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BSI Standards Publication

Potentiometers for use in electronic equipment —

Part 1: Generic specification

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National foreword

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The UK participation in its preparation was entrusted to Technical Committee EPL/40X, Capacitors and resistors for electronic equipment.

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

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**Potentiometers for use in electronic equipment -
Part 1: Generic specification
(IEC 60393-1:2008)**

Potentiomètres utilisés
dans les équipements électroniques -
Partie 1: Spécification générique
(CEI 60393-1:2008)

Potentiometer zur Verwendung
in Geräten der Elektronik -
Teil 1: Fachgrundspezifikation
(IEC 60393-1:2008)

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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

Central Secretariat: Avenue Marnix 17, B - 1000 Brussels

Foreword

The text of document 40/1897/FDIS, future edition 3 of IEC 60393-1, prepared by IEC TC 40, Capacitors and resistors for electronic equipment, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 60393-1 on 2009-07-01.

This European Standard supersedes CECC 41 000:1976.

The following dates were fixed:

- latest date by which the EN has to be implemented
at national level by publication of an identical
national standard or by endorsement (dop) 2010-04-01
- latest date by which the national standards conflicting
with the EN have to be withdrawn (dow) 2012-07-01

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 60393-1:2008 was approved by CENELEC as a European Standard without any modification.

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POTENTIOMETERS FOR USE IN ELECTRONIC EQUIPMENT –

Part 1: Generic specification

1 General

1.1 Scope

This part of IEC 60393 is applicable to all types of resistive potentiometers, including lead-screw actuated types, presets, multi-turn units, etc. to be used in electronic equipment.

It establishes standard terms, inspection procedures and methods of test for use in sectional and detail specifications of electronic components for quality assessment or any other purpose.

It has been mainly written, and the test methods described, to conform to the widely used single-turn rotary potentiometer with an operating shaft.

For other types of potentiometers:

- the angle of rotation may be several turns;
- the reference to an operating shaft shall apply to any other actuating device;
- the angular rotation shall be taken to mean mechanical travel of the actuating device;
- a value for force shall be prescribed instead of a value for torque if the actuating device moves in a linear instead of a rotary manner.

These alternative prescriptions will be found in the sectional or detail specification.

When a component is constructed as a variable resistor, i.e. as a two-terminal device, the detail specification shall prescribe the modifications required in the standard tests.

1.2 Normative references

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

IEC 60027-1, *Letter symbols to be used in electrical technology – Part 1: General*

IEC 60050 (all parts), *International Electrotechnical Vocabulary (IEV)*

IEC 60062, *Marking codes for resistors and capacitors*

IEC 60063:1963, *Preferred number series for resistors and capacitors*

Amendment 1 (1967)

Amendment 2 (1977)

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

Amendment 1 (1992)

IEC 60068-2-1:1990, *Environmental testing – Part 2: Tests – Tests A: Cold*

Amendment 1 (1993)

Amendment 2 (1994)

IEC 60068-2-2:1974, *Environmental testing – Part 2: Tests – Tests B: Dry heat*
Amendment 1 (1993)
Amendment 2 (1994)

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

IEC 60068-2-13, *Environmental testing – Part 2: Tests – Test M: Low air pressure*

IEC 60068-2-14:1994, *Environmental testing – Part 2: Tests – Test N: Change of temperature*
Amendment 1 (1986)

IEC 60068-2-17, *Environmental testing – Part 2: Tests – Test Q: Sealing*

IEC 60068-2-20:1979, *Environmental testing – Part 2: Tests – Test T: Soldering*
Amendment 2 (1987)

IEC 60068-2-21, *Environmental testing – Part 2-21: Tests – Test U: Robustness of terminations and integral mounting devices*

IEC 60068-2-27, *Environmental testing – Part 2: Tests – Test Ea and guidance: Shock*

IEC 60068-2-29, *Environmental testing – Part 2: Tests – Test Eb and guidance: Bump*

IEC 60068-2-30, *Environmental testing – Part 2-30: Tests – Test dB : Damp heat, cyclic (12 h + 12 hour cycle)*

IEC 60068-2-45:1980, *Environmental testing – Part 2: Tests – Test XA and guidance: Immersion in cleaning solvents*
Amendment 1 (1993)

IEC 60068-2-58, *Environmental testing – Part 2-58: Tests – Test Td: Test methods for solderability, resistance to dissolution of metallization and to soldering heat of surface mounting devices (SMD)*

IEC 60068-2-78, *Environmental testing – Part 2-78 – Test Cab: Damp heat, steady state*

IEC 60410, *Sampling plans and procedures for inspection by attributes*

IEC 60617, *Graphical symbols for diagrams*

IEC 60915, *Capacitors and resistors for use in electronic equipment – Preferred dimensions of shaft ends, bushes and for the mounting of single-hole, bush-mounted, shaft-operated electronic components*

IEC 61249-2-7, *Materials for printed boards and other interconnecting structures – Part 2-7: Reinforced base materials clad and unclad – Epoxide woven E-glass laminated sheet of defined flammability (vertical burning test), copper-clad*

IECQ 001002-3, *IEC Quality Assessment System for Electronic Components (IECQ) – Rules of procedure – Part 3: Approval procedures*

IECQ 001005, see www.iecq.org/certificates for relevant information

ISO 1000, *SI units and recommendations for the use of their multiples and of certain other units*

ISO 9000, *Quality management systems – Fundamentals and vocabulary*

2 Technical data

2.1 Units and symbols

Units, graphical symbols and letter symbols should, whenever possible, be taken from the following publications:

- IEC 60027-1;
- IEC 60050;
- IEC 60617;
- ISO 1000.

When further items are required they should be derived in accordance with the principles of the publications listed above.

2.2 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

2.2.1

type

group of components having similar design features and the similarity of whose manufacturing techniques enables them to be grouped together for quality conformance inspection. They are generally covered by a single detail specification

NOTE 1 Components described in several detail specifications may, in some cases, be considered as belonging to the same type and may therefore be grouped for quality assessment purpose.

NOTE 2 Mounting accessories are ignored provided they have no significant effect upon the test results.

NOTE 3 Ratings are to be given in the detail specification.

2.2.2

style

subdivision of a type, generally based on dimensional factors, which may include several variants, generally of a mechanical order

2.2.3

grade

term indicating additional general characteristics concerning the intended application, for example, long-life applications which may only be used in combination with one or more words (for example, long-life grade) and not by a single letter or number. Figures to be added after the term “grade” should be Arabic numerals

2.2.4

variant

subdivision within a style having specific dimensions for some part of its construction, for example, terminals, shaft flats or length (see Annex F)

2.2.5

family (of electronic components)

group of electronic components which predominantly displays a particular physical attribute and/or fulfils a defined function

2.2.6

subfamily (of electronic components)

group of components within a family manufactured by similar technological methods

2.2.7**category temperature range**

range of ambient temperatures for which the potentiometer has been designed to operate continuously; this is defined by the temperature limits of its appropriate category

2.2.8**upper category temperature**

maximum ambient temperature for which a potentiometer has been designed to operate continuously at that portion of the rated dissipation which is indicated in the category dissipation (see 2.2.13)

2.2.9**lower category temperature**

minimum ambient temperature for which a potentiometer has been designed to operate continuously

2.2.10**critical resistance**

resistance value at which the rated voltage is equal to the limiting element voltage. Below the critical resistance the maximum voltage which may be applied across the terminals of a potentiometer is the rated voltage. Above that value the maximum voltage is the limiting element voltage (see 2.2.12, 2.2.14 and 2.2.15)

2.2.11**nominal total resistance**

resistance value for which the potentiometer has been designed and which is generally marked upon the potentiometer

2.2.12**rated dissipation**

maximum allowable dissipation between terminals a and c (see 2.2.29) of a potentiometer at an ambient temperature of 70 °C under the conditions of the electrical endurance test at 70 °C which will result in a change in resistance not greater than that specified for that test

NOTE 1 In practice, the dissipation is modified by the following conditions.

NOTE 2 For high values of resistance, the limiting element voltage (see 2.2.15) may prevent the rated dissipation being attained

NOTE 3 For the dissipation at temperatures other than 70 °C, reference should be made to the rating graphs in the relevant detail specification

NOTE 4 For situations where only terminals a and b or b and c are being used and the control shaft is set at an angle less than 100 % of the effective electrical travel, the limiting moving contact current (see 2.2.17) should also be taken into account.

2.2.13**category dissipation**

maximum allowable dissipation under continuous load at an ambient temperature equal to the upper category temperature, normally expressed as a percentage of the rated dissipation

NOTE The category dissipation may be zero.

2.2.14**rated voltage**

d.c. or a.c. r.m.s. voltage calculated from the square root of the product of the nominal total resistance and the rated dissipation

NOTE At high values of resistance, the rated voltage may not be applicable because of the size and construction of the potentiometer (see 2.2.10, 2.2.12 and 2.2.15).

2.2.15**limiting element voltage**

maximum d.c. or a.c. r.m.s. voltage which may be applied across the element of a potentiometer

NOTE 1 When the term “a.c. r.m.s. voltage” is used in this specification, the peak voltage should not exceed 1,42 times the r.m.s. value.

NOTE 2 This voltage should only be applied to potentiometers when the resistance value is equal to, or higher than, the critical value.

2.2.16**insulation voltage**

maximum peak voltage under continuous operating conditions which may be applied between the potentiometer terminals and other external conducting parts connected together

NOTE The value of the insulation voltage should be not less than 1,42 times the limiting element voltage at normal air pressure. Under conditions of low air pressure, the value of the insulation voltage will be less and should be given in the detail specifications.

2.2.17**limiting moving contact current**

maximum current that may be passed between the resistance element and the moving contact

2.2.18**variation of resistance and voltage output ratio with temperature**

can be expressed either as a temperature characteristic or as a temperature coefficient as defined below

2.2.18.1**temperature characteristic of resistance**

maximum reversible variation of resistance produced over a given temperature range within the category temperature range, expressed normally as a percentage of the resistance related to a reference temperature of 20 °C

2.2.18.2**temperature coefficient of resistance (α_r)**

relative variation of resistance between two given temperatures (mean coefficient), divided by the difference in temperature producing it, preferably expressed in parts per million per °C ($10^{-6}/K$)

NOTE It should be noted that use of the term does not imply that any degree of linearity for this function, nor should any be assumed.

2.2.18.3**temperature coefficient of output ratio (α_o)**

relative variation of voltage output ratio between two given temperatures (mean coefficient) at fixed values of setting and load of the moving contact, divided by the difference in temperature producing it, preferably expressed in parts per million per °C

NOTE 1 The value of α_o may be different for different settings of the output ratio.

NOTE 2 It should be noted that the use of the term does not imply that the function exhibits any degree of linearity, nor should any be assumed.

2.2.19**visible damage**

damage which reduces the usability of the potentiometer for its intended purpose

2.2.20**potentiometer**

component for use as a voltage divider with three terminals of which two are connected to the ends of a resistive element and the third is connected to a moving contact which can be moved mechanically along the resistive element

2.2.21**pre-set or trimmer (or trimming) potentiometer**

potentiometer designed for relatively infrequent adjustment

2.2.22**lead-screw actuated potentiometer**

potentiometer having a lead-screw as multi-turn actuating device

2.2.23**ganged potentiometers**

potentiometers consisting of two or more sections operated by a common operating shaft. The number of sections shall be included in the description, for example, 2-ganged potentiometer or 4-ganged potentiometer

2.2.24**dual concentric potentiometers**

potentiometers consisting of two sections operated independently by concentric operating shafts

2.2.25**shaft-sealed potentiometer**

potentiometer in which a shaft seal is provided to prevent particles and fluid from passing from the exterior of the potentiometer to the interior by way of the shaft bearing (see Figure 1)

2.2.26**shaft-sealed and panel-sealed potentiometer**

potentiometer in which a shaft seal and a panel seal are provided to prevent particles and fluid from entering any equipment in which this potentiometer is mounted (see Figure 2)

2.2.27**fully sealed potentiometer**

potentiometer in which a shaft seal is provided and the housing of the potentiometer is designed to prevent particles and fluid from passing from the exterior of the potentiometer to the interior (see Figure 3)

In some cases a panel seal may additionally be provided.

Such a potentiometer is called a “fully sealed potentiometer” (see Figure 3).

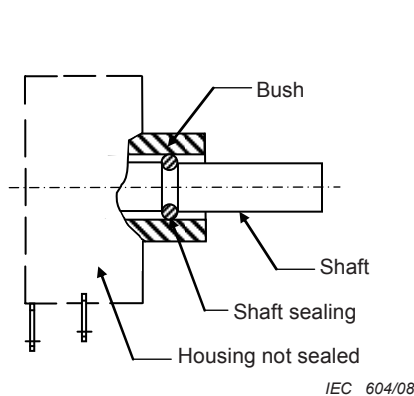


Figure 1 – Shaft-sealed potentiometer

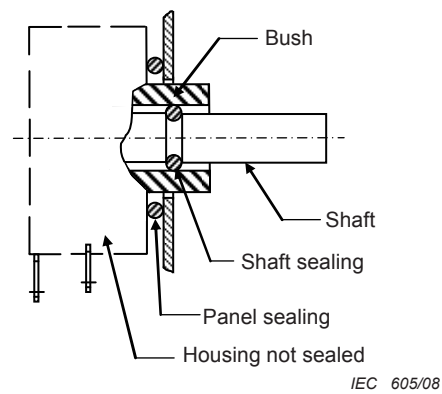


Figure 2 – Shaft- and panel-sealed potentiometer

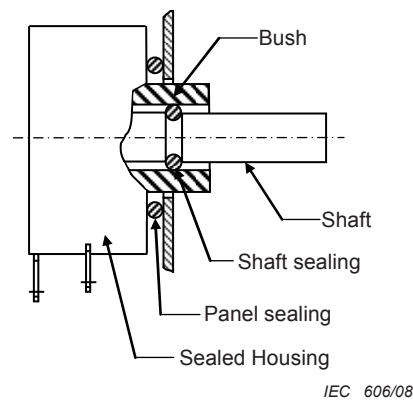


Figure 3 – Fully sealed potentiometer

2.2.28

direction of rotation

defined as clockwise or counter-clockwise when viewing the face of the potentiometer which includes the means of actuation (see Annex G). When doubt exists, the reference face shall be marked in accordance with the detail specification

2.2.29

designation of terminals

preferred designation of the three terminals of the potentiometer is:

- a is the end terminal electrically nearest to the moving contact with the shaft set fully counter-clockwise as defined in 2.2.28;
- b is the terminal of the moving contact;
- c is the other end terminal.

NOTE The numerals 1, 2 and 3, or colours yellow, red and green, may be used as alternatives to a, b and c, respectively. When terminals are marked, the marking should be in accordance with this clause. Additional letters, numbers or colours for other terminals should be allocated in the relevant specification.

2.2.30

variable resistor (two terminals)

variable resistor for use as a current controller with two terminals, one of which being connected to one end of the resistive element and the second to moving contact which can be moved along the resistive element, causing a change in resistance (see 2.2.31)

2.2.31**moving contact (or wiper)**

contact of the potentiometer which moves along the resistive element

2.2.32**tap**

fixed electrical connection made to the resistive element

2.2.32.1**current tap**

electrical connection fixed to the resistive element which is capable of carrying rated element current and may distort the output characteristic

NOTE Current taps on non-wire-wound potentiometers commonly have significant width but low resistance. See 2.2.48.18.

2.2.32.2**voltage tap**

electrical connection fixed to the resistive element which introduces no significant distortion in the output characteristic, usually having significant tap resistance and not being capable of carrying rated element current

NOTE The distinction between current and voltage taps basically applies to taps on non-wire-wound potentiometers. Most taps on wire-wound potentiometers are attached to one turn of wire and can carry rated element current. They do not usually have an effect on resolution or output characteristics.

2.2.33**track**

contact path of the moving contact on the resistive element

2.2.34**stop-clutch device**

device which allows continuous rotation of the actuating device after the moving contact has reached either end of the resistive element

2.2.35**number of turns** (of an actuating device)

total number of times the actuating device completes (or nearly completes) 360° of movement in covering the total mechanical travel

2.2.36**resistance law**

relationship of measured resistance value between terminals a and b or of the output ratio

$\frac{U_{ab}}{U_{ac}}$ to the mechanical position of the moving contact

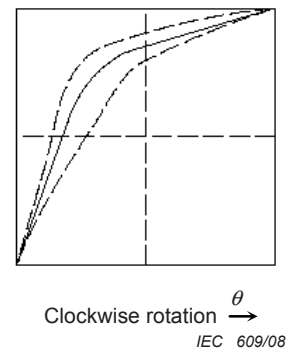
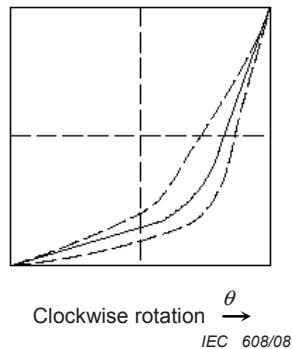
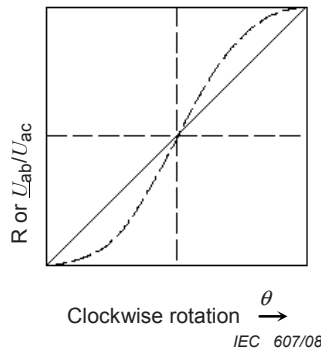
2.2.36.1**common potentiometer laws and classification**

linear resistance law is one having a constant change of resistance or output ratio with angular rotation; non-linear resistance law is one having a variation or lack of constancy in the change of resistance with angular rotation. The resistance law shall conform in general shape to the nominal curves shown in Figure 4 to Figure 6, as applicable

- a) Linear law, see Figure 4;
- b) Logarithmic law, see Figure 5;
- c) Inverse logarithmic law, see Figure 6.

Resistance measurements shall fall within a specified percent of the nominal values shown by the curves at the specified angle of 50 % of electrical rotation.

Examples of common potentiometer law are shown in Annex G of this standard. The sectional or detail specifications may permit, and prescribe the tolerances for, a rate of change of resistance near to the end of the effective travel less than that required by the prescribed law. It may also permit, and prescribe the tolerances for, approximations to the law of the form shown dotted in Figures 4 and 6.



Key

Θ Angle of rotation (clockwise)

Figure 4 – Linear law

Figure 5 – Logarithmic law

Figure 6 – Inverse logarithmic law

2.2.36.2

other potentiometer law

laws other than the widely used laws listed in 2.3.36.1 (for example, sine or cosine) may be required for special applications. The law will then be prescribed in the sectional or detail specification

2.2.37

cycle of operation

cycle of operation, for single and multi-turn potentiometers, which is defined as the travel of the moving contact from one end of the resistive element to the other and back. For continuously rotating potentiometers, a cycle of operation is defined as two revolutions of 360° , in the same direction, of the moving contact

2.2.38

shorted-segment

portion of the resistive element, over which the output ratio remains constant within specified limits as the moving contact traverses the segment with a specified load resistance

2.2.39

terminal resistance

minimum resistance which can be obtained between the terminal connected to the moving contact b and any other terminal a or c; see 2.2.29

2.2.40

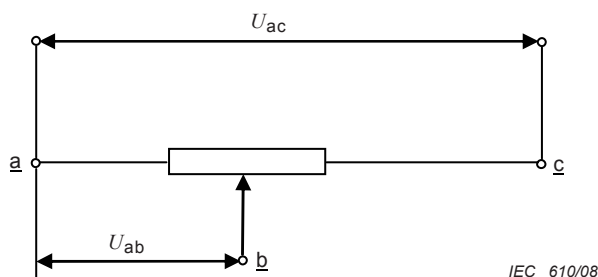
residual resistance

resistance obtained between the end terminal, a or c and the terminal of the moving contact b, when the moving contact is set against the relevant end stop; see 2.2.29

NOTE When there is no sharp change of resistance between the end stop and the point where the minimum effective resistance is observed, the residual resistance, the terminal resistance and the minimum effective resistance become the same. The lowest resistance value need not correspond with the mechanical end stop.

2.2.41**load resistance (R_L)** (see Figure 8)external resistance as seen by the output voltage (connected between the moving contact and either terminal a or c)**2.2.42****total applied voltage (U_{ac})** (see Figure 7)voltage applied between input terminals, for example, the voltage applied between input terminations a and c**2.2.43****output voltage (U_{ab})** (see Figure 7)voltage between terminal b and the specified reference point. Unless otherwise specified, the specified reference point is terminal a**2.2.44****output ratio** (see Figure 7)ratio of the output voltage U_{ab} to the total applied voltage U_{ac} normally expressed as a percentage of the total applied voltage

$$\text{Output ratio} = \frac{U_{ab}}{U_{ac}}$$

**Figure 7 – Output ratio****2.2.45****minimum output ratio**

ratio of the minimum voltage value which can be obtained between the moving contact terminal and one or other of the end terminals to a fixed voltage applied between the end terminals

2.2.46**attenuation**

reciprocal of the output ratio normally expressed as:

$$20 \log \frac{U_{ac}}{U_{ab}} \text{ dB}$$

2.2.47**loading error** (see Figure 8)

difference between the output ratio with an infinite load resistance and the output ratio with a specified finite load resistance at any shaft position as long as it is the same position for both output ratio measurements

NOTE Minimizing the loading error, by compensating the resistive element to give the desired output with a specified load resistance, is referred to as "load compensation".

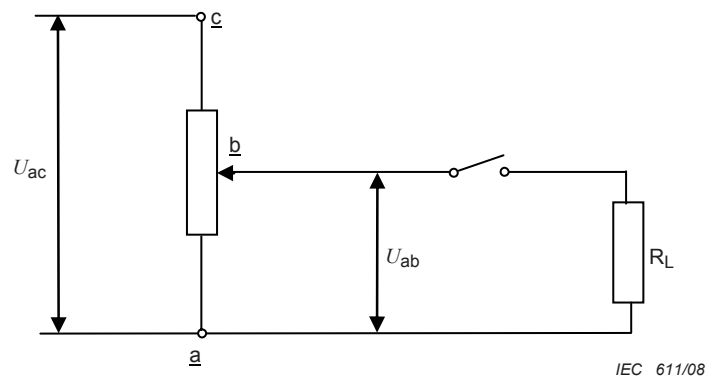


Figure 8 – Loading error

2.2.48

resistance/travel (or angle-of-rotation) relationships

relationships applying to two general constructions:

- potentiometers fitted with end stops or with stop-clutch devices;
- single-turn rotary potentiometers not fitted with end stops or stop-clutch devices.

The amount of travel may be expressed in degrees, number of turns or millimetres. For other constructions the detail specification shall redefine the terms or definitions

NOTE The alternative terms given in parentheses in 2.2.48.1, 2.2.48.3 and 2.2.48.4 are included for information only.

2.2.48.1

total mechanical travel (or angle of rotation) (see Figure 9)

in a) above, the total mechanical travel is the value of the movement of the actuating device while the moving contact traverses the whole of its function between the two end stops or the two positions at which the declutching device operates. In b) above, the total mechanical travel is 360° (continuous)

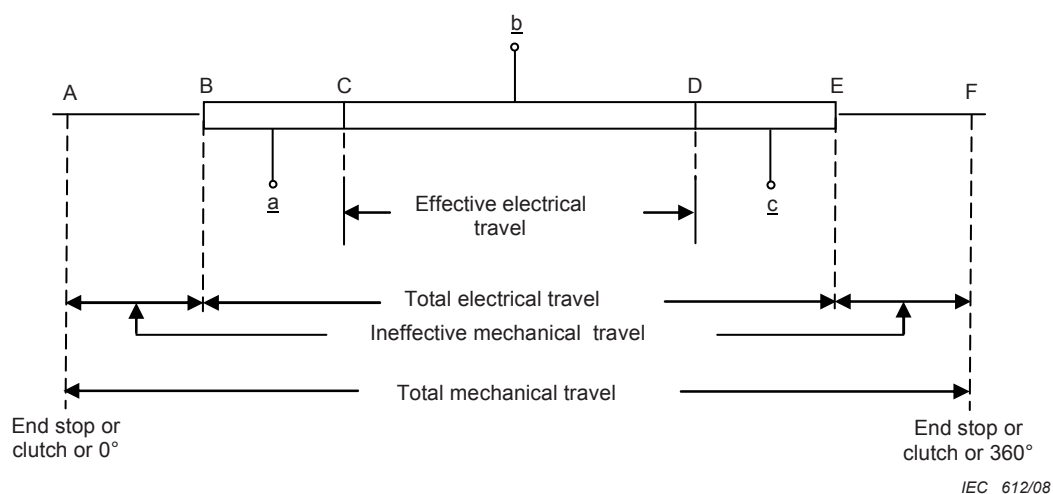


Figure 9 – Total mechanical travel (or angle of rotation)

2.2.48.2**total electrical travel** (see Figure 9)

amount of travel of the actuating device between two end positions during which there should not normally be any interruption in contact between the moving contact and the resistive element

NOTE In a) above, the end positions usually coincide with the end stops or the positions at which the declutching device operates, and the total electrical travel is therefore the same as the total mechanical travel.

2.2.48.3**effective electrical travel (angle of rotation)**

amount of travel of the actuating device necessary to move the moving contact in such a manner that the resistance changes as prescribed by the specified resistance law

NOTE For some constructions of potentiometer, the effective electrical travel may be the same as the total electrical travel.

2.2.48.4**ineffective mechanical travel (angle of rotation)** (see Figure 9)

part of the mechanical travel where the continuity between the moving contact and the resistance element cannot be guaranteed. It is equal to the difference between the total mechanical travel and the total electrical travel

2.2.48.5**total resistance**

total resistance is the resistance between terminals a and c (R_{ac}) when measured as described in 4.6

2.2.48.6**effective resistance**

portion of the total resistance over which the resistance changes in the manner prescribed by the specified resistance law

2.2.48.7**minimum effective resistance**

resistance value, at each end of the effective electrical travel, between terminal b and the nearer end terminal a or c (see 4.4.6), normally expressed as a percentage of the total resistance

2.2.48.8**continuity**

maintenance of electrical contact between the moving contact and the resistive element as a function of the mechanical travel of the moving contact

2.2.48.9**conformity** (see Figure 10)

maximum measured difference between the actual and specified resistance law when it is expressed as a percentage of total resistance or total voltage applied

NOTE Conformity may be expressed in different ways and should be clearly specified in the detail specification. Some methods of expressing conformity are shown in the following subclauses.

$$\text{Output ratio } \frac{U_{ab}}{U_{ac}}$$

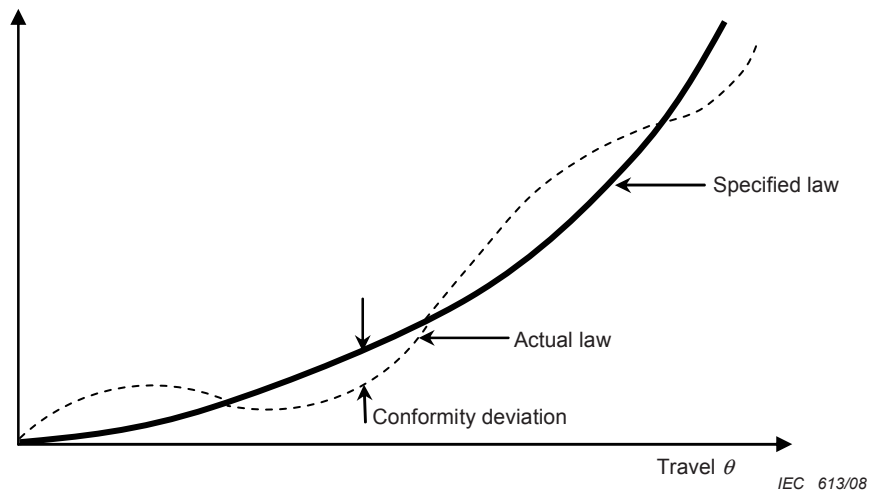


Figure 10 – Conformity

2.2.48.10**absolute conformity** (see Figure 11)

conformity measured over the specified effective electrical travel and expressed as the maximum deviation of the actual from the specified resistance law

$$\text{Output ratio } \frac{U_{ab}}{U_{ac}}$$

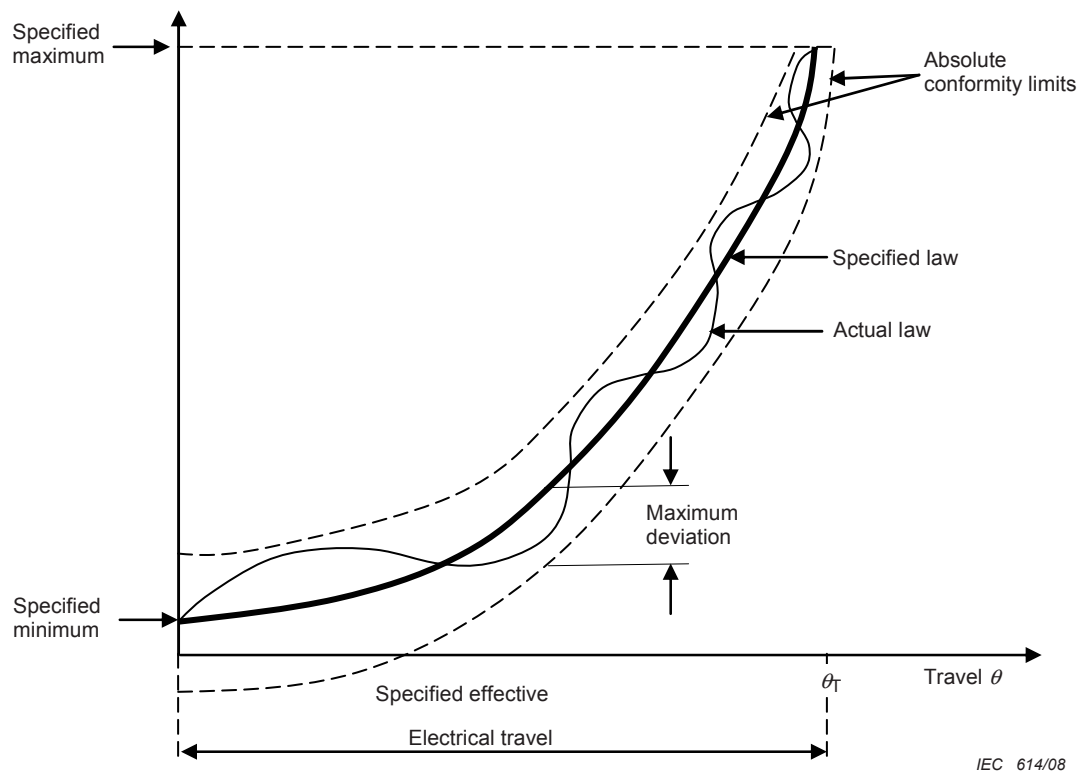
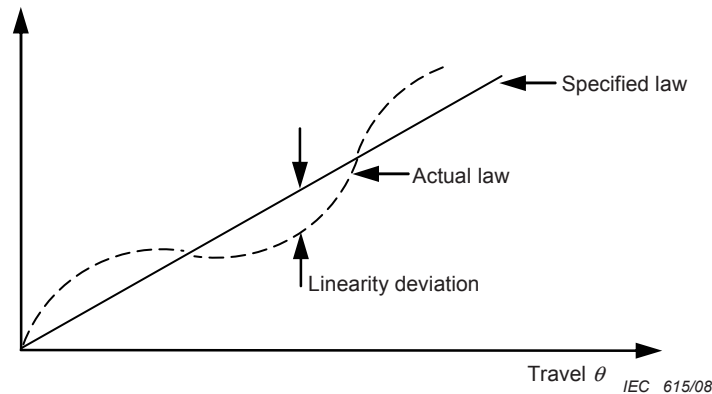


Figure 11 – Absolute conformity

2.2.48.11**linearity** (see Figure 12)

specific type of conformity when the specified law or output ratio is shown as a straight line

$$\text{Output ratio } \frac{U_{ab}}{U_{ac}}$$

**Figure 12 – Linearity****2.2.48.12****independent linearity (best straight line)** (see Figure 13)

specific type of conformity when the maximum vertical deviation, expressed as a percentage of the total applied voltage, of the actual law from a straight reference line with its slope and position is chosen to minimize deviations over the effective electrical travel or any specified portion thereof

NOTE Requirements for minimum and maximum output ratio, when specified, will limit the slope and position of the reference line.

$$\text{Mathematically: } \frac{U_{ab}}{U_{ac}} = P \left(\frac{\theta}{\theta_A} \right) + Q \pm C$$

where

P is the unspecified slope;

Q is the unspecified intercept at $\theta = 0$;

P and Q are chosen to minimize C but are limited by the output ratio requirement;

 θ_A is the amount of effective electrical travel.

$$\text{Output ratio } \frac{U_{ab}}{U_{ac}}$$

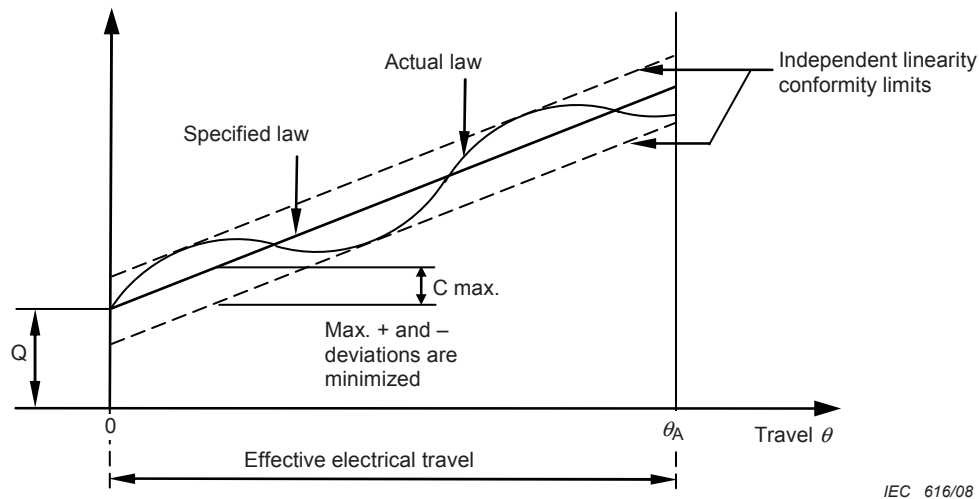


Figure 13 – Independent linearity

2.2.48.13**zero-based linearity (for wirewound potentiometers only)** (see Figure 14)

specific type of conformity when the maximum vertical deviation, expressed as a percentage of total applied voltage, of the actual law from a straight reference line drawn through the specified minimum output ratio extended over the effective electrical travel, with its slope chosen to minimize the maximum deviations. Any specified requirement for maximum output ratio may limit the possibility to change the slope of the reference line. Unless otherwise specified, the specified minimum output ratio will be zero

Mathematically:
$$\frac{U_{ab}}{U_{ac}} = P \left(\frac{\theta}{\theta_A} \right) + B \pm C$$

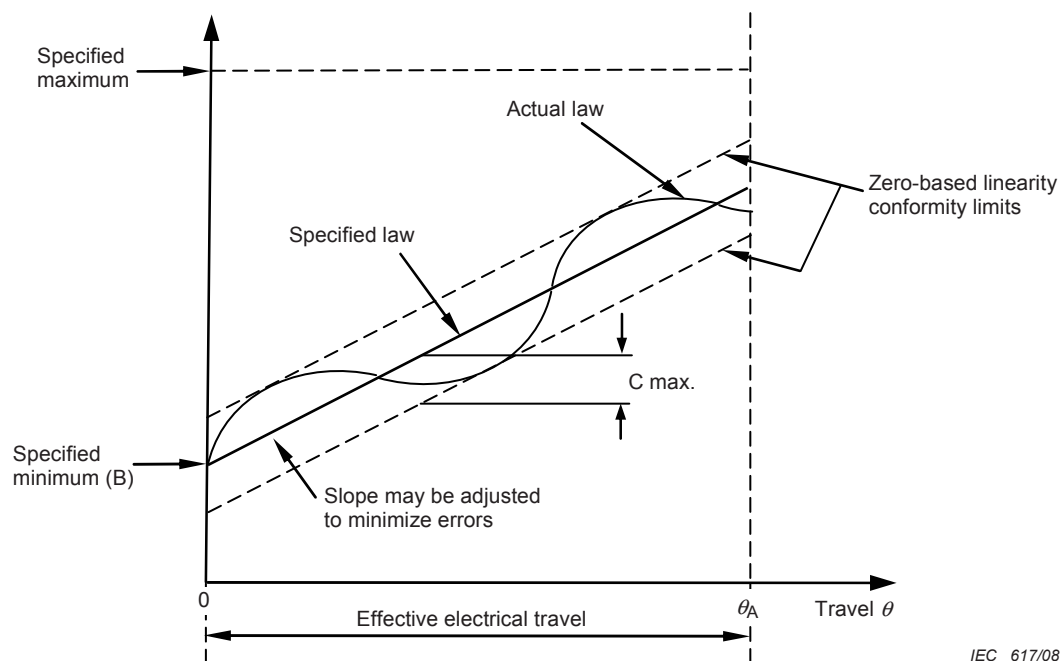
where

P is the unspecified slope limited by the end voltage requirement at the maximum output ratio end;

θ_A is the amount of effective electrical travel.

Unless otherwise specified $B = 0$

Output ratio
$$\frac{U_{ab}}{U_{ac}}$$



IEC 617/08

Figure 14 – Zero-based linearity

2.2.48.14**absolute linearity** (see Figure 15)

specific type of conformity where the maximum vertical deviation, expressed as a percentage of the total applied voltage, of the actual law from a straight reference line drawn through the specified minimum and maximum output ratios which are separated by the specified effective electrical travel. Unless otherwise specified, minimum and maximum output ratios are respectively zero and 100 % of the total applied voltage

Mathematically:
$$\frac{U_{ab}}{U_{ac}} = A \left(\frac{\theta}{\theta_T} \right) + B \pm C$$

where

- A is the given slope;
- B is the given intercept at $\theta = 0$;
- θ_T is the total specified effective electrical travel.

Unless otherwise specified, $A = 1$ and $B = 0$.

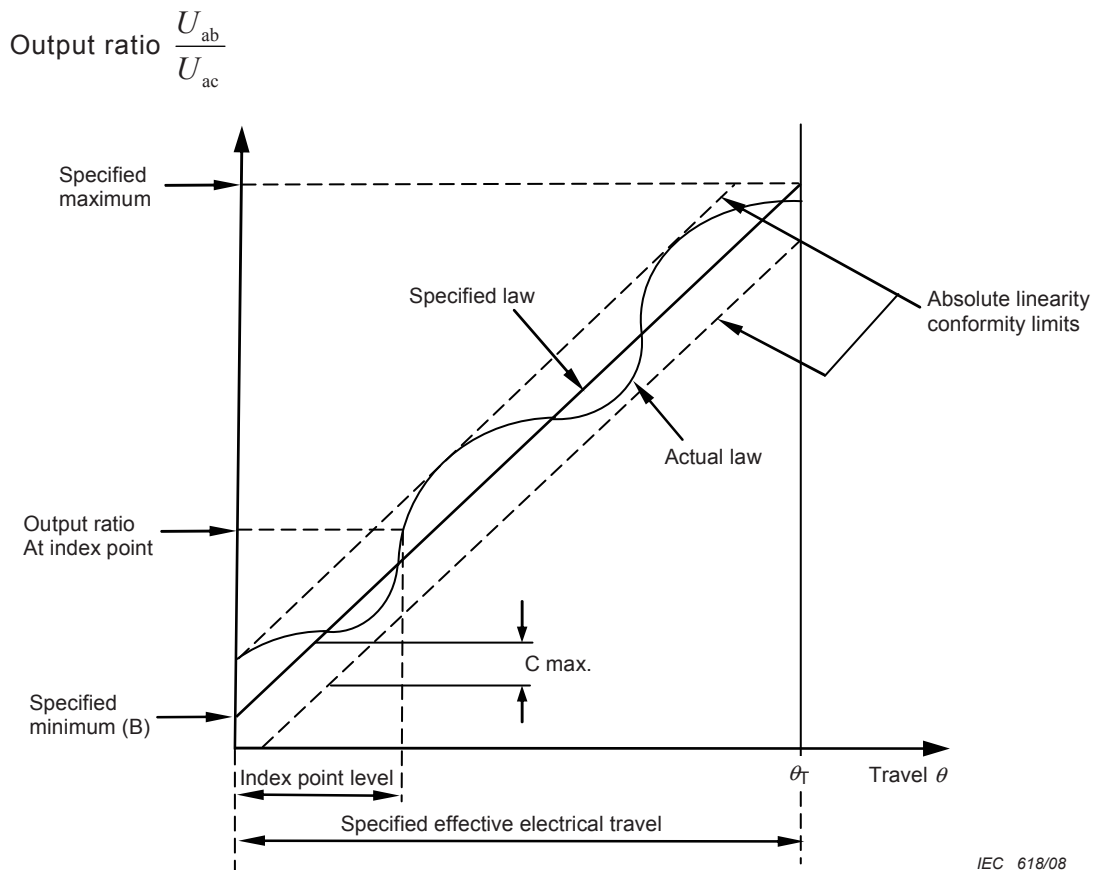


Figure 15 – Absolute linearity

2.2.48.15**terminal based linearity (for wirewound potentiometer only)** (see Figure 16)

specific type of conformity where the maximum vertical deviation, expressed as a percentage of the total applied voltage, of the actual law from a straight reference line drawn through the specified minimum and maximum output ratios which are separated by the effective electrical travel. Unless otherwise specified, minimum and maximum output ratios are respectively, zero and 100 % of total applied voltage

$$\text{Mathematically: } \frac{U_{ab}}{U_{ac}} = A \left(\frac{\theta}{\theta_A} \right) + B \pm C$$

where

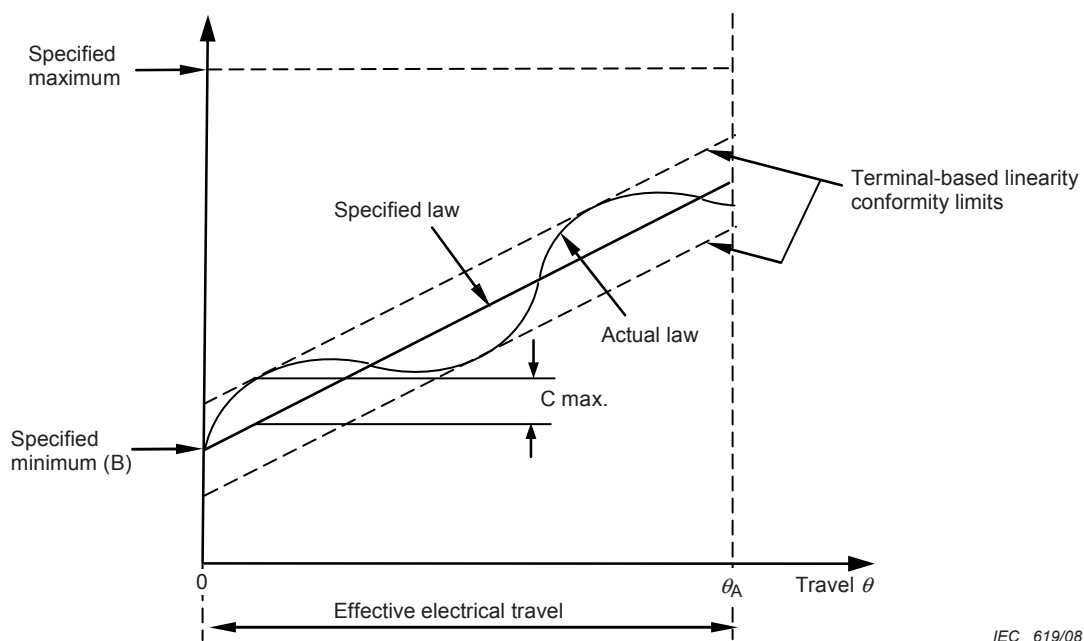
A is the given slope;

B is the given intercept at $\theta = 0$;

θ_A is the amount of effective electrical travel.

Unless otherwise specified $A = 1$ and $B = 0$.

$$\text{Output ratio } \frac{U_{ab}}{U_{ac}}$$



IEC 619/08

Figure 16 – Terminal based linearity

2.2.48.16**index point A**

point of reference, fixing the relationship between a specified actuating device position and the output ratio, and used to establish an actuating device position reference

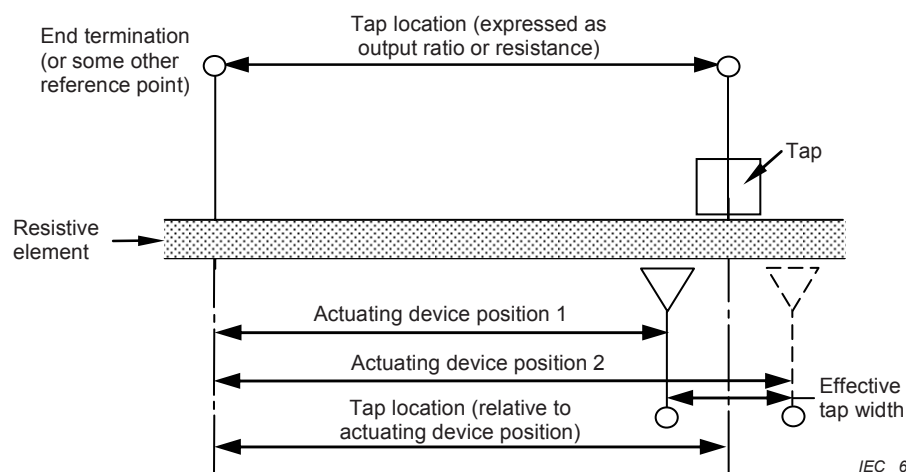
2.2.48.17**tap location**

position of a tap relative to some reference

NOTE This is commonly expressed in terms of resistance, output ratio or actuating device position. When an actuating device position is specified, the tap position is the centre of the effective tap width.

2.2.48.18**effective tap width** (see Figure 17)

travel of the actuating device, during which the voltages at the moving contact terminal $\underline{b}$ and the tap connection are essentially the same as the moving contact is moved past the tap in one direction



IEC 620/08

Figure 17 – Effective tap width

2.2.48.19 (see also 2.2.48.27)**phasing**

relative alignment of the phasing points of each section of a ganged potentiometer

NOTE Unless otherwise specified, phasing requirements apply to a single specified phasing point in each section, and all selections are aligned to the phasing point of the first section.

2.2.48.20**phasing point**

point of reference on each section to describe the relative alignment of the sections of a ganged potentiometer with respect to the position of the moving contacts

2.2.48.21**rotational noise**

any spurious variation in the electrical output not present in the input, when moving the moving contact and caused by contact resistance variation

2.2.48.22**contact resistance variation (CRV)**

change of the resistance between the resistive element and the moving contact when the moving contact is energized with specified current and moved over the adjustment travel in either direction at defined speed

2.2.48.23**equivalent noise resistance (ENR)**

spurious variation in the electrical output not present in the input, defined quantitatively in terms of the equivalent parasitic, transient resistance in ohms, appearing between the moving contact and the resistive element when the operating shaft is rotated or moved

2.2.48.24**output smoothness (for non-wire-wound types only)**

spurious variation in the electrical output not present in the input. Output smoothness includes effects of contact resistance variations, resolution, and other micro-non-linearities in the output. It is expressed as a percentage of the total applied voltage and measured for specified travel increments over the effective electrical travel

2.2.48.25**setting ability or adjustability (including resolution)**

precision with which the resistance or output voltage ratio of a potentiometer can be set to the desired value. It is normally expressed as a percentage of the total resistance.

NOTE A small incremental adjustment in the wire-wound type does not always produce the expected change in output as the moving contact moves off one turn of wire onto another.

2.2.48.26**theoretical resolution (for wire-wound types only)**

reciprocal of the number of turns of wire in the resistance winding in the effective electrical travel and is expressed as a percentage. This term is used in the description of wire-wound potentiometers and is a measure of sensitivity to which the output ratio of the potentiometer may be set

2.2.48.27**simultaneous conformity phasing**

relative alignment of the sections of a ganged potentiometer, from a common reference point, such that the output ratios of all sections fall within their respective conformity limits over the effective electrical travel

2.2.48.28**backlash** (see Figure 18)

maximum difference in the actuating device position that occurs when it is moved to the same actual output ratio point from opposite directions

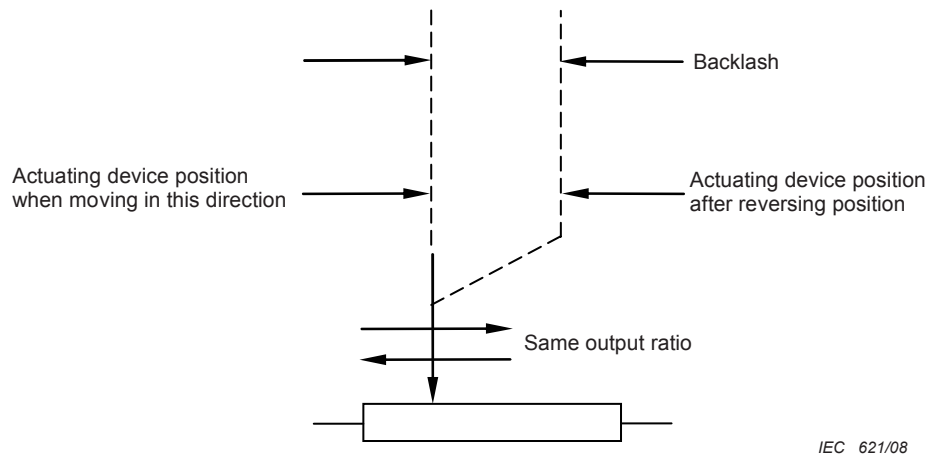


Figure 18 – Backlash

2.2.48.29**dither**

movement of the operating shaft to simulate conditions which may occur in servo systems

2.2.48.30**microlinearity**

relative change of linearity deviation (see 2.2.48.12) measured for small travel increments and expressed as a percentage of the applied voltage

2.2.48.31**setting stability**

refers to the ability of the potentiometer (mainly preset) to remain at the desired setting

NOTE 1 Setting stability may be affected by high temperature exposure, change of temperature, humidity and mechanical shock or vibration.

NOTE 2 The difference of voltage or resistance between the initial measurement made before the environmental test and the measurement made after the test indicates the setting stability in per cent.

2.2.49**rotary potentiometer** (single-turn or multi-turn)

potentiometer which is actuated by an axial shaft perpendicular to the direction of rotation and which may be operated frequently to adjust voltage or resistance values

2.2.50**power potentiometer**

potentiometer having a resistive element which is designed and constructed for high internal temperature rise and heat transfer capability

2.2.51**precision potentiometer**

potentiometer in which the output voltage or resistance law meets a precisely defined law as a function of the position of the actuating device

2.2.52**slide potentiometer**

potentiometer which is actuated by a rectilinear movement of an actuator and may be operated frequently to adjust voltage or resistance values

2.2.53**surface mount potentiometer**

potentiometer whose small dimensions and nature or shape of terminals make it suitable for use in hybrid circuits and on printed boards

2.3 Preferred values**2.3.1 General**

Each sectional specification shall prescribe the preferred values appropriate to the sub-family; for nominal total resistance, see also 2.3.2.

2.3.2 Preferred values of nominal total resistance

The preferred values of nominal total resistance shall be taken from the series specified in IEC 60063 and/or 1, 2, 5 series.

2.4 Marking**2.4.1 General**

Any marking used on the potentiometers or their packages shall be in conformity with that given in the relevant sectional specification.

The order of priority for marking small potentiometers shall be specified.

2.4.2 Coding

When coding is used for resistance value, tolerance or date of manufacture, the method shall be selected from those given in IEC 60062.

3 Assessment procedures

When this standard and related standards are used for the purpose of a full quality assessment system such as the IEC Quality Assessment System for Electronic Components (IECQ), the relevant clauses of Annex H apply.

NOTE Section 3 of the previous edition has been moved to Annex H. To maintain reference to the previous editions of this standard, the clause numbers of Section 3 have been converted into the clause numbers of Annex H as shown by the following example:

Clause 3.1 -> Clause H.1
Clause 3.1.2 -> Subclause H.1.2

4 Test and measurement procedures**4.1 General**

The sectional and/or blank detail specifications shall contain tables showing the tests to be made, which measurements are to be made before and after each test or subgroup of tests, and the sequence in which they shall be carried out. The stages of each test shall be carried out in the order written. The measuring conditions shall be the same for initial and final measurements.

If national standards within any quality assessment system include methods other than those specified in the above documents, these methods shall be fully described.

The issue and amendment status of any IEC 60068 test in this section is given in 1.2.

4.2 Standard atmospheric conditions

4.2.1 Standard atmospheric conditions for testing

Unless otherwise specified, all tests and measurements shall be made under standard atmospheric conditions for testing as given in 5.3 of IEC 60068-1:

Temperature:	15 °C to 35 °C
Relative humidity:	25 % to 75 %
Air pressure:	86 kPa to 106 kPa

Before the measurements are made, the potentiometer shall be stored at the measuring temperature for a time sufficient to allow the entire potentiometer to reach this temperature. The same period as is prescribed for recovery at the end of a test is normally sufficient for this purpose.

When measurements are made at a temperature other than the specified temperature, the results shall, when necessary, be corrected to the specified temperature. The ambient temperature during the measurements shall be stated in the test report. In the event of a dispute, the measurements shall be repeated using one of the referee temperatures (as given in 4.2.3) and such other conditions as are prescribed in this specification.

When tests are conducted in a sequence, the final measurements of one test may be taken as the initial measurements for the succeeding test.

NOTE During measurements, the potentiometer should not be exposed to draughts, direct sunlight or other influences likely to cause error.

4.2.2 Recovery conditions

Unless otherwise specified, recovery shall take place under the standard atmospheric conditions for testing (see 4.2.1). If recovery shall be made under closely controlled conditions, the standard recovery conditions of 5.4.1 of IEC 60068-1 shall be used.

4.2.3 Referee conditions

For referee purposes one of the standard atmospheric conditions for referee tests taken from 5.2 of IEC 60068-1, as given in Table 1, shall be chosen.

Table 1 – Standard atmospheric conditions

Temperature °C	Relative humidity %	Air pressure kPa
20 ± 1	63 to 67	86 to 106
23 ± 1	48 to 52	86 to 106
25 ± 1	48 to 52	86 to 106
27 ± 1	63 to 67	86 to 106

4.2.4 Reference conditions

For reference purposes the standard atmospheric conditions for reference given in 5.1 of IEC 60068-1 apply:

Temperature: 20 °C

Air pressure: 101,3 kPa

4.3 Drying

When drying is prescribed, the potentiometer shall be conditioned before measurement is made using Procedure 1 or Procedure 2 as prescribed in the detail specification.

Procedure 1: for 24 h ± 4 h in an oven at a temperature of 55 °C ± 2 °C and at a relative humidity not exceeding 20 %

Procedure 2: for 96 h ± 4 h in an oven at 100 °C ± 5 °C

The potentiometer shall then be allowed to cool in a desiccator using a suitable desiccant, such as activated alumina or silica gel, and it shall be kept therein from the time of removal from the oven to the beginning of the specified tests.

4.4 Visual examination and check of dimensions**4.4.1 Visual examination**

The condition, workmanship and finish shall be checked by visual examination; see 2.2.19.

There shall be no visible damage.

Marking shall be legible, as checked by visual examination. It shall be in accordance with the requirements of the detail specification.

4.4.2 Dimensions (gauging)

The dimensions indicated in the detail specification as being suitable for gauging shall be checked, and shall comply with the values prescribed in the detail specification.

4.4.3 Dimensions (detail)

All dimensions prescribed in the detail specification shall be checked and shall conform to the values prescribed.

4.4.4 Total mechanical travel (see Figure 9)

The potentiometer shall be mounted for the measurement of the angular position of the actuating device.

The actuating device shall then be set so that the moving contact is at the extreme counter-clockwise end of the total mechanical travel and the angular position (A) shall be recorded.

The actuating device shall then be set so that the moving contact is at the extreme clockwise end of the total mechanical travel and the angular position (F) shall be recorded.

The total mechanical travel is given by position F – position A.

The value calculated shall be within the limits given in the detail specification.

4.4.5 Total electrical travel (see Figure 9)

While mounted for measurement of angular position a voltage not exceeding that given in 4.6.1 shall be applied to terminals a and c.

The actuating device shall be set at the approximate centre of the total mechanical travel and the electrical continuity monitored as the actuating device is turned slowly counter-clockwise until there is an interruption in contact between the moving contact and the resistance element. The angular position (B) of that interruption shall then be recorded. If no interruption occurs, record the position of the end of the mechanical travel.

The actuating device shall then be set at the approximate centre of the total mechanical travel and electrical continuity monitored as the actuating device is turned slowly clockwise until there is an interruption in contact between the moving contact and the resistance element. The angular position (E) of that interruption shall then be recorded. If no interruption occurs, record the position of the end of the mechanical travel.

The total electrical travel is given by position E – position B.

The value calculated shall be within the limits given in the detail specification.

4.4.6 Effective electrical travel (see Figure 9)

While mounted for measurement of angular position, a voltage not exceeding that given in 4.6.1 shall be applied to terminals a and c.

The actuating device shall then be set at the approximate centre of the total electrical travel and then slowly turned counter-clockwise until the output ratio $\frac{U_{ab}}{U_{ac}}$ is within 5 % of the value stated in the detail specification for the minimum effective resistance when expressed as a percentage of the total resistance. The angular position (C) shall then be recorded.

The actuating device shall then be set at the approximate centre of the total electrical travel and then slowly turned clockwise until the output ratio $\frac{U_{bc}}{U_{ac}}$ is within 5 % of the value stated in the detail specification for the minimum effective resistance when expressed as a percentage of the total resistance. The angular position (D) shall then be recorded.

NOTE If a greater accuracy is required, the 5 % tolerance on the output ratio may be reduced as stated in the detail specification.

The angle of the effective electrical travel is given by position D – position C.

The value calculated shall be within the limits give in the detail specification.

The angle of ineffective travel (counter-clockwise) is the amount of travel between position A and position C.

The angle of ineffective travel (clockwise) is the amount of travel between position F and position D.

The values calculated shall be less than those given in the detail specification.

4.5 Continuity (except for continuously rotating potentiometers)

4.5.1 The potentiometer shall be loaded in such a way that none of its ratings is exceeded throughout the measurement. The resistance variation between terminals a and b is observed whilst the shaft or lead-screw is operated steadily in each direction at a rate of 2 to 5 cycles (see 2.2.37) per minute.

The resistance variation between terminations a and b shall be reasonably smooth and unidirectional when the shaft is rotated slowly (or the moving contact of a lead-screw actuated device is traversed slowly).

Unless otherwise specified, there shall be no electrical discontinuity when the moving contact is moved over the total electrical travel.

4.5.2 There shall be no electrical discontinuity when the clutch is acting at each end of the travel of the moving contact of potentiometers fitted with slipping clutches.

4.6 Element resistance

4.6.1 The measurement of resistance shall be made with the moving contact having been set at the end of its travel by counter-clockwise rotation of the actuating device (see note in 4.6.2).

The resistance shall be measured using a direct voltage of small magnitude applied for as short a time as practicable, in order that the temperature of the resistance element shall not rise appreciably during measurement.

In the event of conflicting results, attributable to such test voltages, the voltage specified in the table shall be used for referee purposes.

Table 2 – Measuring voltages

Nominal total resistance R	Measuring voltage $V \begin{smallmatrix} +0 \\ -10 \end{smallmatrix} \%$
<10 Ω	0,1 (see NOTE 1)
10 to 99 Ω	0,3
100 to 999 Ω	1
1 000 to 9 999 Ω	3
10 000 to 99 999 Ω	10
100 000 to 999 999 Ω	25
≥ 1 M Ω	50
NOTE 1 When the nominal total resistance is less than 10 Ω , the measuring voltage should be so chosen that the potentiometer dissipates less than 10 % of its rated dissipation, but does not exceed 0,1 V.	
NOTE 2 When using the digital ohmmeter including multi-meter, the measuring voltages in Table 2 should be maximum value.	