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Process measurement and control devices - General methods and procedures for evaluating performance -
Part 2: Tests under reference conditions

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Process measurement and control devices - General methods and procedures for evaluating performance - Part 2: Tests under reference conditions

FOREWORD

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This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition IEC 61298-2:2008. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

IEC 61298-2 has been prepared by subcommittee 65B: Measurement and control devices, of IEC technical committee 65: Industrial-process measurement, control and automation. It is an International Standard.

This third edition cancels and replaces the second edition published in 2008. This edition constitutes a technical revision.

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

a) Process measurement transmitters (PMT) have been removed from the scope of this standard.

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

Draft	Report on voting
65B/1311/FDIS	65B/1322/RVD

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

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

A list of all parts of the IEC 61298 series, under the general title *Process measurement and control devices - General methods and procedures for evaluating performance*, can be found on the IEC website.

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

– reconfirmed,

– withdrawn, or

– revised.

INTRODUCTION

This document is ~~not intended as a substitute for existing standards, but is rather~~ intended as a reference document for any future standards developed within the IEC or other standards organizations, concerning the evaluation of process instrumentation~~. Any revision of existing standards should take this standard into account~~, except process measurement transmitters (PMT) which are standardized by the IEC 62828 series.

This common standardized basis ~~should~~ can be utilized for the preparation of future relevant standards, as follows:

– any test method or procedure, already treated in this document, ~~should~~ will be specified and described in the new standard by referring to the corresponding clause of this document. Consequently, new editions of this document are revised without any change in numbering and scope of each clause;

– any particular method or procedure, not covered by this document, ~~should~~ will be developed and specified in the new standard in accordance with the criteria, as far as they are applicable, stated in this document;

– any conceptual or significant deviation from the content of this document, ~~should~~ will clearly be identified and justified if introduced in a new standard.

1 Scope

This part of IEC 61298 specifies general methods and procedures for conducting tests and reporting on the functional and performance characteristics of process ~~measurement and control devices~~ instrumentation except process measurement transmitters (PMT) which are standardized by IEC 62828 series. The tests are applicable to any such devices characterized by their own specific input and output variables, and by the specific relationship (transfer function) between the inputs and outputs and include analogue and digital devices. For devices that require special tests, this standard ~~should~~ can be used, together with any product specific standard specifying special tests.

This document covers tests made under reference conditions.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050-300, *International Electrotechnical Vocabulary (IEV) - 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,* available at https://www.electropedia.org/

IEC 60050-351, *International Electrotechnical Vocabulary (IEV) - Part 351: Control technology,* available at https://www.electropedia.org/

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

IEC 61298-1:2026, *Process measurement and control devices - General methods and procedures for evaluating performance - Part 1: General considerations*

3 Terms and definitions

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

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

– IEC Electropedia: available at https://www.electropedia.org/

– ISO Online browsing platform: available at https://www.iso.org/obp

~~**3.1**~~
~~**variable**~~
~~quantity or condition whose value is subject to change and can usually be measured (e.g., temperature, flow rate, speed, signal, etc.)~~
~~[IEV 351-21-01, modified]~~

~~**3.2**~~
~~**signal**~~
~~physical quantity, one or more parameters of which carry information about one or more variables which the signal represents~~
~~[IEV 351-21-51, modified]~~

~~**3.3**~~
~~**range**~~
~~range of values defined by the two extreme values within which a variable can be measured within the specified accuracy~~
~~[IEV 351-27-11, modified]~~

~~**3.4**~~
~~**span**~~
~~algebraic difference between the values of the upper and lower limits of the measuring range~~
~~[IEV 311-03-13]~~

~~**3.5**~~
~~**inaccuracy**~~
~~maximum positive and negative deviation from the specified characteristic curve observed in testing a device under specified conditions and by a specified procedure~~

~~NOTE 1 Accuracy is defined in IEC 60050-300, definition 311-06-08.~~

~~NOTE 2 The term inaccuracy is sometime referred to as measured accuracy. This term should not be used.~~

~~**3.6**~~
~~**error**~~
~~algebraic difference between the indicated value and a comparison value of the measured variable~~
~~[IEV 351-27-04, modified]~~

~~NOTE The error is positive when the indicated value is greater than the comparison value. The error is generally expressed as a percentage of the relevant ideal span.~~

~~**3.7**~~
~~**measured error**~~
~~largest positive or negative value of errors of the average upscale or downscale values at each point of measurement~~

3.1
non-conformity
closeness with which a calibration curve approximates to a specified characteristic curve (which can be linear, logarithmic, parabolic, etc.)

Note 1 to entry: Non-conformity does not include hysteresis.

~~**3.9**~~
~~**non-linearity**~~
~~deviation from linearity~~

~~NOTE 1 Linearity is defined in IEC 60050(300), definition 311-06-05.~~

~~NOTE 2 Non-linearity does not include hysteresis.~~

~~**3.10**~~
~~**non-repeatability**~~
~~deviation from repeatability~~

~~NOTE Repeatability is defined in IEC 60050(300), definition 311-06-06.~~

~~**3.11**~~
~~**hysteresis**~~
~~property of a device or instrument whereby it gives different output values in relation to its input values depending on the directional sequence in which the input values have been applied~~
~~[IEV 351-24-15, modified]~~

~~**3.12**~~
~~**dead band**~~
~~finite range of values within which a variation of the input variable does not produce any measurable change in the output variable~~
~~[IEV 351-24-14, modified]~~

3.2
dead time
time interval between the instant when a variation of an input variable is produced, and the instant when the subsequent variation of the output variable starts ~~[IEV 351-28-41]~~

~~(see IEC 60050-351, Figure 5)~~

[IEC 60050-351, 351-50-30, modified – The definition has been amended and the note to entry has been removed].

3.3
rise time
for a step response, the duration of the time interval between the instant when the output variable (starting from zero) reaches a small specified percentage (for instance 10 %) of the final steady-state value, and the instant when it reaches for the first time a large specified percentage (for instance 90 %) of the same difference ~~[IEV 394-39-11, modified]~~

~~(see IEC 60050-351, Figure 3)~~

[IEC 60050-845:2020, 845-25-067, modified – The definition has been amended and the three notes to entry have been removed.]

3.4
settling time
time interval between the instant of the step change of an input variable, and the instant when the output variable does not deviate by more than a specified tolerance from its final steady state value ~~(see IEC 60050-351, Figure 3). For this standard, a tolerance of 1 % is adopted~~ ~~[IEV 351-24-29]~~

Note 1 to entry: In this document, a tolerance of 1 % is adopted.

[IEC 60050-351:2013, 351-45-37, modified – The definition has been amended and Note 1 to entry has been added.]

3.5
step response time
time interval between the instant of a step change in the input variable and the instant when the output variable reaches for the first time a specified percentage of the difference between the final and the initial steady state value ~~(see IEC 60050-351, Figure 3). For this standard , a specified percentage of 90 % is adopted~~ ~~[IEV 351-24-28]~~

Note 1 to entry: In this document, a specified percentage of 90 % is adopted.

[IEC 60050-351:2013, 351-45-36, modified – The definition has been amended and Note 1 to entry has been added.]

3.6
time constant
time required to complete 63,2 % of the total change of the output of a first-order linear system, produced by a step variation of the input variable
~~[IEV 351-24-24]~~

[IEC 60050-351:2013, 351-45-32, modified – The definition has been amended and the five notes to entry have been removed.]

~~**3.18**~~
~~**test procedure**~~
~~statement of the tests to be carried out, and the conditions for each test, agreed between the manufacturer, the test laboratory, and the purchaser/user before the evaluation starts~~

~~**3.19**~~
~~**type tests**~~
~~a test of one or more devices made to a certain design to show that the design meets certain specifications~~

~~NOTE The type tests are in principle applied only on a sample. Normally are not repeated on all the individual units of equipment made in series.~~

~~**3.20**~~
~~**performance evaluation**~~
~~a complete test to establish the performance of a device under any likely operating conditions to permit comparison with the manufacturer's published or stated performance specification for the device, or the user's requirements~~

~~**3.21**~~
~~**routine test**~~
~~a simplified test to which each individual instrument is subjected during or after manufacture to ascertain whether it complies with certain criteria~~

~~**3.22**~~
~~**sample test**~~
~~a simplified test to check specific characteristics of a device~~

4 Accuracy related factors

4.1 Test procedures and precautions

4.1.1 Selection of ranges for test

4.1.1.1 General

Where there are switched ranges or dial settings (e.g., gain), the tests shall be repeated to cover all ranges or settings. When the device under test (DUT) is supplied calibrated for use, the first set of tests shall be carried out without adjustment.

4.1.1.2 Criteria

The measurements shall be performed with the devices operating at the minimum number of calibration settings necessary to establish the device performance in all required operational settings required by the test program (refer to Clause 5 of IEC 61298-1:2026).

Testing of a device which has provision for substantial adjustment of both span and lower range value ~~may~~ can require an impractically large number of tests. In such a case, preliminary tests shall be conducted to determine the effect of changing span and lower range value adjustments on the characteristic being measured. This should enable some tests to be eliminated from the test program in cases where the characteristic can be inferred reliably from fewer tests. For example, hysteresis ~~may~~ is not ~~be~~ significantly affected by selection of the lower and upper range value if the span is held constant and often ~~may~~ can be inferred for different spans from measurements at a single span setting.

However, the report shall indicate clearly relevant values of the measured parameters for each setting of the adjustments, so that the values of inaccuracy, hysteresis, etc., can all be referenced to the same adjustment of the device.

4.1.1.3 Setting of span and lower range value adjustments

Generally, unless otherwise specified in the test program, the test for accuracy related factors shall be carried out with the adjustments set at the settings A, B, C, D, listed below, and in accordance with Table 1 whenever the span and/or the lower range value adjustments are adjustable further than the adjustments for the manufacturing tolerances.

NOTE Further details on tests of dynamic behaviour, functional characteristics, and drift can be found in Clause 5, Clause 6 and Clause 7, respectively.

Table 1 – Settings of span and lower range value adjustments

Kind of test		Adjustable span	Zero suppression and/or elevation
Complete Tests	Performance evaluation	A	B
	Type test		
Simplified Tests	Routine tests	C	D
	Sample test		

Setting A Span adjustment set at the maximum and minimum values specified by the manufacturer, and at one intermediate value.

Setting B Normally, tests will be done at only one setting of lower range value, without suppression or elevation, but further tests at minimum and maximum settings may be required if the effects are significant.

Setting C Unless otherwise specified in the test programme, the span shall be as set by the manufacturer.

Setting D Unless otherwise specified in the test programme, the lower range value shall be as set by the manufacturer.

4.1.2 Preconditioning cycles

Prior to recording observations, the DUT shall be preconditioned as described in 7.12 of IEC 61298-1:2026 and shall be exercised by three full range traverses in each direction.

4.1.3 Number of measurement cycles and test points

The performance of the DUT shall be verified over the full range for increasing and decreasing values.

Taking into account the economic aspects outlined in 5.2 of IEC 61298-1:2026, the number of measurement cycles and of test points shall be the lowest possible. The number and location of the test points shall be consistent with the kind of test, the degree of accuracy desired, and the characteristics being evaluated.

The number of increasing and decreasing test points shall be the same for each predetermined test point, with the exception of 0 % and 100 %, that are reached only when going downscale or upscale.

The number of measurement cycles and the number of test points depend on the kind of test under consideration. Unless otherwise specified for a particular type of device, the values and locations that should be adopted are given in Table 2.

4.1.4 Additional tests where digital inputs and outputs are provided

Tests shall be made to ensure that the protocols comply with international standards (e.g. RS 232, IEEE 488) or the specifications of the DUT supplier. Tests shall be carried out to confirm that the DUT ~~functions~~ works correctly according to the specified protocol under reference conditions, and without error (or within any error rate specified by the supplier). The levels of logical "1" and "0" shall be determined. ~~Appropriate~~ Tests shall also be made in order to display errors (missing digit sections, etc.), brightness, contrast, and angle of view before loss of brightness/contrast. The update rate shall be recorded, together with display (accuracy) errors.

4.1.5 Measurement procedure

The first measurement shall be performed to the first significant value of the scale after 0 % of input span (e.g. 10 % of input span – see Table 2).

Initially, an input signal equal to the lower range value is generated, and then the input signal is slowly increased to reach, without overshoot, the first test point; after ~~an adequate~~ a stabilization period, the value of the corresponding input and output signal is noted.

Then the input signal is slowly increased to reach, without overshoot, the value of the next test point and, after a stabilization period, the corresponding value of the output signal is recorded.

The operation is repeated for all the predetermined values up to 100 % of the input span. After measurement at this point, the input signal is slowly brought down to the test value directly below 100 % of input span, and then to all the other values in turn down to 0 % of input span, thus closing the measurement cycle.

Table 2 – Number of measurement cycles and number and location of test points

Kind of test		Number of measurement cycles	Number of test points	Location of test points (% of input span)
Complete Tests	Performance evaluation	3 or 5	6	0-20-40-60-80-100
	Type tests		11	0-10-20-30-40-50-60-70-80-90-100
Simplified Tests	Routine tests	1	5	0-25-50-75-100
	Sample tests			

4.1.6 Processing of the measured values

The difference between the output signal values obtained at the various test points for each upscale and downscale traverse and the corresponding ideal values are recorded as the output errors.

The errors generally shall be expressed as percent of the ideal output span. On certain devices (e.g., recorders, or devices with adjustable gain), it ~~may~~ can be more convenient to express the errors as percent of nominal input span (see 7.16 of IEC 61298-1:2026).

For each measuring point, the readings obtained in successive cycles for upscale and downscale error, respectively, shall be averaged to give average upscale and downscale values, and these averaged to give the average value at that point.

All the error values thus obtained shall be shown in a table (see Table 3), and the average values shall be presented graphically (see Figure 1).

4.1.7 Determination of accuracy related factors

4.1.7.1 General

Because of the limited number of measurements (see 4.1.3), the accuracy related factors shall be determined by treating the errors in a mathematically simple way, and not on the basis of statistical methods. ~~The different methods of treatment are described in the following clauses.~~

4.1.7.2 Inaccuracy

Inaccuracy is determined from Table 3 by selecting the greatest positive and negative deviations of any measured value from the ideal value for increasing and decreasing inputs for any test cycle separately, and reporting this in percent of ideal output span.

4.1.7.3 Maximum measured error

Maximum measured error is determined from Table 3 by selecting the greatest positive or negative value from the average upscale errors and the average downscale errors.

4.1.7.4 Non-linearity

For devices that have a linear input/output relationship, the non-linearity is determined from the curve plotted using the overall average of corresponding upscale and downscale average errors (see Table 3 and Figure 1).

The maximum positive or negative deviation between the average curve and the selected straight line, expressed in percent of ideal output span, is the non-linearity, and is independent of dead band and hysteresis.

a) Terminal based non-linearity

   Terminal based non-linearity is determined by drawing a straight line so that it coincides with the average calibration curve at the upper range value and at the lower range value.

   NOTE Where calibrations in workshops and adjustments in the field are made, only terminal based non-linearity is of practical interest. Other expressions of non-linearity are sometimes used.

b) Independent non-linearity

   Independent non-linearity is determined by drawing a straight line through the average curve in such a way as to minimize the maximum deviation. It is not necessary that the straight line be horizontal or pass through the end points of the average calibration curve.

c) Zero based non-linearity

   Zero based non-linearity is determined by drawing a straight line so that it coincides with the average calibration curve at the lower range value (zero) and minimizes the maximum deviation.

Table 3 – Typical table of device errors

Input in % span	1st cycle		2nd cycle		3rd cycle		Average of the cycles		Total average
	Error (in % of ideal span)								
	Up actual	Down actual	Up actual	Down actual	Up actual	Down actual	Up actual	Down average	Average error
	%	%	%	%	%	%	%	%	%
0		–0,04		–0,05		+0,06		–0,05	–0,050
10	+0,06	+0,14	+0,04	+0,15	+0,05	+0,16	+0,05	+0,15	+0,100
20	+0,13	+0,23	+0,08	+0,26	+0,09	+0,26	+0,10	+0,25	+0,175
30	+0,11	+0,24	+0,09	+0,25	+0,10	+0,26	+0,10	+0,25	+0,175
40	–0,04	+0,13	–0,07	+0,15	–0,04	+0,17	–0,05	+0,15	+0,050
50	–0,18	–0,02	–0,16	+0,01	–0,13	+0,01	–0,15	0,00	–0,075
60	–0,27	–0,12	–0,25	–0,10	–0,23	–0,08	–0,025	–0,10	–0,175
70	–0,32	–0,17	–0,30	–0,16	–0,28	–0,12	–0,30	–0,15	–0,225
80	–0,27	–0,17	–0,26	–0,15	–0,22	–0,13	–0,25	–0,15	–0,200
90	–0,16	–0,06	–0,15	–0,05	–0,14	–0,04	–0,15	–0,05	–0,100
100	+0,09		+0,11		+0,10		+0,10		+0,100

Non-repeatability = 0,05 %

Hysteresis = 0,22 %
= hysteresis error + dead band

Maximum measured error = –0,30 %

Inaccuracy = –0,32 % +0,26 %