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2004-01

Industrial-process control systems – Instruments with analogue inputs and two- or multi-state outputs –

Part 1: Methods of evaluating performance

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

Part 1: Methods of evaluating performance

FOREWORD

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

This second edition cancels and replaces the first edition issued in 1991 and constitutes a technical revision. It takes into account the common standardized basis specified in the IEC 61298 series. Any test method or procedure specified and described herein is referred to the corresponding Clause of the IEC 61298 series. Any particular method or procedure not covered by the IEC 61298 series is developed and specified in this standard in accordance with the criteria stated in the IEC 61298 series, as far as they are applicable.

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

FDIS	Report on voting
65B/516/FDIS	65B/524/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.

The committee has decided that the contents of this publication will remain unchanged until 2012. At this date, the publication will be

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- withdrawn;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

A bilingual version of this publication may be issued at a later date.

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. Consequently, the values specified herein shall be used where the manufacturer specifies no other values.

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 shall be taken of the manufacturer's specifications for the instrument, when the test programme is being decided, and the manufacturer should be invited to comment on both the test programme and the results. His comments on the results should be included in any report produced by the testing organisation.

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

Part 1: Methods of evaluating performance

1 Scope

This part of IEC 61003 is applicable to pneumatic and electric industrial-process instruments using measured values that are continuous signals in accordance with IEC 60382, or IEC 60381-1. The other input value (i.e. the set point value) may be either a mechanical (position, force, etc.) or a standard signal.

It should be noted that tests specified herein may be applied to instruments which have other continuous measured values, provided that due allowance is made for such differences.

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

Instruments with feedback are not covered by this standard.

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

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

Considerations other than the performances are listed in Clause 10.

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 60050-351:1998, *International Electrotechnical Vocabulary (IEV) – Part 351 Automatic control*

IEC 60381-1:1982, *Analogue signals for process control systems – Part 1: Direct current signals*

IEC 60382:1991, *Analogue pneumatic signals for process control systems*

IEC 61010-1:2001, *Safety requirements for electrical equipment for measurement, control and laboratory use – Part 1: General requirements*

IEC 61298-1:1995, *Process measurement and control devices – General methods and procedures for evaluating performance – Part 1: General considerations*

IEC 61298-2:1995, *Process measurement and control devices – General methods and procedures for evaluating performance – Part 2: Tests under reference conditions*

IEC 61298-3:1998, *Process measurement and control devices – General methods and procedures for evaluating performance – Part 3: Tests for the effects of influence quantities*

IEC 61298-4:1995, *Process measurement and control devices – General methods and procedures for evaluating performance – Part 4: Evaluation report content*

IEC 61326:2002, *Electrical equipment for measurement, control and laboratory use – EMC requirements*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-351 and in IEC 61298-1, IEC 61298-2, IEC 61298-3, IEC 61298-4, together with the following definitions apply.

3.1
switching point x_1, x_2
measured value (with the input moving either upscale or downscale), at which the output (y) changes from one state to another

3.2
two-state instrument
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-state instrument, having one pair of switching points x_1 and x_2 (x_2 greater than x_1) has the relationships:

$y = y_1$ for $x < x_1$

$y = y_2$ for $x > x_2$

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.

3.3
multi-state instrument
a multi-state instrument (see Clause 7 and Figure 4) has n possible output values and n-1 pairs of switching points. Each pair of switching points may be investigated by the procedure given for the two-state instrument.

3.4
switching differential X_{sd}
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

3.5
instrument with no switching differential
this is considered to be a special case where the switching differential approaches zero

3.6
mean switching point x_m
the mean of the values of upscale and downscale switching points

3.7
switching range X_{sr}
in a multi-state instrument the range of measured values corresponding to the extreme switching points

3.8
set point w (reference input variable)
the point (value) at which it is desired that switching (at x_2 or x_1 as specified) should occur

4 General conditions for tests

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, delivery of the instrument) specified in IEC 61298-1, Clause 6 apply, together with the additional information below.

4.1 Documentary information

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 the language of the local user.

All the relevant publications supplied by the manufacturer, automatically and on request, should be listed.

If they do not contain a clear description, with adequate diagrams, of the operation of the instrument, or if they do not contain an adequate spare parts and specifications list, the nature of the inadequacy should be noted.

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 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.

The method of mounting specified by the manufacturer should be reported. Any restrictions on the use of the instrument caused by this method of mounting shall be noted with explanations.

Any other aspects that may seem relevant to the ease or difficulty of installation should be noted with explanations.

4.4 Supply conditions

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

NOTE For pneumatic instrument care should be taken to ensure that pneumatic connections are leak tight.

5 General testing procedures and precautions

For the purpose of this standard, the general testing procedures and precautions, specified in Clause 7 of IEC 61298-1, shall be applied, together with the additional information below.

5.1 Checking of calibration made prior to delivery

The input-output characteristic that shall be checked (see 7.6 of IEC 61298-1) 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 Switching differential

Except where otherwise specified, if the switching differential 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

For the purpose of this standard, the tests general methods and procedures – if any – specified in IEC 61298-2 and IEC 61298-3 apply, together with the additional information stated below.

6.1 Tests under reference conditions

Methods and procedures for each test are described in the last column of the following table.

In the others column are indicated:

– Clause N° and designation of test;
– Clause number of the reference where the general procedures are specified.

Clause and Designation	Reference	Test methods and procedures description
6.1.1 Switching accuracy related factors	IEC 61298-2 4.1.7	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 switching differential ($x_1 – x_2$) shall be noted.
6.1.1.1 Inaccuracy of switching points	IEC 61298-2 4.1.7.1	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 and reporting this in percent of nominal span of measured value.
6.1.1.2 Non-repeatability of switching points	IEC 61298-2 4.1.7.6	Non-repeatability shall be computed observing the maximum difference, 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 maximum difference or the x_2 maximum difference, is reported as non-repeatability.
6.1.1.3 Inaccuracy of switching differential	IEC 61298-2 4.1.7.1	The switching differential X_{sd} is calculated by subtracting the average value of x_1 from the average value of x_2 (see 6.1.1). Switching differential inaccuracy is determined by selecting the greatest positive and negative deviations of any measured value of the switching differentials – calculated in each of the five cycles – from the X_{sd} value and reporting this in percent of the nominal span of measured value.
6.1.1.4 Non-repeatability of switching differential	IEC 61298-2 4.1.7.6	Non-repeatability shall be computed calculating the differences, in percent of the nominal span of measured value, among all switching differential values noted in 6.1.1. The maximum of those values is reported as non-repeatability of switching differential.
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).
6.1.3 Set point		For the adjustment of set point value w, four cases shall be considered: 1. a) w is an adjustable and directly measurable value; b) w is adjustable at the instrument and an adjusting scale for w is provided; 2. w is adjustable at the instrument, but there is no adjusting scale; 3. w is a pre-selected fixed value.

Clause and Designation	Reference	Test methods and procedures description
6.1.3.1 Set point adjustable and measurable or indicated	IEC 61298-2 4.1.7.1 and 4.1.7.6	Determine values of x_1, x_2 and X_{sd}, and their accuracy-related factors, in accordance with the test procedures in subclause 6.1.1, 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 and reporting this in percent of the nominal span of measured value.
6.1.3.2 Set point adjustable but not indicated	IEC 61298-2 4.1.7.1 and 4.1.7.6	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 and 6.1.2, 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. No determination of x_m-w is possible in this case.
6.1.3.3 Set point not adjustable	IEC 61298-2 4.1.7.1 and 4.1.7.6	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 and 6.1.2, 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 and reporting that in percent of the nominal span of measured value. NOTE For two-state instruments with non-symmetrically adjustable switching differential (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

Methods and procedures for each test are described in the last column of the following table.

In the others column are indicated:

– Clause N° and designation of test;
– Clause number of the reference where the general procedures are specified.

Clause and Designation	Reference	Test methods and procedures description
6.2.1 Ambient temperature	IEC 61298-3 Clause 5	The change in switching points shall be determined at each test temperature specified in 5.2 of IEC 61298-3. 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	IEC 61298-3 Clause 6	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, together with what is stated below. After the stabilisation 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. 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, the relative humidity shall be reduced to the original reference value and, after stabilisation, 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.

Clause and Designation	Reference	Test methods and procedures description
6.2.3 Vibrations	IEC 61298-3 Clause 7	a) During the frequency sweeping, frequencies shall be noted, which cause significant changes in the switching points or spurious operation such as contact bounce. NOTE 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 switching differential 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 7.3 of IEC 61298-3 The instrument shall be subjected to vibration for ½ h 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 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 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.

Clause and Designation	Reference	Test methods and procedures description
6.2.4 Shock, drop and topple	IEC 61298-3 Clause 8	This test shall be performed according to the methods and procedures stated in Clause 8 of IEC 61298-3, 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	IEC 61298-3 Clause 9	The change in switching points caused by ±10° inclinations from the reference position of the instrument shall be determined.
6.2.6 Over-range	IEC 61298-3 Clause 10	This test shall be performed according to the methods and procedures stated in Clause 10 of IEC 61298-3, 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	IEC 61298-3 Clause 11	The effect of the load on the instrument being changed is determined by changing the value of the energy source (voltage, frequency, 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	IEC 61298-3 12.1	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, shall be measured, the load impedance being as specified in 6.3 of IEC 61298-1.

Clause and Designation	Reference	Test methods and procedures description
6.2.9 Short-term supply voltage interruptions	IEC 61298-3 12.4	The test shall be performed as in 12.4 of IEC 61298-3, with the following additional procedures. The set point will be set to a value as specified in the NOTE to item a) in 6.2.3. The test shall be carried out with the output energised and repeated with the output de-energised. 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 at each interruption duration, the period of time between two tests being at least equal to 10 times the duration of the interruption.
6.2.10 Power supply transient overvoltages	IEC 61298-3 12.5	Voltage spikes shall be superimposed on the mains supply. The spike energy shall be 0,1 J and the spike amplitudes shall be 100 %, 200 %, 300 % and 500 % overvoltage (percentage of nominal mains r.m.s. voltage). The power supply lines shall be protected by a suitable suppression filter, consisting of at least a choke of 500 µH, capable of carrying the line current. Two pulses of each amplitude phased to mains peak voltage shall be applied or alternatively at least 10 pulses randomly phased with respect to the mains supply. Use the same input conditions as in the NOTE to item a) in 6.2.3. Any change in switching points shall be noted.
6.2.11 Supply pressure variations	IEC 61298-3 Clause 12.8	The effect on switching points shall be determined when tests, as in 12.8 of IEC 61298-3, are performed. NOTE If the manufacturer's specified limits are less than the preferred test values indicated above, this fact shall be reported with the test results.

Clause and Designation	Reference	Test methods and procedures description
6.2.12 Common mode interference	IEC 61298-3 Clause 13.1	This test shall be performed according to the methods and procedures stated in 13.1 of IEC 61298-3 and in IEC 61326, together with what is stated below. This test shall be carried out by measurement of the changes in switching points caused by the superposition of an a.c. signal of 250 V r.m.s. at mains frequency between earth and each input terminal in turn (Figure 2 – Detail a). The test shall then be repeated using a direct instead of an alternating voltage (Figure 2 – Detail b). Whichever common mode condition is chosen, the tests 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 switching differential X_{sd}, but not less than 1 % of nominal span of measured value.
6.2.13 Normal mode interference (series mode)	IEC 61298-3 Clause 13.2	This test shall be performed according to the methods and procedures stated in 13.2 of IEC 61298-3 and in IEC 61326 together with what is stated below. This test is used to determine the influence on switching points of an a.c. signal (series mode signal) at mains frequency superimposed in series on the input signal. For voltage-input instruments (see Figure 3a), the series mode voltage shall be increased gradually until the change of the switching point equals twice the value of the switching difference, but not less than 1 % of span, or until the amplitude of the series mode signal reaches 1 V peak, whichever occurs first. If the manufacturer specifies a maximum value of less than 1 V peak, then this lower value shall be used. The amplitude of the series mode signal corresponding to this effect shall be recorded. For current-input instruments (see Figure 3b), a series mode current signal shall be used, increased gradually to a limiting value of 10 % of span peak. The interference signal should be mixed with the input signal, in a method which is compatible with the circuit impedances involved. An example of such a method, using a summing amplifier with a current output is illustrated in Figure 3b.

Clause and Designation	Reference	Test methods and procedures description
6.2.14 Earthing	IEC 61298-3 13.3	This test shall be performed according to the methods and procedures stated in 13.3 of IEC 61298-3, 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-state 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	IEC 61298-3 Clause 15	This test shall be performed according to the methods and procedures stated in Clause 15 of IEC 61298-3, together with what is stated below. The test shall be carried out by measurement of the steady-state change of the switching points caused by the applied magnetic fields specified in IEC 61298-3.
6.2.16 Radiated electromagnetic interference	IEC 61298-3 Clause 16	This test shall be performed according to the methods and procedures stated in Clause 15 of IEC 61298-3, together with what is stated below. The steady-state changes of the switching points as: i) a consistent measurable change, ii) 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	IEC 61298-3 Clause 17	This test shall be performed according to the methods and procedures stated in Clause 17 of IEC 61298-3, together with what is stated below. The records may show, for example: a) the effect of ESD on the switching points: i) as a consistent measurable effect, ii) 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.

Clause and Designation	Reference	Test methods and procedures description
6.2.18 Effect of open-circuited and short circuited input	IEC 61298-3 Clause 18	This test shall be performed according to the methods and procedures stated in Clause 18 of IEC 61298-3, together with what is stated below. The changes in switching points during the test and the ultimate steady-state changes shall be recorded.
6.2.19 Effect of open-circuited and short circuited output	IEC 61298-3 Clause 19	This test shall be performed according to the methods and procedures stated in Clause 19 of IEC 61298-3, together with what is stated below. The changes in switching points during the test and the ultimate steady-state changes shall be recorded.
6.2.20 Effect of process medium temperature	IEC 61298-3 Clause 20.1	This test shall be performed according to the methods and procedures stated in 20.1 of IEC 61298-3, together with what is stated below. The steady-state changes in switching points, which result from changes in fluid temperature in four equal steps, shall be measured and reported.
6.2.21 Atmospheric pressure effects	IEC 61298-3 Clause 21	This test shall be performed according to the methods and procedures stated in Clause 21 of IEC 61298-3 together with what is stated below. The changes in switching points during the test shall be measured and reported.
6.2.22 Start-up drift	IEC 61298-2 Clause 7.1	The instrument shall be maintained for 24 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	IEC 61298-3 Clause 23	This test shall be performed according to the methods and procedures stated in Clause 23 of IEC 61298-3, together with what is stated below. The instrument shall be connected as for normal operation. A cyclic input signal shall be applied with a 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

Methods and procedures for each test are described in the last column of the following table.

In the others column are indicated:

– Clause N° and designation of test;
– Clause number of the reference – if any – where the general procedures are specified.

Clause and Designation	Reference	Test methods and procedures description
6.3.1 Transient response of a two-state instrument		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.

Clause and Designation	Reference	Test methods and procedures description
		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 measured value indicated.
6.3.3 Adjustable switching differential		Where the switching differential 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 switching differential adjustment, if any, shall be determined. It is recommended to repeat the measurements at the extreme values of the adjustment range to evaluate the repeatability of the switching points.
6.3.4 Isolation test	**IEC 61010-1**	For the purpose of this test IEC 61010-1 shall be followed, together with the additional information below. Isolation tests 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 IEC 61010-1, so that no appreciable transient overvoltages occur. The test voltage shall be maintained at its maximum value for 1 min. It shall then be gradually reduced to zero.

Clause and Designation	Reference	Test methods and procedures description
6.3.5 Insulation resistance		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-state instrument

7.1 Action

Figure 4 shows the action of a simple multi-state instrument, the three-state instrument.

7.2 Tests

7.2.1 Characteristics of the multi-state instrument

Tests are carried out on each pair of switching points as for the pair of switching points on a two-state instrument. 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 is 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 Design features

Any aspects of design or construction likely to cause difficulties in use should be listed with reasons. So also should any features which appear to be of particular interest, for example the degree of enclosure of the working parts, interchangeability of spares, and weatherproofing, reversal of control action, etc. As far as possible, an assessment of the quality of the components and materials used should also be made.

8.3 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.

The following table reports an example of a summary of tests and the results and information to be reported.

N°	Designation	See Clause	Reference	Information to be reported	
1	Inaccuracy of switching points	6.1.1.1	IEC 61298-2 4.1.7	% of nominal span of measured value	Values of points x_1 and x_2 and their average shall be reported. The switching differential ($x_1 - x_2$) 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	6.1.1.2	IEC 61298-2 4.1.7.6	% of nominal span of measured value	The maximum difference among all x_1 values and among all x_2 values. The maximum value, from either the x_1 maximum difference or the x_2 maximum difference, shall be reported as non-repeatability.
3	Inaccuracy of switching differential	6.1.1.3	IEC 61298-2 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 Xsd. The greatest positive and negative deviations of any measured value of the switching differentials – calculated in each of the five cycles – from the X_{sd} value, shall be reported as switching differential inaccuracy.
4	Non-repeatability of switching differential	6.1.1.4	IEC 61298-2 4.1.7.6	% of nominal span of measured value	The maximum of the differences, among all switching differential values noted in 1, shall be reported as non-repeatability of switching differential.
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) shall be reported as mean switching point x_m.
6	Set point adjustable and measurable or indicated	6.1.3.1	IEC 61298-2 4.1.7.1and 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 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.

N°	Designation	See Clause	Reference	Information to be reported	
8	Set point not adjustable	6.1.3.3	IEC 61298-2 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 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 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.
11	Vibrations	6.2.3	IEC 61298-3 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. NOTE 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 Note in 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 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.

N°	Designation	See Clause	Reference	Information to be reported	
13	Mounting position	6.2.5	IEC 61298-3 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 Clause 10	% of nominal span of measured value	The changes in switching points shall be reported
15	Output load effects	6.2.7	IEC 61298-3 Clause 11		The effect of the load on the instrument shall be noted
16	Supply voltage and frequency variations	6.2.8	IEC 61298-3 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 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	Power supply transient overvoltages	6.2.10	IEC 61298-3 12.5	% of nominal span of measured value	Any change in switching points shall be noted
19	Supply pressure variations	6.2.11	IEC 61298-3 12.8	% of nominal span of measured value	The effect on switching points shall be reported. NOTE If the manufacturer's specified limits are less than the preferred test values, this fact shall be reported with the test results.
20	Common mode interference	6.2.12	IEC 61298-3 13.1	% of nominal span of measured value	Measured changes in switching points shall be reported
21	Normal mode interference (series mode)	6.2.13	IEC 61298-3 13.2	V	The amplitudes of the series mode signals corresponding to the effects researched during tests, shall be reported
22	Earthing	6.2.14	IEC 61298-3 13.3	% of nominal span of measured value	The test shall be carried out by measurement of the steady-state change of the switching points caused by earthing each input and output terminal in turn. Any transient change shall be noted.
23	Magnetic field effects	6.2.15	IEC 61298-3 Clause 15	% of nominal span of measured value	The measured steady-state change of the switching points, caused by the applied magnetic fields, shall be reported.
24	Radiated electromagnetic interference	6.2.16	IEC 61298-3 Clause 16	% of nominal span of measured value	The steady-state 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.

N°	Designation	See Clause	Reference	Information to be reported	
25	Electrostatic discharge	6.2.17	IEC 61298-3 Clause 17		The records may show, for example a) the effect of ESD on the switching points: i) as a consistent measurable effect, ii) 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
26	Effect of open circuited and short circuited input	6.2.18	IEC 61298-3 Clause 18	% of nominal span of measured value	The changes in switching points during the test and the ultimate steady-state changes shall be recorded
27	Effect of open circuited and short circuited output	6.2.19	IEC 61298-3 Clause 19	% of nominal span of measured value	The changes in switching points during the test and the ultimate steady-state changes shall be recorded
28	Effect of process medium temperature	6.2.20	IEC 61298-3 20.1	% of nominal span of measured value	The steady-state changes in switching points, which result from changes in fluid temperature, shall be measured and reported
29	Atmospheric pressure effects	6.2.21	IEC 61298-3 Clause 21	% of nominal span of measured value	The changes in switching points during the test shall be measured and reported
30	Start-up drift	6.2.22	IEC 61298-2 7.1	% of nominal span of measured value	The switching point shall be noted after 5 min and 1 h from the power supply switching on
31	Accelerated operational life test	6.2.23	IEC 61298-3 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.
32	Transient response of a two-state instrument	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.
33	Indication of the measured value	6.3.2		% of nominal span of measured value	The changes in measured value indicated shall be recorded
34	Adjustable switching differential	6.3.3		% of nominal span of measured value	The switching range and/or partial switching range shall be reported
35	Isolation test	6.3.4	IEC 61010-1		Report any appreciable transient overvoltages that occurs during tests
36	Isolation resistance	6.3.5			The measured isolation resistance between each power supply terminal and earth shall be reported

10 Other considerations

10.1 Routine maintenance and adjustment

The operations considered to be necessary for routine maintenance and adjustment should be carried out in accordance with the manufacturer's instructions. (As a guide, this should refer to those operations that should be done at least four times per annum.)

Any aspects that are relevant to the ease or difficulty of the effects of performing these operations should be noted, giving reasons.

10.2 Repair

It is usual for instruments to be capable of division into a number of sub-assemblies and for manufacturers to detail repair procedures in terms of the removal and replacement of such sub-assemblies, which may or may not be suitable for further dismantling by users. To assess the ease with which repairs may be done, the sub-assemblies should be removed one at a time, each shall be dismantled as far as it is permissible and any parts damaged or otherwise requiring replacement should be renewed.

Any aspects which are relevant to the ease or difficulty of performing these repairs should be noted, giving reasons.

10.3 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 programme should be subject to agreement between manufacturer and purchaser or testing organisation, depending on the nature and the extent of the equipment dealt with.

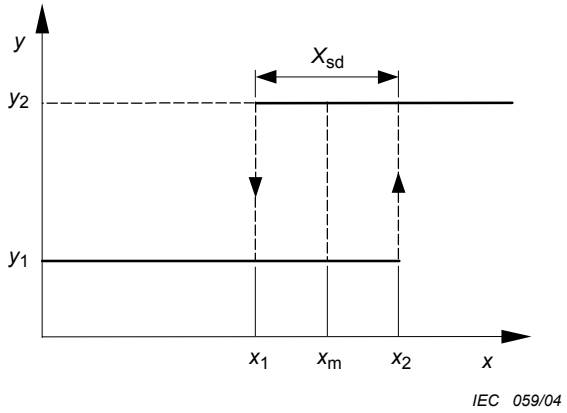

Figure 1 – Two-state instrument

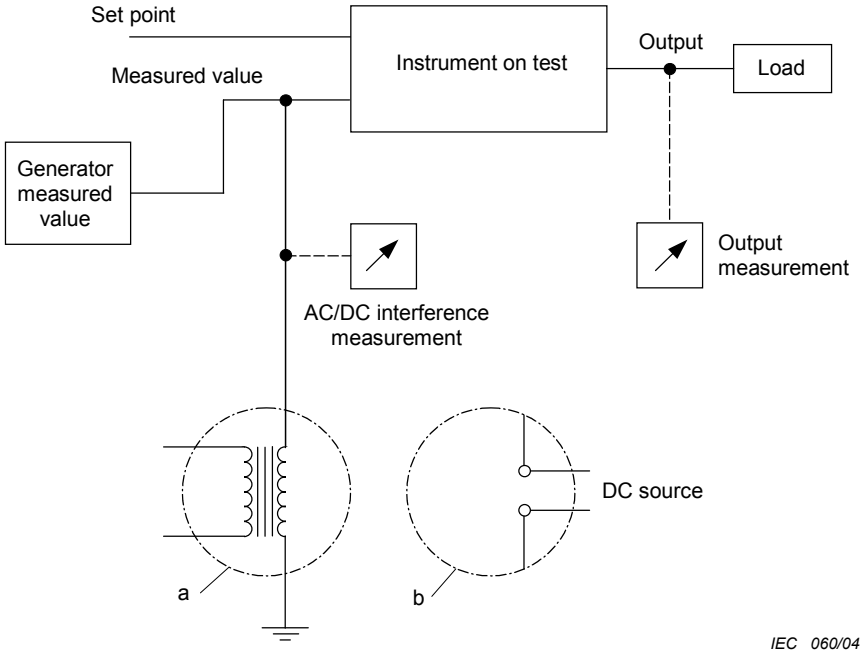

Figure 2 – Arrangement for common mode interference test

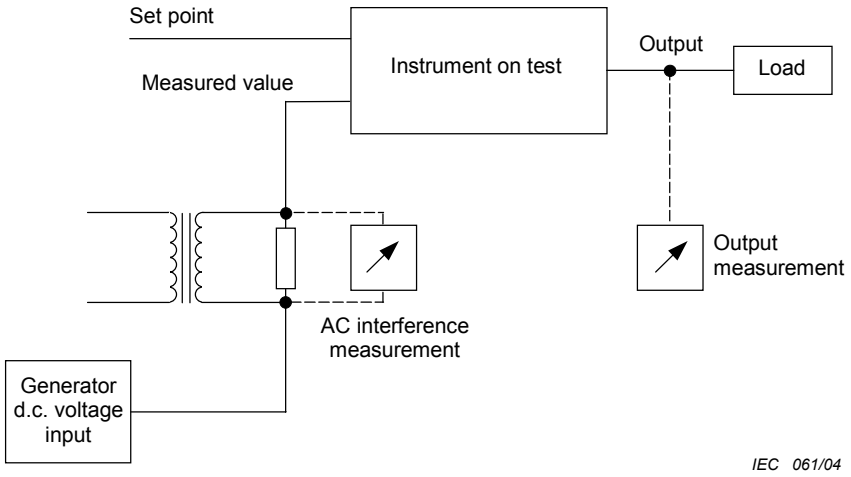

Figure 3a – Voltage input

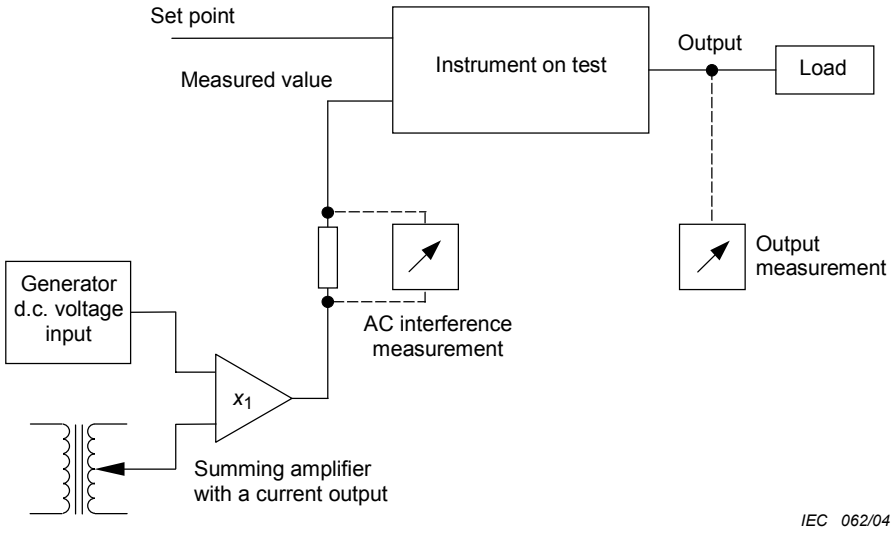

Figure 3b – Current input

Figure 3 – Arrangement for series mode interference test

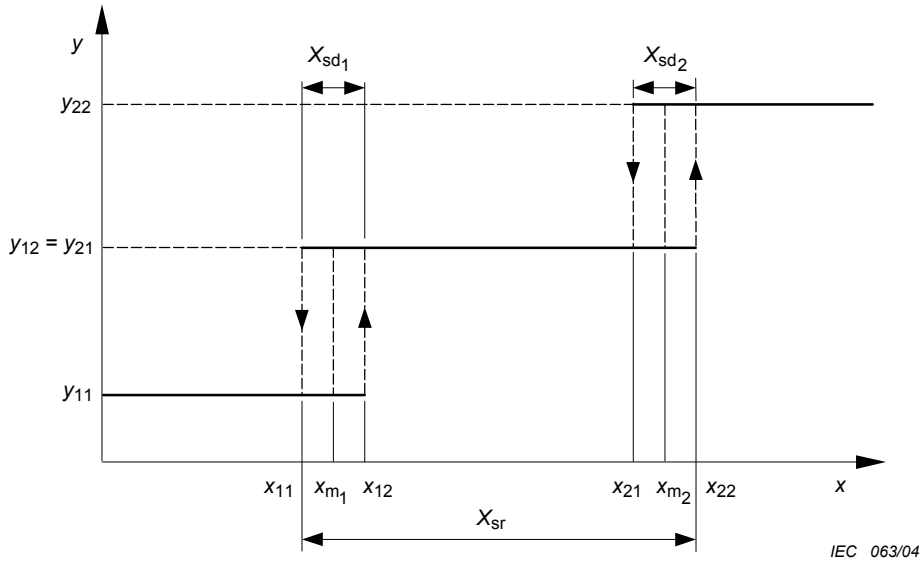

Figure 4 – Three-state instrument

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fairly well ❑
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standard is too academic ❑
standard is too superficial ❑
title is misleading ❑
I made the wrong choice ❑
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(3) average,
(4) above average,
(5) exceptional,
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technical contents.....
logic of arrangement of contents .....
tables, charts, graphs, figures.....
other .....

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