPa.

The phase comparator shall be subjected to these conditions for at least 4 h before being submitted to the group of tests.

5.1.3 Tests under wet conditions

Before the electrical tests, each phase comparator shall be cleaned with Isopropanol and then dried in air for 15 min.

The test shall be conducted in accordance with 9.1 of IEC 60060-1 (Standard wet test procedure), with the following exception: the openings in the collecting vessel designed to measure the wetting rate shall be less than, or equal to, the horizontal cross-section of the indicator.

5.1.4 Type test

The type test shall be performed on three complete phase comparators taken at random and on three test pieces of each material providing high-voltage insulation. If more than one sample does not pass, the test has failed. If only one sample fails, the entire sequence for the type test shall be repeated on three other samples. If, again, any of the samples does not pass, the type test is considered to have failed.

Phase comparators of the same design need only be type tested once. Tests shall be performed in the sequence defined in annex A.

5.1.5 Routine test

The routine test shall be performed according to annex A.

It is not necessary to use the same set-up as in the corresponding type test, but the result shall be equivalent.

5.1.6 Sampling test

Sampling test shall be performed according to annex A. The number of samples shall be in accordance with annex C.