BS EN 61003-1:2016

BSI Standards Publication

Industrial-process control systems — Instruments with analogue inputs and two- or multi-position outputs

Part 1: Methods for evaluating performance

bsi.

National foreword

This British Standard is the UK implementation of EN 61003-1:2016. It is identical to IEC 61003-1:2016. It supersedes BS EN 61003-1:2004 which will be withdrawn 04 November 2019.

The UK participation in its preparation was entrusted by Technical Committee GEL/65, Measurement and control, to Subcommittee GEL/65/2, Elements of systems.

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

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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EN 61003-1

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English Version

Industrial-process control systems - Instruments with analogue inputs and two- or multi-position outputs - Part 1: Methods for evaluating performance (IEC 61003-1:2016)

Systèmes de commande de processus industriels - Instruments avec entrées analogiques et sorties à deux ou plusieurs positions - Partie 1: Méthodes d'évaluation des performances (IEC 61003-1:2016)

Systeme der industriellen Prozessleittechnik - Geräte mit analogen Eingängen und Zwei- oder Mehrpunktverhalten - Teil 1: Verfahren zur Bewertung des Betriebsverhaltens (IEC 61003-1:2016)

This European Standard was approved by CENELEC on 2016-07-19. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard 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 CEN-CENELEC Management Centre or to any CENELEC member.

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

CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

European foreword

The text of document 65B/1040/FDIS, future edition 3 of IEC 61003-1, prepared by SC 65B "Measurement and control devices", of IEC/TC 65 "Industrial-process measurement, control and automation" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 61003-1:2016.

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) 2017-05-04
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2019-11-04

This document supersedes EN 61003-1:2004.

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Endorsement notice

The text of the International Standard IEC 61003-1:2016 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following note has to be added for the standard indicated :

IEC 61326-1:2012	NOTE	Harmonized as EN 61326-1:2013 (not modified).

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

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

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

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

Publication	Year	Title	EN/HD	Year
IEC 60050	series	International Electrotechnical Vocabulary (IEV)	-	-
IEC 60050-300	-	International Electrotechnical Vocabulary - Electrical and electronic measurements and measuring instruments - Part 311: General terms relating to measurements - Part 312: General terms relating to electrical measurements - Part 313: Types of electrical measuring instruments - Part 314: Specific terms according to the type of instrument	-	-
IEC 60050-351	-	International Electrotechnical Vocabulary - Part 351: Control technology	-	-
IEC 61298-1	2008	Process measurement and control devices - General methods and procedures for evaluating performance - Part 1: General considerations	EN 61298-1	2008
IEC 61298-2	2008	Process measurement and control devices - General methods and procedures for evaluating performance - Part 2: Tests under reference conditions	EN 61298-2	2008
IEC 61298-3	2008	Process measurement and control devices - General methods and procedures for evaluating performance - Part 3: Tests for the effects of influence quantities	EN 61298-3	2008
IEC 61298-4	-	Process measurement and control devices - General methods and procedures for evaluating performance - Part 4: Evaluation report content	EN 61298-4	-

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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INDUSTRIAL-PROCESS CONTROL SYSTEMS – INSTRUMENTS WITH ANALOGUE INPUTS AND TWO- OR MULTI-POSITION OUTPUTS –

Part 1: Methods for evaluating performance

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 61003-1 has been prepared by subcommittee SC 65B: Measurement and control devices, of IEC technical committee TC 65: Industrial-process measurement, control and automation.

This third edition cancels and replaces the second edition published in 2004. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) use of the term "two-position output" instead of "two-state instrument" (see 3.2);
b) use of the term "differential gap" instead of "switching differential" (see 3.4);
c) use of "fast transient/burst immunity requirements" instead of "power supply transient overvoltages", and revision of the test method (see 6.2.10);

d) deletion of 6.2.12 “common mode interference” and 6.2.13 “normal mode interference (series mode) ”tests of the previous edition;

e) use of the term “electromagnetic field” instead of “radiated electromagnetic interference”, the test method remained the same (see 6.2.16);

f) use of the term “dielectric strength” instead of “isolation test”, and revision of the reference (see 6.3.4);

g) deletion of Subclauses “8.2 Design features”, “10.1 Routine maintenance and adjustment” and “10.2 Repair” of the previous edition.

The text of this standard is based on the following documents:

FDIS	Report on voting
65B/1040/FDIS	65B/1050/RVD

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

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

A list of all parts of the IEC 61003 series, published under the general title *Industrial-process control systems – Instruments with analogue inputs and two or multi-position outputs*, can be found on the IEC website.

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

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

INTRODUCTION

The methods of evaluation specified in this part of IEC 61003 are intended for use by manufacturers to determine the performance of their products and by users, or independent testing establishments, to verify the manufacturer's performance specifications.

The test conditions in this standard, for example the range of ambient temperatures and power supply, represent those, which commonly arise in use.

The tests specified in this standard are not necessarily sufficient for instruments specifically designed for unusually arduous duties. Conversely, a restricted series of tests may be suitable for instruments designed to perform within a more limited range of conditions.

It will be appreciated that the closest communication should be maintained between the evaluating body and the manufacturer. Note should be taken of the manufacturer's specifications for the instrument, when the test program is being decided, and the manufacturer should be invited to comment on both the test program and the results. His comments on the results should be included in any report produced by the testing organization.

INDUSTRIAL-PROCESS CONTROL SYSTEMS – INSTRUMENTS WITH ANALOGUE INPUTS AND TWO- OR MULTI-POSITION OUTPUTS –

Part 1: Methods for evaluating performance

1 Scope

This part of IEC 61003 is applicable to pneumatic and electric industrial-process instruments or control device using measured values that are continuous signals either a mechanical (position, force, etc.) or a standard electric signal.

These instruments or process control systems modules may be used as controllers or as switches for alarm and other similar purposes.

Electronic product safety issues may impact only a few products covered by this document. Consequently this document does not address such safety issues.

This standard is intended to specify uniform terminologies and testing methods for performance evaluation of industrial-process instruments or process control systems modules with analogue measured values and two- or multi-position outputs.

Considerations other than the performances are listed in Clause 10.

2 Normative references

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

IEC 60050 (all parts), *International Electrotechnical Vocabulary* (available at <http://www.electropedia.org>)

IEC 60050-300, *International Electrotechnical Vocabulary – Electrical and electronic measurements and measuring instruments* (comprising Parts 311, 312, 313 and 314)

IEC 60050-351, *International Electrotechnical Vocabulary – Part 351: Control technology*

IEC 61298-1:2008, *Process measurement and control devices – General methods and procedures for evaluating performance – Part 1: General considerations*

IEC 61298-2:2008, *Process measurement and control devices – General methods and procedures for evaluating performance – Part 2: Tests under reference conditions*

IEC 61298-3:2008, *Process measurement and control devices – General methods and procedures for evaluating performance – Part 3: Tests for the effects of influence quantities*

IEC 61298-4, *Process measurement and control devices – General methods and procedures for evaluating performance – Part 4: Evaluation report content*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-300, IEC 60050-351, IEC 61298-2 and the following apply.

3.1
switching point
x_i
measured value (with the input moving either upscale or downscale), at which the output (y) changes from one position to another

3.2
two-position output
output variable which may assume one of two discrete values

EXAMPLE

Action illustrated in Figure 1, where x is the value of the input variable and y is the value of the output signal.

The two-position output, having one pair of switching points x_1 and x_2 (x_2 greater than x_1) has the relationships:

$$y = \begin{cases} y_1, x < x_1 \\ y_2, x > x_2 \end{cases}$$

For $x_1 < x < x_2$, y may be either y_1 or y_2.

It is y_1 if the last switching point crossed by x was x_1.

It is y_2 if the last switching point crossed by x was x_2.

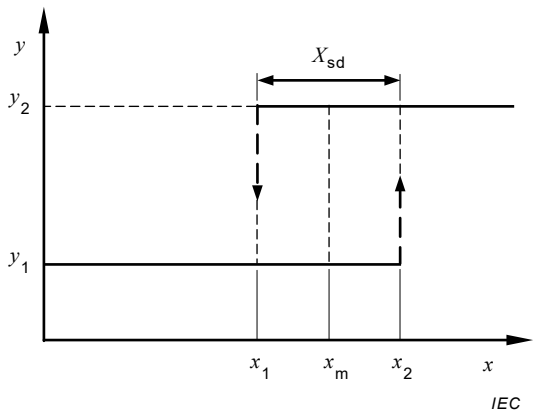

Figure 1 – Action of two-position output

3.3
multi-position output
output variable which may assume any of a set of discrete values

EXAMPLE

A multi-position output has n possible output values and n-1 pairs of switching points, (see Figure 2, a three-position output). Each pair of switching points may be investigated by the procedure given for the two-position output.

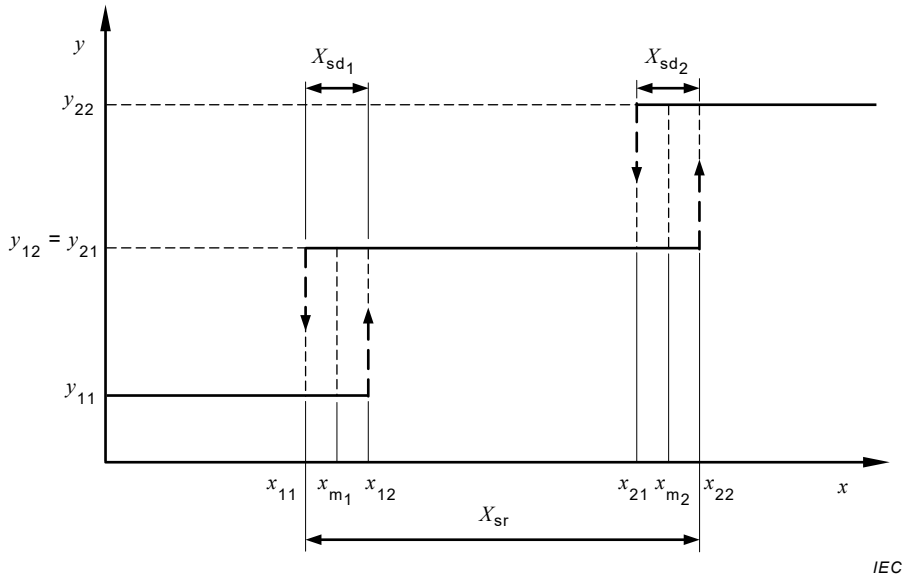

Figure 2 – Action of three-position output

3.4
differential gap
X_{sd}
absolute value of difference between the switching point x_2 with the measured value moving upscale and the switching point x_1 with the measured value moving downscale

SEE: Figure 1 and Figure 2.

3.5
mean switching point
x_m
mean of the values of upscale and downscale switching points

SEE: Figure 1 and Figure 2.

3.6
switching range
X_{sr}
in a multi-position output, range of measured values corresponding to the extreme switching points

SEE: Figure 2.

3.7
set point
w
point value at which it is desired that switching (at x_2 or x_1 as specified) should occur

4 General conditions for tests

4.1 Documentary information

4.1.1 General reference documents

For the purpose of this standard, the general test conditions (e.g. environmental test conditions, supply conditions, load conditions, mounting position, externally induced

vibrations, external mechanical constraints, and delivery of the instrument) specified in Clause 6 of IEC 61298-1:2008 apply, together with Clause 4 of this part of IEC 61003.

The general testing procedures and precautions, specified in Clause 7 of IEC 61298-1:2008, shall be applied, together with Clause 5 of this part of IEC 61003.

The tests general methods and procedures – if any – specified in IEC 61298-2 and IEC 61298-3 apply, together with Clause 6 of this part of IEC 61003.

4.1.2 Collect data

The manufacturer shall supply to the evaluating body information for installation, commissioning, operation, routine maintenance and repair of the instrument. A spare parts list, together with a recommendation of the spare parts to be held in stock, shall be supplied. The language of written information for installation should be primary or accepted language of the country where implemented.

Installation and use guidelines including diagrams, operation instructions, spare parts requirements, and all specifications should be clearly stated.

Additionally, any certificates indicating the degree of intrinsic safety and flameproofing, etc. of electrically powered instruments should be listed. This information should give details of the certificate numbers and the degree of protection provided.

Procedures for installation, routine maintenance and adjustment, repairs and overhaul should be examined by the actual performance of the required operation. This should be performed in accordance with the manufacturer's instructions, so that an evaluation of the instructions can be carried out concurrently.

4.2 Electrical safety

Electrically powered instruments should be examined to determine the degree to which their design protects them against accidental electric shock.

4.3 Installation

The instrument should be installed and set to work according to the manufacturer's instructions, taking account of the various applications which may be met in practice and which require different procedures.

4.4 Supply conditions

Tolerances on supply conditions for mains supplied equipment are given in 6.2.2 of IEC 61298-1:2008. For instruments with self-contained power supplies (e.g. battery-powered) the tolerances are different and shall be agreed.

5 General testing procedures and precautions

5.1 Checking of calibration made prior to delivery

The input-output characteristic that shall be checked (see 7.6 of IEC 61298-1:2008) is the values of the switching points x_1 and x_2 found during the calibration (if any) made prior to delivery.

5.2 Set point

Except where otherwise specified, the set point shall be set to the midscale value or, where no scale is provided, to the middle of the effective range of adjustment.

5.3 Differential gap

Except where otherwise specified, if the differential gap X_{sd} is adjustable, it shall be set to the midscale value or, where no scale is provided, to the middle of the effective range of adjustment.

6 Test methods and procedures

6.1 Tests under reference conditions

6.1.1 Switching accuracy related factors

6.1.1.1 General

The general test description refers to 4.1.7 of IEC 61298-2:2008.

The input measured value x shall be varied slowly at least five times in each direction through its entire range. By observation of the output, the values of points x_1 and x_2 and their average shall be determined.

For each cycle, the individual differential gap $| x_1 - x_2 |$ shall be noted.

6.1.1.2 Inaccuracy of switching points

The general test description refers to 4.1.7.1 of IEC 61298-2:2008.

Switching point inaccuracy is determined by selecting the greatest positive and negative deviations of any measured value of x_1 and x_2, of any cycle, from the set point w for increasing and decreasing inputs.

This should be reported in percent of nominal span of measured value.

6.1.1.3 Non-repeatability of switching points

The general test description refers to 4.1.7.6 of IEC 61298-2:2008.

Non-repeatability shall be computed observing the range, in percent of nominal span of measured value, among all x_1 values and among all x_2 values.

The maximum value, from either the x_1 range or the x_2 range, is reported as non-repeatability.

6.1.1.4 Inaccuracy of differential gap

The general test description refers to 4.1.7.1 of IEC 61298-2:2008.

The differential gap X_{sd} is calculated by subtracting the average value of x_1 from the average value of x_2 (see 6.1.1).

Differential gap inaccuracy is determined by selecting the greatest positive and negative deviations of any measured value of the individual differential gaps – calculated in each of the five cycles – from the X_{sd}.

Reporting this in percent of the nominal span of measured value.

6.1.1.5 Non-repeatability of differential gap

The general test description refers to 4.1.7.6 of IEC 61298-2:2008.

Non-repeatability shall be computed calculating the differences, in percent of the nominal span of measured value, among all individual differential gap values noted in 6.1.1.

The maximum of those values is reported as non-repeatability of differential gap.

6.1.2 Mean switching point

Mean switching point x_m is calculated as the mean of the average values of x_1 and x_2 (see 6.1.1.1).

6.1.3 Set point

6.1.3.1 Set point adjustable and measurable or indicated

The general test description refers to 4.1.7.1 and 4.1.7.6 of IEC 61298-2:2008.

Determine values of x_1, x_2 and X_{sd}, and their accuracy-related factors, in accordance with the test procedures in 6.1.1.1, at least for values of w of 10 %, 50 % and 90 %, the 50 % value being taken last.

Determine values of x_m, in accordance with the test procedures in 6.1.2.

The inaccuracy of set point setting is determined by selecting the greatest positive and negative deviations of any measured value of x_m from the ideal set-point value for each cycle and for each set point.

6.1.3.2 Set point adjustable but not indicated

The general test description refers to 4.1.7.1 and 4.1.7.6 of IEC 61298-2:2008.

Determine values of x_1, x_2 and X_{sd}, and their accuracy-related factors, in accordance with the test procedures in 6.1.1.1, and values of x_m, in accordance with the test procedures in 6.1.2.

Make this test, for at least three values of w, approximately evenly spaced over the effective range of adjustment, the approximately mid-value being taken last.

It is not necessary to determine $x_m - w$ in this case.

6.1.3.3 Set point not adjustable

The general test description refers to 4.1.7.1 and 4.1.7.6 of IEC 61298-2:2008.

Determine values of x_1, x_2 and X_{sd}, and their accuracy-related factors, in accordance with the test procedures in 6.1.1.1, and values of x_m, in accordance with the test procedures in 6.1.2.

The inaccuracy of set point setting is determined by selecting the greatest positive and negative deviations of any measured value of x_m from the value of w declared by the manufacturer. Reporting that in percent of the nominal span of measured value.

For two-position output with non-symmetrically adjustable differential gap (e.g. instruments where x_1 or x_2 instead of x_m is intended to be equal to w), the value of $x_1 - w$ or $x_2 - w$ instead of $x_m - w$ should be taken into account.

6.2 Tests for the effects of influence quantities

6.2.1 Ambient temperature

The general test description refers to Clause 5 of IEC 61298-3:2008.

The change in switching points shall be determined at each test temperature specified in 5.2 of IEC 61298-3:2008. For example: +20 °C (reference), +40 °C, +55 °C, +20 °C, 0 °C, –20 °C, +20 °C. After the first cycle, a second temperature cycle, identical to the first, shall be performed without readjustment of the instrument.

For instruments with a pneumatic output the air supply temperature shall be the same as the instrument temperature.

6.2.2 Humidity

The test shall be performed for electrical instruments only.

This test shall be performed according to the methods and procedures stated in Clause 6 of IEC 61298-3:2008, together with what is stated below.

After the stabilization at the reference relative humidity and temperature, a set of reference measurements shall be taken.

The power supply to the instrument shall be switched off and the relative humidity shall be increased as specified in Clause 6 of IEC 61298-3:2008.

The instrument shall be switched on for the final 4 h of the period in stable conditions and the change in switching points shall be measured immediately after this period.

As specified in Clause 6 of IEC 61298-3:2008, the relative humidity shall be reduced to the original reference value and, after stabilization, the effect of this test on the switching points shall be determined.

After this test, a visual inspection shall be conducted to check for effects of flashover, accumulation of condensation, deterioration of components.

6.2.3 Vibrations

The general test description refers to Clause 7 of IEC 61298-3:2008, together with the following additional requirements.

a) During the frequency sweeping, frequencies shall be noted, which cause significant changes in the switching points or spurious operation such as contact bounce.

   In order to measure the effect of vibrations on the switching behaviour, the sweeping shall be performed with the measured variable input set above the switching point x_2, or below the switching point x_1 to a distance that is twice the value of the differential gap X_{sd}, but not less than 1 % of nominal span of measured value.

   If, during the sweeping, switching occurs, the test shall be repeated with a larger difference between measured value input and switching point (at 0 Hz) until no switching is induced by vibration.

   The largest difference and the frequency, at which the last switching occurred, are to be noted.

b) Endurance conditioning by sweeping.

   The instrument shall be subjected to vibration for 30 min in each of three mutually perpendicular planes, one of which shall be the vertical direction. In each plane, the test shall be run at that frequency which resulted in the largest mechanical resonance during the initial resonance search, or if a resonance was not detected, the vibration frequency shall be swept continuously through the whole frequency range being considered.

c) Final resonance search 7.4 of IEC 61298-3:2008.

   The resonance frequencies, and the frequencies, which cause significant changes in the switching points, found in the initial resonance search and the final resonance search shall

be compared. Difference can be caused by non-elastic deformation, which may lead to the origination of cracks in the mechanical construction.

d) Final measurement 7.5 of IEC 61298-3:2008.

The satisfactory mechanical condition of the instrument shall be verified at the end of the test. Any change of switching points shall be noted. If the instrument has a mechanical set point, determine whether vibration has shifted the set point.

6.2.4 Shock, drop and topple

This test shall be performed according to the methods and procedures stated in Clause 8 of IEC 61298-3:2008, together with what is stated below.

Before the test, a reference measurement of switching points shall be recorded.

After the test, any change in switching points shall be recorded.

6.2.5 Mounting position

The general test description refers to Clause 9 of IEC 61298-3:2008.

The change in switching points caused by ±10° inclinations from the reference position of the instrument shall be determined.

6.2.6 Over-range

This test shall be performed according to the methods and procedures stated in Clause 10 of IEC 61298-3:2008, together with what is stated below.

Under reference conditions, with set point at 50 % (if possible), set the measured value signal to 50 % overload (i.e. to a value equal to 150 % of upper range values) for 1 min. The measured value signal shall then be set to 50 % of span and, after 5 min the change in switching points shall be measured. For instruments using elevated zero signals (e.g. 0,2 bar to 1,0 bar, 4 mA to 20 mA), the test shall be repeated with measured value signals set to 0 (actual zero, not lower range values).

6.2.7 Output load effects

The effect of the load on the instrument being changed in switching point is determined by changing the value of the energy source (voltage, pressure, etc.) and changing the load of the instrument within the permissible limits. Combinations of values are to be selected, which provide the largest and smallest loading for the switch.

6.2.8 Supply voltage and frequency variations

This test shall be performed on instruments with electrical power supply for internal operations.

The effect on switching points of the variations in the electrical power supply, indicated in 12.1 of IEC 61298-3:2008, shall be measured, the load impedance being as specified in 6.3 of IEC 61298-1:2008.

6.2.9 Short-term supply voltage interruptions

The test shall be performed as in 12.4 of IEC 61298-3:2008, with the following additional procedures.

The set point will be set to a value as specified in a) of 6.2.3.

The test shall be carried out with the output energized and repeated with the output de-energized.

Any spurious operations such as contact bounce shall be noted.

In order to assess the repeatability of these results, this test shall be repeated 10 times, the period between two tests being at least equal to 10 times the duration of the interruption.

6.2.10 Fast transient/burst immunity requirements

This test shall be performed according to the methods and procedures stated in 12.5 of IEC 61298-3:2008, together with what is stated below.

Before the test, a reference measurement of switching points shall be recorded.

Use same input conditions as in a) of 6.2.3.

After the test, any change in switching points shall be noted.

6.2.11 Supply pressure variations

The effect on switching points shall be determined when tests, as in 12.8 of IEC 61298-3:2008, are performed.

If the manufacturer's specified limits are less than the preferred test values indicated above, this fact shall be reported with the test results.

6.2.12 Common mode interference

Requirements deleted[1].

6.2.13 Normal mode interference (series mode)

Requirements deleted[1].

6.2.14 Earthing

This test shall be performed according to the methods and procedures stated in 13.3 of IEC 61298-3:2008, together with what is stated below.

This test is applicable only to instruments with electrical inputs and outputs which are isolated from earth.

The test shall be carried out by measurement of the steady position change of the switching points caused by earthing each input and output terminal in turn.

Any transient change shall be noted.

6.2.15 Magnetic field effects

The test shall be carried out by measurement of the steady position change of the switching points caused by the applied magnetic fields specified in Clause 15 of IEC 61298-3:2008.

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[1] This part of IEC 61003 is an old International Standard and it is referred to in many documents. In order not to modify those documents, the numbering of subclauses in this part of IEC 61003 remains unchanged although some subclauses (6.2.12 and 6.2.13) do not apply anymore.

6.2.16 Electromagnetic field

This test shall be performed according to the methods and procedures stated in Clause 16 of IEC 61298-3:2008, together with what is stated below.

The steady position changes of the switching points as:

a) a consistent measurable change,

b) as a random change, not repeatable, and possibly further classified as a transient effect occurring during the application of the electromagnetic field and as a permanent or semi-permanent field after the application of the electromagnetic field,

shall be measured and reported.

Any damage to the instrument, resulting from the application of the electromagnetic field, shall be noted.

6.2.17 Electrostatic discharge (ESD)

This test shall be performed according to the methods and procedures stated in Clause 17 of IEC 61298-3:2008, together with what is stated below.

The records may show, for example:

a) the effect of ESD on the switching points:
   1) as a consistent measurable effect,
   2) as a random effect, not repeatable and possibly further classified as a transient effect occurring during the application of ESD and as a permanent or semi-permanent effect lasting after the application of the ESD;

b) any damage to the instrument resulting from the application of the ESD.

6.2.18 Effect of open-circuited and short-circuited input

This test shall be performed according to the methods and procedures stated in Clause 18 of IEC 61298-3:2008.

The changes in switching points during the test and the ultimate steady position changes shall be recorded.

6.2.19 Effect of open-circuited and short-circuited output

This test shall be performed according to the methods and procedures stated in Clause 19 of IEC 61298-3:2008.

The changes in switching points during the test and the ultimate steady position changes shall be recorded.

6.2.20 Effect of process medium temperature

This test shall be performed according to the methods and procedures stated in 20.1 of IEC 61298-3:2008.

The steady position changes in switching points, which result from changes in fluid temperature in four equal intervals, shall be measured and reported.

6.2.21 Atmospheric pressure effects

This test shall be performed according to the methods and procedures stated in Clause 21 of IEC 61298-3:2008.

The changes in switching points during the test shall be measured and reported.

6.2.22 Start-up drift

The general test description refers to 7.1 of IEC 61298-2:2008.

The instrument shall be maintained at least 12 h with the power supply switched off and no input applied.

With the set point value w set to approximately 50 % (if possible), the power supply (and measured value input) shall then be switched on. The switching point shall be noted after 5 min and 1 h.

6.2.23 Accelerated operational life test

This test shall be performed according to the methods and procedures stated in Clause 23 of IEC 61298-3:2008, together with what is stated below.

The instrument shall be connected as for normal operation. A cyclic input signal shall be applied with peak-to-peak amplitude sufficient to actuate the switching points in turn. The frequency shall be such that proper switching occurs. The output shall be loaded to the maximum rating specified by the manufacturer.

Unless otherwise agreed with the manufacturer, the instrument shall be subject to 100 000 input signal cycles. After the test, any change in switching points shall be measured.

If applicable, the contact resistance before and after the test shall be measured.

6.3 Other tests

6.3.1 Transient response of a two-position output

When the measured value crosses a switching point, it is possible that the corresponding change of output is delayed. This delay is determined by step response measurement. The magnitude of the change of measured value shall be selected to ensure that switching occurs with every change, i.e. the value of change shall be larger than the switching difference. Different measured value changes may give different results thus giving an indication of non-linearity.

With some instruments, e.g. instruments operating by mechanical linkages etc., multiple switching can occur with certain step changes. This can be expected mainly when the end measured value deviates only slightly from the corresponding switching point.

To make the measurement, increase the measured value suddenly from 0% of its range to values, which start below x_2 and increase gradually from one test to the next.

If multiple switching is observed, the number and sequence of the observed switching, as well as the set point and the measured value at which these occur, shall be stated.

Every deviation of the output from a pure step function shall be noted.

This test shall be performed for each switching point at maximum specified loads.

6.3.2 Indication of the measured value

If the instrument includes an indication of the measured value, its indication accuracy shall be determined at five points approximately evenly spaced over the range, with the switching point set to a value outside the range, if possible.

Any interaction between the switching point adjuster or indicator and the measured value indicator shall be investigated particularly when the measured value is close to the switching point.

With the measured value set to give a 50 % reading on the indicator, the switching point shall be set at 40 % to 50 % of span below and above the measured value setting.

The effect on the measured value indication shall be observed under the following conditions:

a) all power switched off,

b) all power switched on,

c) only those power supplies, which do not directly serve to generate the output signal y are switched on (as far as possible).

Record the change in the measured value indicated.

6.3.3 Adjustable differential gap

Where the differential gap is adjustable, its magnitude shall be determined at the maximum and minimum scale value or, in cases where no scale is provided, at the maximum and minimum of the effective range of adjustment.

Where the set point is adjustable, this test shall be carried out with the set point at mid scale. Resolution of differential gap adjustment, if any, shall be determined.

It is recommended to repeat the measurements at the extreme values of adjustment range to evaluate repeatability of the switching points.

6.3.4 Dielectric strength

This test shall be performed according to the methods and procedures stated in 6.3.3 of IEC 61298-2:2008, together with the additional information below.

Test shall be performed with a test voltage of substantially sinusoidal waveform, its frequency being that of the power supply used by the instrument.

The test voltage shall be applied between the two power supply terminals (which shall be connected together) and earth. The remaining terminals shall be connected together and to earth.

The no-load voltage of the testing apparatus shall be initially set to zero test voltage and then connected to the instrument under test. The transformer used for this test shall have a capacity of at least 500 VA.

The test voltage shall be raised gradually to the value determined in accordance to criteria specified in 6.3.3 of IEC 61298-2:2008, so that no appreciable transient overvoltage occurs. The test voltage shall be maintained at its maximum value for 1 min. It shall then be gradually reduced to zero.

6.3.5 Insulation resistance

This test shall be performed according to the methods and procedures stated in 6.3.2 of IEC 61298-2:2008, together with what is stated below.

The insulation resistance, between each power supply terminal and earth, shall be measured. Unless the manufacturer specifies a lower value, this measurement shall be made using a direct voltage of 500 V. In those cases where the instrument output terminals are isolated from earth, the insulation resistance to earth shall be measured at the maximum voltage specified by the manufacturer.

7 Multi-position output

7.1 Action

Figure 2 shows the action of a simple multi-position output, the three-position output.

7.2 Test

7.2.1 Characteristics of the multi-position output

Tests are carried out on each pair of switching points as for the pair of switching points on a two-position output. For each pair of switching points the values equivalent to x_1 and x_2 are determined, from which are calculated X_{sd}, x_m and, where appropriate, $x_m - w$.

7.2.2 Mutual influence of pairs of switching points

With independently adjustable pairs of switching points, the extent, to which each adjustable pair of switching points influences the position of the others, will be determined.

Set one pair of switching points at 50% of its adjustment range. Vary the setting of the switching point for each of the other pairs and measure the switching points of the first pair at each variation. The largest influence observed during this procedure is to be stated for each pair of switching points, together with the adjustment range.

It is recommended that the measurements be repeated at the extreme value of the adjustment range for each of the pairs of switching points being examined.

7.2.3 Determination of switching range

In instruments with jointly adjustable pairs of switching points, these are to be adjusted to at least three values (smallest, largest, and a medium value) of their adjustment range. For each of these adjustments the switching range and/or partial switching range are to be determined.

8 General observations

8.1 Protective finishes

The protective finishes on external parts specified by the manufacturer should be listed with relevant comments.

8.2 Tools and equipment

Tools and equipment essential to the installation, maintenance and repair should be listed.

9 Test report and summary of tests

A complete test report of the evaluation shall be prepared in accordance with IEC 61298-4 after completing all the tests.

All the original documentation, related to the measurements made during the tests, shall be stored by the test laboratory for at least two years, after the report is issued.

Table 1 shows an example of a summary of tests and the results and information to be reported.

Table 1 – An example of a report *(1 of 4)*

N°	Designation	Test Method	Reference	Information to be reported	
1	Inaccuracy of switching points	6.1.1.2	IEC 61298-2:2008 4.1.7	% of nominal span of measured value	Values of points x_1 and x_2 and their average shall be reported. The individual differential gap $\lvert x_1 - x_2 \rvert$ shall be noted for each cycle. The greatest positive and negative deviations of any measured value of x_1 and x_2, of any cycle, from the set point w for increasing and decreasing inputs shall be reported as switching point inaccuracy.
2	Non-repeatability of switching points	6.1.1.3	IEC 61298-2:2008 4.1.7.6	% of nominal span of measured value	Recording the ranges among all x_1 values and among all x_2 values. The bigger range value, between x_1 and x_2 shall be reported as non-repeatability.
3	Inaccuracy of differential gap	6.1.1.4	IEC 61298-2:2008 4.1.7.1	% of nominal span of measured value	The difference between the average value of x_1 from the average value of x_2, shall be reported as X_{sd}. The greatest positive and negative deviations of any measured value of the individual differential gaps – calculated in each of the five cycles – from the X_{sd} value, shall be reported as differential gap inaccuracy.
4	Non-repeatability of differential gap	6.1.1.5	IEC 61298-2:2008 4.1.7.6	% of nominal span of measured value	The maximum of the differences, among all individual differential gap values noted in No.1 of this Table, shall be reported as non-repeatability of differential gap.
5	Mean switching point	6.1.2		% of nominal span of measured value	The mean of the average values of x_1 and x_2 (see 6.1.1.1) shall be reported as mean switching point x_m
6	Set point adjustable and measurable or indicated	6.1.3.1	IEC 61298-2:2008 4.1.7.1 and 4.1.7.6	% of nominal span of measured value	The greatest positive and negative deviations of any measured value of x_m from the ideal set-point value for each cycle and for each set-point shall be reported as inaccuracy of set point setting.
7	Set point adjustable but not indicated	6.1.3.2	IEC 61298-2:2008 4.1.7.1 and 4.1.7.6	% of nominal span of measured value	Values of x_1, x_2 and X_{sd}, and their accuracy-related factors and values of x_m, shall be reported.
8	Set point not adjustable	6.1.3.3	IEC 61298-2:2008 4.1.7.1 and 4.1.7.6	% of nominal span of measured value	Values of x_1, x_2 and X_{sd}, and their accuracy-related factors and values of x_m, shall be reported.
9	Ambient temperature	6.2.1	IEC 61298-3:2008 Clause 5	% of nominal span of measured value	The changes in switching points at each test shall be reported.
10	Humidity	6.2.2	IEC 61298-3:2008 Clause 6	% of nominal span of measured value	Changes in switching points during tests shall be reported. Results of visual inspection, conducted after the test, to check for effects of flashover, accumulation of condensation, deterioration of components, shall be reported.

Table 1 *(2 of 4)*

N°	Designation	Test Method	Reference	Information to be reported	
11	Vibrations	6.2.3	IEC 61298-3:2008 Clause 7	Frequencies: Hz --- Differences between measured value input and switching point: % of nominal span of measured value	During the three distinct stages of this test the following values shall be reported: a) Initial resonance search During the frequency sweeping, frequencies shall be noted, which cause significant changes in the switching points or spurious operation such as contact bounce. When, during the sweeping, switching occurs, the largest difference between measured value input and switching point, at which the last switching occurred, are to be noted (see 6.2.3 a)). b) Endurance conditioning by sweeping That frequency, which resulted in the largest mechanical resonance during the initial resonance search, shall be reported, or, if a resonance was not detected, the fact shall be noted. c) Final resonance search The resonance frequencies, and the frequencies, which cause significant changes in the switching points, found in the initial resonance search and the final resonance search shall be compared and noted. d) Final measurement The satisfactory mechanical condition of the instrument shall be verified at the end of the test and reported. Any change of switching points shall be noted. If the instrument has a mechanical set point, determine and note whether vibration has shifted the set point.
12	Shock, drop and topple	6.2.4	IEC 61298-3:2008 Clause 8	% of nominal span of measured value	Before the test, a reference measurement of switching points shall be recorded. After the test, any change in switching points shall be recorded.
13	Mounting position	6.2.5	IEC 61298-3:2008 Clause 9	% of nominal span of measured value	The change in switching points shall be recorded.
14	Over-range	6.2.6	IEC 61298-3:2008 Clause 10	% of nominal span of measured value	The changes in switching points shall be reported.
15	Output load effects	6.2.7			The effect of the load on the instrument shall be noted.
16	Supply voltage and frequency variations	6.2.8	IEC 61298-3:2008 12.1	% of nominal span of measured value	The effect on switching points, measured during test, shall be reported.
17	Short-term supply voltage interruptions	6.2.9	IEC 61298-3:2008 12.4		The effect on the instrument of short-term supply voltage interruptions shall be noted. Any spurious operations such as contact bounce shall be noted.
18	Fast transient/burst immunity requirements	6.2.10	IEC 61298-3:2008 12.5	% of nominal span of measured value.	Any change in switching points shall be noted

Table 1 *(3 of 4)*

N°	Designation	Test Method	Reference	Information to be reported	
19	Supply pressure variations	6.2.11	IEC 61298-3:2008 12.8	% of nominal span of measured value	The effect on switching points shall be reported. If the manufacturer's specified limits are less than the preferred test values, this fact should be reported with the test results.
20	Earthing	6.2.14	IEC 61298-3:2008 13.3	% of nominal span of measured value	The test shall be carried out by measurement of the steady position change of the switching points caused by earthing each input and output terminal in turn. Any transient change shall be noted.
21	Magnetic field effects	6.2.15	IEC 61298-3:2008 Clause 15	% of nominal span of measured value	The measured steady position change of the switching points, caused by the applied magnetic fields, shall be reported.
22	Electromagnetic field	6.2.16	IEC 61298-3:2008 Clause 16	% of nominal span of measured value	The steady position changes of the switching points as: – a consistent measurable change, – as a random change, not repeatable, and possibly further classified as a transient effect occurring during the application of the electromagnetic field and as a permanent or semi-permanent field after the application of the electromagnetic field, shall be measured and reported. Any damage to the instrument, resulting from the application of the electromagnetic field, shall be noted.
23	Electrostatic discharge	6.2.17	IEC 61298-3:2008 Clause 17		The records may show, for example a) the effect of ESD on the switching points: 1) as a consistent measurable effect, 2) as a random effect, not repeatable and possibly further classified as a transient effect occurring during the application of ESD and as a permanent or semi-permanent effect lasting after the application of the ESD; b) any damage to the instrument resulting from the application of the ESD.
24	Effect of open circuited and short-circuited input	6.2.18	IEC 61298-3:2008 Clause 18	% of nominal span of measured value	The changes in switching points during the test and the ultimate steady position changes shall be recorded.
25	Effect of open circuited and short-circuited output	6.2.19	IEC 61298-3:2008 Clause 19	% of nominal span of measured value	The changes in switching points during the test and the ultimate steady position changes shall be recorded.
26	Effect of process medium temperature	6.2.20	IEC 61298-3:2008 20.1	% of nominal span of measured value	The steady position changes in switching points, which result from changes in fluid temperature, shall be measured and reported.
27	Atmospheric pressure effects	6.2.21	IEC 61298-3:2008 Clause 21	% of nominal span of measured value	The changes in switching points during the test shall be measured and reported.
28	Start-up drift	6.2.22		% of nominal span of measured value	The switching point shall be noted after 5 min and 1 h from the power supply switching on.

Table 1 *(4 of 4)*

N°	Designation	Test Method	Reference	Information to be reported	
29	Accelerated operational life test	6.2.23	IEC 61298-3:2008 Clause 23	% of nominal span of measured value	After the test, any change in switching points shall be measured. If applicable, the contact resistance before and after the test shall be measured.
30	Transient response of a two-position output	6.3.1			If multiple switching is observed, the number and sequence of the observed switching, as well as the set point and the measured value at which these occur, shall be stated. Every deviation of the output from a pure step function shall be noted.
31	Indication of the measured value	6.3.2		% of nominal span of measured value	The changes in measured value indicated shall be recorded.
32	Adjustable differential gap	6.3.3		% of nominal span of measured value	The switching range and/or partial switching range shall be reported.
33	Dielectric strength	6.3.4	IEC 61298-2:2008 6.3.3		Report any appreciable breakdown or flashover that occurs during tests.
34	Insulation resistance	6.3.5	IEC 61298-2:2008 6.3.2		The measured insulation resistance between each power supply terminal and earth shall be reported.

10 Partial evaluation

When a full evaluation in accordance with this standard is not required, the tests which are required shall be performed and the results reported in accordance with the subclauses of this standard which are relevant.

The testing program should be subject to agreement between manufacturer and purchaser or testing organization, depending on the nature and the extent of the equipment dealt with.

Bibliography

IEC 61326-1:2012, *Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 1: General requirements*

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