BS EN IEC 62812:2019

BSI Standards Publication

Low resistance measurements — Methods and guidance

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National foreword

This British Standard is the UK implementation of EN IEC 62812:2019. It is identical to IEC 62812:2019, incorporating corrigendum March 2020.

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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Compliance with a British Standard cannot confer immunity from legal obligations.

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Amendments/corrigenda issued since publication

Date	Text affected
31 March 2020	Implementation of IEC corrigendum February 2020: Section 5.4, second paragraph and Figure 11 diagram key corrected

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EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN IEC 62812

July 2019

ICS 31.040.01

English Version

Low resistance measurements - Methods and guidance (IEC 62812:2019)

Mesures de faibles résistances - Méthodes et recommandations (IEC 62812:2019)

Messung niederohmiger Widerstände - Verfahren und Leitfaden (IEC 62812:2019)

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European foreword

The text of document 40/2665/FDIS, future edition 1 of IEC 62812, prepared by IEC/TC 40 "Capacitors and resistors for electronic equipment" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN IEC 62812:2019.

The following dates are fixed:

- latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2020-03-06
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2022-06-06

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The text of the International Standard IEC 62812:2019 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 60115-2	NOTE	Harmonized as EN 60115-2
IEC 60115-8	NOTE	Harmonized as EN 60115-8
IEC 60301	NOTE	Harmonized as EN 60301
IEC 61249-5-1	NOTE	Harmonized as EN 61249-5-1

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Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

NOTE 1 Where 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.

Publication	Year	Title	EN/HD	Year
IEC 60068-1	-	Environmental testing - Part 1: General and guidance	EN 60068-1	-
IEC 60115-1 (mod)	2008	Fixed resistors for use in electronic equipment - Part 1: Generic specification	EN 60115-1	2011
-	-		+ A11	2015
IEC 60294	-	Measurement of the dimensions of a cylindrical component with axial terminations	EN 60294	-

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INTERNATIONAL STANDARD

NORME INTERNATIONALE

Low resistance measurements – Methods and guidance

Mesures de faibles résistances – Méthodes et recommandations

INTERNATIONAL
ELECTROTECHNICAL
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CONTENTS

FOREWORD 4
1 Scope 6
2 Normative references 6
3 Terms and definitions 6
4 Resistance measurement phenomena 7
4.1 General 7
4.2 Lead and contact resistance 7
4.3 Self-heating 9
4.4 Variation of resistance with temperature 10
4.5 Thermoelectric e.m.f. 12
4.6 Peltier effect 15
5 Methods of measurement 16
5.1 General 16
5.2 Four-wire resistance measurement 16
5.3 Offset compensation method 19
5.4 Current inversion method 22
5.5 Differential current inversion method 25
5.6 Short-term trigger method 28
6 Connecting the specimen 32
6.1 Resistors with lead wires for soldered assembly 32
6.1.1 Connecting leaded resistors in a test fixture 32
6.2 Resistors with solder terminations for surface mount assembly 33
6.2.1 Connecting SMD resistors on a test substrate 33
6.2.2 Connecting SMD resistors in a test fixture 35
7 Information to be given in the relevant component specification 36
Annex A (normative) Letter symbols and abbreviated terms 37
A.1 Letter symbols 37
A.2 Abbreviated terms 38
Annex B (informative) Test results of soldering pad with Kelvin connection for surface mount resistors 39
B.1 General 39
B.2 Test procedures 39
B.2.1 Test substrates 39
B.2.2 Test method 41
B.3 Measurement result and studies 42
Bibliography 45

Figure 1 – Resistance measurement using two-wire sensing 8
Figure 2 – Variation of resistance with temperature (random example) 10
Figure 3 – Resistances on a resistor with lead wires 11
Figure 4 – SMD chip resistor on a PCB 12
Figure 5 – Thermoelectric e.m.f. 13
Figure 6 – Thermocouples on a resistor with lead wires 14
Figure 7 – Resistance measurement affected by thermoelectric e.m.f. 15

AVA Documents
Document Sharing Hub

Full document details: BS EN IEC 62812:2019

Figure 8 – Four-wire resistance measurement 17
Figure 9 – Offset compensation method for resistance measurement 19
Figure 10 – Current and voltage in the offset compensation method 20
Figure 11 – Current inversion method for resistance measurement 22
Figure 12 – Current and voltage in the current inversion method 23
Figure 13 – Current and voltage in the differential current inversion method 26
Figure 14 – Example of resistor specimen 31
Figure 15 – Connecting leaded resistors in a test fixture 32
Figure 16 – Resistance of cylindrical copper lead wires 33
Figure 17 – Soldering pad of test substrate for Kelvin (four-point) connections 34
Figure 18 – Resistance of PCB conductor tracks with 35 µm copper thickness 35
Figure 19 – Example for connecting SMD resistors on a test fixture 36
Figure B.1 – Lengths of soldering pad 40
Figure B.2 – Position of voltage sense conductor 40
Figure B.3 – Thickness of the solder printing screen and position of sense line 43
Figure B.4 – Position of voltage-sensing line 43
Figure B.5 – Soldering pad length 44
Figure B.6 – Recommended soldering pad 44

Table 1 – Relative Seebeck coefficients of selected metals 13
Table A.1 – Letter symbols 37
Table B.1 – Thickness of solder printing screen 41
Table B.2 – Table of test conditions 42

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Full document details: BS EN IEC 62812:2019

INTERNATIONAL ELECTROTECHNICAL COMMISSION

LOW RESISTANCE MEASUREMENTS – METHODS AND GUIDANCE

FOREWORD

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International Standard IEC 62812 has been prepared by IEC technical committee 40: Capacitors and resistors for electronic equipment.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
40/2665/FDIS	40/2671/RVD

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

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

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The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

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

The contents of the corrigendum of March 2020 have been included in this copy.

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LOW RESISTANCE MEASUREMENTS – METHODS AND GUIDANCE

1 Scope

Resistance measurements are typically compromised by a variety of phenomena, for example serial resistance in the measurement path, self-heating or non-ohmic properties. Whether the effect of such phenomena on a resistance measurement is acceptable or not depends on the magnitude of each effect in comparison to the resistance and to the required accuracy. Hence, the risk of erroneous resistance measurements increases with decreasing resistance and with a tightening of the permissible tolerance.

This document specifies methods of measurement and associated test conditions that eliminate or reduce the influence of adverse phenomena in order to improve the attainable accuracy of low-resistance measurements.

The methods described in this document are applicable for the individual measurements of the resistance of individual resistors, and also for resistance measurements as part of a test sequence. They are applied if prescribed by a relevant component specification, or if agreed between a customer and a manufacturer.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 60068-1, *Environmental testing – Part 1: General and guidance*

IEC 60115-1:2008, *Fixed resistors for use in electronic equipment – Part 1: Generic specification*

IEC 60294, *Measurement of the dimensions of a cylindrical component with axial terminations*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60115-1 and the following apply.

A list of used letter symbols and abbreviated terms is provided in Annex A.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
electromotive force
e.m.f.
difference in potential that gives rise to an electric current

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3.2
thermoelectric e.m.f.
E_T
potential difference occurring at the junctions of dissimilar conductors when a temperature difference exists between the junctions

3.3
low resistance
resistance for which the predictable error when measured with a conventional two-wire sensing method is significant in comparison to the required precision or to the stated tolerance

3.4
four-wire sensing
Kelvin sensing
four-terminal sensing
four-point sensing
electrical impedance measuring technique using separate pairs of wires for carrying the measuring current and for sensing the potential difference in order to eliminate the impedance contribution of wiring and contact resistances

3.5
two-wire sensing
conventional electrical impedance measuring technique using one pair of wires for carrying the measuring current and for sensing the potential difference on the same wires

4 Resistance measurement phenomena

4.1 General

The measurement of a low resistance usually relies on the measurement of a low voltage, which requires a number of precautions against typical detrimental phenomena such as offset voltages, radio frequency interference, electromagnetic interference, electrical noise, or non-ohmic contacts. However, these phenomena are not discussed here as they are not specifically related to the measurement of resistance.

The voltage to be measured increases with an increase of the measuring current, which may also result in effects which are adverse to the measurement. Such phenomena are discussed in Clause 4.

4.2 Lead and contact resistance

A conventional method for measuring a resistance is to use a constant current source with a known (or measured) output current and a voltmeter for measuring the voltage across the unknown resistor, while the connection is built with a single pair of test leads, as shown in Figure 1.

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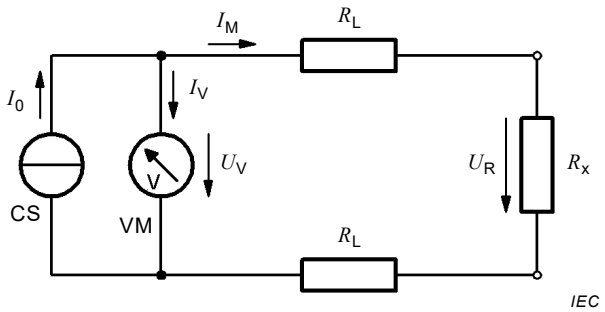

Key

CS current source

VM voltmeter, measuring voltage U_V

R_L lead resistance, including contact resistance to the specimen

R_x resistance to be measured

I_O supply current from current source

I_V current passing through the voltmeter

I_M current passing through the unknown resistor

Figure 1 – Resistance measurement using two-wire sensing

In this circuit, the source current I_0 splits up into the current I_M passing through the path with the unknown resistor and the current I_V passing through the voltmeter, where I_V depends on the measured voltage U_V and the voltmeter's impedance R_V.

$$I_0 = I_M + I_V \tag{1}$$

$$I_V = \frac{U_V}{R_V} \tag{2}$$

The voltmeter measures the following voltage drop of current I_M along both lead and contact resistances R_L, plus along the unknown resistor R_x:

$$U_V = I_M \cdot (2R_L + R_x) \tag{3}$$

This leads to the apparent result of the resistance measurement, R', based on the measured voltage U_V and the known sourced current I_0:

$$R' = \frac{U_V}{I_0} = \frac{I_M}{I_M + I_V} \cdot (2R_L + R_x) = \frac{2R_L + R_x}{1 + \frac{2R_L + R_x}{R_V}} \tag{4}$$

With $I_V \to 0$, which is the case if $R_V >> (2R_L + R_x)$, the apparent result tends towards:

$$R' = \frac{U_V}{I_0} = \frac{I_M}{I_M + 0} \cdot (2R_L + R_x) = 2R_L + R_x \tag{5}$$

This final apparent result still bears the error ΔR of

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$$\Delta R = R' - R_x = 2R_L \tag{6}$$

This error will only be negligible if ($2R_L$) << R_x, where the negligibility depends on the required accuracy for the measurement of R_x.

EXAMPLE 1 A 1 m copper wire with a cross section of 0,5 mm^2 has a resistance of 35 mΩ. Using a pair of these wires for two-wire sensing for measuring a 100 mΩ resistor results in an unacceptable error of 70 %. The current passing through the voltmeter due to its limited impedance is not likely to gain any significance on the error figure.

EXAMPLE 2 Using the same circuit for measuring a 10 Ω resistor results in 0,7 % error, while first assuming the current through the voltmeter to be zero. This 0,7 % error may be acceptable if the relative tolerance of the resistance is given as ±10 %, but not if it is only ±1 %.

Using a voltmeter in this circuit with an impedance of 1 MΩ results in only a −0,001 % additional error, which is not significant compared to the error caused by the lead wires. If the voltmeter, however, has an impedance of only 10 kΩ, the additional error is −0,1 % and thus may no longer be negligible.

EXAMPLE 3 For a resistor of 1 kΩ, measured as above, even the seemingly small error of only 0,007 % renders the described circuit useless, if it is a high precision type with, for example, a relative tolerance of ±0,01 %.

Using a voltmeter in this circuit with an impedance of 1 MΩ results in the additional error of −0,1 %. Comparing the absolute error contributions, this influence is even larger than the error caused by the lead wires.

4.3 Self-heating

The measuring current I_M passing through the unknown resistor with its resistance R_x causes dissipation of the power P_R

$$P_R = I_M^2 \cdot R_x \tag{7}$$

The dissipation P_R produces a temperature rise on the unknown resistor, which depends on the ability of the test assembly or fixture to dissipate heat to the environment, expressed as the thermal resistance R_{th}. The steady-state temperature rise $\Delta\vartheta_{R\infty}$ on the unknown resistor is

$$\Delta\vartheta_{R\infty} = R_{th} \cdot P_R \tag{8}$$

which adds to the ambient temperature next to the specimen, ϑ_{amb}, and thereby leads to the steady-state temperature $\vartheta_{R\infty}$ on the unknown resistor of

$$\vartheta_{R\infty} = \vartheta_{amb} + \Delta\vartheta_{R\infty} = \vartheta_{amb} + R_{th} \cdot P_R \tag{9}$$

NOTE The heat conduction out of the unknown resistor is considered to be a linear system for the purpose of this specification. This is based on the general observation that radiation and convection from the body of most low-power resistors only have a minor share in the total heat dissipation. A more complex consideration can be suitable for large resistors where radiation and convection from the body's surface prevail over conduction through the terminals or lead wires.

The temporal rise of the temperature $\vartheta_R(t)$ on the unknown resistor before reaching the steady state is determined by the thermal time constant τ_{th} of the unknown resistor in its test assembly or fixture:

$$\vartheta_x(t) = \vartheta_{amb} + \Delta\vartheta_{R\infty} \cdot (1 - e^{-t/\tau_{th}}) \tag{10}$$

Knowledge of the thermal time constant τ_{th} is necessary for measurements aiming at the steady state and for determination of the timing of switched measurements alike.

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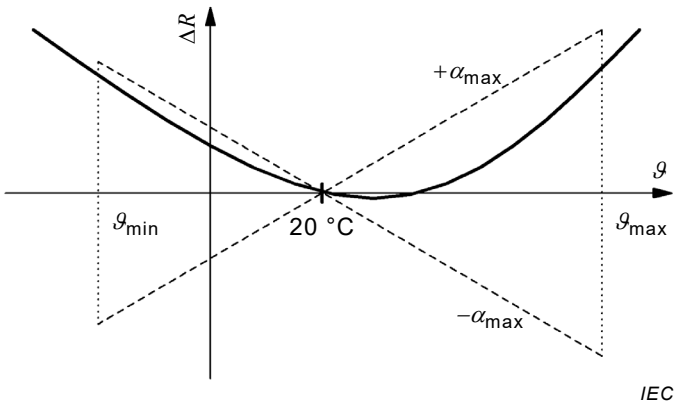
The raised temperature on the unknown resistor due to self-heating not only affects the specimen, but also spreads the heat to the test assembly or mounting and affects those parts of the measurement circuit as well. Therefore, the raised temperature will be root cause of the variation of resistance with temperature, as discussed in 4.4, and of the thermoelectric e.m.f., as discussed in 4.5.

Self-heating is decreased by reducing the measuring current I_M as much as possible while still providing the required voltage for a measurement with the desired accuracy. However, setting the measuring current is not a common feature with resistance meters. Other options to reduce the self-heating are to activate the measuring current for a short period only, as discussed in Clause 5, and of course to enhance the heat flow from the specimen and the test fixture.

4.4 Variation of resistance with temperature

One of the reference conditions prescribed in IEC 60115-1 for measuring the resistance is the reference temperature of 20 °C. For practical reasons, however, most tests and measurements are permitted to be executed under standard atmospheric conditions for testing as defined in IEC 60068-1, which includes a permissible range for the ambient temperature from 15 °C to 35 °C.

If measured with sufficient accuracy, a resistor measured at 15 °C or at 35 °C will not show the same resistance as when measured at 20 °C. In fact, there is a variation of resistance with temperature for almost every type of resistor, which typically does not follow a linear relationship. The slope and the amount of variation depend substantially on the technology and manufacturing of the resistor and in some cases also on the actual resistance.



Key

α temperature coefficient of resistance

ΔR resistance change

Figure 2 – Variation of resistance with temperature (random example)

As a specification figure for resistors, the limitation of the permissible range for such resistance variation in a given temperature range is usually given by a pair of symmetrical linear slopes through the reference point at 20 °C, $+\alpha_{max}$ and $-\alpha_{max}$ as shown in Figure 2. The value α_{max} is the absolute value of the specified temperature coefficient of resistance, or TCR.

EXAMPLE 1 Thick film chip resistors of 100 mΩ or lower are typically offered with a TCR of $500 \cdot 10^{-6}$/K or above. Measuring the resistance at 35 °C results in a possible deviation of ±0,75 % from the resistance at the reference temperature 20 °C. Such a deviation may be acceptable if the relative tolerance of the resistance is given as ±10 %, but not if it is only ±1 %.

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